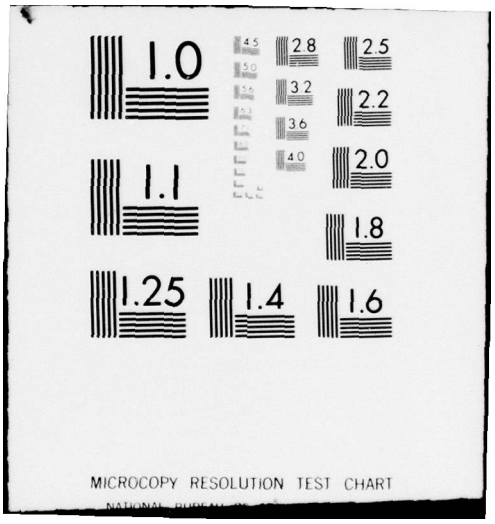
AD-A064 050 ROME AIR DEVELOPMENT CENTER GRIFFISS AFB N Y F/G 17/2.1
WOLFGANG PFISTER, 1906-1976: AN APPRECIATION OF HIS LIFE AND WO--ETC(U)
SEP 78 K TOMAN

UNCLASSIFIED RADC-TM-78-7 NL

| OF |
AD
A064 050

END
DATE
FILMED
3-79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART

RADC-TM-78-7
IN-HOUSE REPORT
SEPTEMBER 1978

# Wolfgang Pfister, 1906-1976: An Appreciation of His Life and Work



KURT TOMAN





ROME AIR DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
GRIFFISS AIR FORCE BASE, NEW YORK 13441

This report has been reviewed by the RADC Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RADC-TM-78-7 has been reviewed and is approved for publication.

APPROVED: Edward E. Altshuler

EDWARD E. ALTSHULER
Acting Chief, Propagation Branch
Electromagnetic Sciences Division

APPROVED: Allan C. Schell

ALLAN C. SCHELL
Chief, Electromagnetic Sciences Division

If your address has changed or if you wish to be removed from the RADC mailing list, or if the addressee is no longer employed by your organization, please notify RADC (EEP) Hanscom AFB MA 01731. This will assist us in maintaining a current mailing list.

Do not return this copy. Retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER (14) RADC-TM-78-7 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) (6) WOLFGANG PFISTER, 1906-1976: AN APPRECIATION OF HIS LIFE AND WORK | | 5. TYPE OF REPORT & PERIOD COVERED In-House |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) (10) Kurt Toman | | 8. CONTRACT OR GRANT NUMBER(s) (12) 19p. |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Deputy for Electronic Technology (RADC/EEP) Hanscom AFB Massachusetts 01731 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F (16) 23051201 (17) J2 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Deputy for Electronic Technology (RADC/EEP) Hanscom AFB Massachusetts 01731 | | 12. REPORT DATE (11) September 1978 13. NUMBER OF PAGES 18 |
| 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office) | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This paper was presented at the 19th General Assembly of the International Union of Radio Science, Helsinki, Finland, 30 July-8August 78.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Wolfgang Pfister
Ionospheric research
Radio science

