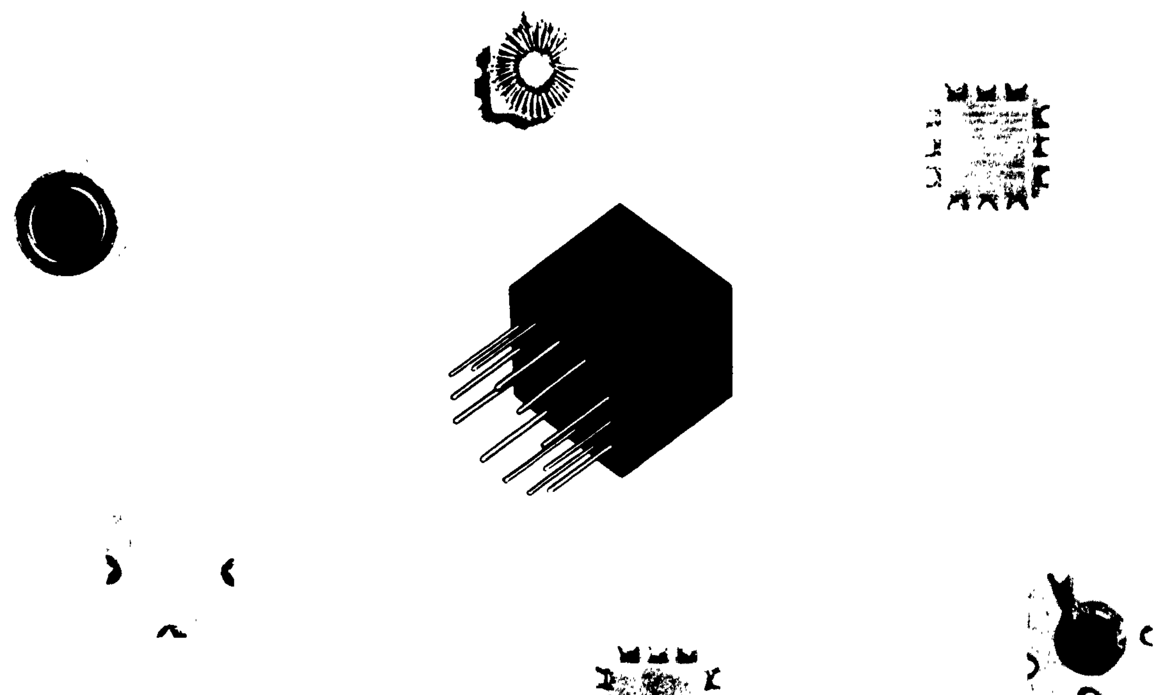
AD 408 282

TWENTIETH QUARTERLY REPORT

MICRO-MODULE PRODUCTION PROGRAM



The object of the Micro-Module Production Program is to provide micro modular design and construction of electronic circuits, which will equip the U.S Army with a broad new production potential for the construction of micro-miniature electronic equipment, offering a great reduction in size, weight and maintenance with improved reliability.

Period Covered — January 1, 1963 to April 1, 1963

MICRO-MODULE PRODUCTION PROGRAM

SIGNAL CORPS CONTRACT DA-36-039-SC-75968

SIGNAL CORPS SPECIFICATION SCL-6243 • MARCH 17, 1958

RADIO CORPORATION OF AMERICA

SURFACE COMMUNICATIONS DIVISION • DEFENSE ELECTRONIC PRODUCTS • CAMDEN 2, NEW JERSEY

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HIGHLIGHTS OF THE TWENTIETH QUARTER

RELIABILITY

At the end of this quarter, 10-element modules of Program Extension II reached a total of 22,314,000 element-hours of operating-life tests. The mean-time-between-failure (MTBF) now stands at 425,800 hours calculated at a 60 percent confidence level. The program objective was 75,000 hours.

Over 250 million solder-joint hours of test have been logged during micromodule and microelement operating-life tests. No solder joints have failed during this testing. At a 60 percent confidence level, a joint failure-rate of 0.00036 percent per 1000 hours has been demonstrated.

PEM PROGRAMS

At the end of this quarterly period, a reduction of the pilot-run program was requested on the following subcontract tasks:

> AEROVOX, Multilayer capacitors; ASTRON and SPRAGUE, electrolytic capacitors; CENTRALAB, variable capacitors; COORS PORCELAIN, metalized substrates; CTS CORP., semiprecision resistors; PHILCO, 2N501A germanium and 2N495 silicon transistors; RCA, silicon VHF power transistor; and MIDLAND MFG., crystals.

This request was made in response to a directive from the Signal Corps, requiring completion of all microelement vendor subcontracts by August 31, 1963.

In accordance with this directive, the original PEM pilot-run quantity will be deleted. This will enable the subcontractors to complete the evaluation of all test data and the preparation of final reports on or before the August 31 deadline. The necessary changes in PEM subcontracts are being prepared for approval. A coordinated effort between the subcontractors, RCA, and the Signal Corps has been initiated to expedite the completion of the redirected pilot-run effort.

COMPLETED INDUCTOR TASKS

ALADDIN delivered final-grade pulse transformers and a final report on its task.

CAMBRIDGE THERMIONIC completed life tests on HF and VHF inductors and will submit a draft of its final report at the end of the quarter.

RADIO INDUSTRIES completed the 15-Mc trimmer inductor task. Ten final-grade units and a final report were submitted to SurfCom.

MICRO-MODULE ASSEMBLY

MALLORY and PAKTRON have completed the installation of 90 percent of all module-assembly equipment.

MICROPAC DESIGN VINDICATED

That the MicroPac Computer design is fundamentally sound was authenticated recently by successful operation, from 32°F to 110°F, of the ComPac IIA Computer whose functional logic and electronic circuitry are identical to those of MicroPac. Moreover, the MicroPac uses micromodules carefully tested under the stipulated military service environments, whereas the ComPac IIA millimodules had not been subjected to environmental testing before their use in this equipment.

1. ABSTRACT

This abstract is a brief description of the significant accomplishments of the Semiconductor and Materials Division of RCA and of other industrial participants in the U.S. Army Signal Corps Micro-Module Program during the Nineteenth Quarterly period from January 1, 1963 to March 31, 1963.

1.1 STATUS OF PROGRAM PHASES

The Initial Program and Program Extension I have been successfully completed. Under Program Extension II, Equipment all final-grade communications and digital equipment modules have been delivered. Most of the digital modules taken from life test and submitted for use in testing the MicroPac Computer had completed 6000 to 7000 hours of life test. Life testing of MicroPac modules is now complete. All AN/PRC-51 communication modules, submitted for Group-C testing, have completed 2000 hours of life testing. The life tests will be extended to 10,000 hours. Under Program Extension II, Production Engineering Measure, programs are in progress for determining feasibility of mass production of micro-modules and of all types of microelements, including capacitors, resistors, inductors, transistors, diodes, and crystals.

1.2 PROGRAM EXTENSION II, PEM, ACTIVITIES

Capacitors — Aerovox finished its pre-production deliveries of multilayer capacitors; this completes contract requirements. This company also completed fabrication of the first pilot-run lot of approximately 350 microelements. The initial Group-A tests were witnessed by RCA and Signal Corps personnel with satisfactory results. Aerovox and RCA, Somerville completed some significant tests to resolve the pre-production moisture-resistance problem. Data now available indicate a process has been found which will eliminate this trouble. The tests will be completed early in the next quarter.

Aerovox reported that no failures occurred on 135 encapsulated capacitors of extended-temperature-coefficient range after 270,000 hours of life test. Only two failures have occurred among 1021 bare microelements which completed 2000 hours of life test (a total of 2,094,000 element-hours). Approximately 80 percent of the required test samples have been delivered by Aerovox.

Cornell-Dubilier completed fabrication of all pilot-run lots of single-layer ceramic capacitors. The results of testing are summarized herein. Preparation of its final report has begun.

Astron and Sprague obtained approval of the respective electrolytic capacitor pre-production test facilities. Both subcontractors are proceeding with their pre-production test programs.

Centralab completed all preproduction life testing and obtained approval to start the pilot-run phase of its PEM program on trimmer capacitors.

Coors Porcelain has made some significant improvements in its metalizing facility. Preproduction parts delivered to RCA, Somerville, during this quarterly period met the land-area metalization requirements, but did not meet the specification for substrate edges.

Inductors — Aladdin submitted its final report on the microelement pulse transformer subtask. The report was reviewed by RCA, Somerville, and was forwarded to SurfCom.

Aladdin concluded that with heavy-polyurethane wire insulation, its pulse transformers can pass the specified life-test requirements.

Collins resubmitted 20 prototype medium-frequency fixed-inductor microelements and a test report. These test results were satisfactory, and Collins was granted approval to start construction of final-grade samples.

Collins also delivered 75 final-grade high-frequency microelement inductors. Test modules were made by RCA, Somerville, and sent to Collins for Group-B and -C tests.

