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INTRODUCTION TO THE HISTORICAL SESSION

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Abstract

The Annual Frequency Control Symposium celebrates its Golden Anniversary this year. Highlights from symposia predating the published proceedings are featured, along with some global remarks pertinent to this happy occasion.

Remarks

This is a good time to look back and examine briefly the history of our symposium. It furnishes a sense of perspective; one sees both breathtaking progress, and at the same time, the continued persistence of the same generic technical barriers. The published proceedings contain papers that are historical (e.g., [1-8]) as well as visionary (e.g., [2, 9-12]). These brief remarks will be patterned on the contents of [2, 3, & 13].

The early years of the Annual Frequency Control Symposium (AFCS) were largely given over to studies of the properties and uses of that remarkable substance, quartz; Figure 1. The same environmental effects that concern us today also challenged our predecessors; Figure 2. At the start of our symposium series, the transistor was just in its infancy, but it soon began to reduce the size of crystal devices, albeit not at the same rate as electronic circuitry; Figure 3.

The long-term progress in quartz frequency control is distilled in Figures 4 and 5. Figure 4 gives the achievable accuracy of commercial oscillators subjected to environmental stresses as function of year, while Figure 5 depicts the obtainable stability of precision oscillators when the environmental perturbations are minimized.

Figure 6 plots observed precision, retrace, and accuracy versus cost for quartz, rubidium, cesium, and hydrogen frequency sources. One sees the obvious need for improvements in retrace and accuracy of quartz sources vis-à-vis quantum sources. Also worthy of note is the slope of the 'precision' line; because the slope is greater than unity, one may conclude that to obtain the best value for the money one should purchase the most expensive standard!

Anniversaries

In accord with the custom of some countries to classify anniversaries according to substances, we give in Figs. 7 and 8 a whimsical view of AFCS anniversaries past and future; may they be many in number, replete with new ideas, and fruitful in progress.

Pre-Tenth Symposia

The AFCS began publishing proceedings with the tenth. Booklets are extant for symposia numbers 4, 5, 7, 8, and 9. Those for the 4th and 5th contain only the titles of papers; those for the 7th, 8th, and 9th also contain abstracts. The contents of these five symposia are given in the Appendix; it is intended to publish the abstracts for 1953-1955 separately as a technical report.

In the 4th AFCS, we find even then a search for quartz substitutes. Martin Buerger discusses synthesis of nepheline, (Na, K)$AlSiO_4$. W. G. Cady, by then an Emeritus Professor, also gave a talk. (This was apparently his last, until the special session in honor of his 90th birthday at the 1964 AFCS. At that time he made some remarks, I recall, to the effect that physics in his day could be carried out by single investigators, whereas today (1964) some of the abstracts of the high-energy physics community had more authors than words.)

The 5th AFCS booklet contains notations in the hand of E. A. Gerber. Here we find the first hint of quantum frequency control with a paper from Princeton (probably by R. H. Dicke) on the widths of microwave absorption lines.

In the 7th AFCS we find papers by R D. Mindlin, K. S. Van Dyke, V. Bottom, R. H. Dicke, C. Frondel and R. Roy (when Penn State was still a College).

The 8th AFCS contains another Dicke paper, but also papers by Ed Gerber and Art Warner. The abstract of Ed's paper listed research work on, among other things, 'Activity dips in VHF crystal units as influenced by geometry of the blanks, the surface finish and the mounting structure.' Sounds familiar, doesn't it? Arthur W. Warner, Jr. (December 11, 1915 - June 27, 1996), who attended the 50th AFCS, reported at the 1954 AFCS on reduction of resonator aging by diminishing contamination, use of glass enclosures, polishing of the crystal, and application of 'compact gold electrodes.'

By the 9th AFCS, quantum frequency control was beginning to take off, with papers by Fritz Reder, R. H. Dicke, and Jerrold Zacharias. Art Warner gave a talk on high precision measurements (one part per billion), with a discussion of noise and phase jitter. E. M. Shideler's abstract reports, among other things, that 'Special plating patterns and spotting techniques were developed to eliminate activity dips and the work done along this line seems to indicate that the weight and distribution of the plating materials are of prime importance in the elimination of activity dips.' Very interesting information, indeed.

Conclusions

The fifty AFCSs have witnessed dramatic improvements in the art and science of frequency control. I have a feeling and an ardent hope that the progression seen in Figures 4 and 5 will not saturate, but that the infusion of new ideas and technologies will permit the field of frequency control to grow in the future in a manner commensurate with its fruitful past.

References

[1] V. E. Bottom, "A History of the Quartz Crystal Industry in the USA," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, pp. 3-12.

[2] A. Ballato, "The Future of the Quartz Crystal Industry - Worldwide," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, pp. 576-582.

[3] A. Ballato, "Fortieth Annual Frequency Control Symposium - Award Banquet Remarks," Proc. 40th Annual Frequency Control Symposium, Philadelphia, PA, May 1986, pp. 4-5.

[4] Special Session, "Reminiscences of Early Frequency Control Activities in Honor of the 40th Anniversary of the Frequency Control Symposium," Proc. 40th Annual Frequency Control Symposium, Philadelphia, PA, May 1986, pp. 6-25.

[5] A. McCoubrey, "History of Atomic Frequency Standards; A Trip Through 20th Century Physics," these proceedings.

[6] N. D. Bhaskar, L. Mallette, T. McClelland, and J. White, "A Historical Review of Atomic Frequency Standards Used in Space," these proceedings.

[7] M. E. Frerking, "Fifty Years of Progress m Crystal Frequency Standards," these proceedings.

