

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH

By **Ya. L. Alpert** and **D. S. Fligel**

*Institute of the Earth's Magnetism, Ionosphere,
and Radio Wave Propagation of the Academy of Sciences of the USSR*

Translated from Russian by **James S. Wood**

This volume presents a comprehensive review of current developments in the area of propagation of VLF and ELF electromagnetics. Frequencies covered range from the VLF maximum of approximately 100 kHz to the ELF minimum of about 1 Hz. Propagation in the waveguide formed by the earth's surface and the lower ionosphere is thoroughly discussed. The book also includes an account of the most recent and sometimes controversial research in magnetospheric plasma above the ionosphere as well as discussions of ELF and VLF wave propagation within the ionosphere.

Values of the refractive index and attenuation factor calculated with regard for the contribution of neutral particles are given for the lower ionosphere (D-region), the outer ionosphere (3000 to 6000 km), and the magnetosphere (to 100,000 km). Various theoretical relations derived rigorously and by

asymptotic techniques for the field in the waveguide are subjected to analysis, and the theoretical results are compared with the greater body of experimental data found in the literature.

Excellent for the first year graduate student in physics and electrical engineering, this Special Research Report will also prove invaluable for space, radio, plasma, and theoretical physicists, electrical engineers, geophysicists, astronomers and astrophysicists, and research workers in fluid mechanics.

Ya. L. Alpert is a leading Soviet authority on all aspects of radio wave propagation. Alpert and his co-workers have pioneered methods of analysis of waveforms of "atmospherics" and conducted provocative work on use of electromagnetic waves emitted from nuclear explosions.

SPECIAL FEATURES

• 353 references • 85 illustrations • 18 tables

CONTENTS: Introduction • Properties of the ionosphere at low and very low frequencies • Statement of the problem • Solution for a sharply bounded homogeneous model of the earth-ionosphere waveguide • Analysis of the pole equation • The electric field equations • Numerical calculations of the poles: influence of the interfaces • Field amplitude; the antipode effect (results of measurements and theoretical calculations) • Phase spectra, diurnal phase variation, and phase velocity • Resonance excitation of the earth-ionosphere waveguide (theory and experiment) • Influence of the earth's magnetic field • The atmospherics; propagation of discrete signals in the earth-ionosphere waveguide • Transmission of low-frequency waves through the ionosphere in the geometric-optical approximation • Propagation of low-frequency waves in the outer ionosphere • Conclusion • Literature cited.

Consultants Bureau
Special Research Report

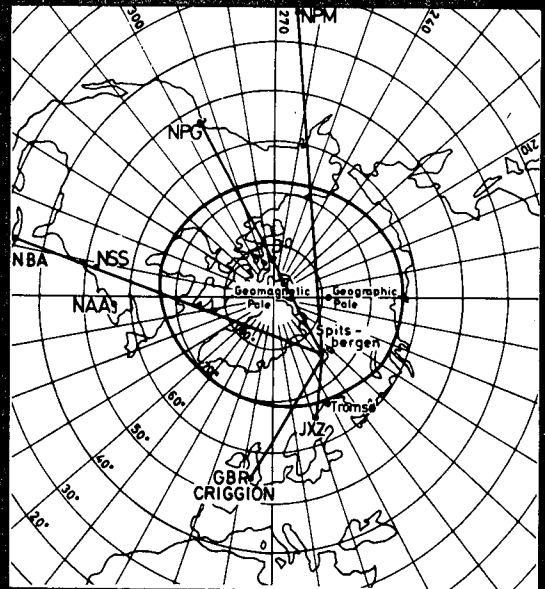
Approx. 172 pages 1970 \$22.50

LCC No. 69-12526

SBN 306-10836-4

A NEW SPECIAL RESEARCH REPORT

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH



By Ya. L. Alpert
and D. S. Fligel

PLENUM PUBLISHING CORPORATION
Plenum Press • Consultants Bureau • IFI/Plenum Data Corporation
227 WEST 17th STREET, NEW YORK, N. Y. 10011

In United Kingdom: Plenum Publishing Co. Ltd., Donington House,
30 Norfolk Street, London, W.C. 2.