Radio Industries completed the task requirements with the submission of 10 final-grade 15-Mc microelement trimmer inductors. A report and test data on the effort were also submitted to SurfCom. Radio Industries has agreed to replace the 24, 455-kc final-grade trimmer inductors, having TC-3 cup cores, with final-grade inductors equipped with TC-4 cup cores.

Cambridge Thermionic completed 1500 hours of life test on 50 final-grade D-core top-element inductors; thus far no failures have occurred. They will submit a draft of the final report on this task by the end of this quarter.

Test results show that microelement inductors mounted in deep, glass-mica substrates are compatible with current micro-module assembly techniques.

Transistors — Texas Instruments and Sperry Semiconductors have completed all Phase III Group-A tests; Philco and G. E. have completed all Phase II Group-A, -B, and -C tests.

Diodes — Fairchild and MicroSemiconductor, and Hughes have placed a sufficient number of diodes on 1000 hour temperature aging to supply the required 300 Phase III test elements.

Diode Mounting — Effort was directed toward establishing wafer metalization requirements and welding parameters. Best results have been obtained with wafers metalized with a base-plate of molymanganese, an over-plate of nickel, and finally a gold flash.

Micro-Modules — Communication modules have completed a total of 5,544,000 element-hours of test with no catastrophic failures; there have been two degradational failures. The corresponding MTBF for a 10 element communications module is 176,900 hours calculated on a 60 percent confidence level.

Digital Micro-Modules have completed 16,760,000 element-hours of operating life test; there were two catastrophic failures. The MTBF for a 10-element module is 527,000 hours calculated at a 60 percent confidence level.

The combined MTBF for a 10-element Program Extension II module is 425,800 hours calculated at a 60 percent confidence level.

Design and construction of all module assembly facilities and installation of all equipment are about 90 percent complete.

The MicroPac Computer — The necessary changes in the mechanical orientation and structure of the MicroPac Computer to obtain satisfactory operation over the required temperature range of -30°C to +52°C were determined from the results of measurements of internal temperature versus rate of flow of cooling air. The sense amplifiers were found to meet all requirements in their present design.

2. PURPOSE

2.1 THE MICRO-MODULE (MM) CONCEPT

The Micro-Module Concept is a new approach to electronic equipment design which is applicable throughout the electronic industry to both military and commercial equipments. The conventional methods utilized in the past, having been exploited virtually to the limits of their capabilities, leave much to be desired in regard to fulfillment of current and future needs for electronic equipment applications.

In order to correct this inadequacy, the Micro-Module Production Program was established jointly by the Army and RCA. RCA undertook the major responsibility of Leader Contractor for the utilization of the best that the entire electronic industry has to offer in skills, materials, and processes adaptable to this completely new concept of modular construction.

The Micro-Module Concept upon which the program is based is that of utilizing micro-elements with standardized dimensions of 0.31 x 0.31 x .01 inch, in lieu of conventionally shaped components. The standardized dimensions and shape permit high-density packing of micro-elements into micro-modules. By efficient grouping of the modules, compact subassemblies and complete equipments are formed which have a new order of volumetric efficiency. A component density of 600,000 parts per cubic foot is an ultimate goal of this program. This density represents an improvement as great as 10:1 in some equipments over conventional assembly techniques.

In constructing a micro-module, the required number and types of micro-elements are assembled by stacking them in accordance with the pertinent circuit function, the assembly is tested, and then encapsulated. Micro-modules are, in turn, assembled in aggregates representing equipment subassemblies in various arrangements depending on the equipment applications.

The selection of the most suitable basic materials, the eventual completely-controlled mechanized processing of these materials to form micro-elements, and the automatic assembly of micro-elements to form micro-modules will result in the attainment of a new high order of reliability without sacrifice of performance and with eventual savings in production and maintenance costs.

Reliability goals were established at 15,000 hours mean-time-to-failure for a 50 part module in the initial, basic program. There are certain reliability advantages inherent in the micro-module approach. The reduced dimensions and compact, rugged construction provide better capability of withstanding environment extremes. The space savings also permit application of redundancy and controlled environment within an equipment for greater reliability.

2.2 INDUSTRY PARTICIPATION

Neither RCA nor any other single company possesses or controls the many and diverse skills required for the successful accomplishment of the Micro-Module Program.

Rather, the key to its success has been the mutual cooperation between RCA, as the leader contractor, and the many companies of the entire electronics industry.

The components branch of the industry, particularly, has played a tremendous part in the Micro-Module Program in the development and manufacture of electronic micro-elements and micro-modules.

The effect of the Micro-Module Concept within the electronic industry will be an orderly and logical application of both known and, as yet, unknown techniques to this unique new dimension for both military and commercial electronic equipment.

2.3 PROGRAM

The authorization of work under the Micro-Module Program includes four divisions of effort whose descriptions and objectives are as follows:

A. The Initial Program: The objectives of this original program was the establishment of the feasibility and reliability of micro-modules and of a limited range and selection of micro-elements. Certain subassemblies, constructed with micro-modules, and a micro-modular version of the AN/PRC-34 helmet receiver were also required. This part of the over-all program has been completed.

B. Program Extension I: This extension has the purpose of providing extended ranges of values and different tolerances of micro-elements included in the initial program. Investigation and development of additional types of micro-elements needed for Extension II and improvement of processes for constructing micro-modules are also included. This part of the program also has been completed.

C. Program Extension II (Equipment): Includes development of Radio Set AN/PRC-51 including a helmet receiver, Receiver, Radio R-1018( )/PRC-51 and Transmitter, Radio T-792( )/PRC-51; the development of a General Purpose Computer Set for Digital Data (MicroPac); and the design and construction of micro-modules for the above equipments. Delivery of all the required AN/PRC-51 Radio Sets has been completed. The MicroPac Computer was undergoing tests and some mechanical redesign at the end of the period.

D. Program Extension II (Production Engineering Measure): Under this extension processes, techniques, and facilities, are being planned and established for mechanized production of microelements and modules, which will be compatible with a production rate of 25,000 micro-modules per month.

3. NARRATIVE OF DATA

3.1 ADMINISTRATION

3.1.1 DESIGN PLANS

Design plan revisions for all PEM tasks, E through 39, were submitted to the Signal Corps for approval.

3.1.2 TECHNICAL ACTION REQUESTS

During the current quarterly period, the following Technical Action Requests were issued:

TAR, RCA-76 - Authorization for Fairchild Semiconductor to proceed with Phase III of the PEM on Task 32-1.

TAR, RCA-77 - Authorization for Hughes Semiconductor to proceed with Phase III of the PEM on Task 32-3.

TAR, RCA-78 - Revision of design plan for Task 39, Micro-module Pilot Run.

TAR, RCA-79 - Request for approval of pre-production and initiation of the pilot run by Centralab, Task 28-5.

TAR, RCA-81 - Approval for MicroSemiconductor's test facilities and authorization to start Phase III of the PEM on diodes under Task 32-1.

TAR, RCA-82 - Concerning completion of vendor subcontracts by August 31, 1963.

TAR, RCA-83 - Approval to use Fairchild's 2N918 transistor package in TO-51 case.

TAR, RCA-84 - Waiver request for 4.3 mc I-F Amplifier modules for Task 36-1 (2.9).

TAR, RCA-85 - Request for pre-production approval and initiation of pilot test run by Sprague Electric Company, Task 28-4.

3.1.3 PROGRESS CHARTS

Submission of Financial and Technical Progress Charts was continued on a monthly basis.

3.1.4 PROJECT PROCEDURES

Effort was continued on coordinating and evaluating the PEM tasks for Program Extension II.

3.1.5 REPORTS

The Eighteenth Quarterly Report was delivered. Monthly Letter Progress Reports for December, 1962 and for January and February, 1963 were issued.

Instruction booklets for the AN/PRC-51 Radio Set were submitted. Proceedings of the Micro-module Industry Conference (Philadelphia, Pa. September, 1962) were published.

The 19th Quarterly Report was completed and sent to the printer. Preparation of the Micro-module Design Guide was continued. A draft of the major part of the latter was submitted to the Signal Corps for review and approval.

3.2 PASSIVE PARTS

3.2.1 CAPACITORS

3.2.1.1 PROGRAM EXTENSION II, PRODUCTION ENGINEERING MEASURE FOR CAPACITORS AND SUBSTRATES

Objectives and Status

The objective of this PEM is to establish microelement production facilities capable of supporting a micro-module production program. Subcontracts for multilayer and single-layer ceramic capacitor, electrolytic capacitors, variable ceramic capacitor, and metalized substrate production facilities were granted to Aerovox Corporation, Cornell-Dubilier Electronic Company, Astron Corporation and Sprague Electric Company, Centralab Division of Globe Union, and Coors Porcelain Company, respectively.

All subcontractors completed their production facilities and initiated preproduction test programs. The subcontractors for single and multilayer capacitors satisfactorily completed preproduction programs and initiated the pilot-production run and acceptance-test phases. The electrolytic capacitor manufacturers have completed preproduction element fabrication and have initiated the test phase.

