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Table des matières - Contents

# SAMUEL SILVER

## 1915 - 1976

The unexpected death of Professor Samuel Silver on 5 November 1976 at the early age of 61 will be deeply felt by his many friends in URSI, especially by all who were associated with him in the former Commission VI and, later on, by those of us who first made close contact with him after his election to the Board of Officers in 1963.

Samuel Silver was born in Philadelphia, USA, and graduated in physics from Temple University there. Later, in 1940, he was granted a Ph.D. in theoretical physics at MIT. During World War II, at the Radiation Laboratory of the Massachusetts Institute of Technology, he was engaged in research on the novel types of microwave antenna that were required in the newly-born and rapidly developing field of radar.

After the War, he worked at the Naval Research Laboratory in Washington and, in 1947, joined the University of California at Berkeley and was made Professor of Electrical Engineering in 1950. Later, as Professor of Engineering Science, he directed the Electronics Research Laboratory and in 1960 was responsible for the founding of the Space Science Laboratory at Berkeley. He was awarded a Guggenheim Fellowship in 1953, for his work on the scattering and diffraction of electromagnetic waves, and again in 1960, for his research on the physics of the upper atmosphere. These awards and his election to the National Academy of Engineering in 1968 are indications of the value of his contributions to science in the USA.

Professor Silver's contacts with URSI over more than two decades began during the Assembly in 1950 with his association with Commission VI. His active personal interest and long experience in the problems of e m wave propagation and antenna design received their recognition when he was elected Chairman of the Commission in 1954 following his nomination as Acting Chairman after the resignation, for health reasons, of Dr. van Atta. At that time the work of the Commission was dealt with in three more or less independent Sub-Commissions. It was largely due to his influence that the internal cohesion of the Commission was preserved. Much later, in URSI Bulletin No 181, and in the wider context of science as a whole, Professor Silver stressed the "interdependence of "virtually all the sciences" and he added "there is truly "no way to define areas of scientific endeavour that are "absolutely unrelated and are completely separable from "each other". His belief in the interdependence of the different disciplines of science must doubtless have influenced his views on the desirability of avoiding the fragmentation of Commission VI.

Professor Silver was elected President of URSI in Munich in 1966 and, after the end of his term of office, he remained a member of the Board until 1972. It was at the Warsaw Assembly in 1972 that he was elected to the small group of Honorary Presidents in recognition of the valuable services he had rendered to the Union over a long period.

During his Presidency, one of Professor Silver's special concerns was the creation of a better appreciation of the functions of the Unions, and of ICSU also, in the international scientific community. He admitted that, in an abstract sense, "science is apolitical and is not "concerned with national identities and national interests." Nevertheless he was a realist and he recognised that, as a human activity, the pursuit of science is, in fact, "strongly conditioned by national interests and political "forces of tremendous dimensions". He was a firm believer in the ability of the Unions to lower the political barriers which tend to interfere with the free exchange of scientific knowledge between scientists separated from each other by national frontiers.

Although a Union such as URSI is concerned primarily with advanced scientific research, Professor Silver supported the view that it should also have an educational function in bringing science and technology to all countries, including those still at the developing stage. It was soon after his election as President of the Union that the Board of Officers accepted his proposal for the URSI Young Scientists Scheme. As a result, URSI provided substantial funds in 1969, and again in 1972, which made it possible for groups of promising young research scientists, some from the developing countries in Africa, Asia, and Latin America, to attend the URSI Assemblies in Ottawa and Warsaw and, thereby, to have the opportunity of making personal contact with more experienced workers from other countries.

Although Professor Silver's membership of the Board, and hence his formal links with URSI, ended in 1972, he continued to take a lively interest in the activities of the Union, and in the debate on its reorganisation which was opened during the 1969 Assembly while he was still President. During his visits to Europe for private reasons, he always made a point of spending a day in the URSI Secretariat in Brussels where he was always most welcome, not only as Honorary President but also for his personal qualities. Between these visits, he kept in touch by correspondence and, indeed, the last letter received from him in the URSI Secretariat was written less than three weeks before his death.

Professor Silver's widow, Marjorie, was his constant companion at URSI events and was a familiar figure among the ladies who attended URSI Assemblies. To her and to the members of her family we offer our sincere sympathy.

C.M. Minnis

Professor F.L. Stumpers (Vice-President of URSI) writes:

During the URSI Assembly in Zurich in 1950,Professor Balth van der Pol introduced me to several members of other delegations, among them Professor Samuel Silver. Since Silver's book on microwave antenna theory was already well known, I was amazed at meeting such a young man. We were both members of the Commission VI delegations of our countries, but we also had a strong common interest in radio astronomy; in consequence there were several meetings where we met each other.

In 1950 the Commission on Radio Electronics was separated from Commission VI on Radio Waves and Circuits, but van der Pol remained Chairman of the latter one. I missed the Assembly in Sydney in 1952, but Silver was there. On that occasion four Sub-Commissions were set up on information theory, terrestrial noise and circuit parameters, microwave optics, and antennas and circuits. Dr. L.C. van Atta was elected Chairman of Commission VI, but he had to resign for health reasons in 1953 and, shortly afterwards, the Board of Officers nominated Professor Silver as acting Chairman of Commission VI.

Silver sent a letter to the Official Members asking for papers summarizing the major developments and delineating important problems for future research. Van der Pol had already suggested that the Sub-Commission on terrestrial noise and circuit parameters should cooperate with the Sub-Commission on information theory, and that the Sub-Commission on microwave optics should also look at Fourier transforms, stochastic processes and aperture problems. The Sub-Commission on antennas was not active, since van Atta had intended to chair it himself. Silver suggested antenna synthesis as a problem which could bring together circuit theory and field theory aspects. He had been an interested onlooker in Spencer's Sub-Commission on microwave optics, in view of his special interest in electromagnetic theory and the uncertainty principle.

From my own experience, first while assisting van der Pol in the Sub-Commission on information theory, and later when I became Chairman of this Sub-Commission myself, I know that both van der Pol and Silver were worried about the possibility that there would not be enough interaction between the Sub-Commissions. Obviously there were certain subjects in which they worked independently of each other, but Silver always tried to find also other subjects which would stimulate a cross-fertilization of ideas such as antennas and data processing; statistically inhomogeneous media; the transition from Maxwell's equations to the limiting cases of geometrical optics on the one hand and of circuit theory on the other. At the Assembly, there were also joint sessions with other Commissions having the same objective.

In his introduction to the 1960 Monograph on Radio Waves and Circuits (Elsevier,1960) which he edited, Silver mentioned the seeming diversity of the subject matter falling to Commission VI, but he also remarked: "The fore-"sight and genius of Professor van der Pol in setting up "the Commission have proved themselves in the growth of "the Commission, its effectiveness in stimulating new "areas of study, and as the medium for effecting exchange "of information between scientists of many countries. The "Commission has become an international forum for dis-"cussion of topics of peripheral interest in other inter-"national Unions but which are vital to the growth of the "individual fields and, in concert, to the growth of "communications.....The underlying unity of the fields of "the Commission has become increasingly evident particu-"larly in the recent developments of space communications, "and the future will see a greater element of unity of "subject matter rather than diversity in the work of the "Commission.

In the Bolljahn Memorial Lecture (1972), Silver commented on his participation in the work of Commission VI: "It opened the door to years of rich experiences such "as few other have been privileged to experience and "enjoy". The same satisfaction on looking back at his experience in Commission VI,and at the many interesting things that happened there, comes out clearly in his article for the URSI Golden Jubilee Memorial in 1963.