PLENUM PUBLISHING CORPORATION

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH

By **Ya. L. Alpert** and **D. S. Fligel**

*Institute of the Earth's Magnetism, Ionosphere,
and Radio Wave Propagation of the Academy of Sciences of the USSR*

Translated from Russian by **James S. Wood**

This volume presents a comprehensive review of current developments in the area of propagation of VLF and ELF electromagnetics. Frequencies covered range from the VLF maximum of approximately 100 kHz to the ELF minimum of about 1 Hz. Propagation in the waveguide formed by the earth's surface and the lower ionosphere is thoroughly discussed. The book also includes an account of the most recent and sometimes controversial research in magnetospheric plasma above the ionosphere as well as discussions of ELF and VLF wave propagation within the ionosphere.

Values of the refractive index and attenuation factor calculated with regard for the contribution of neutral particles are given for the lower ionosphere (D-region), the outer ionosphere (3000 to 6000 km), and the magnetosphere (to 100,000 km). Various theoretical relations derived rigorously and by

asymptotic techniques for the field in the waveguide are subjected to analysis, and the theoretical results are compared with the greater body of experimental data found in the literature.

Excellent for the first year graduate student in physics and electrical engineering, this Special Research Report will also prove invaluable for space, radio, plasma, and theoretical physicists, electrical engineers, geophysicists, astronomers and astrophysicists, and research workers in fluid mechanics.

Ya. L. Alpert is a leading Soviet authority on all aspects of radio wave propagation. Alpert and his co-workers have pioneered methods of analysis of waveforms of "atmospherics" and conducted provocative work on use of electromagnetic waves emitted from nuclear explosions.

continued

SPECIAL FEATURES

• 353 references • 85 illustrations • 18 tables

CONTENTS: Introduction • Properties of the ionosphere at low and very low frequencies • Statement of the problem • Solution for a sharply bounded homogeneous model of the earth-ionosphere waveguide • Analysis of the pole equation • The electric field equations • Numerical calculations of the poles: influence of the interfaces • Field amplitude; the antipode effect (results of measurements and theoretical calculations) • Phase spectra, diurnal phase variation, and phase velocity • Resonance excitation of the earth-ionosphere waveguide (theory and experiment) • Influence of the earth's magnetic field • The atmospherics: propagation of discrete signals in the earth-ionosphere waveguide • Transmission of low-frequency waves through the ionosphere in the geometric-optical approximation • Propagation of low-frequency waves in the outer ionosphere • Conclusion • Literature cited.

Consultants Bureau
Special Research Report

Approx. 172 pages

1970

\$22.50

LCC No. 69-12526

SBN 306-10836-4

PLENUM PUBLISHING CORPORATION

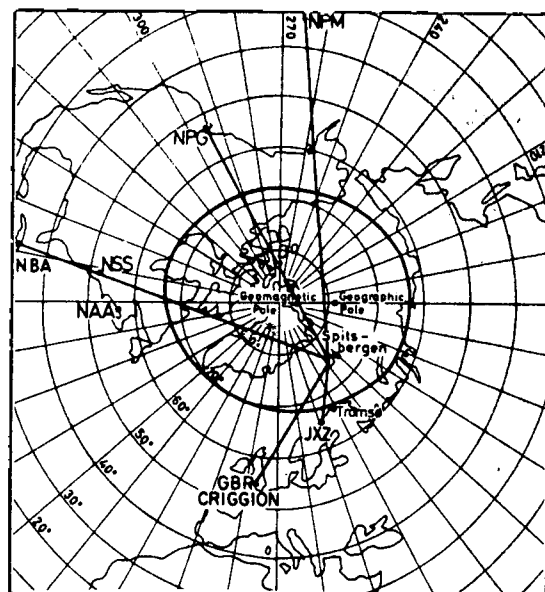
Plenum Press • Consultants Bureau • IFI/Plenum Data Corporation
227 WEST 17th STREET, NEW YORK, N. Y. 10011

In United Kingdom: Plenum Publishing Co. Ltd., Donington House,
30 Norfolk Street, London, W.C. 2.

1969 — 456 / APS / PRINTED IN U.S.A.