The variable capacitor subcontractor completed the preproduction test programs. Test data and results were submitted to the Signal Corps, along with the proposed specifications and revision to the purchase order. After approval was granted Centralab initiated fabrication of pilot-run parts. Refinement and improvement of the metalized substrate facility is being continued by Coors Porcelain in order to increase the yield to an economically feasible level. Parts are being processed concurrently to complete the delivery requirement for the preproduction run.

Hi-Q Division, Aerovox Corporation, Multilayer Ceramic Capacitors

During this period, 385 preproduction samples of multilayer ceramic capacitors were delivered by Aerovox to Surf Com. This completes the contract requirements for the preproduction phase of this program.

Aerovox completed the first lot of general-purpose capacitors required for the pilot run. One half of this lot, approximately 350 elements, was submitted to Group-A acceptance tests. These tests were witnessed by RCA and the Signal Corps resident inspector. The results were satisfactory and Group-A testing was continued. Fabrication of the remaining 2285 general-purpose capacitors specified for the pilot run was scheduled for completion during the first part of the next quarterly period.

As reported in previous quarterly reports, Aerovox had experienced moisture-resistance failures during preproduction testing on their precision-type multilayer capacitors. It has been difficult to analyze the failure mechanism and, as a result, effective corrective actions have been difficult. During this quarterly period, additional tests were performed by both Aerovox and RCA in order to resolve the moisture resistance problem. The results of their tests are discussed below:

a. Seventeen test capacitors were incorporated in test modules by RCA. These units were constructed with standard module-assembly techniques except that two coats of DC-271 was applied. Results of the moisture-resistance test performed by Aerovox are shown in Table 3.2.1-1. Seven insulation resistance failures occurred. The data also show that there was an improvement in the insulation resistance of the seven failures after drying at room temperature for 25-1/2, 50, and 74 hours. After 74 hours only two of the original seven failures had not improved above the minimum requirement of 1000 megohms.

b. In conjunction with the above tests, Aerovox prepared 18 additional micro-elements from the same sample lot. However, the coating applied on these samples was that used on conventional, military-grade ceramic capacitors (phenolic resin and wax impregnated). These units were subjected to the same moisture-resistance test; no failures occurred. These data are shown in Table 3.2.1-2.

TABLE 3.2.1-1.
MOISTURE-RESISTANCE TESTS PERFORMED BY AEROVOX ON ENCAPSULATED PRECISION MULTILAYER CAPACITORS

		Initial Value			4-1/2 Hours After Test		25-1/2 Hours After Test		50 Hours After Test	74 Hours After Test
Module Number	Element Number	Capacitance (pf)	Drift Frequency (%)	Insulation Resistance (megohms)	Capacitance (pf)	Insulation Resistance (megohms)	Capacitance (pf)	Insulation Resistance (megohms)	Insulation Resistance (megohms)	Insulation Resistance (megohms)
968	1	3092	.02	>100 K	3131	15	3120	50	375	2.4 K
	2	3064			3085	>100 K	3082	>100 K	>100 K	>100 K
	3	2962			2993	15	2993	80	180	400
969	4	2974			3005	400	3004	400	5 K	10 K
	5	3062			3067	45 K	3066	60 K	100 K	>100 K
	6	3064	↓		3080	200	3078	600	3 K	8 K
970	7	3072	.09		3172	>100 K	3170	>100 K	>100 K	>100 K
	8	2903	.02		Short	Short	Short	Short	Short	Short
	9	3084			3088	3 K	3088	6 K	10 K	17 K
971	10	3153	↓		3254	35	3176	1 K	14 K	>100 K
	11	3000	.03		3012	35 K	3008	60 K	>100 K	
	12	3076	.02		3087	12 K	3082	>100 K		
972	13	3016	.04		3025	>100 K	3022	>100 K		
	14	2956	.02		2960	>100 K	2958	>100 K		
	15	3042	.04		3048	70	3044	150		
973	16	3090	.08		3096	80 K	3093	>100 K		
	17	2993	.08	↓	2956	13 K	2954	>100 K	↓	↓
				Number of Failures		7		6	3	2

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Specification Requirements	ΔC	IR
	5%(max)	1000 megohms (min)

NOTES:

a. Elements in Modules 968, 969, and 970 were subjected to moisture-resistance test with 10 dc volts applied. No voltage was applied to remainder of test elements as per specification requirement.

b. Insulation resistance measured at a rated 50 dc volts.

c. 3000 pf, NPO with terminations at notches 2 and 3, in standard test modules.

TABLE 3.2.1-2.
MOISTURE-RESISTANCE TESTS PERFORMED ON 18 NPO, 3000 pf AEROVOX PRECISION MULTILAYER CAPACITORS
These Microelements were Coated with Phenolic Resin and Wax Impregnation

MICROELEMENT SAMPLE NUMBER	INITIAL VALUE			5 HOURS AFTER TEST	
	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)	CAPACITANCE (pf)	INSULATION RESISTANCE (megohms)
1	3094	.02	> 100 K	3095	100 K
2	3080			3080	
3	2991			2996	
4	3149	↓		3151	
5	3044	.04		3045	
6	2929	.02		2931	
7	2983			2986	
8	3122			3124	
9	3070			3074	
10	3087			3088	
11	3081			3083	↓
12	2921			2921	1.2 K
13	3073			3074	35 K
14	2963			2964	> 100 K
15	2977			2978	
16	3159			3161	
17	3096			3100	↓
18	3035	↓	↓	3043	60 K

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NOTES:

a. Samples 1 through 9 were subjected to moisture resistance with 10 dc volts applied. No voltage was applied to remainder of group.

b. Insulation resistance was measured at a rate potential 50 dc volts.

c. As a result of the above, RCA initiated an accelerated program in an attempt to achieve a solution to the problem of performance in modules as quickly as possible. One test was performed by dividing 24 elements into four groups and coating them in the following manner:

Group 1 - Control (no coating)

Group 2 - Standard DC-271 module coating

Group 3 - Standard DC-271 module coating (two coats)

Group 4 - DC-271, as received; a heavy coating was applied by dipping.

Leads were soldered to the terminations prior to coating. Results of the tests on these elements are shown in Table 3.2.1-3. These results indicate that any variations in the coating technique can affect the performance of the element in a module during the moisture-resistance test.

d. The effect of moisture resistance was evaluated on capacitors terminated at notches 3 and 8 instead of the standard termination at notches 2 and 3. Aerovox sent RCA 12, 2300 pf capacitors, terminated at notches 2 and 3, for encapsulation in test modules. The results of this test were satisfactory, and the data are summarized in Table 3.2.1-4. Early in the next quarter, other capacitor samples will be terminated at notches 1 and 3 and submitted to the moisture-resistance test.

TABLE 3.2.1-3.
MOISTURE-RESISTANCE TEST EVALUATION PERFORMED BY RCA ON AEROVOX PRECISION MULTILAYER CAPACITORS
(Coated Microelements, 10 dc Volts Applied)

MICRO-ELEMENT TEST GROUP	TYPE OF COATING	MICRO-ELEMENT NUMBER	INITIAL VALUE			6 HOURS AFTER NINE CYCLES			6 HOURS AFTER 12 CYCLES (a)		
			CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)
1	Control Unit (No Coating)	1	851	.07	750 K	851	.10	2 K	851	.12	30 K
		2	844	.07	750 K	844	1.60	< 1	845	5.54	< 1
		3	847	.07	500 K	848	.08	200 K	848	.09	150 K
		4	848	.07	500 K	849	.19	< 1	849	.19	< 1
		5	842	.07	750 K	842	.14	300 K	843	.14	200 K
		6	847	.07	750 K	848	.09	150 K	848	.10	70 K
2	Standard DC-271 Module Coating	7	851	.07	750 K	851	.07	800 K	851	.08	100 K
		8	846	.07	1000 K	846	.07	800 K	846	.07	500 K
		9	854	.07	750 K	855	.07	50 K	854	.08	100 K
		10	853	.07	750 K	853	.07	800 K	853	.07	500 K
		11	854	.07	750 K	855	.10	8 K	857	.43	4
		12	850	.08	500 K	851	.09	600 K	851	.10	400 K
3	Standard DC-271 Module Coating (two coats)	13	853	.07	300 K	853	.11	350 K	853	.12	100
		14	849	.06	450 K	849	.05	400 K	849	.06	200 K
		15	846	.07	300 K	847	.17	2.5 K	847	.20	1.5 K
		16	854	.08	400 K	854	.14	4.5 K	854	.16	2 K
		17	847	.08	450 K	846	.08	400 K	846	.08	200 K
		18	846	.07	350 K	846	.07	400 K	846	.07	200 K
4	Heavy Coat DC-271 (b) Applied by dipping	19	855	.08	550 K	856	.33	500	856	.35	600
		20	377	.07	750 K	377	.09	5 K	377	.09	10 K
		21	376	.07	750 K	376	.07	1000 K	376	.07	500 K
		22	370	.07	750 K	374	.59	1000 K	374	.62	500 K
		23	371	.07	1000 K	371	.08	1000 K	371	.08	500 K
		24	377	.07	750 K	378	.08	< 1	378	.09	< 1

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(a) The capacitors were subjected to nine cycles of moisture resistance testing before the measurements were made The units were then subjected to an additional three cycles of moisture resistance testing No vibration tests were performed.