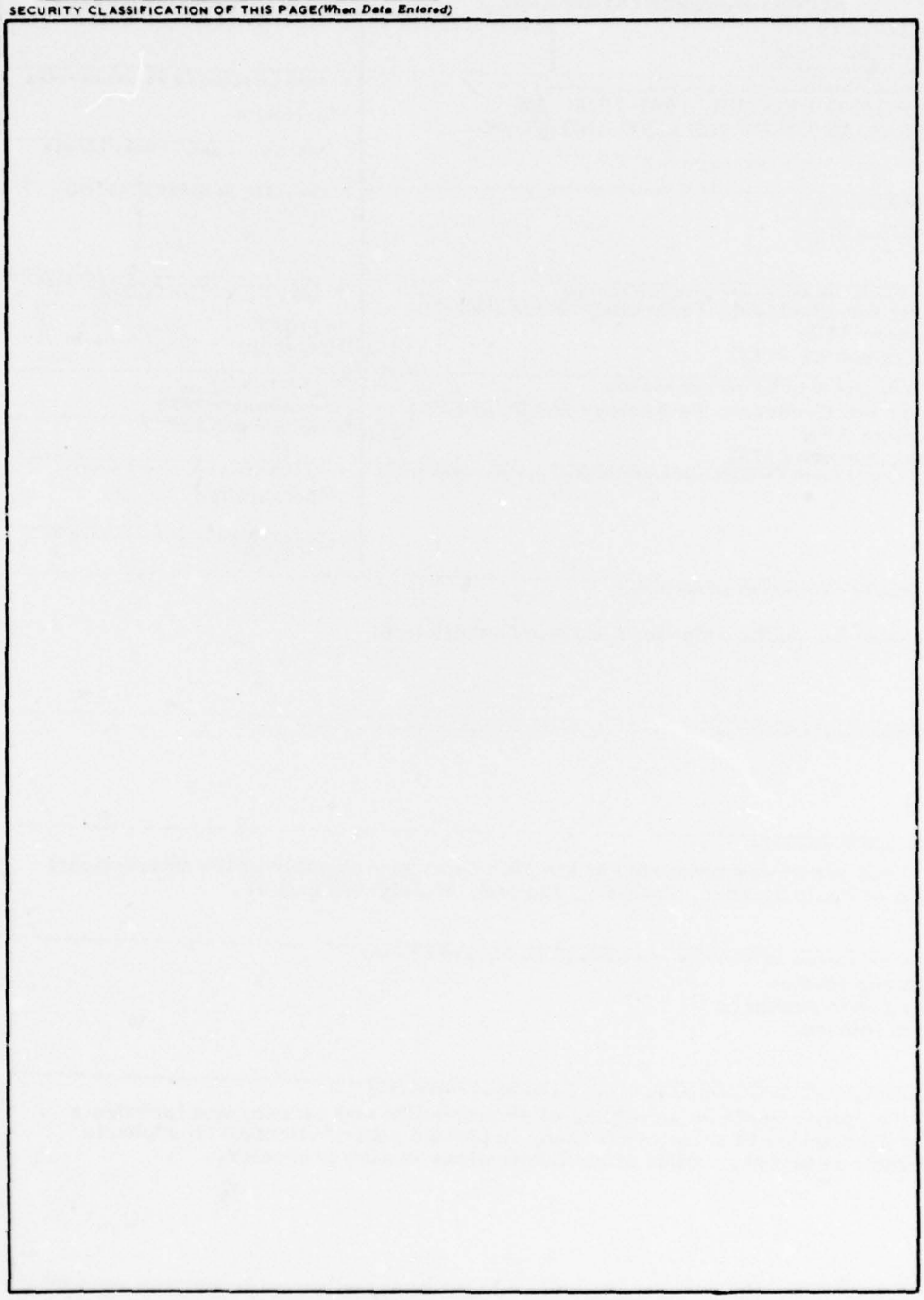
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The paper contains an outline of Pfister's life and career, and includes a brief description of some of his many important contributions to ionospheric and radio research. A list of his publications is also presented.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)



## Preface

The document retrieval effort by John Armstrong and Randall Bergman of the Air Force Geophysics Laboratory Research Library is gratefully acknowledged.

## Contents

Dr. Wolfgang Pfister

# Wolfgang Pfister, 1906-1976: An Appreciation of His Life and Work

## 1. INTRODUCTION

With the death of Wolfgang Pfister on 4 September 1976, the field of ionospheric physics lost a man whose name and contributions have become indelibly engraved in its annals. Wolfgang Pfister was born in Munich, Germany, 16 August 1906. His father was president of the judicial court for Upper Bavaria, and was also active in election reforms in the Weimar Republic. His mother was an activist for women's rights.

Pfister studied at the Humanistische Gymnasium in Munich. In 1929 he received the Diplom Ingenieur from the Technischen Hochschule (T.H.) Munich, and joined Siemens in Berlin, where he worked on the development of "talking pictures." He resumed his studies at the same school and in 1934 received his PhD under Dieckmann for his thesis on the investigation of the non-quasistationary current distribution in conducting wire systems. Results were applied to the construction of an effective HF antenna for large dirigibles such as the Hindenburg. Thereafter, Pfister joined the Deutsche Versuchsanstalt fuer Luftfahrt (DVL), an Aviation Research Laboratory in Berlin where he soon became Division Chief, a post he held until 1945. In the two years following World War II, he struggled for physical and professional survival. In 1946 he married Josephine Mueller in Regensburg, Germany.

Received for publication 3 October 1978

In 1947 he accepted an invitation that took him to Wright-Patterson AFB in Dayton, Ohio. His stay there was brief. In October 1948 he went to the Air Force Cambridge Research Center (Cambridge Field Station), and remained with that organization until his retirement in 1974. For Pfister, retirement did not mean cessation of scientific work. He continued his studies and analyses of radar signals and their Doppler- and angle-of-arrival signatures resulting from irregularities in the auroral ionosphere. In 1975 he attended the General Assembly of the International Union of Radio Science in Lima, Peru, where he presented what was to be his last paper to Commission G. It dealt with the "Spectral Analysis of F Region Drift Measurements in Goose Bay, Labrador." He became critically ill in July 1976 and died on 4 September 1976.