In 1959, on the initiative of Dr. Lloyd Berkner, the URSI Committee on Space-Radio-Relay was formed. Berkner found that Silver, whose term of office as Chairman of Commission VI was nearing its end, was prepared to chair this new Committee. From his introductory letter to the members (URSI Bulletin No 119, 1960) one can already notice that he hoped to see, in the activities of the new Committee, the same collaboration between different disciplines that he had earlier promoted in Commission VI.In 1963, during the URSI Assembly in Tokyo, he organised the sessions on radio research in space. There, with his colleague H.F. Weaver, he presented a paper on planetary research in the millimetre and infrared regions of the spectrum. This shows that, also in research, Silver was ahead of his time, for it is interesting to note that, 15 years later in 1978, the Assembly will include a session on research on infrared, sub-millimetre and millimetre waves.

Silver's Vice-presidency and his Presidency of URSI coincided with my Chairmanship of Commission VI, and he always gave me his full support and showed his interest in the continuing well-being of "his" Commission. His scientific achievements, his guidance in international scientific cooperation and, most of all, his warm personal friendship will make the memory of Samuel Silver unforgettable. We are sad because we have lost him, but thankful for the privilege of having known him.

Professor L.B. Felsen (Vice-Chairman of URSI Commission B) writes:

Professor Silver's scientific orientation ranged from theory to application, with strong emphasis on the latter. A physicist by academic training, he soon bridged the gap with engineering by becoming involved from 1943-1946 in microwave antenna problems at the MIT Radiation Laboratory. The book Microwave Antenna Theory and Design (Vol.12,MIT Radiation Laboratory Series, 1949), for which he served as Editor and major contributor, became the foundation for modern microwave antenna research and development and is still a standard reference text. Silver's own perceptions of his scientific interests and activities are contained in a fascinating lecture delivered on the occasion of the bestowal upon him of the second John T. Bolljahn Memorial Award (IEEE Transactions - AP, May 1972). Apart from the clarity with which the various scientific endeavors are described there, which demonstrates his qualities as an outstanding teacher, the reader cannot fail to note the thoughtful attribution of credit to others, especially graduate students, who participated in the work.

While his scientific accomplishments and his dedication to his profession earned Professor Silver the admiration and respect of his peers, those who knew him well loved him for his human qualities. He was uncompromising in his quest for excellence and in upholding what he perceived to be basic principles of integrity and conduct within and outside the scientific sphere. He was truly an educator, freely giving advice and counsel. He was modest, unassuming and gentle when dealing with people, but impatient with those whom he thought pompous or hypocritical. He had a highly developed sense of humor and would relate a good joke with relish. He was proud of his ethnic and religious heritage as a Jew and even included in his curriculum vitae the sources of his pre-college religious education. He was compassionate of the human condition but realistic about the difficulties in effecting a change. To many who knew him, he was a true friend. He will be sorely missed.

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## RICHARD SAMUEL RETTIE
## 1918 - 1976

The death occurred in Ottawa, on 18 November 1976, of Dr. Richard Rettie, past President of the Canadian National Committee for URSI.

Dr. Rettie received his B.Sc. at Queen's University, Kingston, Canada, in 1941 and subsequently joined the Radio Brench of the Canadian National Research Council. In 1949, while he was a Rhodes Scholar at the University of Oxford, he received his D. Phil. in Physics.

In 1965, the Churchill Research Range Branch of the NRC, now the Space Research Facilities Branch, was established under his supervision and he became its head in

1966. His extensive experience was recognised in 1969 when he became Science Advisor to the Science Secretariat of the Privy Council office in Ottawa and, later, when he returned to NRC in 1971 to become Executive Director for External Relations.

In the international field, Dr. Rettie was an active member of the UN Committee on the Peaceful Uses of Outer Space and was Chairman of the Conference on this subject held in Vienna in 1968.

It was during Dr. Rettie's period of office as President of the Canadian URSI Committee that the invitation to hold our XVI General Assembly in Ottawa in 1969 was accepted. The success of this Assembly owed much to the enthusiasm of the Canadian Organising Committee of which he was the dynamic Chairman. During the Assembly itself, those of us in the international Secretariat could not fail to appreciate his constant personal supervision of the local arrangements and his never-failing readiness to take immediate steps to resolve the problems, major or minor, which inevitably arise during any large international meeting.

Dr. Rettie is survived by his widow and son to whom we tender our sincere sympathy.

C.M. Minnis

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## SIR DAVID MARTIN
## 1914 - 1976

It is particularly sad to record the death, on 16 December 1976, in London of Sir David Martin, while he was still at the height of his career. In his capacity as Executive Secretary of the Royal Society, he had served for many years as Secretary of the URSI Committee in the United Kingdom. Although not a radio scientist himself, he most effectively provided the necessary contact between the Committee and the Royal Society.

David Christie Martin was born in Scotland and, after graduating in chemistry from the University of Edinburgh in 1937, he obtained his Ph.D. in 1939. Following his service, during World War II, in the Department of Research and Development of the British Ministry of Supply, he became General Secretary of the Chemical Society before leaving to take up his appointment with the Royal Society. As Executive Secretary of the Society over many years, he necessarily had to keep in touch with scientific developments in disciplines other than his own. Because of his long experience and the breadth of his interests, and also his exceptional administrative abilities, he was a greatly valued member of many committees, not only in the United Kingdom but also in international circles.

In committee meetings, he tended to avoid becoming involved immediately when heated arguments developed. He had the ability to remain unruffled and apparently detached, until the temperature began to fall. Professor Manneback, for many years Secretary of the Royal Belgian Academy, once aptly described him as a "sheet anchor" on such occasions. But he knew how to judge the appropriate moment to intervene in the debate and to introduce his considered opinions in his own characteristically calm and collected manner. On many occasions his views and his advice on a problem led to its solution, or at least pointed the way towards one.

Sir David was one of the two Administrative Members of the Special Committee for the IQSY, established by ICSU in 1962, whose offices and other facilities in London were generously provided by the Royal Society. Thanks to the almost day-to-day contacts between him and the IQSY Secretariat, administrative problems were never allowed to develop, with the happy result that the IQSY Committee itself was free to concentrate its attention on the organisation of the international scientific programme and related matters until the termination of the Committee in 1967. As Chairman of the IQSY Publications Committee he supervised the subsequent preparation and publication of the seven volumes in the series Annals of the IQSY.

Elsewhere in the international scientific community, Sir David was well known as a member of the UK delegations to General Assemblies of ICSU. As recently as October 1976, he attended the Assembly in Washington D.C. where he served as Chairman of the Resolutions Committee. He travelled widely and was interested in the lowering of the barriers which tend to hinder the free passage of ideas and of scientists across national frontiers. For many years he was a member of the ICSU Committee on the Free Circulation of Scientists.

David Martin will be mourned not only by those of us in URSI who knew him, but also by the much wider circle of friends who had the opportunity of meeting him and Lady Martin, who frequently accompanied him to ICSU and other international meetings and to whom we extend our deep sympathy.

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THE HISTORY OF RADIO SCIENCE

Several informal contacts have recently been made between scientists associated respectively with URSI and with the International Union for the History and Philosophy of Science (IUHPS). The possibility has been mentioned of establishing a joint inter-Union Committee which would include a number of radio scientists who have expressed an interest in the origin and the evolution of radio science over almost a century. This possibility will be further discussed at the forthcoming meeting of the URSI Board of Officers and at the General Assembly of IUHPS this summer.

In the meantime, Prof. R. Taton, President of the History Division of IUHPS, has kindly asked Monsieur Cazenobe, Chargé de recherches at the CNRS in France, to express some of his views on the development of radio science before 1914. The resulting article is included in this issue of the Bulletin. The author has stated that his article has been written in a dogmatic style designed to stimulate a reaction on the part of the reader.