[8] J. Norton, J. Cloeren, and P. G. Sulzer, "Brief History of the Development of Ultra-Precise Oscillators for Ground and Space Applications," these proceedings.

[9] J. H. Staudte, "The Future of the Crystal Industry - World Wide," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, pp. 583-591.

[10] W. H. Horton, "Future of the Quartz Industry - World Views," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, p. 592.

[11] T. Takeuchi, "Future of the Quartz Crystal Industry World Views," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, pp. 593-594.

[12] R. Fischer, "Current Trends and Future Projections in the Crystal Industry Worldwide," Proc. 35th Annual Frequency Control Symposium, Philadelphia, PA, May 1981, pp. 595.

[13] A. Ballato, "Frequency and Time Sources - Past, Present, and Future," Japanese Journal of Applied Physics, Vol. 24, (1985) Supplement 24-1, pp. 9-12.

ANNUAL FREQUENCY CONTROL SYMPOSIA

YEAR	ANNIVERSARY	FORMULA	CRYSTAL CLASS	PIEZOELECTRIC?
1951	05-Wood	(Cellulose/lignin)	Fibrous Crystalline Polymer	YES
1956	10 - Tln/Aluminum	Sn/Al	4/m; m3m	NO; NO
1961	15 - "Crystal"	SiO_2	Isotropic	NO
1966	20 - China	$Al_20_3•2Si0_2•2H_2O$	polycrystals (kaolln)	NO
1971	25 - Sllver	Ag	m3m	NO
1976	30 - Pearl	CaO_3 (calcite/aragonite)	polycrystals; ($\bar{3}$m mmm)	NO
1981	35 - Coral	$CaCo_3$ (calcite)	polycrystals ($\bar{3}$m)	NO
1986	40 - Ruby	Al_2O_3	$\bar{3}$m	NO
1991	45 - Sapphire	Al_2O_3	$\bar{3}$m	NO
1996	50 - Gold	Au	m3m	NO

Figure 7. Frequency control symposia anniversaries: 1951-1996.

ANNUAL FREQUENCY CONTROL SYMPOSIA

YEAR	ANNIVERSARY	FORMULA	CRYSTAL CLASS	PIEZOELECTRIC?
2001	55 - Emerald	$Al_2(Be\ Si_2\ O_6)_3$	6/m mm (beryl)	NO
2006	60 - Diamond	C	m3m	NO
2011	65 - Rubidium	Rb	m3m	NO
2016	70 - Cesium	Cs	m3m	NO
2021	75 - Hydrogen	H_2	m3m	NO
2026	80 - Ammonia	NH_3	23	YES!
2031	85 - I-Quartz	SiO_2	32	YES!
2036	90 - Lithium Niobate	$LINbo_3$	3m	YES!
2041	95 - Gallium Arsenide	GaAs	$\bar{4}$3m	YES!
2046	100 - Sympos-ium	Sym	???	???

Figure 8. Frequency control symposia anniversaries: 2001-2046.

APPENDIX

SYMPOSIUM PROGRAM

FOURTH ANNUAL FREQUENCY CONTROL
REVIEW OF TECHNICAL PROGRESS

26-27 APRIL 1950

SIGNAL CORPS ENGINEERING LABORATORIES
FORT MONMOUTH, N.J.

SYMPOSIUM PROGRAM

FOURTH ANNUAL REVIEW OF TECHNICAL PROGRESS

SIGNAL CORPS ENGINEERING LABORATORIES
FREQUENCY CONTROL BRANCH
FORT MONMOUTH, NEW JERSEY

26-27 April 1950

Gibbs Hall, Fort Monmouth Officers' Club

WEDNESDAY, 26 April 1950

Morning Session 9:00 a.m. - 12:30 p.m.

Opening Orientation Remarks, Signal Corps Engineering Laboratories - E. W. Johnson, Chief, Frequency Control Branch, Introducing Colonel W. A. Beasley, Deputy Commander, Signal Corps Engineering Laboratories 9:00 a.m. - 9:15 a.m.

Synthetic Crystal Investigations

Introduction - H. H. Waesche, Chairman 9:15 a.m. - 9:20 a.m.

1. Synthesis of Tourmaline - Baird Associates- 9:20 a.m. - 9:45 a.m.
2. Crystal Synthesis and Twinning Studies University of Minnesota 9:45 a.m. - 10:10 a.m.
3. Synthesis of Nepheline, Edward Washken Laboratories; Address by Dr. M. J. Buerger, Professor, Mineralogy and Petrography, Massachusetts Institute of Technology 10:10 a.m. - 11:00 a.m.

Intermission

4. Quartz Synthesis Studies - Antioch College 11:10 a.m. - 11:45 a.m.
5. Synthesis of Quartz and Other Crystal Studies - Brush Development Company 11:45 a.m. - 12:30 p.m.

Luncheon, Green Room, Gibbs Hall 12:40 p.m. - 1:20 p.m.

Afternoon Session

6. Summary of Synthetic Quartz Investigations - Bell Telephone Laboratories — 1:30 p.m. - 1:45 p.m.

Summary and General Discussion, "Synthetics" — 1:45 p.m. - 2:00 p.m.

Frequency Control Development

Introduction - W. L. Doxey, Chairman — 2:00 p.m. - 2:05 p.m.

1. Address: Piezoelectricity as a Branch of Thermodynamics - Dr. W. G. Cady, Professor Emeritus, Department of Physics, Wesleyan University — 2:05 p.m. - 2:55 p.m.

General Discussion — 2:55 p.m. - 3:05 p.m.

Intermission

2. Investigation Overtone Crystal Units (50-150 mc) - Radio Corporation of America — 3:20 p.m. - 3:45 p.m.

3. Investigation of Contoured Metal Plated Crystal Units (Low Frequency) - Radio Corporation of America — 3:45 p.m. - 4:10 p.m.

