

Quartz Resonator Handbook

Manufacturing Guide FOR "AT" TYPE UNITS

Edited by ROGER E. BENNETT

Prepared For
THE DEPARTMENT OF THE ARMY
By
UNION THERMOELECTRIC DIVISION
Comptometer Corporation
Niles, Illinois
1960

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HANDBOOK

MANUFACTURING GUIDE

FOR "AT" TYPE UNITS

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PREFACE

Quartz resonator units are commonly specified in terms of their performance. Therefore, the designs, particularly the refined practical designs, become the responsibility of the manufacturer. The purpose of this Handbook is to furnish the engineer engaged in the design of quartz resonator units of the AT type with pertinent basic information, particularly information on the relation of the performance characteristics of a resonator to its physical parameters. A little process information is included, chiefly in the Appendices.

Readers interested in the physics of piezoelectricity may find some factual items of interest, but this book is in no sense a substitute for or recapitulation, in any way, of any significant part of the important books on piezoelectricity.* Likewise, readers interested in the use of quartz resonators in electrical circuits should refer primarily to other books,** and use this Handbook only to add to their knowledge of the component.

For the convenience of librarians and bibliographers and to fix responsibility for the final form of the material, the chief editor's name appears alone upon the title page. Actually the Handbook is the product of a cooperative effort which included contributions from nearly all of the small group of engineers who are actively engaged -- in industry and in government laboratories -- in improving the quality of quartz resonators and increasing the efficiency of manufacturing them.

* W. G. Cady, Piezoelectricity (N.Y., McGraw-Hill, 1946); Raymond A. Heising, Quartz Crystals for Electrical Circuits (N.Y., D. Van Nostrand, 1946); P. Vigoreux and C. F. Booth, Quartz Vibrators and Their Applications (London, His Majesty's Stationery Office, 1950); Warren P. Mason, Piezoelectric Crystals and Their Application to Ultrasonics (N.Y., D. Van Nostrand, 1950); G.J.S. Little, R. Bechmann, and others, Piezoelectricity (London, Her Majesty's Stationery Office, 1957).

** The basic compendium of such information, including logistic information on military types is John P. Buchanan, Handbook of Piezoelectric Crystals for Radio Equipment Designers, Wright Air Development Center, Technical Report 56-156 (October, 1956). Much material on circuitry is to be found in the books by Heising and Vigoreux, cited above.

Dr. Virgil E. Bottom of McMurry College, acting as a part-time member of the Union Thermoelectric staff, helped to determine the general editorial policy and wrote most of Part I up to the section on Modes of Motion.

Mr. Len A. Tyler, Senior Physicist of the Union Thermoelectric Division of Comptometer Corporation, acted as co-editor of the entire Handbook, and is responsible for most of the basic evaluation and judgments. The material on Shape and Contour and on the Thickness-Frequency Coefficient in Part II is his, as well as many smaller sections.

Mr. Chester Rutkowski of Motorola Inc., and formerly of Union Thermoelectric, contributed heavily to the data used for the section on the Temperature Coefficient of Frequency, and reviewed most of the conclusions as they were being formed. He also contributed most of the material on the thickness of plated electrodes and on metallic resistance, and was a major contributor of data and conclusions about high frequency units operating on harmonics, and upon many other subjects, including bonding cements.

Mr. James T. Lavan of the Union Thermoelectric staff was a major contributor of data in all areas.

Mr. John Deininger rejoined the Union Thermoelectric staff after this book had taken form. He assisted in general editing and wrote parts of the sections on electrical measurements and on cleaning.

Mr. Joseph F. Brumbach of Comptometer Corporation contributed some of the material on high frequency harmonic units, on electrical measurements, and is responsible for much of the work on inharmonic overtones.

The more recent and confirmatory work on inharmonic overtones, as well as much of the work on holder capacitances is by Mr. Jack Stringe of Union Thermoelectric.

Mr. Edward A. Roberts, Vice-President of Comptometer Corporation, contributed the material on atmospheric loading.

Dr. Wallace E. Richmond, a part-time member of the Union Thermoelectric staff, contributed general editorial advice, and did a very great deal of work on process manuals, which appears here in a very much abridged form.

Mr. Leroy Rose of Union Thermoelectric is a major contributor of material in a number of areas.

The material on abrasives is very much abridged from an old Union Thermoelectric report by Mr. Forrest E. Layton, now of Pioneer Tool and Engineering, with some evaluations from a more recent Union Thermoelectric report by Dr. Richmond and Mr. Ralph P. Chalker, Operational Manager of the Union Thermoelectric Division.

Mr. Shirl Hone, contributed the basic analysis of thickness of plating and resistance.

Mr. Richard D. Cortright, General Manager of the Union Thermoelectric Division, directed the entire project, made many of the more fruitful contacts with the industry in search of information and guidance, and determined the final organization of the Handbook.

Mr. Roger A. Sykes of Bell Telephone Laboratories, reviewed an early draft, and Arthur W. Warner gave assistance in addition to his published papers. Mr. Don Hammond of Hewlett Packard began furnishing information and advice when he was employed by the U. S. Army Signal Research and Development Laboratories. Specific indebtedness to him and to Mr. Jack Saunders of Collins Radio Company, and formerly of Union Thermoelectric, appears in connection with X-ray techniques. Much of the first basic analysis of the temperature coefficient of frequency was made with the help of Mr. A. R. Chi, formerly with the U. S. Army Signal Research and Development Agency, and now with the U. S. Naval Research Laboratories. Mr. Leland Sogn of Dayton Air Force Depot has furnished data and general cooperation of very great value.

Indebtedness to the manufacturers of quartz resonators is comprehensive. It cannot be acknowledged in detail because through reports on government contracts, letters, telephone conversations, and direct conversations, a great mass of information has circulated within the industry, and while the Handbook has been in preparation, has been made available for it. Frequently the originator would be difficult to trace. A few specific acknowledgments are made in the text, but in general it is only possible to both commend and thank the industry for its generosity.

The need for such a Handbook was first conceived by the U. S. Army Signal Supply Agency, and the book has been supported by them both by contract, and by advice. The contract under which the book was written operates under a Technical Guidance Committee, representing the U. S. Army Signal Supply Agency, the U. S. Army Signal Research and Development Agency, and the U. S. Army Signal Materiel Support Agency. The following members of these agencies

were active on this committee during the preparation of this book:

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The U. S. Army Signal Research and Development Agency, particularly through Dr. Edward A. Gerber and Dr. Rudolph Bechmann, furnished assistance beyond the official committee responsibility. Dr. Gerber helped with initial planning. Dr. Bechmann is the author of Appendix I, contributed heavily to the section on Frequency-Temperature Characteristics, and made many other suggestions.