The Secretary General will be glad to receive comments on this article for transmission to M. Cazenobe. In a wider sense, any reader who is interested in the historical aspects of radio science is invited to inform the Secretary General. He should say also whether he is interested, for example, in only a particular branch of the whole subject, or in all the developments that occurred during a given period of time. In his article, M. Cazenobe refers to the need to study documents and publications of great historical value, but of little current general interest, which may be stored and forgotten in the archives of libraries and elsewhere. It would be interesting to know whether any of our readers are aware of the existence of such material and whether they would be interested in examining it.

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# RADIO SCIENCE BEFORE 1914

J. Cazenobe, CNRS, France

(Translation; for original text see page 15)

At first sight, the history of the earliest developments in the practice of radio science, and in the underlying theory, appears to have been well understood for many years. "Radio" had not long been born when there appeared already "histories of wireless telegraphy". Since then, there have been innumerable publications of this kind in many countries, and hardly a decade passes without the publication of new historical works. But what can be concluded from these numerous and precocious volumes? Nothing more than the existence of a powerful and continuing interest in this adventure of mankind and in its innumerable practical consequences. In fact, very few of these works provide accurate scientific and technological information. Some are based on preconceived ideas, many are superficial, none is complete, and most of them contain glaring errors. Hence, the historian who is not content with fragmentary or vague information, who wishes to learn something from history or to understand the hesitations and the final decisions associated with the gradual emergence of radio science, is obliged to return to the original sources. But to what sources? To the hidden archives lying in libraries; to documents relating to patents, to papers presented before scientific academies or congresses, to the scientific and technological articles of all kinds, and in all languages, contained in now often forgotten periodicals. For an isolated worker, the effort required in the study of such documents is necessarily great, and must be limited in its extent. But however modest it may be, it is worthwhile.

When, nearly 10 years ago, the present author began to speculate on the origins of present-day radio science, he did not suspect that it would be necessary to spend a considerable amount of time on the period which is sometimes called "heroic" or even "prehistoric" and which has been referred to by M. Ponte as the period of "radio en bois" ("steam radio"). As compared with the parallel practical and theoretical approaches to radio science which followed the appearance of the three-electrode tube, the programmes of research characteristic of this period may seem to have been of little importance when judged by the methods used and the results obtained. However, when one looks more closely, one sees not a series of groping steps in the dark, associated with a lack of skill and hesitant progress, but rather a sequence of advances, closely linked together, whose setbacks and successes both seem to have been the necessary precursors of subsequent changes. A new branch of science was being created around a series of technical advances. Fundamental problems were attacked and, as far as possible, resolved: directive antennas,the ground wave, the coupling of circuits and the reduction of damping, tuning, detection and even, to a limited extent, the modulation of a continuous wave. At the practical level, the transmitter benefitted from new designs of the equipment inherited from electrical technology: the Ruhmkorff coil, resonant transformers, the electric arc and the alternator. At the same time, the earliest precursors of electronics can be discerned in receivers: the metal filings in coherers, self-restoring detectors, electrolytes and crystals. What were the results? A remarkable extension of the range of communication, the early allocation of distinct frequency bands, better protection against atmospheric noise, a real improvement in the reliability of equipment and ease of operation,promising trials of radiotelephony.......we tend to underestimate this progress, but those who made it possible also seem to have done so. At the Société Internationale des Electriciens in 1910, Commandant Ferrié remarked that if wireless telegraphy had preceded telegraphy with wires, the invention of the latter would have been regarded as an unquestionable step forward......and probably the results they achieved were not in line with their expectations. But still, Fleming had constructed a thermo-electronic diode in 1904 and de Forest a thermo-ionic triode in 1907 while, in 1910, Langmuir was inventing......the vacuum. Although it could not be appreciated at the time, radio science had made a new beginning.

Was it even necessary to start again? The path for future solid-state electronics, namely the exploitation of the properties of non-metallic conduction, had already been prepared during the studies of the abnormal behaviour of the metal filings in coherers. The first patents for crystal detectors date from 1906, and Braun had experimented with other mineral materials in 1901. Moreover, it is now possible to show experimentally that the so-called phenomenon of "spontaneous decohesion", discovered by Branly in 1897, rediscovered by Chunder Bose in 1899, used by Thomas Tommasina and Ducretet in 1899 and 1900 and by de Forest in 1903, etc. was nothing more than an attenuated rectification effect. The use of carbon preceded that of galena. The more one studies the archives, the clearer it becomes that the now current expression "the electronic revolution" is inappropriate. On the level of practical progress, there was rather a continuous evolution followed by a growing appreciation, at the theoretical level, of the rôle played by electronics in these phenomena: after 1914 for the crystal, but earlier for tubes.

It appears, however, that the advent of the tube has been generally misinterpreted. The triode has been regarded as an almost accidental improvement of Fleming's diode, or as a sort of second stage in the development of vacuum electronics. But what do we find when we examine the history more closely? That there was an appreciable gaseous residue in the triode of 1907, that it was operated without a grid potential and with a faint bluish glow (the Townsend regime), that it had been preceded in 1906 by an amplifying diode which had a region of negative slope in its characteristic curve, that de Forest had earlier experimented with an arc whose unidirectional conducting properties, known since 1882, had been studied by Lang, Eichburg and Kalleir, Blondel, and whose ability to oscillate (and hence to amplify) had been appreciated by Duddell. Before using an arc, de Forest had used a Bunsen burner: the first plasma detector. Thus the triode was, in the genetic sense, the offspring of the flame; it represented, essentially, a method permitting the exploitation, in radiotelegraphy, of the phenomenon of ionisation by collision in a tube containing low-pressure gas, the ionisation being assisted by an incandescent filament. Looked at in this light, the triode can certainly not be regarded as a descendant of the Fleming diode. It was the result of a marriage of two sources of light: the incandescent lamp and the electric arc lamp and, for this reason, it can not be treated as an isolated development. Between it and the mercury-vapour triode of Von Lieben, there is no major difference. Finally, what difference is there, in practice or in concept, between the triode and the mercury-vapour rectifier that had been studied by Cooper Hewitt since 1895? At the Société française de Physique in 1905, Maurice Leblanc gave a surprising description of this rectifier: it is a triode having two anodes and a hot cathode maintained "in a state of dis-"integration" by an electric heating device. It can be concluded, from the experimentally obtained characteristic curve, that it exhibited a "negative resistance" effect. Moreover, the device can be used as an oscillator or variable resistance "exploseur" which can generate "perfectly regular" alternating current at frequencies near 100 kHz, that is, near those used for radiotelegraphy at that time. Thus the traditional background to the de Forest tube is older than is generally believed: it goes back to the very origins of radio science, for before the triodes there were diodes, and before the hot-cathode diode there had been cold-cathode diodes which had been used for the detection of electromagnetic waves in 1895 by Zehnder, in 1897 by Righi, and in 1898 by Tuma. Thus between 1895 and 1910, "ionics" preceded, heralded and, in a certain sense, influenced what was later to become known as "electronics".

At the same time, the development of ideas in the field of radio science was less spectacular than the progress made on the practical side. This does not imply that it was less important but simply that, at a time when everything had to be constructed almost from basic materials, it was inevitable that the theory could not always overtake, accompany or even closely follow practical developments. Situations arose where a technical innovation, condemned to be a success without being understood, had to be followed up without the reward of any further progress. For example, coherers presented problems that could not be resolved. There were many, often contradictory explanations which could not be resolved in the absence of the basic concepts that would have enabled the phenomenon to be seen as something outside the field of macrophysics. The crystal was hardly less mysterious, even though the direction in which further advances could be made was easier to discover; its rectifying properties were attributed to thermoelectricity or to electrolysis! Also, for a long time, the search continued for the ideal coherer and for the perfect crystal rectifier, without any assurance that they existed. Of course they were never found.