4. Development of Thinner Saw Blades - The Norton Company — 4:10 p.m. - 4:25 p.m.

5. Development of Improved Sawing Equipment - P. R. Hoffman Company — 4:25 p.m. - 4:35 p.m.

6. Miniaturized Solder-in Crystal Units Bliley Electric Company — 4:35 p.m. - 4:50 p.m.

7. High Temperature Crystal Units - August E. Miller; 500 kc Package Oscillator - August E. Miller — 4:50 p.m. - 5:10 p.m.

General Discussion — 5:10 p.m. - 5:30 p.m.

Evening Program

Cocktails — 6:00 p.m. - 7:00 p.m.

Dinner — 7:00 p.m

Speakers:

Toastmaster, Lt. Colonel William M. Young,
Director,
Squier Signal Laboratory
Introducing:

Major General Francis H. Lanahan,
Commanding General,
Fort Monmouth

Dr. Donald H. Menzel,
Professor of Astrophysics,
Harvard University
"Action on the Sun,"
with motion picture

Green Room, Gibbs Hall

THURSDAY, 27 APRIL 1950

Morning Session

9:00 a.m. - 12:30 p.m.

Frequency Control Research

Introduction - W. L. Doxey, A. C. Prichard, Chairmen	9:00 a..m. - 9:05 a.m.
1. Detwinning of Crystalline Quartz - National Bureau of Standards	9:05 a.m. - 9:25 a.m.
2. Theoretical Studies and Crystal Measurements - Wesleyan University	9:25 a.m. - 10:00 a.m.
3. Investigation of Geometric Factors Affecting Quartz Crystal Units - Tufts College	10:00 a.m. - 10:25 a.m.
Intermission	10:25 a. m. - 10:40 a.m.
4. Factors Affecting The Reactance Curve of Crystal Units - Colorado Agricultural and Mechanical College	10:40 a.m. - 11:15 a.m.
5. Magnetostriction Devices and Oscillator Circuits - Armour Research Foundation	11:15 a.m. - 11:40 a.m.
6. Stroboscopic X-ray Studies of Oscillating Crystals - Pennsylvania State College	11:40 a.m. - 12:10 p.m.
General Discussion	12:10 p.m. - 12:30 p.m.
Luncheon, Green Room, Gibbs Hall	12:40 p.m. - 1:25 p.m.

Afternoon Session

Frequency Control Circuits and Test Equipment

Introduction - A. C. Prichard, Chairman	1:25 p.m. - 1:30 p.m.
1. Theoretical Investigation of Oscillator Circuits - University of Illinois	1:30 p.m. - 1:50 p.m.
2. High Frequency Crystal Controlled Oscillator Circuits - Georgia Tech Research Institute	1:50 p.m. - 2:25 p.m.
3. Development of Frequency Meters FR-4, 5, and 6 - Lavoie Laboratories	2:25 p.m. - 2:40 p.m.
4. Development of Frequency Calibrator and C. I. Meter - Reeves-Hoffman Company	2:40 p.m. - 3:00 p.m.
5. Broad Aspects of Signal Corps Research - Dr. Harold A. Zahl, Director of Research, Signal Corps Engineering Laboratories	3:00 p.m. - 3:15 p.m.
6. Summary - Frequency Control Research Problems at Massachusetts Institute of Technology and Harvard University - A. C. Prichard	3:15 p.m. - 3:25 p.m.
Intermission	
7. Frequency Control Branch Research and Development Program - E. W. Johnson, Chairman	3:35 p.m. - 4:15 p.m.
8. Concluding Summary - E. W. Johnson	4:15 p.m. - 4:45 p.m.

SYMPOSIUM PROGRAM

FIFTH ANNUAL REVIEW OF TECHNICAL PROGRESS

SIGNAL CORPS ENGINEERING LABORATORIES
FREQUENCY CONTROL BRANCH
FORT MONMOUTH, NEW JERSEY

1 - 3 May 1951

Berkeley-Carteret Hotel, Asbury Park, N.J.

TUESDAY, 1 MAY 1951

Morning Session 11:00 a.m. - 12:15 p.m.

Opening Orientation Remarks, Signal Corps Engineering Laboratories - E. W. Johnson, Chief, Frequency Control Branch Introducing Lt. Col. Wm. M. Young, Director, Squier Laboratory, Introducing Brig. Gen Harry Reicheldorfer, Commanding General, Signal Corps Engineering Laboratories 11:00 a.m. - 11:15 a.m.

SYNTHETIC CRYSTAL INVESTIGATIONS

1. Crystal Synthesis Activities, Signal Corps Engineering Laboratories 11:15 a.m. - 11:45 a.m.
2. Growth of Pegmatite Minerals Washington University 11:45 a.m. - 12:15 p.m.

Luncheon 12:15 p.m. - 1:30 p.m.

Afternoon Session

3. Crystal Synthesis and Twinning Studies, University of Minnesota 1:30 p.m. - 2:00 p.m.
4. Quartz Synthesis, Antioch College 2:00 p.m. - 2:30 p.m.

Intermission 2:30 p.m. - 2:45 p.m.

5. Synthesis of Quartz Crystals Brush Development Company 2:45 p.m. - 3:30 p.m.
6. Synthesis of Quartz at High Temperature and Pressures, Bell Telephone Laboratories 3:30 p.m. - 4:15 p.m.
7. Question and Answer Session on Signal Corps Report Requirements 4:15 p.m. - 4:30 p.m.

General Discussion 4:30 p.m. - 5:30 p.m.