(b) Used as received.

TABLE 3.2.1-4.
MOISTURE-RESISTANCE TESTS PERFORMED BY RCA ON ENCAPSULATED NPO, 2300 pf AEROVOX PRECISION MULTILAYER CAPACITORS
(Units were Terminated at Notches 3 and 8)

		INITIAL DATA			2 HOURS AFTER TEST			6 HOURS AFTER TEST		
MODULE NUMBER	MICRO-ELEMENT NUMBER	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)	CAPACITANCE (pf)	DRIFT FREQUENCY (%)	INSULATION RESISTANCE (megohms)
1000	1	2291	.02	>100 K	2292	.06	40 K	2292	.05	60 K
	2	2211	.02	↓	2211	.04	300 K	2211	.04	400 K
	3	2248	.02	↓	2249	.06	40 K	2249	.06	60 K
1001	4	2380	.02	>100 K	2383	.07	15 K	2383	.06	70 K
	5	2369	.02	↓	2370	.06	40 K	2370	.06	90 K
	6	2358	.02	↓	2364	.12	50 K	2364	.12	30 K
1002	7	2220	.02	>100 K	2222	.08	600 K	2221	.07	800 K
	8	2298	.02	↓	2298	.03	1000 K	2298	.03	1000 K
	9	2213	.02	↓	2313	.03	500 K	2213	.03	600 K
1003	10	2194	.02	>100 K	2196	.04	30 K	2196	.04	80 K
	11	2260	.02	↓	2260	.04	45 K	2260	.04	80 K
	12	2205	.03	↓	2206	.05	50 K	2206	.05	100 K

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Specification Limits $\frac{\Delta C}{5\%(max)}$ Insulation Resistance 1000 megohms (min)

NOTES:
a. Microelements in modules 1000 and 1001 were subjected to moisture resistance tests with 10 dc volts applied. No voltage was applied to remainder of test elements.

e. Additional tests have been initiated to either determine the nature of the failure mechanism, or to incorporate protective measures. These tests include:

1. testing .010-inch thick single-layer capacitors made by Aerovox with the same material as that used for making multilayer, precision capacitors.

2. making test modules with elements that had two coats of DC-271. These elements required a longer curing time so that the two coats of DC-271 could set properly.

3. tests of precision capacitor samples impregnated under vacuum with DC-200 silicone.

The above tests will be completed at the beginning of the next quarterly period and the results will be published in the 21st Quarterly Report.

<u>Hi-Q Division of Aerovox Corporation, Extended-Temperature-Coefficient Range for Ceramic Multilayer Capacitors</u>

During this quarterly period, Aerovox completed life testing of capacitors of extended-temperature-coefficient range, incorporated in test modules. A summary of the test data for the 135 elements tested are given in Table 3. 2. 1-5. No failures occurred during or after the 270, 000 component hours of testing. To date a total of 2, 094, 000

TABLE 3.2.1-5.
SUMMARY OF AEROVOX LIFE-TEST DATA FOR MULTILAYER CAPACITOR OF EXTENDED-TEMPERATURE-COEFFICIENT RANGE
(Sheet 1 of 3)
(135 Microelements were Encapsulated in Modules)

CAPACITOR TYPE AND TEST PARAMETER	INITIAL VALUES	LIFE-TEST HOURS	
		500	2000
N030: AVERAGE CAPACITANCE, 525 pf, 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.2
Maximum Capacitance Change - percent	-	-	0.3
Maximum Dissipation Factor - percent	.07	.07	.09
Minimum Insulation Resistance - megohms	>100 K	>100 K	>100 K
Accumulative Component-Hours	-	7500	30,000
N080: Average Capacitance, 516 pf, dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.2
Maximum Capacitance Change - percent	-	-	0.4
Maximum Dissipation Factor - percent	.08	.08	.08
Minimum Insulation Resistance - megohms	> 100 K	> 100 K	> 100 K
Accumulative Component-Hours	-	7500	30,000
N150: AVERAGE CAPACITANCE, 617 pf, 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.2
Maximum Capacitance Change - percent	-	-	0.2
Maximum Dissipation Factor - percent	.08	.09	.08
Minimum Insulation Resistance - megohms	> 100 K	> 100 K	> 100 K
Accumulative Component-Hours	-	-	30,000
N220: AVERAGE CAPACITANCE, 626 pf, 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	-	-
Number of Degradational Failures	-	-	-
Average Capacitance Change - percent	-	-	0.2
Maximum Capacitance Change - percent	-	-	0.3
Maximum Dissipation Factor - percent	.08	.09	.08
Minimum Dissipation Factor - percent	>100 K	>100 K	> 100 K
Accumulative Component-Hours	-	7500	30,000

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TABLE 3.2.1-5.
SUMMARY OF AEROVOX LIFE-TEST DATA FOR MULTILAYER CAPACITOR OF EXTENDED-TEMPERATURE-COEFFICIENT RANGE
(Sheet 2 of 3)
(135 Microelements were Encapsulated in Modules)

CAPACITOR TYPE AND TEST PARAMETER	INITIAL VALUES	LIFE-TEST	
		500	2000
N330: AVERAGE CAPACITANCE, 723 pf., 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.1
Maximum Capacitance Change - percent	-	-	0.2
Maximum Dissipation Factor - percent	.08	.09	.08
Minimum Insulation Resistance - megohms	>100 K	>100 K	> 100 K
Accumulative Component-Hours	-	7500	30,000
N470: AVERAGE CAPACITANCE, 746 pf., 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.1
Maximum Capacitance change - percent	-	-	0.3
Maximum Dissipation Factor - percent	.08	.09	.08
Minimum Insulation Resistance - megohms	90 K	>100 K	>100 K
Accumulative Component-Hours	-	7500	30,000
N750: AVERAGE CAPACITANCE, 802 pf., 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.2
Maximum Capacitance Change - percent	-	-	0.4
Maximum Dissipation Factor - percent	.08	.08	.08
Minimum Insulation Resistance - megohms	20 K	>100 K	>100 K
Accumulative Component-Hours	-	7500	30,000
N1500: AVERAGE CAPACITANCE, 787 pf., 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.3
Maximum Capacitance Change - percent	-	-	0.6
Maximum Dissipation Factor - percent	.24	.26	.25
Minimum Insulation Resistance - megohms	>100 K	>100 K	> 100 K
Accumulative Component-Hours	-	7500	30,000

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TABLE 3.2.1-5.
SUMMARY OF AEROVOX LIFE-TEST DATA FOR MULTILAYER CAPACITOR OF EXTENDED-TEMPERATURE-COEFFICIENT RANGE
(Sheet 3 of 3)
(135 Microelements were Encapsulated in Modules)

CAPACITOR TYPE AND TEST PARAMETER	INITAL VALUES	LIFE-TEST	
		500	2000
N2200: AVERAGE CAPACITANCE, 1173 pf, 50 dc VOLTS			
Number on Test	15	15	15
Number of Catastrophic Failures	-	0	0
Number of Degradational Failures	-	0	0
Average Capacitance Change - percent	-	-	0.6
Maximum Capacitance Change - percent	-	-	1.4
Maximum Dissipation Factor - percent	.03	.04	.02
Minimum Insulation Resistance - megohms	>100 K	>100 K	>100 K
Accumulative Component-Hours	-	7500	30,000

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NOTES:

a. Life testing was performed at 85°C with applied voltage of 100 dc volts which is twice rated voltage.

b. The values of capacitance and dissipation factor for N2200 were measured at 1 KC. Parameters of all the other capacitor types were measured at 1 Mc.

component hours of life testing have been accumulated on extended-temperature-coefficient multilayer capacitors. Only two failures have occurred out of the total of 1021 elements completing 2000 hours of life test.

During this period, 877 of the required 1125 test samples were delivered. The remaining 248 samples will be delivered during the next period.

Cornell-Dubilier Electronics Division of Federal Pacific Electric Co., Single-Layer Ceramic Capacitors

As reported in previous quarterly reports, Cornell-Dubilier had been authorized to proceed with its pilot-production phase. Fabrication of parts was initiated, and the acceptance-test program followed immediately as each lot was completed.