The tube encountered more favourable conditions. At the beginning of the century, there was an increasing understanding of the physics of what Langmuir called " a "pure electron discharge in a vacuum", and also of the ionisation of hot gases. But still there were doubts and uncertainties. The memoir published by Richardson in 1903 ought, it seems, to have ensured the final acceptance of the idea that electrons alone were responsible for the conductivity of a vacuum, in the presence of an incandescent filament, which had been observed by Hittorf in 1883 and, therefore, before Edison. But Richardson's formula, deduced from the work of J.J. Thomson and based on thermodynamical considerations, agreed only imperfectly with a number of experimental results. Rather than accept the idea of the "evaporation of electrons", many workers preferred that based on the reaction of gaseous molecules on the filament; that is, on a chemical phenomenon. This was the view of Soddy (1908), Fredenhagen (1912), Pring and Parker (1912), Pohl and Pringsheim (1913) and others. In fact the confirmation of Richardson's theory was impossible in the absence of a technique for obtaining a sufficiently high vacuum and for outgassing electrodes. Indeed the technique for the manufacture of high-vacuum tubes only became available at the beginning of the War in 1914, and one can say that the battle over the theories was finally won thanks to the cooperation of the technicians who developed military radiotelegraphy: a good example of the beneficial interaction between scientific and industrial research.

The great interest of this period is, in fact, that it is possible to study how these two branches of research affect each other without being diverted from their own respective objectives: on the one hand mathematical and experimental physics and, on the other, technological advances and their practical applications. The study is eased by the fact that the links between the two branches are still distended, that they are still in their early stages, and that they come together slowly in a manner that is characteristic of all beginnings and fresh starts in history. In this respect the birth of radio science is of especial value. It allows us to watch the creation of a new body of theoretical and practical knowledge, embodying various widely dispersed elements which coalesce and grow at the same time. We see the creation of radio science in its initial form, and its expansion to include radioelectronics through the reorganisation of different types of knowledge devoted to practical innovation which has the effect of bringing them closer together with beneficial results.

In view of this, radio science is of interest not only to the historian. It represents also a fruitful and even sometimes a priveleged field for a study of technology and of the nature of knowledge and its validity. It calls for reflexion. When one makes an effort to follow, as closely as the available historical documents will permit, the slow but systematic development of modern radio technology, one cannot but be impressed by the extraordinary coherence of the effort devoted to research. In the succession of achievements, there is only an extremely small place for what is arbitrary or accidental. Almost everything had to be built up from nothing and everything was done at the time and in the order which made it possible to succeed. The repetition of unsuccessful experiments can be regarded, in retrospect, as a necessary check preceding a decision to abandon a particular line of research. Everything seems to have proceeded as if some sort of technological reasoning had presided over the organisation of the successive phases of development. To establish its existence and its meaning, and to unravel the process of development, this is one of the particularly important, and even essential, objectives of historical research. In 1949, Gaston Bachelard questioned whether the philosopher was really "condemned to think of "his radio receiver in terms of its dials and the size of "the loudspeaker". We can reply that he is not: there are no such condemnations in the field of knowledge. But we must begin by making fresh studies of the subject and, perhaps, rewriting, in a more reasoned manner, the history of the origins of radio science.

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## LA RADIOELECTRICITE D'AVANT 1914

J. Cazenobe, CNRS, France

L'histoire des premiers développements des faits et idées radioélectriques paraît au premier abord fort bien connue, et depuis très longtemps. La "radio" venait à peine de naître que paraissaient déjà des "Histoires de la T.S.F.". Depuis, les publications, par tous pays, ont été innombrables, et il ne se passe guère de décade sans qu'en surgissent de nouvelles. Mais que conclure de cette abondance et de cette précocité? Rien d'autre que l'existence d'un puissant et constant intérêt suscité par cette aventure humaine aux conséquences pratiques indéfiniment multipliées... En fait, bien peu de ces travaux apportent une information scientifique et technique précise et détaillée; certains sont de parti-pris, beaucoup sont superficiels, aucun n'est complet et la plupart comportent des erreurs manifestes. De la sorte, celui qui ne se contente pas de renseignements fragmentaires ou approximatifs, celui qui à l'histoire demande un enseignement et s'efforce de comprendre les hésitations et les choix d'une réalité en train de se faire, celui-là est contraint de revenir aux sources. Aux sources? C'est-à-dire à ces archives devenues secrète qui dorment, dispersées dans les bibliothèques: la littérature des brevets, des comptes rendus d'Académies ou de Congrès, des articles scientifiques et techniques en tout genre et toutes langues que renferment des périodiques aujourd'hui bien oubliés. Pour un chercheur isolé, l'effort de documentation est forcément pénible, et il ne peut être que limité. Mais, si modeste soit-il, il en vaut la peine.

Lorsque, il y aura bientôt dix ans de cela, l'auteur de ces lignes s'est interrogé, dans une intention purement spéculative, sur les origines de la radioélectronique contemporaine, il ne soupçonnait pas qu'il lui faudrait s'arrêter longuement sur cette période que l'on a coutume de dire "héroïque" ou même"préhistorique" et que l'on a parfois caractérisée (M. Ponte) comme époque de la "radio en bois". Comparées au double mouvement de réalisation et de théorisation qui a suivi l'apparition de la lampe à trois électrodes, les tensions de recherche de ce temps peuvent paraître dérisoires quant à leurs moyens et à leurs résultats. Mais dès qu'on y regarde d'un peu plus près, on aperçoit, beaucoup plus qu'une suite de tâtonnements, piétinements et maladresses, une série d'initiatives rigoureusement enchaînées dont les échecs, comme les réussites, paraissent avoir été les conditions indispensables des changements ultérieurs. Une science s'est formée autour d'une technique qui a progressé. Des problèmes fondamentaux ont été abordés et, dans la mesure du possible, résolus: ceux du rayonnement dirigé ou non dirigé, de la propagation à la surface du sol, du couplage et du désamortissement des circuits, de la "syntonisation", de la détection, et même, jusqu'à un certain point, de la modulation analogique...etc. Sur le plan des réalisations, on a assisté à l'émission, au renouvellement du matériel hérité de l'Electrotechnique (la bobine de Ruhmkorff, le transformateur à résonance, l'arc et l'alternateur), tandis que, parallèlement, se formaient à la réception les signes précurseurs de l'Electronique (la limaille, l'auto-décohérent, l'électrolyte et le cristal). Les résultats? Une énorme extension des portées, un début d'isolement des canaux d'information, une meilleure protection contre les parasites, un gain réel en sécurité et commodité d'utilisation, des essais encourageants de radiotéléphonie.... Nous sous-estimons d'ordinaire ces progrès. Il est vrai que leurs

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INTERNATIONAL UNION OF RADIO SCIENCE

# URSI Information Bulletin
## Cumulative Index
## No 190 (1974) - No 200 (1976)

Each reference indicates the serial number of the Bulletin followed by the page number. When both English and French texts have appeared, only the reference to the English text is given. The year of publication is not shown in the index but can be found from the Table below.

| | 1974 | 1975 | 1976 |
|---|---|---|---|
| March | 190 | 194+ | 197 |
| June | 191 | 194+ | 198 |
| September | 192 | 195 | 199 |
| December | 193 | 196 | 200 |

+ The material for the March and June 1974 issues was combined in No 194.