WEDNESDAY, 2 MAY 1951

Morning Session 9:00 a.m. -12:15 p.m.

FREQUENCY CONTROL STUDIES

8. Effect of Crystal Geometry on the Slope of the Reactance Curve, Colorado A&M9:00 a.m. - 9:30 a.m.
9. Theoretical Investigation of Partially Plated Crystals, Wesleyan University 9:30 a.m. - 10:00 a.m.
10. Detwinning of Quartz National Bureau of Standards 10:00 a.m. - 10:15 a.m.

Intermission 10:15 a.m. - 10:30 a.m.

11. Crystal Studies Utilizing Stroboscopic X-Rays, Penn. State College 10:30 a.m. - 11:00 a.m.
12. Effect of Plating on Aging Characteristics of Crystals, Georgia Institute of Technology 11:00 a.m. - 11:30 a.m.
13. Theoretical Investigation of Oscillator Circuits, University of Illinois 11:30 a.m. - 11:45 a.m.
14. Precision Electro-mechnanical Filters, Tufts College 11:45 a.m. - 12:15 p.m.

Luncheon 12:15 p.m. - 1:30 p.m.

15. Very High Frequency Oscillator Circuits, Georgia Institute of Technology 1:30 p.m. - 2:15 p.m.
16. Improvement of Heat Dissipation Characteristics of Crystal Units, Colorado A&M 2:15 p.m. -

Intermission 2:45 p.m. - 3:15 p.m.

17. Reduction of the Doppler Contribution to Widths of Microwave Absorption Lines, Princeton University 3:15 p.m. - 3:30 p.m.
18. Use of Scintillating Crystals for the Detection of Soft X-rays, University of Oregon 3:30 p.m. - 4:00 p.m.
19. Relations Between Current, Voltage, and Amplitude of Vibration in Piezoelectric Crystals 4:00 p.m. -

Discussion 4:30 p.m. - 5:30 p.m.

Evening Program

Dinner 7:00 p.m.

Speakers:

Toastmaster, Lt. Colonel William M. Young

Principal Speaker:

Dr. Frederick H. Pough
American Museum of
National History
"The Glamorous Crystal"
with slides.

Crystal Terrace

Berkeley Carteret Hotel

THURSDAY, 3 MAY 1951

Morning Session 9:00 a.m. - 12:30 p.m.

MANUFACTURING AND TESTING

21. 500 KC Packaged Oscillator as Developed by A. E. Miller 9:00 a.m. - 9:15 a.m.
22. Contouring Equipment as Developed by Bausch & Lomb Company 9:15 a.m. - 9:30 a.m.
23. Precision Quartz Saw as Developed by P. R. Hoffman Company 9:30 a.m. - 9:45 a.m.
24. Thin Saw Blades as Developed by the Norton Company 9:45 a.m. - 10:00 a.m.

Intermission 10:00 a.m. - 10:15 a.m.

25. Practical Application of Proportional Temperature Control Devices 10:15 a.m. - 10:30 a.m.
26. Use of the Crystal Impedance Meter in the Laboratory and in Production 10:30 a.m. - 10:45 a.m.
27. Consideration of Drive Levels in the CR-18, CR-23 and Other Crystal Units 10:45 a.m. - 11:15 a.m.
28. Apparatus and Method for Production Testing of Plated Type Crystal Units, Hunt Corporation 11:15 a.m. - 12:30 p.m.

Afternoon Session 2:00 p.m. - 5:00 p.m.

Luncheon 12:30 p.m. - 2:00 p.m.

29. General Discussion of MIL-C Type Specifications Including a Discussion of CR/4U Type Crystals, Bell Telephone Laboratories 2:00 p.m. -2:30 p.m.
30. Low Frequency Crystals in HC-6U Holders, Radio Corporation of America 2:30 p.m. - 2:45 p.m.
31. General Discussion of Manufacturing Problems 2:45 p.m. - 5:30 p.m.

----symposium program----

7th Annual

FREQUENCY CONTROL REVIEW

of

TECHNICAL PROGRESS

18 - 20 MAY 1953

SIGNAL CORPS ENGINEERING LABORATORIES

FORT MONMOUTH, N.J.

SYMPOSIUM PROGRAM

SEVENTH ANNUAL REVIEW OF TECHNICAL PROGRESS

SIGNAL CORPS ENGINEERING LABORATORIES

FREQUENCY CONTROL BRANCH - CHEMICAL PHYSICS BRANCH

FORT MONMOUTH, NEW JERSEY

18, 19, 20 May 1953

Berkeley-Carteret Hotel, Asbury Park, N.J.

Outline of Meetings

Monday, 18 May 1953

9:00 a.m.	Registration	Palm Terrace
11:00 a.m.	General Session	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Piezoelectric Vibrators	Crystal Terrace

Tuesday, 19 May 1953

8:30 a.m.	Frequency Control Devices and Applications	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Fundamental Properties of Crystals	Crystal Terrace
3:00 p.m.	Research and Development in the United Kingdom	Crystal Terrace
3:45 p.m.	Quartz Synthesis	Crystal Terrace
7:00 p.m.	Annual Dinner	Crystal Terrace

Wednesday, 20 May 1953

8:30 a.m.	Circuitry and Test Equipment	Crystal Terrace
9:00 a.m.	Crystal Chemistry and Growing Techniques	Solarium
10:45 a.m.	Crystal Unit Production Forum	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Crystal Unit Production Forum (Contd.)	Crystal Terrace
1:30 p.m.	Crystal Chemistry and Growing Techniques (Contd.)	Solarium

