**TABLE OF CONTENTS**

Personnel vii.

Publications and Reports xv

Introduction xxii

**GENERAL PHYSICS**

I. Molecular Beams

   Search for Continuously Created Hydrogen 1

   Theory of Metallic Adsorption on Real Metal Surfaces 6

II. Microwave Spectroscopy

   Work Completed 7

   Microwave Magnetoresistance Measurements 7

   Electronic Contribution to Ultrasonic Attenuation in a Metal Film 7

III. Radio Astronomy

   Observations of Interstellar O$^{18}$H 9

   Long Baseline Stellar Interferometer 10

   Results of Inferring Atmospheric Temperature from Simulated Microwave Measurements 11

   Digital Synchronous Detector 14

   Radiometer with a 23.8-GHz Parametric Amplifier 14

   Possible Microwave Experiment for a Planetary Probe to Venus 15

IV. Solid-State Microwave Electronics

   Status of Research 19

   Investigation of the Anomalous Mode of an Avalanche Diode 19

   60-GHz Mixer 20

   S-band Mixer 20

   Frequency Doubler 21

   L-band Quadrupler 21

   Avalanche Diode Oscillator 21

   High Dynamic Range Mixer for the 200-400 MHz Band 22

   Mixer Theory 22

   D-C Amplifier 22

QPR No. 90 iii
## CONTENTS

V. Electronic Instrumentation 23  
   Status of Research 23  
   Precision Power Supply 23  
   Effects of Power-Supply Variations on the Resolution of a Double-Focussing Mass Spectrometer 24  
   Detection Schemes for Automated Mass Spectrometers 33

VI. Optical and Infrared Spectroscopy 37  
   On the Dielectric Response Function 37

VII. Geophysical Research 47  
   Optical Radar Observations of Mesospheric Aerosols in Norway during the Summer 1966 47

VIII. Magnetic Resonance 51  
   High Resolution Nuclear Magnetic Resonance in Solids 51

IX. Physical Acoustics 53  
   Light Scattering from Thermal Ripplons 53  
   Dispersion Relation for Waves on the Interface between Two Viscous Liquids 53  
   Diffraction of Light by Ultrasonic Waves in Single Crystals 53  
   Nonlinear Acoustics 54

X. Electrodynamics of Media 55  
   Saturation Power in CO₂ Lasers 55  
   Theory and Experiment of Rotational Cross Relaxation in CO₂ Laser 61

**PLASMA DYNAMICS**

XI. Plasma Physics 69  
   Electron Mobility, Collision Frequency, and Mean-Free Path in Argon 69  
   Velocity Space Diffusion in a Magnetic Field 75  
   Nonlinear Harmonic Generation at Plasma Resonances 76

XII. Gaseous Electronics 83  
   Microwave Cavity Diagnostic Techniques 83
# CONTENTS

## XIII. Plasmas and Controlled Nuclear Fusion

- **Active Plasma Systems**  
  - System D: Spectroscopic Measurement of the Ion Temperature  
  - Hexapole Experiment  
  - Interactions of a Spiraling Electron Beam with a Plasma  
  - Oscillations in an Inhomogeneous Cold Plasma  
  - Stability of Electron Beams with Velocity Shear  

## Active Plasma Effects in Solids

- Microwave Instabilities in n-InSb Subjected to DC Electric and Magnetic Fields  
- Collision-Induced Instability for Helicon Waves  
- Acoustic Wave Propagation and Amplification in InSb  
- Slow Helicon Propagation in Periodic Semiconductor Structures  

## XIV. Spontaneous Radiofrequency Emission from Hot-Electron Plasmas

- Experimental Study of Enhanced Cyclotron Radiation from an Electron-Cyclotron Resonance Discharge  

## XV. Interaction of Laser Radiation with Plasmas and Nonadiabatic Motion of Particles in Magnetic Fields

- Strong Turbulence Theory for a Transverse Electromagnetic Wave – Comparison with the Single-Particle Calculation  

## COMMUNICATION SCIENCES AND ENGINEERING

## XVI. Statistical Communication Theory

- Work Completed  
  - A Three-State Amplification System  
  - An Experimental Investigation of Spectral Fluctuations in Nonstationary Acoustical Noise  
  - Noise Due to Time-Varying Current Excitation of Carbon Resistors  
  - An Investigation of Jitter in a Silicon-Controlled Rectifier  
  - Small-Signal Method for Determining Jitter in Regenerative Switching Circuits  

## XVII. Processing and Transmission of Information

- Angle-of-Arrival Dispersion of a Plane Wave Traversing a Two-Dimensional Cloud  
- On the Fourier Transforms of Boolean Functions  

QPR No. 90
## CONTENTS

### XVIII. Detection and Estimation Theory

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theses Completed</td>
<td>187</td>
</tr>
<tr>
<td>State Variables, the Fredholm Theory and Optical Communications</td>
<td>187</td>
</tr>
<tr>
<td>Asymptotic Approximations to the Error Probability for Detecting Gaussian Signals</td>
<td>187</td>
</tr>
<tr>
<td>Closed-Form Error Expressions in Linear Filtering</td>
<td>187</td>
</tr>
<tr>
<td>Performance of the Optical Smoother</td>
<td>187</td>
</tr>
<tr>
<td>Asymptotic Approximations to the Error Probability for Square-Law Detection of Gaussian Signals</td>
<td>191</td>
</tr>
<tr>
<td>Channel Capacity for an rms Bandwidth Constraint</td>
<td>201</td>
</tr>
<tr>
<td>Performance of a Class of Receivers for Doppler-Spread Channels</td>
<td>205</td>
</tr>
</tbody>
</table>

### XIX. Speech Communication

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech Computer Facility</td>
<td>217</td>
</tr>
</tbody>
</table>

### XX. Linguistics

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrapulmonic Consonants (Ejectives, Implosives, Clicks)</td>
<td>221</td>
</tr>
<tr>
<td>The Vowel System of Faroese and the Faroese Verschärfung</td>
<td>228</td>
</tr>
</tbody>
</table>

### XXI. Cognitive Information Processing

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimization of Boolean Expressions by Computer Program</td>
<td>241</td>
</tr>
<tr>
<td>Bit-Plane Encoding</td>
<td>247</td>
</tr>
</tbody>
</table>

### XXII. Communications Biophysics

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustically Evoked Cortical Potentials in the Rat during Sleep and Waking</td>
<td>252</td>
</tr>
<tr>
<td>Efferent Inhibition of Electrically Stimulated Response in Cat Auditory-Nerve Fibers</td>
<td>266</td>
</tr>
<tr>
<td>Auditory-Nerve Responses to Electric Stimuli</td>
<td>270</td>
</tr>
<tr>
<td>Gustatory Postexcitatory Depression</td>
<td>275</td>
</tr>
</tbody>
</table>

### Author Index

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author Index</td>
<td>283</td>
</tr>
</tbody>
</table>