## 2. PROFESSIONAL LIFE

Pfister's professional career began in 1932 and lasted more than 40 years, resulting in a large number of publications. In 1935, at the age of 29, he disclosed an invention on the subject of increasing the directivity of a vertically polarized antenna. This was achieved by mechanically separating a vertical antenna element into sections, while electrically connecting the inner conductor of one with the outer conductor of the other section, and vice versa.

A patent search was initiated on 6 May 1935. It revealed that patents for related inventions had been awarded in England (1920) and Germany (1929), but the identical antenna concept had already been invented and patented, as of 8 March 1934, by a Frenchman, Monsieur Andre Morizot. Pfister did not receive a patent for his invention. Curiously, this antenna design, which increased an antenna's directivity, was re-invented in 1963 by Ken Bowles for use in the 50 MHz antenna array of the incoherent-scatter facility at Jicamarca, Peru.

Pfister's entire professional career can be subdivided into four phases: (1) Antennas, (2) Tropospheric Radio Wave Propagation, (3) Ionospheric Radio Wave Propagation, and (4) Satellite and Rocket Measurements of the Ionosphere.

Phase 1 on antennas was ushered in through his thesis and subsequent invention. In this phase of work he dealt with the design of antennas for aircrafts and boats at VHF and UHF. This phase extended from 1932 to 1935 and involved primarily studies of directional antennas and determination of antenna patterns.

Phase 2 on tropospheric radio wave propagation began in 1936. It involved studies of VHF propagation along a curved earth, and led to publications in the IRE Proceedings in 1937 and 1938.

During the period from 1936 to 1945, Wolfgang's work involved radio wave propagation in the troposphere over a layered, conducting ground; direction finding; jamming of frequency-modulation navigation receivers; determining the limits in ground-wave navigation; etc. He also developed and designed a precision navigation system for aircraft. Four Erika stations were installed (Cherbourg, Boulogne, Munich, Vienna) covering northern Europe, each consisting of five spaced transmitter houses and elaborate antenna towers.

World War II ended and a bleak period followed until, in 1949, a paper appeared in the Journal of Geophysical Research entitled "Effect of the D Ionospheric Layer on VLF." This was the serious beginning of Phase 3, ionospheric radio wave propagation, which lasted until 1976, the year of his death.

From 1949 to 1959, many scientific contributions resulted from Pfister's innovation of using an airborne ionospheric laboratory for obtaining measurements of ionospheric characteristics and propagation effects. Pfister was instrumental in the development of a D-region chemistry computer code used for the study of solar ionization and nuclear effects. He participated in the International Geophysical Year (1957/58) and contributed to professional groups such as the U.S. National Committee of the International Union of Radio Science, serving for three years as Secretary of the Commission "On the Ionosphere" (now Ionospheric Radio). He was a contributing member of Working Group II of the Committee for Space Research (COSPAR) and of the Inter-Union Commission on Solar Terrestrial Physics. He also provided much guidance and critical appraisal in various research fields to a new generation of ionospheric physicists at Pennsylvania State University.

In Pfister's phase 4, a subset of phase 3, satellites and rockets were used to measure the structure and characteristics of ionospheric irregularities, ionospheric electron density profiles, and electric fields. Phase 4 seems to have started in 1956 with a paper on the study of fine structure and irregularities in the ionosphere by means of rockets and satellites, prior to the launch of the U.S.S.R. Sputnik on 4 October 1957. Phase 4 seems to have ended in 1970. It resulted in publications on the measurement of charge density and temperature in the aurora; the measurement of electric fields by means of retarding potential analyzers; pulse delay measurements from rockets; satellite measurements of the spatial-temporal variations of electron density; the measurement of ionospheric irregularities with satellite probes; and rocket-borne ionospheric measurements using electron and ion probes.

In 1968, Pfister began publishing a comprehensive series of AFCRL reports on the general subject of pulse sounding with closely spaced receivers measuring atmospheric motion and fine structure in the ionosphere. During the 1968 to

1975 period he also published a study on the wavelike nature of inhomogeneities in the E region, and made a critical survey of probe measurements of electron and ion temperatures. In these late years of his career, Pfister's professional interest centered on characteristics of radar returns from ionospheric irregularities as observed by means of ground-based or airborne radars. In these studies, he tried to find ways of minimizing the expected effects of auroral or ground clutter on high-frequency radar performance by searching for beam-forming and data-processing techniques that would allow the neutralization of these effects. He envisioned that localized "hot-spots" in clutter caused by auroral irregularities could be nullified.

Some of Pfister's earlier work was referenced in books of Hollmann, Vilbig, and Zenneck in Germany; and references to his work appeared in books by Budden, Ratcliffe, and Kelso and in Bowhill's reviews of Radio Science.