Detailed Schedules

MONDAY MORNING, 18 May 1953

General Session

11:00 a.m. Introductory Program Signal Corps Engineering Laboratories

Mr. W. L. Doxey, Chief, Frequency Control Branch, Squier Signal Laboratory

Lt. Col. Robert K. Saxe, Director, Squier Signal Laboratory

Brig. Gen. Edwin R. Petzing, Commanding, Signal Corps Engineering Laboratories

12:15 p.m. Luncheon

MONDAY AFTERNOON, 18 May 1953

Piezoelectric Vibrators

1. 1:30 p.m. Investigations in the Mathematical Theory of Vibrations of Anisotropic Bodies - R. D. Mindlin - Columbia University
2. 2:00 p.m. Piezoelectric Crystal Studies - K. S. Van Dyke - Wesleyan University
3. 2:30 p.m. Research Investigations on Fundamental and Overtone Crystals - V. E. Bottom - Colorado A&M College
4. 3:00 p.m. Ring Resonators - L. G. Chase - Motorola, Inc.

   3:30 p.m. Intermission
5. 3:45 p.m. Aging Study of Metal Plating on Quartz Crystals - R. Belser - Georgia Institute of Technology
6. 4:15 p.m. Improvement in Crystal Units for Precise Frequency Control - R. A. Skyes - A. W. Warner - J. P. Griffin - Bell Telephone Laboratories
7. 4:45 p.m. Drive Level, Sputtering, and X-Ray Studies - E. A. Gerber, R. Morris, S. S. Brody - Frequency Control Branch, SCEL, Fort Monmouth, N.J.

TUESDAY MORNING, 19 May 1953

Frequency Control Devices and Applications

1. 8:30 a.m. Low Frequency Electromechanical Filters - S. P. Lapin - Motorola, Inc.
2. 9:00 a.m. Characteristics of Electromechanical Filters - C. R. Mingins - A. D. Frost - Tufts College

3. 9:30 a.m. Transistor Circuit Applications to Frequency Control - E. Gonzalez - Frequency Control Branch, Squier Signal Laboratory
4. 10:00 a.m. Frequency Control Above 150 mc/sec - D. Fraser - Georgia Institute of Technology

   10:30 a.m. Intermission
5. 10:45 a.m. Frequency Control Systems - R. W. Frank - R. W. Stuart - General Radio Co.
6. 11:15 a.m. Frequency and Time Interval Standards - W. D. George - National Bureau of Standards
7. 11:45 a.m. Molecular Absorption Phenomena - R. H. Dicke - Princeton University - Radio Corporation of America

TUESDAY AFTERNOON, 19 May 1953

Fundamental Properties of Crystals

1. 1:30 p.m. Surface Structure of Quartz Crystals - G. W. Arnold - Naval Research Laboratories
2. 2:00 p.m. X-Ray Diffraction Studies of Piezoelectric Crystals - R. Pepinsky - The Pennsylvania State College
3. 2:30 p.m. Radiations and Physical Properties of Crystals - C. Frondel - Harvard University

Research and Development in the United Kingdom

4. 3:00 p.m. Review of Research and development in the United Kingdom - H. T. Mitchell - British Post Office

Quartz Synthesis

5. 3:45 p.m. Status of Raw Quartz - H. H. Waesche - Frequency Control Branch, Squier Signal Laboratory
6. 4:00 p.m. Growth of Quartz Crystals at High Pressures - G. T. Kohman - A. C. Walker - Bell Telephone Laboratories
7. 4:30 p.m. Growth of Quartz at Low Pressures - D. R. Hale - W. H. Charbonnet - Brush Laboratories Co.
8. 5:00 p.m. Twinning in Synthetic Quartz - J. W. Gruner - University of Minnesota

TUESDAY EVENING, 19 May 1953

7:00 p.m. Annual Dinner, Crystal Terrace, Berkeley Carteret Hotel
Guest Speaker - Dr. I. M. Levitt, Director Fels Planetarium,
Franklin Institute, Phila., Pa.
Subject: "Space Travel - The Human Being in Space"

WEDNESDAY MORNING, 20 May 1953

Circuitry and Test Equipment

1. 8:30 a.m. Crystal Impedance Meter TS-710/TSM - R. Green - Radio Frequency Laboratories
2. 8:50 a.m. A Direct Reading Frequency Meter - P. G. Hansel - Servo Corporation of America
3. 9:15 a.m. Crystal Oscillators in the VHF and UHF Regions - G. I. Davies - Davies Laboratories - Naval Research Laboratories
4. 9:40 a.m. Theory of Oscillator Circuits - J. W. Hoffman - B. Silverman - C. V. Jakowatz - University of Illinois
5. 10:00 a.m. Oscillator Design Considerations for Military Equipment - E. A. Roberts - Armour Research Foundation - Wright Air Development Center

10:30 a.m. Intermission

Crystal Unit Production Forum

6. 10:45 a.m. Procurement - Philadelphia Signal Corps Supply Agency
7. 11:15 a.m. Inspection - Philadelphia Signal Corps Supply Agency
8. 11:45 a.m. Specifications - Bureau of Ships

12:15 p.m. Luncheon

WEDNESDAY AFTERNOON, 20 May 1953

1. 1:30 p.m. Crystal Requirements for Communications Equipment - Collins Radio Company
2. 2:00 p.m. Pressure-mounted VHF Crystals - Bliley Electric Company
3. 2:30 p.m. Training Aids and Production Short Cuts - Hunt Corporation

3:00 p.m. Intermission

4. 3:15 p.m. The Human Factor and Crystal Testing - Pioneer Electric & Research Corp.
5. 3:45 p.m. Crystal Production Problems Associated with Air Force Equipment Design - Wright Air Development Center
6. 4:00 p.m. General Discussion