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artisans nous en ont quelques fois donné l'exemple. En 1910, le Commandant Ferrié déclarait à la Société Internationale des Electriciens que si la T.S.F. avait précédé la Télégraphie avec fil, l'invention de cette dernière constituerait un perfectionnement indéniable.... Et sans doute les résultats n'étaient-ils pas à la mesure des espoirs que l'on avait conçus. Mais quoi, Fleming avait construit une diode thermo-électronique en 1904, de Forest une triode thermo-ionique en 1907, et en 1910 Langmuir était en train d'inventer...le vide. Sans que l'on pût encore s'en rendre compte, la Radiotechnique prenait un nouveau départ.

Etait-il même nécessaire qu'elle repartît? L'Electronique "du plein", celle de l'exploitation des propriétés de conduction non métallique manifestées par les contacts entre solides, n'était-elle pas en préparation depuis les travaux sur le comportement aberrant des limailles? Les premiers brevets concernant les cristaux redresseurs datent de 1906, mais Braun essayait différents minerais depuis 1901. D'autre part, nous pouvons aujourd'hui expérimentalement vérifier que le prétendu phénomène de "décohésion spontanée" découvert par Branly en 1897, redécouvert par Chunder Bose en 1899, utilisé par Thomas Tommasina et Ducretet en 1899 et 1900, par de Forest en 1903, etc... se ramenait à un effet (atténué) de conductibilité unilatérale. Le charbon précédait la galène. Plus on remue les archives, moins il est commode de donner un contenu précis à l'expression pourtant devenue courante de "révolution électronique". En fait, au niveau des réalisations, il y eût plutôt une"évolution continuée" suivie d'une prise de conscience théorique de "l'électronicité" des phénomènes - postérieure à 1914 pour le cristal et plus précoce pour la lampe.

Il semble d'ailleurs que l'apparition de cette dernière ait été généralement mal interprétée. On a considéré la triode comme un perfectionnement presque accidentel de la diode de Fleming, une sorte de second témoin de naissance de "l'Electronique du vide". Mais qu'enseigne l'histoire examinée à un plus fort grossissement? Que la triode de 1907 était peu vidée, qu'elle fonctionnait sans polarisation de grille et avec une douce lueur bleutée (en régime de Townsend); qu'elle avait été précédée en 1906 d'une diode amplificatrice dont la courbe caractéristique devait comporter une région à pente négative; qu'auparavant, de Forest avait essayé l'arc dont la conductibilité unilatérale, connue depuis 1882, avait été étudiée en 1897,-98,-99 par Lang, Eichberg et Kalleir, Blondel, et dont la capacité d'osciller, donc d'amplifier, avait été reconnue par Duddell en 1899. Avant l'arc, de Forest s'était servi d'un bec Bunsen - le premier détecteur à plasma. Génétiquement, la triode est en quelque sorte fille de la flamme. Elle fut essentiellement un moyen de donner une fonction radiotélégraphique au phénomène de l'ionisation par choc dont la production s'est trouvée facilitée par la présence d'un filament incandescent dans une atmosphère peu raréfiée. A cet égard, elle n'est nullement l'héritière de la diode de Fleming. Elle résulte de l'accouplement de deux appareils d'éclairage: la lampe à incandescence et la lampe à arc. C'est pourquoi elle ne peut être tenue, en son temps, pour une réalisation isolée. Entre elle et la triode à vapeur de mercure de Von Lieben, point de différence majeure; et, finalement,quelle différence de classe ou "d'esprit" de réalisation, entre elle et le redresseur à vapeur de mercure étudié depuis 1895 par Cooper Hewitt? De ce redresseur, Maurice Leblanc a donné en 1905 devant la Société française de Physique une description qui surprend: c'est un montage triode à deux plaques et cathode chaude maintenue "à l'état de désagrégation" par un dispositif de chauffage électrique. Le tracé expérimental de sa courbe caractéristique permet de conclure également à un effet de "résistance négative". Aussi bien l'appareil peut-il être utilisé comme oscillateur ou "exploseur à résistance variable" capable de produire des courants alternatifs "parfaitement réguliers" à des fréquences voisines de 100 kHz - de l'ordre des fréquences radiotélégraphiques de l'époque. La "tradition" dans laquelle s'inscrit la lampe de de Forest est donc plus ancienne qu'on ne le croit. Elle remonte même aux origines de la Radioélectricité; car avant les triodes, il y avait eu des diodes, et avant les diodes à cathode chaude, il y avait eu des diodes à cathode froide utilisées pour la détection des ondes électromagnétiques en 1895 par Zehnder, en 1897 par Righi, en 1898 par Tuma. Ainsi, entre 1895 et 1910, la "Ionique" a précédé, annoncé et d'une certaine façon conditionné ce que nous avons par la suite appelé l'Electronique.

Dans le même moment, le mouvement des idées proprement radioélectriques n'a pas eu un caractère aussi spectaculaire que celui des réalisations. Mais cela ne signifie pas qu'il fut de moindre importance. Simplement, dans cette période où tout était à construire, et à partir de presque rien, il était inévitable que la théorie ne pût toujours devancer, accompagner ou suivre la pratique. Il s'est trouvé des situations où l'entreprise technique, condamnée à réussir sans comprendre, a été contrainte de persévérer sans progresser. C'est ainsi que les limailles ont posé aux électriciens des questions insolubles. Les explications n'ont point manqué; mais elles se sont contredites en vain, faute des instruments conceptuels qui leur eussent permis de s'élaborer à une échelle autre que celle des phénomènes de la Macrophysique. Le cristal ne fut guère moins mystérieux, encore que la bonne direction de travail fût dans son cas plus aisée à découvrir: on a imputé sa conductibilité unilatérale à des effets de thermoélectricité ou d'électrolyse! Aussi, pendant longtemps, a-t-on continué de chercher le tube à limaille idéal ou le cristal redresseur parfait, sans pouvoir être assuré qu'ils étaient réalisables. Bien entendu, on ne les a pas trouvés.

La lampe a bénéficié de conditions plus favorables. En ce début du siècle, la connaissance scientifique de ce que Langmuir a appelé "la décharge des électrons purs dans le vide" et de l'ionisation des gaz chauds se précisait peu à peu. Mais, encore, que d'hésitations et d'incertitudes! Le mémoire de Richardson, publié en 1903, aurait dû, semble-t-il, accréditer définitivement l'interprétation purement électronique de la conductibilité du vide en présence d'un filament incandescent, observée par Hittorf en 1883 - donc avant Edison. Mais la formule de Richardson, déduite des travaux de J.J. Thomson et de considérations empruntées à la Thermodynamique, ne s'accordait qu'imparfaitement avec un certain nombre de résultats expérimentaux. A l'idée d'une "vaporisation d'électrons", beaucoup, et pendant longtemps, préférèrent celle de la réaction des molécules gazeuses sur le filament. On pensait à un phénomène chimique. Ce fut le cas de Soddy (1908), Fredenhagen (1912), Pring et Parker (1912), Pohl et Pringsheim (1913)...etc. En fait, la vérification de la théorie de Richardson n'était possible qu'à la condition que l'on sût produire dans l'ampoule un degré de vide suffisant et que l'on réussît à chasser les gaz occlus des électrodes. Or, la technique de fabrication des lampes "dures" ne fut vraiment mise au point qu'au moment de la guerre de 1914, et l'on peut dire que la bataille théorique a été finalement gagnée avec le concours des techniciens de la Radiotélégraphie militaire: bel exemple d'appui réciproque de la recherche scientifique et de la recherche industrielle.