A NEW SPECIAL RESEARCH REPORT

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH



By Ya. L. Alpert
and D. S. Filgel

(7/10/22)

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH

By **Ya. L. Alpert** and **D. S. Fligel**

*Institute of the Earth's Magnetism, Ionosphere,
and Radio Wave Propagation of the Academy of Sciences of the USSR*

Translated from Russian by **James S. Wood**

This volume presents a comprehensive review of current developments in the area of propagation of VLF and ELF electromagnetics. Frequencies covered range from the VLF maximum of approximately 100 kHz to the ELF minimum of about 1 Hz. Propagation in the waveguide formed by the earth's surface and the lower ionosphere is thoroughly discussed. The book also includes an account of the most recent and sometimes controversial research in magnetospheric plasma above the ionosphere as well as discussions of ELF and VLF wave propagation within the ionosphere.

Values of the refractive index and attenuation factor calculated with regard to the contribution of neutral particles are given for the lower ionosphere (D-region), the outer ionosphere (3000 to 6000 km), and the magnetosphere (to 100,000 km). Various theoretical relations derived rigorously and by

asymptotic techniques for the field in the waveguide are subjected to analysis, and the theoretical results are compared with the greater body of experimental data found in the literature.

Excellent for the first year graduate student in physics and electrical engineering, this Special Research Report will also prove invaluable for space, radio, plasma, and theoretical physicists, electrical engineers, geophysicists, astronomers and astrophysicists, and research workers in fluid mechanics.

Ya. L. Alpert is a leading Soviet authority on all aspects of radio wave propagation. Alpert and his co-workers have pioneered methods of analysis of waveforms of "atmospherics" and conducted provocative work on use of electromagnetic waves emitted from nuclear explosions.

continued

SPECIAL FEATURES

• 353 references • 85 illustrations • 18 tables

CONTENTS: Introduction • Properties of the ionosphere at low and very low frequencies • Statement of the problem • Solution for a sharply bounded homogeneous model of the earth-ionosphere waveguide • Analysis of the pole equation • The electric field equations • Numerical calculations of the poles: influence of the interfaces • Field amplitude; the antipode effect (results of measurements and theoretical calculations) • Phase spectra, diurnal phase variation, and phase velocity • Resonance excitation of the earth-ionosphere waveguide (theory and experiment) • Influence of the earth's magnetic field • The atmospherics; propagation of discrete signals in the earth-ionosphere waveguide • Transmission of low-frequency waves through the ionosphere in the geometric-optical approximation • Propagation of low-frequency waves in the outer ionosphere • Conclusion • Literature cited.

Consultants Bureau
Special Research Report

Approx. 172 pages

1970

\$22.50

LCC No. 69-12526

SBN 306-10836-4

PLENUM PUBLISHING CORPORATION

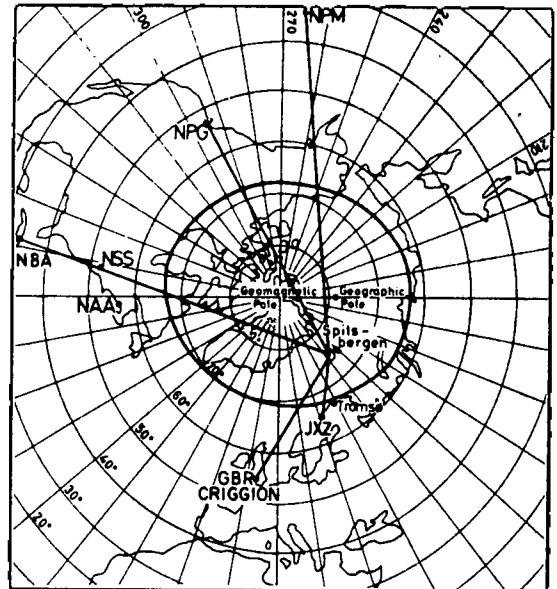
Plenum Press • Consultants Bureau • IFI/Plenum Data Corporation
227 WEST 17th STREET, NEW YORK, N. Y. 10011

In United Kingdom: Plenum Publishing Co. Ltd., Donington House,
30 Norfolk Street, London, W.C. 2.

1969 — 456 / APS / PRINTED IN U.S.A.

A NEW SPECIAL REPORT

PROPAGATION OF ELF AND VLF WAVES NEAR THE EARTH



By Ya. L. Alpert
and D. S. Fligel

PLenum PUBLISHING CORPORATION