## 3. PERSONAL PROFILE

Pfister was the oldest of three brothers. His two younger brothers live in Germany and one of them, Raimund, is a well-known linguist. Pfister is survived by his wife, Josephine, who resides in Lexington, Massachusetts, where the Pfisters have lived since 1951, and two sons, Andreas and Leonhard. Andreas, the younger son, lives in the Boston area. Leonhard received his PhD degree in meteorology from the University of Washington in 1977 for his work, "A Theoretical Study of Baratropic Instability With Possible Application to the Stratosphere."

In his bachelor years in Germany, Pfister enjoyed sailing, hiking, swimming, skiing, glider flying, and rock climbing; he also made pencil sketches and played piano as an accompanist in a music group. Later, as a devoted family man, he imparted his enthusiasm for outdoor activities and music to his family. After his retirement he became involved in local and national politics, and he campaigned for Udall's presidency in 1975. He reached out for improvements in protecting the environment and supported the Environmental Defense Fund. He was also interested in subjects dealing with the poverty of nations and the poverty of power. Pfister believed that man's emotional and social growth lagged behind the growth in technology. He felt that reducing the technological growth rate would reduce crime rates, racial disturbances, drug abuse, mental illnesses, divorce rates, etc., thereby improving the quality of life. Accelerating man's social and emotional growth, to cope effectively with the social consequences of a fast growing technology, did not seem feasible to him.

Wolfgang Pfister pursued his personal beliefs and convictions quietly and unobtrusively, but with wisdom and thoroughness. One had to probe to gain access to Pfister's insights, as it was his nature not to overwhelm others with the perceptions he had developed privately. He had a penetrating intellect and was always ready to explain and defend his scientific insights or hypotheses rather than rest his case on the silent power of his reputation. He usually revealed new ideas in a final rather than tentative state, and it was difficult for his colleagues to find faults in his reasoning. He was uncompromisingly dedicated to the truth. Of his own work, he stated with clarity, and without hesitation, what had and what had not been accomplished in a particular scientific study. Pfister was a "straight arrow" man. For relaxation, he read the poetry and prose of Karl Heinz Waggerl.

## 4. CONCLUDING REMARKS

Pfister's concern for ecology and his need to participate in shaping and analyzing new ideas for improving the human condition led him to take issue with book reviews and, in the process, express his own visions. One published review, dated 1 July 1976, ended as follows:

"What we need now is a reexamination of old fundamental beliefs, a breaking down of ideological barriers between different disciplines of human endeavor, in short, ecological reasoning in the broadest sense of the word, so that in the end the general citizen can comprehend again what is going on around him."

## 5. WOLFGANG PFISTER'S PUBLICATIONS


1932

Verfahren zur Erregung eines Luftfahrzeuges in $\lambda/2$, DVG (Publication data at present unknown).

1933

Eigenerregung eines Schiffskoerpers, DVG.

1935

Untersuchungen ueber die nicht-quasistationaere Stromverteilung in linearen Leitersystemen, Leipzig, Barth, 1935. Inaugural-dissertation, under Dieckmann, Muenchen. Republished in Annalen der Physik, 1935, 22: 31-52.

Ausbreitung der Mikrostrahlen ($\lambda$ = 50cm). (Publication data at present unknown)

Untersuchungen ueber das Strahlungsfeld von Ultrakurzwellenantennen, Hochfrequenztechnik und Elektroakustik 46: 8-15 (with Paul von Handel).

Messungen der vertikalen Strahlungscharakteristik von Rundfunkantennen, Hockfrequenztechnik und Elektroakustik, 45 (No. 4): 109-111 (with Paul von Handel and Kurt Krueger).

Ueber die Strahlungskennlinien und die Ausbreitung ultrakurzer Wellen (7-10 m), Luftfahrtforschung, 13 (No. 7): 80-86 (with Paul von Handel).

1936

Die Ausbreitung der ultrakurzen Wellen (cm, dm, m-Wellen) laengs der gekruemmten Erdoberflaeche, Hochfrequenztechnik und Elektroakustik 47: 182-190 (with Paul von Handel).

Ultra-short-wave propagation along the curved Earth's surface, Institute of Radio Engineers, Proceedings, 25 (No. 3), pt. 1: 346-363, Translation of the preceding item. (Discussion of the above appeared in Proc.I.R.E. 26: 240-245, 1938.)

1937

Ultrakurzwellen - Ausbreitung DVL-Jahrbuch, pp. 560-564.

1938

Reflexion am geschichteten Medium, Hochfrequenztechnik und Elektroakustik, 51 (No. 5): 156-162 (with O.H. Roth).

1939

Modellmessungen an Flugzeugfestantennen zur Aufnahme von Strahlungskennlinien im Kurzwellenbereich Hochfrequenztechnik und Elektroakustik, 53: 41-45 (with Harmening).