Le grand intérêt de cette période est précisément qu'elle permet d'analyser le processus par lequel s'articulent les unes sur les autres, sans cesser de répondre à des finalités différentes, la Physique mathématique et la Physique expérimentale d'une part, et la Technique expérimentale et la Pratique utilitaire de l'autre. L'analyse est d'autant plus aisée que les liens sont encore distendus, qu'ils sont saisis au moment de leur formation et qu'ils se nouent avec la lenteur caractéristique de tous les commencements et recommencements de l'histoire. A cet égard, les débuts de la Radioélectricité ont une valeur exemplaire. Ils nous font assister à la genèse d'un nouveau corps de connaissances théorico-pratiques, à partir d'éléments hétérogènes et dispersés qui s'agrègent en même temps qu'ils se multiplient. Nous voyons la Radioélectricité des origines se constituer et s'élargir en Radioélectronique par une réorganisation de différents types de savoir dans l'axe de la pratique novatrice qui suscite leur rapprochement et en bénéficie.

A ce titre, elle n'intéresse pas seulement l'historien. Elle représente un champ d'investigation fécond et parfois même privilégié pour l'épistémologue et le technologue. Elle appelle réflexion. Lorsque l'on s'efforce de suivre, d'aussi près que l'état de la documentation historique le permet, la lente et systématique construction des moyens de la Radiotechnique moderne, on ne peut manquer d'être frappé par l'extraordinaire cohérence de l'effort de recherche. Dans l'enchaînement des oeuvres, il n'y a qu'une place infime pour l'arbitraire et l'accident. Tout, ou pre ue, était à faire, et tout a été fait au moment et dans l'ordre où cela pouvait être fait. La répétition des essais infructueux prend elle-même, rétrospectivement, le sens d'une vérification indispensable précédant la fermeture d'un chantier de découverte. Tout semble s'être passé comme si une sorte de Raison spécifiquement technique à l'oeuvre dans l'histoire avait présidé à l'organisation des phases successives du développement. En établir l'existence et le sens, en dégager la procédure, telle serait l'une des tâches particulièrement importante, sinon obligée, de la recherche historique. En 1949, Gaston Bachelard se demandait si le philosophe était vraiment "condamné à penser son "appareil de radio sous les espèces des boutons de "réglage et de l'ampleur du pavillon". On peut répondre que non: il n'y a point de telles damnations épistémologiques. Mais il faut commencer par réétudier et peut-être réécrire, l'histoire raisonnée des débuts de la Radioélectricité.

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## URSI-CCIR COOPERATION

1. Introduction

The Director of CCIR has circulated a list of Questions and Study Programmes that are considered to be especially important by the International Frequency Registration Board (IFRB). Some of these require more urgent attention than others, because of the needs of IFRB for the World Administrative Radio Conference in 1979. A special joint meeting of CCIR Study Groups will begin in mid-September 1978 and documents for submission to this meeting will be required early in 1978.

Many research workers who are associated with URSI already have direct or indirect links with the national governmental administrations which maintain relations with CCIR. The results of their work are, therefore, communicated to the appropriate CCIR Study Groups.

However, there are other scientists, working in the field of telecommunications, who have no contact with their national administrations and, in the past, URSI has been able to perform a useful service by submitting documents to CCIR based on the experience of such scientists.

The Secretary General of URSI would be glad to hear from anyone who is engaged on work relating to the Questions and Study Programmes listed below and who does not already have contacts with the appropriate national administration in his country.

2. Study Group 5

IFRB believes it is important to have recommendations based on the following Study Programmes in connection with the preferred frequencies for tropospheric scatter systems, the design of space telecommunication systems, and the determination of earth-station coordination areas. The topics listed are illustrative only and do not cover all the details contained in the Study Programmes.

SP 5B-1/5 Propagation data required for trans-horizon radio-relay systems. Topics: distribution in time of basic transmission loss in metric, decimetric and centimetric bands for each month of the year; other statistical information relating to climatic and geographical influences on loss; effects of diffraction, partial reflection, scattering, solar and other noise.

SP 5C-2/5 Propagation data required for space telecommunication systems. Topics: statistical data relating to attenuation, fading, refraction, scintillation and beam divergence of waves passing through the troposphere, and to noise radiation from various sources; phenomena affecting system performance and their prediction.

SP 5D-2/5 Propagation data affecting the sharing of the radio frequency spectrum between terrestrial systems and the earth stations of space telecommunication services. Topics: the contribution of various tropospheric factors to trans-horizon signal strength; climatic and geographical influences.

3. Study Groups 1, 5, 6 and 7

IFRB would like recommendations also on other questions some of which are relevant to the fields covered by the URSI Commissions. For example:

1) Limitation of antenna radiation away from the direction that is necessary for the service, in the range 4 - 27.5 MHz.

2) Directivity of antennas at great distances.

3) Radio noise.

4) Propagation curves and data at frequencies above 30 MHz.

5) Propagation via sporadic-E and other anomalous ionization.

6) Problems of hf ionospheric communications near the equator.

7) Fieldstrangth of sky-waves above 1.5 MHz.

8) Ionospheric effects on propagation below 1.6 MHz.

9) Standard-frequency and time-signal emissions.

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YOUNG SCIENTISTS FROM DEVELOPING COUNTRIES

On the occasion of the ICSU General Assembly in Washington D.C. in October 1976, the National Academy of

Sciences organised a Symposium on "Science: A Resource for Human Kind". Several graduates from developing countries, at present working in Universities in the USA, presented their views on the utilisation of science and of scientists for the benefit of developing countries. A group of young scientists from 15 developing countries collectively prepared a document entitled "Scientific and Scholarly Learning: How appropriate are they to Developing Countries?", and edited by D. Gowon (Nigeria), G. Haim (Israel) and A. Umano (Costa Rica). The following résumé of the recommendations contained in this document is based on a report which appeared in the COSTED Newsletter for January 1977.

1) There is a need for regionally-based institutions of higher education in which the emphasis is on the application of science to the most pressing problems of developing countries. Graduates should maintain close links with these institutions.

Institutions which sponsor students from under-developed countries should be encouraged to tailor their education, as far as possible, to the needs of the societies from which the students come.

The home country of a student should make every effort to encourage his return, including the offer of assistance in finding meaningful employment.

There is a need for a publication, dealing with the problems of scientists from the Third World, which would enhance the communications between scholars from the developing countries.

2) Scholars returning to their home countries must try to influence their governments, administrations and society in general by showing how science can be applied to local conditions. They should write articles in local newspapers, in a style that will permit the general public to understand and appreciate science.

They should also help to create an appropriate infrastructure by devoting time and efforts to middle-level and secondary education, writing text-books, training technicians, etc. These are necessary to the development of the appropriate environment for basic and applied research.

The over-centralization of power and know-how in education should be avoided. Regional centres, with help from a central organisation, can often deal more effectively with the problems of their own respective areas.

3) A scientist should attempt to influence the decision makers in his society, in particular in relation to the need for a national research council having the power to make decisions about priorities in the use of the country's resources and to allocate government funds to different projects. However, the scientist must avoid becoming over-entangled in bureaucratic responsibilities.

Basic research is essential for the maintenance of a high level of scholarship. However, applied research must often be directed towards the solution of the very pressing needs of underdeveloped societies which face serious problems. The scholar must make an educated decision as to which type of research he will undertake.

The importance of personal success, as understood in most competitive developed countries, should be replaced by other forms of fulfilment. The scholar should attempt to devote himself to working for society and should contribute to the betterment of the low living conditions in which many people live in the developing countries.