WEDNESDAY MORNING, 20 May 1953

Crystal Chemistry and Growing Techniques

Joint Session - Frequency Control Branch - Chemical Physics Branch

1. 9:00 a.m. Studies of Silica Transfer and Diffusion - R. G. Yalman - Antioch College
2. 9:20 a.m. Silica Structures - M. J. Buerger - Edward Washken Laboratories
3. 9:40 a.m. Composition of Fluid Inclusions in Minerals - E. Roedder - University of Utah
4. 10:00 a.m. Pegmetite Studies - A. F. Frederickson - J. E. Cox - Washington University

10:20 a.m. Intermission

5. 10:30 a.m. Stability Relations in Barium Titanate and Other Minerals - R. Roy - E. F. Osborn - The Pennsylvania State College
6. 11:00 a.m. Growth of Barium Titanate - H. C. Kremera - The Harshaw Chemical Company
7. 11:30 a.m. Ferromagnetic Perovskite Compounds - D. Heinz - Polytechnic Institute of Brooklyn

12:15 p.m. Luncheon

WEDNESDAY AFTERNOON, 20 May 1953

1. 1:30 p.m. Polymorphism in Natural Micas - E. W. Heinrich - A. A. Levinson - University of Michigan
2. 1:50 p.m. Synthetic Mica Progress - R. A. Hatch - J. E. Comeforo - U.S. Bureau of Mines
3. 2:10 p.m. Infrared Studies of Crystals - G. B. B. M. Sutherland - University of Michigan

2:40 p.m. Intermission

4. 2:55 p.m. Infrared Spectroscopy of Crystals - R. S. Halford - Columbia University
5. 3:25 p.m. Magnetochemistry of Crystals - P. W. Selwood - Northwestern University
6. 3:45 p.m. Preparation of Ultra High Purity Germanium - W. E. Metcalf - R. K. Riel - C. E. Smith - Eagle-Pitcher Company
7. 4:05 p.m. High Purity Silicon - F. B. Litton
H. C. Anderson - Foote Mineral Company

----symposium program----

8th Annual

FREQUENCY CONTROL REVIEW

of

TECHNICAL PROGRESS

12 - 14 APRIL 1954

SIGNAL CORPS ENGINEERING LABORATORIES

FORT MONMOUTH, N.J.

SYMPOSIUM PROGRAM

EIGHTH ANNUAL REVIEW OF TECHNICAL PROGRESS

SIGNAL CORPS ENGINEERING LABORATORIES

FREQUENCY CONTROL BRANCH

FORT MONMOUTH, NEW JERSEY

12, 13, 14 April 1954

Berkeley-Carteret Hotel, Asbury Park, N.J.

Outline of Meetings

Monday, 12 April 1954

9:00 a.m.	Registration	Palm Terrace
10:30 a.m.	General Session	Crystal Terrace
11:30 a.m.	Luncheon	Oval Lounge
1:30 p.m.	Properties of Crystalline Materials and of Piezoelectric Vibrators	Crystal Terrace

Tuesday, 13 April 1954

9:00 a.m.	Aging Forum	Crystal Terrace
11:45 a.m.	Temperature Control Systems	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Temperature Control Systems (Contd)	Crystal Terrace
2:00 p.m.	Research and Development in the United Kingdom	Crystal Terrace
3:00 p.m.	Frequency Control by Means Other Than Quartz Crystals	Crystal Terrace
7:00 p.m.	Annual Dinner	Crystal Terrace

Wednesday, 14 April 1954

9:00 a.m.	Filters, Oscillators and Frequency Control Systems	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Production Forum	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Crystal Unit Production Forum (Contd.)	Crystal Terrace

Detailed Schedules

MONDAY MORNING, 12 April 1954

General Session

9:00 to 10:30 a.m. Registration

10:30 a.m. Introductory Program - Signal Corps Engineering Laboratories

Mr. W. L. Doxey, Chief, Frequency Control Branch, Squier Signal Laboratory

Lt. Col. John V. Fill, Director, Squier Signal Laboratory

Col. F. F. Uhrhane, Commanding, Signal Corps Engineering Laboratories

Dr. Harold A. Zahl, Director of Research, Signal Corps Engineering Laboratories

11:30 a.m. Luncheon - Guest Speaker, J. L. Grover, Radio Corporation of America
"Application of Quartz Crystals to Color Television Equipment"

MONDAY AFTERNOON, 12 April 1954

Properties of Crystalline Materials and of Piezoelectric Vibrators

1. 1:30 p.m. Research and Development Within Frequency Control Branch - E. A. Gerber - Frequency Control Branch, SCEL
2. 2:00 p.m. Lattice Parameters of Natural and Synthetic Quartz - D. L. Hammond - Frequency Control Branch, SCEL
3. 2:30 p.m. Quartz Crystal Imperfections - G. W. Arnold, Jr. - Naval Research Laboratory
4. 3:00 p.m. X-Ray Diffraction Studies of Piezoelectric Crystals - R. Pepinsky - The Pennsylvania Station University

3:30 p.m. Intermission

5. 3:45 p.m. Mathematical Theory of Vibrations of Elastic Bodies - R. D. Mindlin - Columbia University

Quartz Synthesis

6. 4:15 p.m. Growth of Quartz at Low Pressures - D. R. Hale - Brush Laboratories Company
7. 4:45 p.m. Growth of Quartz Crystals at High Temperatures and Pressures - A. C. Walker - Bell Telephone Laboratories