1940

Der heutige Stand der Forschung ueber die Ausbreitung entlang der Erdoberflaeche ohne Beruecksichtigung der Ionosphaere, Deutsche Versuchsanstalt fuer Luftfahrt, Berlin-Adlershof. Zentrale fuer Wissenschaftliches Berichtswesen, III-26-III-p.51ff. Copy available from U.S. Defense Documentation Center as ATI 74-243.

1941

Ausbreitungsunterlagen in Kurvendarstellungen fuer das gesamte Wellengebiet ohne Beruecksichtigung der Ionosphaere, Deutsche Versuchsanstalt fuer Luftfahrt, Berlin-Adlershof, IID/124, Technical report, available from U.S. Defense Documentation Center as ATI 10580.

1942

Die Ausbreitung der elektrischen Wellen laengs der Erdoberflaeche (ohne Beruecksichtigung der Ionosphaere), Deutsche Akademie der Luftfahrtforschung, 4:221-229, Dec. 1942. Available from U.S. Defense Documentation Center as ATI 25817.

same, published in Deutschen Akademie der Luftfahrtforschung, Mitteilungen, Bd. 2, Heft 2, 1943.

Die Messung der elektrischen Leitfaehigkeit bei geschichtetem Boden (note on the article of Grosskopf and Vogt). Hochfrequenztechnik und Elektroakustik 59: 118-119.

1944

Ausbreitungsunterlagen fuer Funkmessgeraete in Kurvendarstellung, Deutsche Versuchsanstalt fuer Luftfahrt, Berlin-Adlershof. Zentrale fuer Wissenschaftliches Berichtswesen, FB 1946. Technical report, available from U.S. Defense Documentation Center as ATI 18530, in English translation (No. F-TS-1849-RE).

Untersuchungen ueber den Einfluss eines Stoersenders bei Navigationsverfahren welche mit Frequenzdemodulation im Empfaenger arbeiten, Zentrale fuer Wissenschaftliches Berichtswesen, FB-1922. Technical report, available from U.S. Defense Documentation Center as ATI 19067, (with W. Kuestner).

Der Einfluss von Wasser in fluessiger oder fester feinverteilter Form auf die DK der Luft, Ferdinand Braun-Institut, Bad Aibling, IIB/4058. Technical report available from U.S. Defense Documentation Center as ATI-57424.

Die Ausbreitung der Bodenwelle in Kurvendarstellungen fuer das gesamte Wellengebiet, Deutsche Luftfahrtforschung (Document) Nr. 1517/2, Berlin, Adlershof. Technical report available from U.S. Defense Documentation Center as ATI 10552.

Die Abhaengigkeit der Reflexionsamplitude von Flughoehe und Entfernung fuer verschiedene Funkmessgeraete, Reichsstelle fuer Hochfrequenzforschung, Ferdinand Braun-Institut, Bad Aibling, LB 1/4. Technical report available from U.S. Defense Documentation Center as ATI 32310 (with W. Kuestner).

Zur Frage des Aufwandes bei der Stoerung von Bodenbetrachtungsgeraeten, Reichsstelle fuer Hochfrequenzforschung, Ferdinand Braun-Institut, Bad Aibling, LB 1/6. Technical report available from U.S. Defense Documentation Center as ATI 22474.

Ausbreitungskurven fuer grosse Flughoehen im UKW Bereich, Reichsstelle fuer Hochfrequenzforschung Ferdinand Braun-Institut, Bad Aibling, LB 1/8. Technical report available from U.S. Defense Documentation Center as ATI 22545.

1945

Partielle Reflexion und Strahlenkonzentration bei Unstetigkeitsflaechen in der Atmosphaere, Reichsstelle fuer Hochfrequenzforschung, Ferdinand-Braun Institut, Bad Aibling, Eia/5/59. Technical report available from U.S. Defense Documentation Center as ATI 20257.

Antennen in Form gegenphasig gespeister Kreisgruppen, Reichsstelle fuer Hochfrequenzforschung, Ferdinand-Braun Institut, Bad Aibling, LB 1/11. Technical report available from U.S. Defense Documentation Center as ATI 28229.

Beschreibung der Versuchsapparatur fuer die Untersuchungen ueber die Genauigkeit der Wellenausbreitung bezueglich der Laufzeit, Ferdinand-Braun Institut Landsberg, L-Ber-1/12. Technical report available from U.S. Defense Documentation Center as ATI 27001 (with Gottfried Moeltgen).

1947

Ultrakurzwellenausbreitung, Deutsche Luftfahrtforschung JB-1937-vol. 3. Available from U.S. Defense Documentation Center as ATI 55516.

Theorie der Wellenausbreitung laengs der Erde (Einschliesslich Einfluss der Troposphaere), FIAT Review of German Science.