Previously four of the required six pilot-run lots were completed. The remaining two lots were being fabricated at the end of this report period. Results of the pilot-run fabrication and testing are summarized as follows:

a. Lot 1 — Six hundred of the 4000 pf general-purpose capacitors were fabricated and passed Group-A tests. As was previously reported, 120 samples of this lot were placed on life test and incurred an exceptionally high failure rate (65 total failures) during the 2000-hour life test. It was felt that the failures occurred because of the sensitivity of the bare ceramic elements to environmental contamination. Cornell-Dubilier was then authorized to retest a second group of 120 samples with an epoxy coating applied. Two catastrophic failures were reported for this second test group, both apparently dielectric breakdowns. The subcontractor has indicated that an improved formulation will be utilized for refabrication of this lot to provide satisfactory reliability and permit qualification approval. Results of this rerun will be reported upon completion of testing.

b. Lot 2 — Six hundred 25 pf N220 precision capacitors were fabricated and passed Group-A tests. The 120-bare elements subjected to life testing completed 2000 hours of test with one failure; the failure was caused by a hairline crack which may have been incurred by excessive pressure in marking the part. Corrective action was taken to insure that the marking pressure would not cause cracks in subsequent lots of capacitors.

c. Lot 3 — Seven hundred 30 pf NPO precision capacitors were fabricated and passed Group-A tests. The 120 elements completed 1730 hours of the 2000 hour life test at the end of this period; no failures were reported.

d. Lot 4 — One thousand 18 pf NPO precision capacitors were fabricated; these parts failed to pass Group-A testing because of poor adherence of the metalization. Cornell-Dubilier initiated the fabrication of replacement parts. These units are scheduled to be completed and submitted for Group-A inspection at the beginning of the next period.

e. Lots 5 and 6 — These last two lots comprise 1100, 1000 pf general-purpose capacitors. Initial quantities of the K1000 wafers fired under the procedures used for the previous lots indicated that the standard kiln temperature profile produced unsatisfactory substrates. Consequently, Cornell-Dubilier fired a new lot of substrates in a laboratory batch kiln. Although this equipment had production limitations, Cornell-Dubilier was able to complete the substrate requirements for Lots 5 and 6. The metalization of these parts will be completed by the third week of the next quarterly period.

Cornell-Dubilier also submitted 48 capacitor test samples to RCA from lots 1, 2, and 3 for incorporation in test modules. Thirty-six of these samples were assembled in modules and returned to Cornell-Dubilier for Group-B and -C tests. The remaining 12 samples will be incorporated in modules as soon as the additional samples from the other lots are received.

Cornell-Dubilier initiated preparation of the final report covering this PEM effort and is currently compiling data. As part of this work, this subcontractor prepared and submitted to RCA a proposal for additional facilities which would reduce the cost of single-layer capacitors, in quantity, by an estimated 70 percent. This proposal includes requirements for additional ceramic firing and metalizing facilities, and specialized gauging, inspection, test facilities and fixtures. RCA is presently evaluating this proposal.

Electrolytic Capacitors

Both Astron and Sprague satisfactorily completed their preproduction facilities, and had initiated preproduction-sample fabrication prior to this period. Early in this quarter, the test facilities for both subcontractors were approved by the Signal Corps. The following is a summary of progress during this quarterly period.

Astron Corporation — The electrolytic capacitor preproduction elements were completed early in this period. Astron was delayed in completing its preproduction samples because of delays in obtaining substrates from the supplier. Group-A testing was completed and samples were delivered to RCA for incorporation in test modules. These samples had an excess amount of solder in the notches and were returned to Astron for reworking. Astron subsequently resubmitted these samples, test modules were constructed by RCA, and the modules were returned to the subcontractor during the latter part of this period.

Sprague Electric Company — Sprague completed fabrication of preproduction test samples. These samples were constructed with analysis-phase substrates because the substrate supplier could not deliver final design substrates in time for the preproduction program. Group-A tests were completed and 60 samples submitted to RCA for incorporation in test modules. It was found that one element in each of 16 modules was incorrectly located during module assembly. Upon disassembling these modules, 14 elements became defective as a result of open connections and lost leads. The defects in these 14 elements could also be attributed to the termination design and metalization of the substrates. Sprague has taken steps to insure that subsequent preproduction units would incorporate design improvements in these areas.

Twenty-six test modules, including 20 reassembled modules, were returned to Sprague for continued testing. Six of these modules were found to contain cracks in the shell. These cracks could have been caused by excessive solder in the notches, capacitor leads protruding into the notches, or difficulties in aligning three 0.250-inch thick microelement capacitors in one module. Sprague also indicated that another module crack occurred after the thermal shock test. It is believed that the cracking could have been caused by difficulties associated with encapsulating three thick 47 uf-10 v. capacitors in one module. Future test modules will be constructed with no more than two microelements per module.

Sprague reported that no catastrophic failures occurred on preproduction units after 1000 hours of life test. There were, however, three degradational deviations in the dissipation factor. The interim preproduction-test report was prepared and will be submitted to RCA for review early next quarter.

Centralab Division of Globe Union - Variable Ceramic Capacitors

During this quarterly period, Centralab completed all life testing and submitted final preproduction-test results. Preproduction variable capacitors (154 samples) were delivered to Surf Com, thus completing the delivery requirements.

Eighteen samples encapsulated in test modules completed 2000 hours of life test with only one failure. This failure was due to a capacitance change in excess of the three percent maximum permitted. This nonconformance was similar to the nonconformance of three of the 60 bare elements reported in the previous quarterly.

Other variable capacitors (92 units) were incorporated in test modules and placed on life test. Measurements taken at 1000 hours of life test indicated that eight failures occurred. Four units exhibited excessive capacitance change, two units exhibited low-insulation resistance, and two were open. This test will be completed at the beginning of the next quarterly period at which time final measurements will be available.

The above information was included in the Centralab preproduction test report. This report and a proposed revision to the variable capacitor PEM specification, were submitted to the Signal Corps for approval. Approval of Centralab's preproduction program was granted during the latter part of this period. The start of the pilot-run phase also was approved, and Centralab immediately initiated fabrication of the pilot-production parts.

Coors Porcelain - Metalized Substrates

Previously, it was reported that the performance of the Coors metalizing facility was erratic in the operation of the loading and transfer stations, and of the orientation feeder. Coors has redesigned and improved this facility by incorporating improved transfer and handling devices, and changed the orientation feeder into a two-step operation.

The parts delivered to RCA during this period demonstrated a capability for meeting the metalization requirements for the land areas, but not the metalization requirements for the substrate edges. To date over 4600 preproduction substrates, of the required 27000 have been delivered to RCA. These substrates will be held until the completion of the preproduction phase. At that time, all of the required samples will be delivered to the Signal Corps.

During this quarterly period, Coors installed all necessary mechanical modifications in the line and continued to improve the process. Preproduction fabrication has also been continued simultaneous with fault correction. The various stations of the line have been operated under controlled conditions in order to establish process parameters. The station at which the metalizing is done has demonstrated a part-handling efficiency of better than 95 percent.

3.2.2 RESISTORS, PROGRAM EXTENSION II, PRODUCTION ENGINEERING MEASURE

Objectives and Status

Program Extension II, PEM for resistors is directed toward resolving basic process and production problems for the manufacturing of microelement resistors and toward establishing sources of supply for a broad range of resistor microelement capability. The first phase, process analysis, was directed toward the analysis of various processes to determine the most economical way of producing a quality product. Completion of the first phase has resulted in the selection of two subcontracts — CTS Corporation and Microlectron, Inc. — were selected to produce cermet resistors.

The second phase, facilitation, is in process at both subcontractors. During this phase CTS and Microlectron have set up pilot lines and have demonstrated the technical performance of the line by producing and testing 100 preproduction samples. They will both demonstrate the production rate capability of their pilot lines by producing 2500 cermet resistor microelements by means of the manufacturing techniques developed during the process-analysis phase and refined during the preproduction phase.

3.2.2.1 PRECISION RESISTORS

Electra Manufacturing Company delivered 600 type MF3C metal-film tubular resistors. These units were soldered on "window"-type substrates (substrates with a 0.200-inch-square hole). One 30 ohm and one 100,000 ohm resistor were mounted on each of 300 substrates forming two-element resistor microelements. The microelements were subjected to Group-A tests in accordance to RCA Specification A-8972063. The microelements are being built into test modules as they complete Group-A inspection. The Group-B test modules have been built and 12 modules have already started Group-B tests. These 12 will be included in the 188 modules scheduled for Group-C testing when all microelements have completed Group-A inspection and have been built into test modules.

The Group-A test results revealed that the average noise level for these units was not as low as the samples measured during the initial screening tests. The noise level is attributed to the extremely thin metal film required by the very small size of these units, and the spiraled path cut on the surface of the resistors in order to bring them to the proper resistance value. These two factors result in an average noise level higher than that of a conventional metal-film which is, physically, many times larger. The relationship between noise level and resistance value will be determined and presented upon completion of the task. No other major problems are anticipated during the remainder of the testing.