TUESDAY MORNING, 13 April 1954

Aging Forum

1. 9:00 a.m. An Evaluation of Metals and Techniques for Coating Quartz Piezoelectric Resonators - R. B. Belser and W. H. Hicklin - Georgia Institute of Technology
2. 9:30 a.m. Frequency Aging on HF Crystals and VHF Crystal Units - P. E. Mulvihill - Frequency Control Branch, SCEL
3. 10:00 a.m. Aging Effects of Plated High Frequency Crystal Units - A. W. Warner - Bell Telephone Laboratories

10:30 a.m. Intermission

4. 10:45 a.m. Study of Aging Effects on Military Plated Crystal Units - P. D. Gerber - Radio Corporation of America
5. 11:15 a.m. Discussion

Temperature Control Systems

6. 11:45 a.m. Lavoie Crystal Ovens - N. E. Tetrault - Lavoie Laboratories

12:15 p.m. Luncheon

TUESDAY AFTERNOON, 13 April 1954

Temperature Control Systems (Contd)

1. 1:30 p.m. Triple Point Thermostats - C. P. Saylor and R. Alvarez - National Bureau of Standards

Research and Development in the United Kingdom

2. 2:00 p.m. Advancements in Research and Development in the United Kingdom - H. T. Mitchell - British Post Office

Frequency Control By Means Other Than Quartz Crystals

3. 3:00 p.m. Frequency Stabilization by Non-piezoelectric Crystals - R. M. Gogolick and R. M. Ulmer - Horizons, Inc.

3:30 p.m. Intermission

4. 3:45 p.m. Frequency Control Above 500 Mc - D. W. Fraser - Georgia Institute of Technology

5. 4:15 p.m. Spectroscopic Line Breadth of Microwave Frequencies - R. H. Dicke - Princeton University

6. 4:45 p.m. Reduction of Doppler Broadening of the Ammonia Spectral Line - L. E. Norton - Radio Corporation of America

TUESDAY EVENING, 13 April 1954

7:00 p.m. Annual Dinner - Crystal Terrace - Berkeley Carteret Hotel
Guest Speaker - J. E. Doerr - National Park Service
"Your National Parks and Monuments"

TUESDAY EVENING, 13 April 1954

Filters, Oscillators and Frequency Control Systems

1. 9:00 a.m. Low Frequency Electro-Mechanical Filters - S. L. Lapin - Motorola, Inc.

2. 9:30 a.m. Feasibility Study for Packet Oscillator Design - H. E. Gruen and E. A. Roberts - Armour Research Foundation

3. 10:00 a.m. Crystal Oscillators in the VHF Region - G. L. Davies - Davies Laboratory

10:30 a.m. Intermission

4. 10:45 a.m. Transistor Oscillators - B. J. Dasher - Georgia Institute of Technology

5. 11:15 a.m. Present Status of Radio Frequency Control Systems in Military Radio Communications Equipment - R. E. Lacy - Radio Communications Branch, SCEL

6. 11:45 a.m. The Computer Type Decade Frequency Generator - R. W. Frank - General Radio Company

12:15 p.m. Luncheon

WEDNESDAY AFTERNOON, 14 April 1954

Production Forum

1. 1:30 p.m. Crystal Requirements for Future Radio Equipments - R. E. Lacy - Radio Communications Branch, SCEL

2. 2:00 p.m. Quartz Crystal Reliability Problems - W. R. Prendergast - Canadian Signals Research and Development Establishment, Canada

3. 2:30 p.m. Current Mobilization Activities - Signal Corps Supply Agency, Philadelphia, Pa.

3:00 p.m. Intermission

4. 3:15 p.m. Process Control of Inductance in Crystal Manufacturing - T. G. Clark - Western Electric Company

5. 3:45 p.m. Some Problems Encountered in the Production of High Harmonic Crystals - Pioneer Electric and Research Corporation

6. 4:15 p.m. Discussion of Crystal Unit Manufacturing Techniques - G. F. Fisher - Midland Manufacturing Company, Inc.

4:45 p.m. Discussion

SYMPOSIUM PROGRAM

9th ANNUAL

FREQUENCY CONTROL REVIEW

OF

TECHNICAL PROGRESS

25, 26, 27 MAY 1955

SIGNAL CORPS ENGINEERING LABORATORIES

FORT MONMOUTH, N.J.

SYMPOSIUM PROGRAM

NINTH ANNUAL REVIEW OF TECHNICAL PROGRESS

SIGNAL CORPS ENGINEERING LABORATORIES

FREQUENCY CONTROL BRANCH

FORT MONMOUTH, NEW JERSEY

25, 26, 27 May 1955

Hotel Berkeley-Carteret, Asbury Park, N.J.

Outline of Meetings

Wednesday, 25 May 1955

8:30 a.m.	Registration	Palm Terrace
10:15 a.m.	General Session	Crystal Terrace
11:30 a.m.	Luncheon	
1:00 p.m.	Properties of Crystalline Materials and of Piezoelectric Vibrators	Crystal Terrace

Thursday, 26 May 1955

9:00 a.m.	Stability Characteristics in Frequency Control	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	VHF and UHF Frequency Control	Crystal Terrace
3:45 p.m.	Quartz Synthesis	Crystal Terrace
7:00 p.m.	Annual Dinner	Crystal Terrace

Friday, 27 May 1955

9:00 a.m.	High Precision Frequency Control	Crystal Terrace
12:15 p.m.	Luncheon	
1:30 p.m.	Production Forum	Crystal Terrace