1948

Elektronenemission, Elektronenbewegung und Hochfrequenztechnik Teil II-11.-Wellenausbreitung, Fiat Review of German Science, 1939-1946. Electronics including fundamental emission phenomena, part II-11-Wave propagation. Published by Office of Military Government for Germany, FIAT, Wiesbaden, pp. 127-171. Available from U.S. Defense Documentation Center as ATI 129 974 (with W. Becker, B. Beckmann, and others).

1949

Effect of the D-ionospheric layer on very low frequency radio waves, Journal of Geophysical Research, **54** (No. 4): 315-337. (Also published as U.S. Air Force Cambridge Research Laboratories Geophysical Research Papers, No. 7, Dec. 1950, available from U.S. Defense Documentation Center as AD 638-153.)

1951

Radio Direction Finding and Navigational Aids, some reports on German work issued in 1944-45, Gt. Brit. Department of Scientific and Industrial Research, Radio Research Board, London. Radio Research Special Report No. 21. Available from U.S. Defense Documentation Center as ATI 181 743 (with Paul von Handel, H. Jannsen, and others).

1952

Studies of Ionospheric Region E (and discussion), U.S. Air Force Cambridge Research Center, Geophysical Research Papers No. 11, pp. 235-254.

1953

Note on Lindquist's paper, An investigation of the ionizing effect in the E-layer near sunrise, Journal of Geophysical Research, **58**: 282.

Magneto-ionic multiple splitting determined with the method of phase integration, Journal of Geophysical Research, **58** (No. 1): 29-40.

1954

title unknown, cited in Science Citation Abstracts, 1962 and 1972, in Program and Abstracts, National Research Council, U.S. National Committee of URSI, Washington, D.C., 1954.

1955

Further remarks on the bifurcation in the E-layer, Letter in Physical Review, **97** (No. 4): 1183-1184 (with J.C. Ulwick and R.J. Marcou).

Studies of the refractive index in the ionosphere: the effect of the collision frequency and of ions, The Physics of the Ionosphere, London, Physical Society, 1955, pp. 394-401.

1956

Ionospheric Effects on Positioning of Vehicles at High Altitudes, U.S. Air Force Cambridge Research Center, Air Force Surveys in Geophysics, No. 83. Available from U.S. Defense Documentation Center as AD 98 777 (with T.J. Keneshea).

1957

The ionosphere, Handbook of Geophysics for Air Force Designers, edited by C.F. Campen, Jr., et al. 1st ed. Washington, D.C., 1957. Chap. 15 (with T.J. Keneshea, N.J. Oliver, T.P. Markham, and A.L. Carrigan).

1958

Study of fine structure and irregularities of the ionosphere with rockets and satellites, in Scientific Uses of Earth Satellites, James A. Van Allen. 2d rev.ed. Ann Arbor, Univ. of Michigan, 1958, pp. 283-291. (Based on 10th meeting, 26-27 June 1956, of the Upper Atmosphere Rocket Research Panel at Ann Arbor.)

Ray-tracing technique in a horizontally stratified ionosphere using vector representations, Journal of Geophysical Research, **63** (No. 2): 303-313 (with R.J. Marcou and J.C. Ulwick).

The analysis of rocket experiments in terms of electron-density distributions, Journal of Geophysical Research, 63 (No. 2): 315-333 (with J.C. Ulwick).

Measurements of ionospheric fine-structure by high altitude rockets, Paris, North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development, AGARDograph, No. 34: 183-192.

1959

Analysis of pulse-delay data from rockets for the determination of electron density, Journal of Atmospheric and Terrestrial Physics, 15 (No. 1-2): 161-167 (with J.C. Ulwick).

1960

Polar Satellite Propagation Measurements, Lowell Technological Institute Research Foundation, Contract AF19(604)-4156, Scientific Report No. 1 AFCRL-TN-60-647, (with Carlisle Dieter, Kenneth Kinnard, Gary Sales, and Jack Waaramaa).

1961

Some results of direct probing in the ionosphere, Journal of Geophysical Research, 66 (No. 4): 1293-1297 (with J.C. Ulwick and R.P. Vancour).

1962

Rocket and satellite data, discussion in International Scientific Radio Union, Monograph on ionospheric radio, edited by W.J.G. Beynon, Amsterdam, 1962, pp. 115-121, 261.

Firing of an Astrobee 200 rocket with a multiple ionospheric experiment, Institute of Radio Engineers, Proceedings, 50 (No. 11): pp. 2272-2286 (with J.C. Ulwick, R.P. Vancour, R.T. Bettinger, O.C. Haycock, and K.D. Baker).

1963

Survey of RF impedance probes, in Aeronomy Report 1, Direct Aeronomic Measurements in the Lower Ionosphere, an Informal Conference Record, Univ. of Illinois, Urbana, Ill,, 1963, pp. 31-36. Available from U.S. Defense Documentation Center as AD 461-487.