3.2.2.2 UTILITY RESISTORS

Paktron has designed and built a tape-application fixture to eliminate the noise problem encountered with the original qualification-test lot. Six preliminary samples built with this new fixture have been sent to RCA, Somerville, for test. Each of these samples consist of two 800 ohm resistance paths on one side of the substrate and two one megohm resistance paths on the other side of the substrate. This combination results in a four-element microelement resistor. Initial testing of these samples has indicated that they are well within the noise specification requirements. Additional testing will be carried out to assure that processing these samples into modules will not adversely affect the noise level. Paktron is continuing efforts toward reducing the lower limit of their capability.

3.2.2.3 SEMI-PRECISION RESISTORS

Microlectron

Microlectron started load life testing of the 360 pilot-run test samples on December 26, 1962. At 1000 hours, the maximum change in resistance for any individual resistance path was 1.5 percent, and the average for all of the 769 resistance paths (360 microelement resistors) on test was approximately 0.4 percent. The rate of change for the group was decreasing, and all units were expected to continue to be within tolerance at the 2000 hour reading.

The Group-B tests were nearing completion at the time of the 1000 hour load-life test measurement; no failures were anticipated in those units. There have been two irregularities in the load life testing. During the first week of testing, one of the heating elements of the load-life over-heated causing the test module hot-spot to increase to approximately 130°C for a period of several hours. And, just prior to the 1000 hour measurement, the failure of a voltage regulator on a power supply permitted a 40 percent overload on part of the units for approximately six hours. Both of the irregularities were recorded on the voltage and temperature recorders which had been installed to provide for documentation of any such occurrences. Neither of these irregularities is expected to have a serious effect on the parts. Work has begun on the final report and it is expected to be completed by Microlectron during the next quarter.

CTS Corporation

CTS Corporation has completed the preproduction portion of their contract and has received authorization to begin pilot-run production. Manufacture of parts has been delayed because of difficulty in obtaining satisfactory substrates. The CTS manufacturing process causes a build-up of metalization in the notches of the substrate. This causes the parts to become oversized which reduces the yield of usable production parts. This problem was analyzed by CTS and RCA. It was decided by RCA that if the notches were made larger, CTS and the other vendors in the program could obtain increased yields. RCA initiated a purchase order to one of the substrate suppliers to make available to any of the vendors in the program substrates with notches larger than the notches in the standard substrates. CTS will utilize these large-notch substrates during pilot-run production.

3.2.3 INDUCTORS, EXTENSION II, PEM

OBJECTIVES AND STATUS

The objective of the inductor task under Program Extension I was to introduce inductors with improved temperature and magnetic stability and increased power-handling capabilities into the Micro-Module Program. This work included the qualification of a source for providing pulse and 455-kc if transformers in microelement form. A series of reliability tests were to be made on inductors at an ambient temperature of 125°C. The Program Extension I inductor task has been completed.

The analysis phase of the Production Engineering Measure for inductors under Program Extension II extends inductance and frequency capabilities beyond those achieved in the Initial Program. One subtask is devoted to provide an improved inductor-packaging method which will be compatible with the precision-header, dip-soldering technique of module assembly.

3.2.3.1 Microelement Pulse Transformers

The microelement pulse transformer task was started as part of Program Extension I and was continued under Program Extension II. This task consisted in the design, preparation, and testing of preliminary prototype and final-grade samples. Life testing of 100 resubmitted final-grade samples was completed, and a final report was submitted to complete the task requirements.

During the last quarter, an investigation was made on various types of wire insulation. A PERT-type chart for improved insulation tests on Aladdin final-grade pulse transformers was presented in the 19th Quarterly report. In this quarterly report, the results of the tests performed are discussed, and a recommendation is presented for the use of heavy-polyurethane insulated wire which is wound on ferrite bobbins coated with Glyptal. Table 3.2.3-1 summarizes the results of these tests on improved wire insulation. The PERT-type chart is repeated in Figure 3.2.3-1.

Wire Insulation For Final-Grade Pulse Transformers

It was reported in the last quarterly report that two of the 100 final-grade 01-717 pulse transformers shorted when they were measured after 1200 hours of life test and subjected to the 100 rms-volt dielectric-strength test. During the continuation of life testing on the remaining 98 units, additional failures occurred; these results are discussed later on in the report under Group-C tests.

In view of the life test failures, RCA requested that 12 unmounted microelement pulse transformers be constructed and tested. These units were wound on ferrite bobbins. One group of six samples was wound with nylon-coated polyurethane insulated wire; both of these wire types had been tested as shown on the PERT-type chart mentioned above.

TABLE 3.2.3-1.
SUMMARY OF INSULATION RESISTANCE MEASUREMENTS ON ALADDIN FINAL-GRADE PULSE TRANSFORMERS WOUND WITH VARIOUS TYPES OF INSULATED WIRE

WIRE TYPE	PERT CHART CONTROL TEST[a]	VALUE	INSULATION RESISTANCE (MEGOHMS)							
			INITIAL AT 25°C	50°C	100°C	72 HOURS AT 100°C	150°C	16 HOURS AT 150°C	160°C	FINAL AT 25°C
No. 44 Single Polyester (10 Samples)	026	AVG	11.7K	3.6K	1.16K	1.24K	52	56	32	39K
		MIN	3.2K	50	190	270	26	20	12.5	16K
No. 45 Nylon Polyurethane, (10 Samples)	027	AVG	3K	4.4K	219	418	10.8	18.2	12	36K
		MIN	1.5K	1.3K	36	120	3.7	7.3	4.5	1.2K
No. 45 Heavy Polyurethane (10 Samples)	028	AVG	35K	91K	21.5K	48K	390	596	284	184K
		MIN	1.4K	28K	3K	3.6K	120	160	65	45K
No. 45 Heavy Polyurethane, Bobbin Coated with Glyptol (10 Samples)	046	AVG	500K	340K	237K	565K	403	740	260	680K
		MIN	300K	180K	25K	22K	260	210	83	150K

(a) See Figure 3.2.3-1.

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RCA, Somerville, subjected these samples to a wet-insulation-resistance test that is used to detect mechanical wire abrasion. The results of these tests revealed that the six samples wound with heavy-polyurethane insulated wire had higher insulation resistance values than the nylon-coated polyurethane insulated wire. These tests confirmed the results shown in Table 3.2.3-1 and substantiated Aladdin's discovery that the 100 resubmitted final-grade life-test samples were not wound with the recommended heavy-polyurethane insulated wire, but were wound with nylon-coated polyurethane wire. The error arose from the similarity in the trade names for both types of wire insulation; Soderex for heavy-polyurethane, and Soderon for the nylon-polyurethane. The similarity resulted in the issuance from stock of the wrong type of insulated wire to manufacturing. Aladdin has eliminated the recurrence of this situation by part number identification of all insulated wire carried in stock.

Group-B Tests

In the 19th Quarterly Report, it was reported that 12 final-grade 01-717 pulse transformers satisfactorily passed low-frequency vibration tests. These 12 units and an additional group of six final-grade units were subjected to high-frequency tests at RCA, Somerville. It should be noted that the additional six samples were not previously subjected to any tests. After these tests were completed, the 18 samples were returned to Aladdin for immersion and moisture-resistance tests. The data obtained on the high-frequency vibration tests are summarized in Table 3.2.3-2, and Table 3.2.3-3 summarizes the moisture-resistance test results for the 18 samples.