Governments, international organisations and other bodies that sponsor students from developing countries should attempt to select scientists who will be truly concerned with the needs of the more underpriveleged sections of their societies. They should try to increase the number of students coming from the lowest or poorest strata of the populations of underdeveloped countries.

Institutions should gear the training programmes of visiting scientists to the type of problem that they will face on their return home.

Scientists returning to developing countries are often frustrated initially by the lack of an appropriate infrastructure, by a lack of understanding on the part of their governments, and by other problems. The provision of resettlement grants would be helpful; these would assist returning scientists during the transition period while they were deciding how best to apply their newly-gained experience to the needs of their countries.

The members of the Washington group have offered their services to ICSU and are prepared to give their advice on the problems of scientists returning to developing countries.

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IUCAF

Radio Astronomy

The revised IUCAF proposals on radio astronomy for the World Administrative Radio Conference in 1979 have now been distributed to all IUCAF correspondents and national administrations responsible for matters concerning frequency allocations.

Space Research

A document with proposals on frequency allocations for space research is in preparation, and scientists have been asked, through COSPAR, to make their requirements known to IUCAF. A rapid response is desirable so that all opinions can be taken into account at the next IUCAF meeting in a few months time.

11 February 1977

F. HORNER
Secretary, IUCAF.

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ELECTROMAGNETIC COMPATIBILITY - WROCŁAW 1976

The Third Wrocław Symposium on Electromagnetic Compatibility was held from 24-26 September 1976. It was organised by the Association of Polish Electrical Engineers, the Wrocław Technical University and the Institute of Telecommunications; it was cosponsored by national organisations in Bulgaria, France, Hungary, Italy, Japan, Sweden, UK, USA and USSR, and by international organisations, including URSI. Among the 186 participants, 76 came from 17 European and North-American countries, other than Poland.

The Report on the Symposium contains the text of 62 papers in one or other of the two working languages: Russian and English. More than half of the texts are in English, and each paper is preceded by a brief summary in the second language.

In his address, the Chairman of the Symposium, Prof. Holownia, referred to the rapidly increasing consumption of electrical energy and the expanding use of telecommunication systems. As a result, there is a growing need for giving attention to the scientific and technical problems relating to the protection of the electromagnetic environment and to the compatibility of the great and increasing variety of systems which utilise and sometimes pollute the electromagnetic spectrum.

The many very different topics covered by the papers presented at Wrocław reflect the need for exchanges of ideas between scientists and engineers working in unrelated fields, but having a common interest in controlling what was referred to, in his inaugural address, by the Polish Minister of Posts and Telecommunications as "electromagnetic pollution or even electromagnetic smog".

Both the Wrocław and the Montreux EMC Symposia provide platforms which facilitate such exchanges across national frontiers.

The record of the Symposium, entitled Electromagnetic Compatibility, 1976, has been published by Wydawnictwo Politechniki Wrocławskiej (1976) as No 27 in the series Scientific Papers of the Institute of Telecommunications and Acoustics of Wrocław Technical University. The price is 55 zlotys.

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## XXth COSPAR MEETING 1977

The XXth COSPAR Meeting and associated Symposia will be held in Tel Aviv, Israel from 7 to 18 June 1977. Scientific sessions will be arranged, by COSPAR Working Groups 1 - 8, on a wide variety of subjects relating to physical and biological research in space, the applications of space techniques to astrophysical research and to studies of the Moon and planets, etc.

In addition, there will be four Symposia on:

A. New instrumentation for space astronomy;
B. Travelling interplanetary phenomena;
C. The Viking experiments;
D. The contribution of space observations to global food information systems.

Further details about the programme are available from

COSPAR Secretariat,
51 boulevard de Montmorency,
F - 75016 Paris, France.

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## ELECTROMAGNETIC COMPATIBILITY, MONTREUX 1977

The Second International Symposium and Technical Exhibition on Electromagnetic Compatibility will be held in Montreux, Switzerland, from 28-30 June 1977. As on the previous occasion, the Symposium will deal with the problems of the interaction of electromagnetic energy with electronic and biological systems, the immunity of electronic systems to interference and their compatibility with the electromagnetic environment.

The Symposium is held under the auspices of the Director General of the Swiss PTT, with the cooperation of URSI, CISPR, IEEE, SAE, EUREL and the Association of Polish Electrical Engineers. The Chairman of the Organising Committee is Prof. Dr. F.E. Borgnis (Swiss Federal Institute of Technology) and the Chairman of the Programme Committee; Prof. Dr. F.L. Stumpers (Philips Research Laboratories, Eindhoven).

Following the opening meeting, papers will be presented in three parallel sessions on High-voltage and power lines, Walsh functions, Electromagnetic interference and computers, Safety and EMC, Avionic systems, Ignition noise, Car electric equipment, and Interference to communication systems.

On the second day the subjects will be Electric and magnetic fields, Shielding, Immunity, Frequency management, Design for EMC, and Statistics.

On the final day, the subjects will be NEMP and transient control, CISPR-type measurements, EMC system specifications, EMC and life, Automatic measuring systems, and Effect of radio noise on telecommunication system specifications.

Highlights of the programme include papers on compatible design of large electronic systems (for aerospace, marine and ground transport), on the influence of dynamic and static fields on living organisms, and the sessions sponsored by the IEEE Group on EMC and by URSI Commission E on satellite systems, frequency management, quasi-impulsive noise and noisy signals. There will also be round-table discussions on MIL-STD applications, and on measuring techniques and workshops on EMC diagnostics, shielding and other subjects.

A total of about 114 papers will be presented by authors from Australia, Austria, Canada, France, F.R.

Germany, Hungary, India, Italy, Japan, Netherlands, Poland, Spain, Switzerland, United Kingdom, USA and USSR. The full texts will be made available to registered participants in the 550-page Symposium Record. The Registration Fee is 240 Swiss francs, including a copy of the Record. Additional copies of the Record will be available at 75 Sw.Fr. during the Symposium, or 95 Sw.Fr. afterwards. Reductions of the Registration Fee will be envisaged for members of cosponsoring organisations, early registrants and students.

It is expected that about 20 organisations will participate; they will exhibit modern measuring systems, shielding and other special technologies. Other exhibits will deal with training and educational facilities in France, Germany, Switzerland and the USA. Technical excursions and social events are also being planned.

Further information is available from:

Mr. T. Dvorak,
ETH-Zentrum HF,
CH - 8092 Zurich, Switzerland.
Phone: (01) 32 62 11, Extension 2790.

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IAGA/IAMAP ASSEMBLIES

The General Scientific Assembly of IAGA and the Special Assembly of IAMAP will be held in the University of Seattle, Washington, USA from 22 August to 3 September 1977.

Both IAGA and IAMAP have arranged separate series of scientific sessions which together cover the fields of geomagnetism, upper atmospheric and magnetospheric physics, the physics of the lower atmosphere and meteorology. In addition, several joint IAGA/IAMAP Symposia will deal with topics of interest to both Associations.

Further information on the programme can be obtained from the Secretaries of the Associations:

IAGA Dr. N. Fukushima,
Geophysical Research Laboratory,
University of Tokyo,
Tokyo 113,
Japan.

IAMAP Dr. S. Ruttenberg,
NCAR,
P.O.Box 3000,
Boulder, Colorado 80307, USA.

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## CIRCUIT THEORY

The 5th Summer Symposium on Circuit Theory is being organised by the Institute of Radioengineering and Electronics of the Czechoslovak Academy of Sciences. It will be held during the period 5-9 September 1977 at the House of Culture, Kladno-Sitna, about 30 km north-west of Prague. There are good bus services from Kladno to Prague and to Prague Airport.