Spatial and temporal variations of electron density from an orbiting satellite, Space Research III (COSPAR), Amsterdam, North-Holland, 1963, pp. 194-208 (with J.C. Ulwick).

RF probe measurements from a recent Churchill firing into an auroral absorption, in Aeronomy Report No. 1, Direct Aeronomic Measurements in the Lower Ionosphere, an Informal Conference Record, Univ. of Illinois, Urbana, Ill., 1963, pp. 173-175. Available from U.S. Defense Documentation Center as AD 461-487 (with J.C. Ulwick and O.C. Haycock).

1964

Description of standing wave impedance, COSPAR Information Bulletin, No. 17, Feb. 1964 (with J.C. Ulwick, et al).

Rocket Measurements With Electron and Ion Probes in an Aurora, U.S. Air Force Cambridge Research Laboratories, Environmental Research Papers No. 56. Available from U.S. Defense Documentation Center as AD 609 454 (with J.C. Ulwick, O.C. Haycock and K.D. Baker).

Direct Satellite Probe Measurements of Ionospheric Irregularities in the F-Region and the Polar Cap, U.S. Air Force Cambridge Research Laboratories, Upper Atmosphere Physics Lab, Environmental Research Papers No. 74, AFCRL 64-1021. Available from U.S. Defense Documentation Center as AD 612 650 (with J.C. Ulwick and R.E. McInerney).

1965

Direct satellite probe measurements of ionospheric irregularities in the polar cap, in Symposium on High Latitude Particles and the Ionosphere, Alpbach, Austria, March 1964, Proceedings, London, Academic Press, 1965 (with J.C. Ulwick and R.E. McInerney).

Plasma sheath effects on rocket antennas, in Interactions of Space Vehicles With an Ionized Atmosphere, edited by Siegfried Singer, Oxford, N.Y., Pergamon Press, 1965 (with J.C. Ulwick) Air Force Surveys in Geophysics No. 177.

Effects of rocket outgassing on RF experiments, Radio Science, **69D** (No. 9): 1219-1225. Also issued as U.S. Cambridge Research Laboratories Environmental Research Papers No. 148, AFCRL-65-751. Available from U.S. Defense Documentation Center as AD 629 120 (with J.C. Ulwick).

Analysis of ionospheric winds and turbulence over Puerto Rico with a correlation method-I, Journal of Atmospheric and Terrestrial Physics, 27: 7-30. Also issued as U.S. Cambridge Research Laboratories Environmental Research Paper No. 100, AFCRL 65-273. Available from U.S. Defense Documentation Center as AD 616 808 (with T.J. Keneshea, and M.E. Gardner).

Study of fine structure and irregularities of the ionosphere with rockets and satellites, in Scientific Uses of Earth Satellites, edited by James A. Van Allen, Ann Arbor, Univ. of Michigan Press 1965, pp. 283-291.

Rocket measurements with electron and ion probes in an aurora, Space Research V (COSPAR), Proceedings of the Fifth International Space Science Symposium, Florence, Italy, May 8-20, 1964, pp. 293-311, Amsterdam, North-Holland, 1965 (with J.C. Ulwick, O.C. Haycock, and K.D. Baker).

Direct Satellite probe measurement of ionospheric irregularities, in Space Research V (COSPAR), Amsterdam, North-Holland, 1965, pp. 171-178 (with J.C. Ulwick and R.E. McInerney).

Plasma sheath effects on rocket antennas, in Interactions of space vehicles with an ionized atmosphere, edited by S.F. Singer, Oxford, N.Y., Pergamon Press, 1965, pp. 271-281. Also published as Air Force Cambridge Research Laboratories Air Force Surveys in Geophysics, No. 177, April 1966 (with J.C. Ulwick).

Measurements with retarding potential analyzers and planar ion traps in the D-region, in Aeronomy Report No. 10, Second Conference on Direct Aeronomic Measurements in the Lower Ionosphere, Univ. of Illinois, Urbana, Ill., 1965, pp. 49-53. Available from U.S. Defense Documentation Center as AD 651 305 (with J.A. Sandock).

Experimental and theoretical studies of antenna impedance in the D- and E-regions, same as preceding item, pp. 74-78 (with J.C. Ulwick, R.D. Baker and A.M. Despain).

1966

Plasma Sheath Effects on Rocket Antennas, Air Force Cambridge Research Laboratories, Air Force Surveys in Geophysics, No. 177 (AFCRL-66-233). Available from U.S. Defense Documentation Center as AD 632 547.

1967

Interpretation of rocket measurements in a visible aurora, American Geophysical Union. Transactions, **48**, Washington, D.C., 1967 (with K.D. Baker).