Detailed Schedules

MONDAY MORNING, 25 May 1955

General Session

8:30 to 10:15 a.m. Registration

10:15 a.m. Introductory Program - Signal Corps Engineering Laboratories

Dr. E. A. Gerber, Chief, Frequency Control Branch, Components Division

Lt. Col. John V. Fill, Director, Components Division

Brig. General F. F. Uhrhane, Commanding, Signal Corps Engineering Laboratories

Dr. Harold A. Zahl, Director of Research, Signal Corps Engineering Laboratories

11:30 a.m. Luncheon

MONDAY AFTERNOON, 25 May 1955

Properties of Crystalline Materials and of Piezoelectric Vibrators

1. 1:00 p.m. Research and Development in Frequency Control - E. A. Gerber - Frequency Control Branch, SCEL
2. 1:30 p.m. Mathematical Theory of Vibrations of Elastic Plates - R. D. Mindlin - Columbia University
3. 2:00 p.m. Determining Strain Patterns in Thickness Shear Resonators - K. S. Van Dyke - Wesleyan University
4. 2:30 p.m. Frequency Spectra in Quartz Resonators - C. R. Mingins and A. D. Frost - Tufts College

3:00 p.m. Intermission

5. 3:15 p.m. Effects of Ionic Diffusion on the Physical Properties of Quartz - H. E. Wenden - Harvard University
6. 3:45 p.m. Optical Absorption Spectra Studies of Natural and Synthetic Quartz - G. W. Arnold, Jr. - Naval Research Laboratory
7. 4:15 p.m. Effects of Impurities on the Resonator and Lattice Properties of Quartz - Donald L. Hammond - Frequency Control Branch, SCEL

THURSDAY MORNING, 26 May 1955

Stability Characteristics in Frequency Control

1. 9:00 a.m. An Evaluation of Metals and Techniques for Coating Quartz Piezoelectric Resonators - Richard B. Belser and Walter H. Hicklin - Georgia Institute of Technology
2. 9:30 a.m. Study of Aging Effects on Military Plated Crystal Units - P. D. Gerber - Radio Corporation of America
3. 10:00 a.m. Frequency-Temperature Behavior of Resonators of Natural and Synthetic Quartz - Rudolf Bechmann - The Brush Laboratories Company

10:30 a.m. Intermission

4. 10:45 a.m. Methods of Obtaining Reduced Tolerances in Crystals Over a Wide Temperature Range - L. F. Koerner - Bell Telephone Laboratories, Inc.
5. 11:15 a.m. Transistor Oscillators - E. Gonzales-Correa - Solid State Devices Branch, SCEL
6. 11:45 a.m. Research and Development in Canada - L. F. Bennett, Canadian Military Electronics Standards Agency, and D. M. Eisen, Canadian Radio Manufacturing Company

12:15 p.m. Luncheon

THURSDAY AFTERNOON, 26 May 1955

VHF and UHF Frequency Control

1. 1:30 p.m. Packet Oscillator Circuits - E. Roberts and H. Gruen - Armour Research Foundation
2. 2:00 p.m. VHF Crystal Test Circuits - G. K. Guttwein - Frequency Control Branch, SCEL
3. 2:30 p.m. Methods of Measuring the Equivalent Electrical Parameters of Quartz Crystals - William B. Wrigley - Georgia Institute of Technology

3:00 p.m. Intermission

4. 3:15 p.m. Precision Frequency Control Above 500 MC - Donald W. Fraser and Edward G. Holmes - Georgia Institute of Technology

Quartz Synthesis

5. 3:45 p.m. Laboratory and Pilot Plant Growth of Quartz at Moderate Pressure - D. R. Hale, Hans Jaffe, W. H. Charbonnet - The Brush Laboratories Company

6. 4:15 p.m. Growth of Quartz at High Temperatures and Pressures - A. C. Walker - Bell Telephone Laboratories, Inc.

THURSDAY EVENING, 26 May 1955

7:00 p.m. Annual Dinner - Crystal Terrace, Hotel Berkeley-Carteret - Guest Speaker - Willy Ley - "A Survey of Space Satellite Proposals"

FRIDAY MORNING, 27 May 1955

High Precision Frequency Control

1. 9:00 a.m. The Primary Frequency and Time Standard - W. D. George - National Bureau of Standards

2. 9:30 a.m. High Precision Crystal Measurements - A. W. Warner - Bell Telephone Laboratories, Inc.

3. 10:00 a.m. Research and Development in the United Kingdom - H. T. Mitchell - British Post Office Engineering Department

10:30 a.m. Intermission

4. 10:45 a.m. Molecular and Atomic Frequency and Time Standards - F. H. Reder - Frequency Control Branch, SCEL

5. 11:15 a.m. Spectroscopic Line Breadth of Microwave Frequencies - R. H. Dicke - Princeton University

6. 11:45 a.m. An Atomic Frequency Standard - Jerrold R. Zacharias - Massachusetts Institute of Technology

12:15 p.m. Luncheon

FRIDAY AFTERNOON, 27 May 1955

Production Forum

1. 1:30 p.m. VHF Crystal Resonators - E. M. Shideler - Scientific Radio Products, Inc.

2. 2:00 p.m. Methods of Measurement and Test of Crystal Units in Britain - W. J. Young - Standard Telephone and Cables Ltd.

3. 2:30 p.m. High Stability Crystal Units - Otis Ivia - James Knights Company

4. 3:00 p.m. Current Mobilization Activity - Arnold Ratner - Signal Corps Supply Agency

3:30 p.m. Intermission

5. 3:45 p.m. Production Procedures for VHF Crystals (5th Harmonic 60-100 MC) - R. D. Cortright - Union Thermoelectric Corporation

6. 4:15 p.m. Ultrasonic Quartz Cutting - Norman E. Gibbs - Raytheon Manufacturing Company

7. 4:45 p.m. Mechanization of Crystal Manufacturing Processes - Lester V. Wise - Bulova Research and Development Laboratories, Inc.

5:15 p.m. Discussion