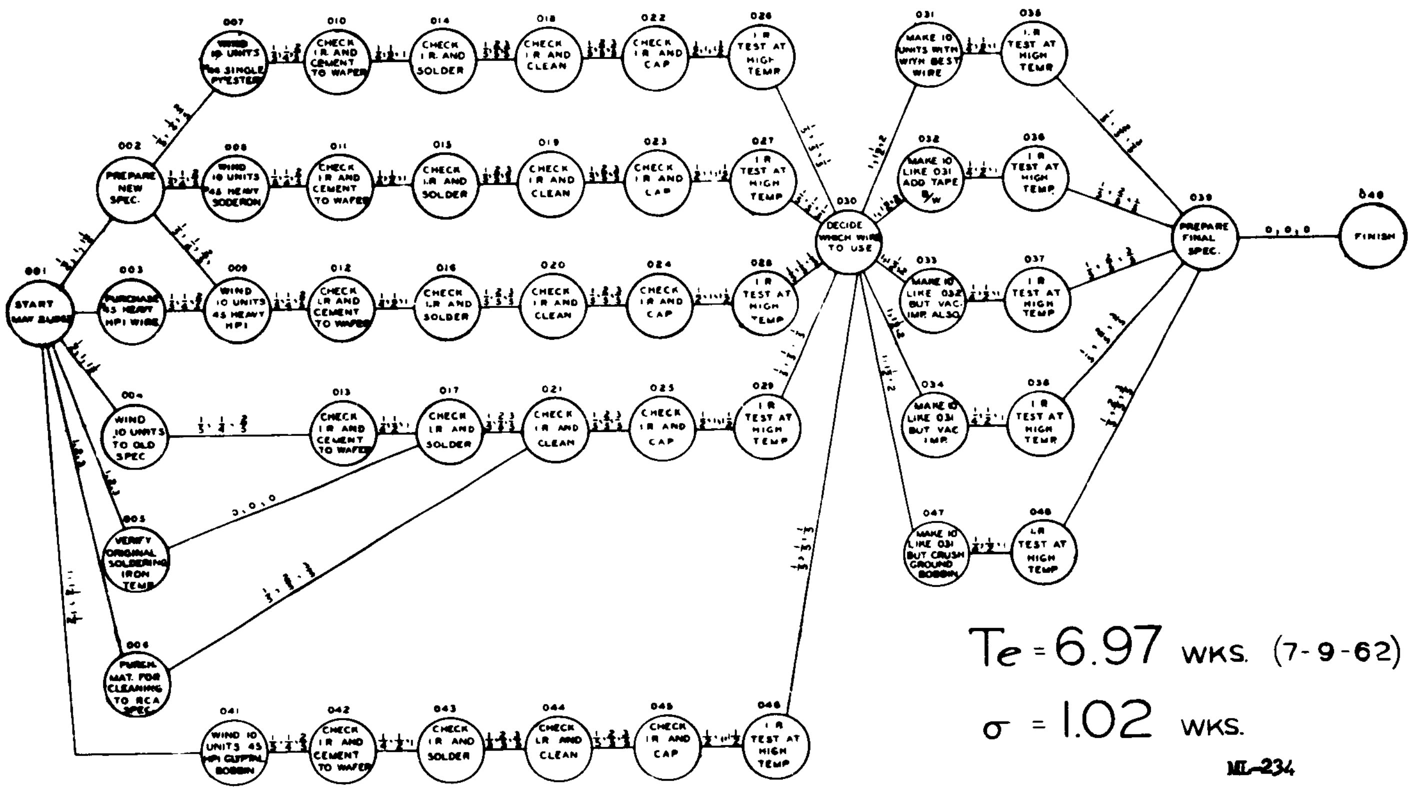

Figure 3.2.3-1. Pert Chart for Improved Insulation Tests on Aladdin Final-Grade Pulse Transformers

TABLE 3.2.3-2.
GROUP-B, HIGH-FREQUENCY VIBRATION TEST MEASUREMENTS ON 18 FINAL-GRADE ALADDIN 01-717 PULSE TRANSFORMERS

AVERAGE MEASUREMENT	OUTPUT AMPLITUDE (VOLTS)		RISE TIME (μ SEC)		FALL TIME (μ SEC)		OVER-SHOOT (%)	DROOP (VOLTS)		BACKSWING (VOLTS)		RECOVERY (μ SEC)		INSULATION RESISTANCE (MEGOHMS)	DIELECTRIC STRENGTH
	SEC 1	SEC 2	SEC 1	SEC 2	SEC 1	SEC 2		SEC 1	SEC 2	SEC 1	SEC 2	SEC 1	SEC 2		
Before Vibration	1.00	1.00	.070	.120	.051	.052	3.5	.193	.182	.248	.212	3.68	3.66	-	OK
After Immersion	1.00	.996	.0714	.133	.033	.026	1.8	.207	.190	.250	.213	3.48	3.97	3.78×10^5	OK
After Moisture Resistance (b)	1.00	.999	.070	.132	.040	.030	1.95	.207	.194	.215	.196	3.40	3.30	1.11×10^5	One Short (a)

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(a) One of the 18 units failed the dielectric strength test. The insulation resistance on this unit was 20 megohms.

(b) The average measurements shown do not include the readings taken on the shorted unit.

TABLE 3.2.3-3.
GROUP-B TEST DATA ON 18 FINAL-GRADE ALADDIN 01-717 PULSE TRANSFORMERS

VALUE	INSULATION RESISTANCE (MEGOHMS)		
	BEFORE "B"-TESTS	AFTER IMMERSION	AFTER MOISTURE RESISTANCE
Average	3.3×10^5	3.78×10^5	1.34×10^5 (a)
Minimum	1×10^5	2×10^5	0.1×10^5

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(a) One unit failed; the insulation resistance value of 20 megohms was not included in the average value.

The group of 12 pulse transformers passed all tests following the high-frequency vibration tests. These units had a minimum insulation resistance of 10^4 megohms after moisture resistance tests. These 12 samples passed two complete series of Group-B tests without failures and only minor degradational changes.

One unit from the additional group of six samples shorted after the moisture resistance tests. The insulation resistance of the sample was 20 megohms; the remaining five units had a minimum insulation resistance of 10^5 megohms.

Group-C Tests

During the previous quarter it was reported that two of the 100 final-grade 01-717 pulse transformers shorted after 1200 hours of life test. After 2000 hours, complete dynamic and static tests were performed; five additional units failed winding to winding insulation. Table 3.2.3-4 summarizes the Group-C static tests, and Table 3.2.3-5 summarizes the Group-C dynamic tests. Table 3.2.3-6 shows the test data obtained on the seven units that failed. When the remaining 93 final-grade samples were placed on extended Group-C life testing, three more units became shorted. Aladdin reported that these three shorts were caused by equipment malfunctioning.

TABLE 3.2.3-4.
SUMMARY OF GROUP-C STATIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	PRIMARY INDUCTANCE (μh)	LEAKAGE INDUCTANCE (μh)	CAPACITANCE PRI/SEC (pf)	CAPACITANCE DISTRIBUTED (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE (x 10^5 megΩ)	DIELECTRIC STRENGTH
Measurements on 100 Samples prior to Group-C life tests.(a)	Max	142	1.85	38	6.92	2.66	34.6	4	OK
	Avg	128.04	1.60	31.94	5.61	2.50	32.97	3.87	OK
	Min	118.5	1.40	15.5	4.94	2.43	31.4	1	OK
Measurements on 93 Samples(b) after 2000 hours of life test	Max	141.1	1.95	38.5	6.27	2.66	34.0	2	OK
	Avg	128.1	1.66.	33.6	5.70	2.48	33.0	1.86	OK
	Min	117.3	1.50	15.5	4.84	2.40	31.0	.02	OK
Measurements on 86 samples(c) after 4000 hours of life tests	Max	136.4	2.05	37.0	7.33	2.70	34.3	4	OK
	Avg	127.6	1.76	31.2	5.50	2.50	32.7	3.53	OK
	Min	114.9	1.50	15.0	4.35	2.42	31.3	2	OK

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(a) All test measurements made by Aladdin.

(b) A total of seven final-grade units failed; two after 1200 hours and five after 2000 hours of life test.

(c) Aladdin reported that three units shorted as a result of an equipment malfunction. Four additional units were removed so that 14 unencapsulated spares could be placed on the life-test board.

TABLE 3.2.3-5.
SUMMARY OF GROUP-C DYNAMIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	OUTPUT AMPLITUDE (p-p volts) SEC 1	OUTPUT AMPLITUDE (p-p volts) SEC 2	RISE TIME (μ sec) SEC 1	RISE TIME (μ sec) SEC 2	FALL TIME (μ sec) SEC 1	FALL TIME (μ sec) SEC 2	OVER-SHOOT (%)	DROOP (volts) SEC 1	DROOP (volts) SEC 2	BACK SWING (volts) SEC 1	BACK SWING (volts) SEC 2	RECOVERY (μ sec) SEC 1	RECOVERY (μ sec) SEC 2
Measurements on 100 Samples prior to Group-C life tests(a)	Max	1.03	1.02	.07	.13	.056	.072	5	.21	.20	.25	.24	3.5	4.0
	Avg	1.008	1.001	.066	.113	.052	.059	2.7	.194	.179	.247	.214	3.38	3.39
	Min	1.00	1.00	.06	.10	.048	.044	1	.17	.16	.23	.20	3.0	2.5
Measurements on 93 Samples(b) after 2000 hours of life test	Max	1.00	1.00	.080	.160	.055	.048	3.00	.22	.22	.24	.23	4.0	4.0
	Avg	.99	.98	.078	.136	.045	.039	1.92	.205	.197	.210	.208	3.39	3.45
	Min	.750	.70	.075	.120	.040	.029	.0	.20	.18	.20	.20	3.0	3.0
Measurements on 86 Samples(c) after 4000 hours of life test	Max	1.0	1.0	.070	.130	.040	.040	1.0	.20	.19	.22	.22	4.0	4.0
	Avg	1.0	1.0	.070	.115	.039	.037	1.0	.196	.183	.22	.214	3.37	3.57
	Min	1.0	1.0	.070	.110	.035	.030	1.0	.18	.18	.22	.20	3.0	3.0

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(a) All test measurements made by Aladdin.

(b) A total of seven final-grade units failed; two after 1200 hours and five after 2000 hours of life test.

(c) Aladdin reported that three units shorted as a result of an equipment malfunction. Four additional samples were removed from life test so that 14 unencapsulated spares could be placed on the life-test board.