The earlier meetings in this series were referred to as "Summer Schools". The present Symposium will cover discrete signal processing, active filter theory and practice, computer-aided circuit design, and phase-locked loops and frequency-synthesis theory.

The papers to be presented will be either invited lectures or short contributions. Both types of paper will be published in the Proceedings.

Further information is available from:

Organising Committee SSCT 77,
Institute of Radioengineering and Electronics,
Czechoslovak Academy of Sciences,
Lumumbova 1,
180-88 Praha 8, Czechoslovakia.

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## EUROPEAN MICROWAVE CONFERENCE

The 7th European Microwave Conference will be held at the Bella Centre, Copenhagen, Denmark from 5 to 8 September 1977.

The sessions will be designed to achieve a balance between the practical and the theoretical aspects of microwave techniques in the following fields:

Antennas and Scattering
Measurements,including measurements of biological

effects.
Remote sensing equipment and techniques.
Sub-nanosecond and gigabit electronics.
Solid-state devices, technology and circuits.
Microwave tubes.
Passive component theory and practice.
Navigational and traffic aids.
Communications systems.
Propagation in microwave and optical guiding structures.
Industrial applications, including power measurements.

All the papers will be presented in English and will be published in the Conference Proceedings which will be available to all the participants.

An exhibition of microwave materials, components and total microwave systems will be held in conjunction with the Conference.

Further information on the Conference is available from the Conference Chairman:

Prof. Preben Gudmandsen,
Electromagnetics Institute,
348 Technical University of Denmark,
DK - 2800 Lyngby, Denmark.

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## BIOLOGICAL EFFECTS OF ELECTROMAGNETIC WAVES

This international symposium is being organised by Commissions A and B of URSI, and will take place from 30 October - 4 November 1977. It is sponsored by the International Union of Radio Science (URSI) and by the United States National Committee for URSI in cooperation with the International Radiation Protection Association(IRPA). The aim of the symposium is to provide an international forum and to bring together scientists from both the physical and biological disciplines.

The conference will be held in a self-contained conference facility, located in Airlie, Virginia, in a lovely country setting about 50 miles from Washington, D.C.

Papers on the following and similar topics are invited:

Sensory effects.
Behavioral effects.
Mutagenic and developmental effects.
CNS effects.
Immunological and hematopoietic effects.
Dosimetry.
Microwave exposure systems.
Instrumentation.
Hyperthermia.
Diagnostic applications.
ELF effects.
Standards.

Prospective authors must submit a 300-word double-spaced abstract and a summary of the research to be presented. The abstracts will be available in printed form at the meeting. The summary will be used for the review and evaluation of papers for acceptance, and should not exceed three type-written pages. The abstract and summary should be mailed to the following address before 1 June 1977:

Professor A.W. Guy, Technical Program Chairman,
Bioelectromagnetic Research Laboratory,
Department of Rehabilitation Medicine,
University of Washington,
Seattle, Washington 98195, USA.

Papers accepted for oral presentation may be submitted for consideration for inclusion in a peer-reviewed Special Supplement to Radio Science, (Symposium issue).It is expected that this volume will become available in the summer of 1978.

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## THE SCIENTIFIC BASIS OF TELECOMMUNICATIONS AND REMOTE SENSING

The US National Committee of URSI, in cooperation with several IEEE Groups, is organising an open scientific meeting which will be held in Boulder, Colorado, from 9-13 January 1978. The Chairman of the Technical Programme Committee is Dr. J.R. Wait. The theme will be the common scientific basis of telecommunications and of remote sensing, in so far as the influence of the environment is concerned.

The topics for discussion which have, so far, been suggested by the US Commission Chairmen are listed below:

| Commission | Topics |
|---|---|
| A | Fiber optics, and digital communication standards. |
| B | Integrated and fiber optics, multiple scattering, inverse scattering, communication satellite antennas, and SEM singularities. |
| C | Radio, optical, cable telecommunication systems, information and communication theory, signal techniques and processing, teaching of telecommunication science, and multipath effects. |
| E | Natural and man-made radio noise, effects of noise on system performance, and scientific spectrum sharing. |
| F | Space telecommunications, radio meteorology, radio oceanography, turbulence, and millimetre waves. |
| G | Ionospheric effects on communication, radio probing of the ionosphere, ionospheric irregularities, ionosphere structure, incoherent scatter, and ionospheric modification. |
| H | Wave dispersion characteristics, propagation in plasmas, antennas in plasmas, non-linear phenomena, diagnostic techniques, and plasma experimentation. |

Abstracts should be submitted, by 15 September 1977, in accordance with the instructions contained in Radio Science Vol.12 (March/April 1977). The Chairman of the Steering Committee is:

Professor S.W. Maley,
Department of Electrical Engineering,
University of Colorado,
Boulder, Colorado 80309,
USA.

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MEASUREMENTS IN TELECOMMUNICATIONS

In accordance with the decision of URSI to give renewed emphasis to its activities in the field of communication science, URSI Commission A (Electromagnetic Metrology) and Commission C (Signals and Systems) have decided to organise an open symposium on measurements in telecommunications in cooperation with the French Committee for URSI.

The Symposium will be held in France in the Palais des Congrès at Perros-Guirec or(and) Trégastel. These two coastal towns are on the north Brittany coast and are close to Lannion, the location of one of the major laboratories of the Centre National d'Etudes des Télécommunications (CNET).

Aims

The Symposium is open to scientists and engineers who are actively concerned with all types of measurements that are necessary for the design and operation of telecommunication systems in accordance with CCIR and CCITT recommendations.

Emphasis will be placed on measurement methods, and the scientific problems associated with the design of measuring equipment, for all communication systems and all frequency bands, including the optical band.

The objective is to bring together both measurement experts and telecommunication specialists with the intention of generating a synthetic view of the problem of measurement, encouraging cross-fertilization between the different techniques in use, and creating a better understanding of current trends in instrumentation.

Programme

The following topics are envisaged but it is not intended to impose tight restrictions on the field to be covered:

1. Basic measurement techniques in telecommunications: short time intervals, delays, pulse characteristics, frequency stability, frequency domain and time domain measurements and their respective field of application,... processing of measurement data.

2. Characteristics of transmission systems and of various two-ports and multi-ports that occur as part of

telecommunications systems: radiation patterns, transfer functions, attenuation, group delay, bandwidth, linear and nonlinear distortions, noise, interference,...

3. Characterization of signals within transmission systems: levels, power spectral density, in or out of band spectral components, instabilities, jitter, statistics of errors in digital systems,...

4. Audio signals and video signals: objective measurements and subjective criteria. Quality of transmission.

5. Measurements on traffic. Measurements for monitoring performance of communication networks and grade of service.

6. Measurements on radioelectric, thermal, chemical,.. environments of systems.

Programme Committee

Chairman: Dr. J.M. Richardson, Director of the Office of Telecommunications, Washington D.C., USA.

Vice-Chairmen: Dr. H.M. Altschuler, Senior Scientist, National Bureau of Standards, Boulder, Col., USA;

M. J. Le Mézec, Assistant Scientific Director, CNET, Lannion, France.

Registration

Intending participants are requested to notify M. Le Mézec, as early as possible, of the topics (see above) in which they are particularly interested and whether they will be accompanied by someone else. Since accommodation is limited, priority will, if necessary, be given to the earliest replies received.

All correspondence concerning the Symposium should be sent to

M. J. Le Mézec,
Colloque URSI - Mesures,
CNET,
F - 22301 Lannion, France.