Charge densities and temperatures measured in active auroras, Space Research VII (COSPAR), Amsterdam, North-Holland, 1967, pp. 665-673 (with J.C. Ulwick and K.D. Baker).

Auroral investigations by means of rockets, Space Science Reviews, 7 (No. 5-6): 642-688.

1968

The use of amplitude fading and phase fluctuations for the study of motions in the ionosphere, National Research Council. United States National Committee of URSI. Program and Abstracts, Spring Meeting. 1968, Washington, D.C.

A new technique for measuring electric fields in the ionosphere, International Association of Meteorology and Atmospheric Physics. Report of the Proceedings, XIV General Assembly, Lucerne, September 1967, Toronto, 1968, pp. 203ff.

Rocket measurements of bremsstrahlung x-rays and related parameters during auroral absorption events, Space Research VIII (COSPAR), Amsterdam, North-Holland, 1968, pp. 171-177 (with J.C. Ulwick and K.D. Baker).

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, U.S. Air Force Cambridge Research Laboratories, Environmental Research Papers No. 295. Available from U.S. Defense Documentation Center as AD 683 240 (with K. Bibl).

1969

Use of retarding potential analyzers for electric field measurements, International Council of Scientific Unions. Committee on Space Research, 11th Plenary Meeting, Tokyo, May 17-18, 1968. Small rocket instrumentation techniques: Proceedings of the Symposium, Amsterdam, North-Holland, 1969, pp. 66-72.

1970

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 3, The Application of the Generalized Correlation and Cross Spectral Analysis to the Model of Turbulent Drift, Air Force Cambridge Research Laboratories, Environmental Research Papers No. 317. Available from U.S. Defense Documentation Center as AD 705 539.

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 4, Wavelike Structure in the E-Region Derived From Drift Experiments, Air Force Cambridge Research Laboratories, Environmental Research Papers, No. 329. Available from U.S. Defense Documentation Center as AD 712 346.

1971

Estimate of angular cross-errors due to horizontal gradients in the ionosphere, Ionospheric and Tropospheric Limitations to Radar Accuracy, Comp. by Don L. Evans, U.S. Air Force Cambridge Research Laboratories, Air Force Surveys in Geophysics, No. 231, AFCRL 71-0169, pp. 37-41. Available from U.S. Defense Documentation Center as AD 722 046.

The wave-like nature of inhomogeneities in the E-region, Journal of Atmospheric and Terrestrial Physics, 33 (No. 7): 999-1025.

1972

Critical survey of electron and ion temperatures measured with probes, Space Research XII (COSPAR), Berlin, Akademie-Verlag, 1972, pp. 1261-1274.

A modernized technique for ionospheric drifts with spectral analysis, Space Research XII (COSPAR), Berlin, Adademie-Verlag, 1972, pp. 975-992.

1974

Drift measurement with spectral analysis during periods of chemical releases into the ionosphere, Methods of measurements and results of lower ionosphere structure, edited by K. Rawer, Berlin, Akademie-Verlag, 1974, pp. 401-406.

Motions in upper-atmosphere using spectral data from spaced antennas, American Meteorological Society Bulletin, 55 (No. 6): 654 (with K. Bibl, B.W. Reinisch, and Gary Sales).

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 5, Period of Chemical Releases as Example of Spectral Analysis, Air Force Cambridge Research Laboratories, Environmental Research Papers, No. 468. Available from U.S. Defense Documentation Center as AD 781 040.

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 6, Spectral Analysis of the Interlaced Sets of Data, Air Force Cambridge Research Laboratories, Environmental Research Papers, No. 470. Available from U.S. Defense Documentation Center as AD 781 043.

1975

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 7, Data Processing With Different Techniques for Cross-Power Spectra, Air Force Cambridge Research Laboratories, Environmental Research Papers, No. 506. Available from U.S. Defense Documentation Center as ADA 015 045 (with G. Sales and R. Varad).

Pulse Sounding With Closely Spaced Receivers as a Tool for Measuring Atmospheric Motions and Fine Structure in the Ionosphere, Pt. 8, Application to Aircraft Signals, Air Force Cambridge Research Laboratories Environmental Research Papers No. 507. Available from U.S. Defense Documentation Center as ADA 014 784 (with G. Sales).

Velocities of small and medium scale ionospheric irregularities deduced from Doppler and arrival angle measurements, Space Research XV (COSPAR), Berlin, Akademie-Verlag, 1975, pp. 405-411.

# *MISSION*
# *of*
# *Rome Air Development Center*

*RADC plans and conducts research, exploratory and advanced development programs in command, control, and communications ($C^3$) activities, and in the $C^3$ areas of information sciences and intelligence. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.*

**Printed by**
**United States Air Force**
**Hanscom AFB, Mass. 01731**