TABLE 3.2.3-6.
SUMMARY OF GROUP-C STATIC TESTS ON SEVEN ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS THAT FAILED LIFE TEST

MEASUREMENTS ON SEVEN FAILURES TAKEN:	PRIMARY INDUCTANCE (μh)	LEAKAGE INDUCTANCE (μh)	CAPACITANCE PRI/SEC (pf)	CAPACITANCE DISTRIBUTED (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE (megohms)	DIELECTRIC STRENGTH
Prior to Life Test	119.8	1.48	32	6.16	2.44	32.4	4×10^5	OK
After 1200 hours	120.5	1.50	33	6.16	2.47	32.2	2×10^5	OK
After 2000 hours	118.0	1.55	32	6.32	2.42	31.8	25	OK
Prior to Life Test	123.0	1.62	32	5.41	2.52	33.5	4×10^5	OK
After 1200 hours	123.7	1.70	31	5.80	2.53	33.7	2×10^5	OK
After 2000 hours	121.7	1.68	33	5.48	2.52	33.0	300	OK
Prior to Life Test	136.2	1.54	34	5.78	2.46	32.4	4×10^5	OK
After 1200 hours	136.4	1.60	0	5.59	2.45	32.1	2×10^5	OK
After 2000 hours	134.9	1.62	short	6.03	2.44	31.7	short	short
Prior to Life Test	122.1	1.63	24	5.25	2.50	32.8	4×10^5	OK
After 1200 hours	120.3	1.70	23	5.85	2.51	32.8	2×10^5	OK
After 2000 hours							short	short
Prior to Life Test	137.9	1.85	32	5.35	2.55	33.7	4×10^5	OK
After 1200 hours	139.5	1.90	32	5.20	2.55	33.8	2×10^5	OK
After 2000 hours	136.4	1.95	0	5.60	2.52	33.2	2×10^5	OK
Prior to Life Test	120.9	1.58	32.0	5.68	2.47	33.2	4×10^5	OK
After 1200 hours	121.4	1.65	0	5.89	2.47	33.0	short	short
Prior to Life Test	123.0	1.62	34	5.80	2.43	31.9	1×10^5	OK
After 1200 hours	123.6	1.55	33	5.97	2.47	31.8	short	short

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Aladdin placed 14 spare unencapsulated units on Group-C test. This was done to determine if the encapsulant could be the cause of insulation damage. Four of the remaining 90 units were removed from test so that the 14 spare samples could be placed on life test. This left 86 of the original 100 final-grade units still on extended life test to 4000 hours. A summary of the dynamic test data taken after 4000 hours is shown on Table 3.2.3-5. Four units had an insulation resistance of less than 1000 megohms; the minimum value was 200 megohms. All 86 units passed the dielectric-strength test, and all other static and dynamic parameters had satisfactory values.

The 14 unencapsulated samples were taken off of life test after 1200 hours and subjected to Group-C static tests; no failures were noted. However, the interwinding capacitance on the 14 unencapsulated samples was considerably lower than the interwinding capacitance measured on the encapsulated final-grade units. A further discussion of this data will be given further on in this report. The test data for these units is shown on Table 3.2.3-7. The 14 unencapsulated spares are continuing on life test to 2000 hours. Table 3.2.3-8 shows the summary of Group-C dynamic tests on these units prior to life tests. No dynamic test data was taken after 1200 hours of life testing.

Failure Analysis of Final-Grade Aladdin 01-717 Pulse Transformers

An analysis was made of several of the insulation-resistance failures that occurred during Group-C life tests. This analysis revealed that the shorts occurred between adjacent layers of the primary and secondary windings. It was found that the primary and secondary windings were impregnated with a clear epoxy material. Subsequent tests confirmed that this clear epoxy material was actually the encapsulation epoxy which filtered through the porous ferrite core material when the module is evacuated to remove voids (the black filler particles of the encapsulant did not diffuse into the porous ferrite core). A quantity of the clear epoxy was filtered from standard module encapsulating material for use in the twisted-wire tests described below.

Wire Twist Tests

Test experiments were performed to determine if the clear epoxy that filtered into the final-grade pulse transformers, during encapsulation, was detrimental to the wire insulation. These tests were performed on both nylon-coated polyurethane wire (Soderon) and the recommended heavy-polyurethane (Soderex) insulation wire. Twisted wire samples of each type of wire were coated with the clear encapsulation epoxy. The purpose of these tests was to compare the performance of the coated samples with corresponding uncoated twisted-wire samples.

A total of 100 twisted-wire samples were prepared; 50 samples were coated with heavy-polyurethane wire, and 50 samples were coated with nylon-coated polyurethane wire. Each of these two groups was divided into two subgroups. One group of samples was coated with the clear epoxy and the other group remained uncoated.

All samples were placed in an oven and subjected to 100°C temperature. After 430 hours, 12 test samples from each of the four groups (total of 48) were removed from the oven and subjected to a dielectric-strength test. The results of these tests are

TABLE 3.2.3-7.
SUMMARY OF GROUP-C STATIC TESTS ON 14 UNENCAPSULATED ALADDIN TYPE 01-717 PULSE TRANSFORMERS

DESCRIPTION	VALUE	PRIMARY INDUCTANCE (μh)	LEAKAGE INDUCTANCE (μh)	CAPACITANCE PRI/SEC (μμf)	CAPACITANCE DISTRIBUTED (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE (megohms)	DIELECTRIC STRENGTH
Measurements on 14 Samples prior to Life Test (a)	Max	133.2	2.1	24.0	5.75	2.61	34.2	4×10^5	OK
	Avg	124.0	1.63	21.96	5.04	2.53	33.0	3.93×10^5	OK
	Min	117.1	1.4	17.0	4.65	2.43	32.2	3×10^5	OK
Measurements on 14 Samples after 1200 hours of Life Test	Max	133.9	1.9	23.0	4.28	2.60	34.1	4×10^5	OK
	Avg	125.7	1.66	20.19	3.81	2.51	33.0	3.28×10^5	OK
	Min	118.7	1.5	18.6	3.51	2.46	32.3	4×10^3	OK

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(a) All test measurements made by Aladdin.

TABLE 3.2.3-8.
SUMMARY OF GROUP-C DYNAMIC TESTS ON 14 UNENCAPSULATED ALADDIN TYPE 01-717 PULSE TRANSFORMERS

DESCRIPTION	VALUE	OUTPUT AMPLITUDE (p-p volts) SEC 1	OUTPUT AMPLITUDE SEC 2	RISE TIME (μ sec) SEC 1	RISE TIME SEC 2	FALL TIME (μ sec) SEC 1	FALL TIME SEC 2	OVER-SHOOT (%)	DROOP (volts) SEC 1	DROOP SEC 2	BACK SWING (volts) SEC 1	BACK SWING SEC 2	RECOVERY (μ sec) SEC 1	RECOVERY SEC 2
Measurements on 14 unencapsulated units prior to Life Tests (a)	Max	1.04	1.00	.075	.10	.038	.026	2.0	.22	.02	.25	.25	4.0	4.2
	Avg	1.003	1.00	.070	.096	.036	.024	1.43	.20	.193	.25	.22	3.54	3.75
	Min	1.00	1.00	.070	.08	.032	.024	1.0	.20	.18	.25	.21	3.2	3.5

MT-144

(a) All test measurements made by Aladdin.

shown in Figure 3.2.3-2. The uncoated heavy-polyurethane wire test samples were superior to all other combinations. The remaining 52 samples will remain in the life test oven to 2000 hours.

As a result of these evaluations, the Aladdin 01-717 design has been modified to insure that the encapsulation epoxy does not degrade the wire insulation. This change involves impregnating the wound bobbin and sleeve assembly with a material that will not degrade the heavy-polyurethane wire insulation.

TABLE 3.2.3-7.
SUMMARY OF GROUP-C STATIC TESTS ON 14 UNENCAPSULATED ALADDIN TYPE 01-717 PULSE TRANSFORMERS

DESCRIPTION	VALUE	PRIMARY INDUCTANCE (μh)	LEAKAGE INDUCTANCE (μh)	CAPACITANCE PRI/SEC (pf)	CAPACITANCE DISTRIBUTED (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE (megohms)	DIELECTRIC STRENGTH
Measurements on 14 Samples prior to Life Test [a]	Max	133.2	2.1	24.0	5.75	2.61	34.2	4×10^5	OK
	Avg	124.0	1.63	21.96	5.04	2.53	33.0	3.93×10^5	OK
	Min	117.1	1.4	17.0	4.65	2.43	32.2	3×10^5	OK
Measurements on 14 Samples after 1200 hours of Life Test	Max	133.9	1.9	23.0	4.28	2.60	34.1	4×10^5	OK
	Avg	125.7	1.66	20.19	3.81	2.51	33.0	3.28×10^5	OK
	Min	118.7	1.5	18.6	3.51	2.46	32.3	4×10^3	OK

MT-143

(a) All test measurements made by Aladdin.

TABLE 3.2.3-8.
SUMMARY OF GROUP-C DYNAMIC TESTS ON 14 UNENCAPSULATED ALADDIN TYPE 01-717 PULSE TRANSFORMERS

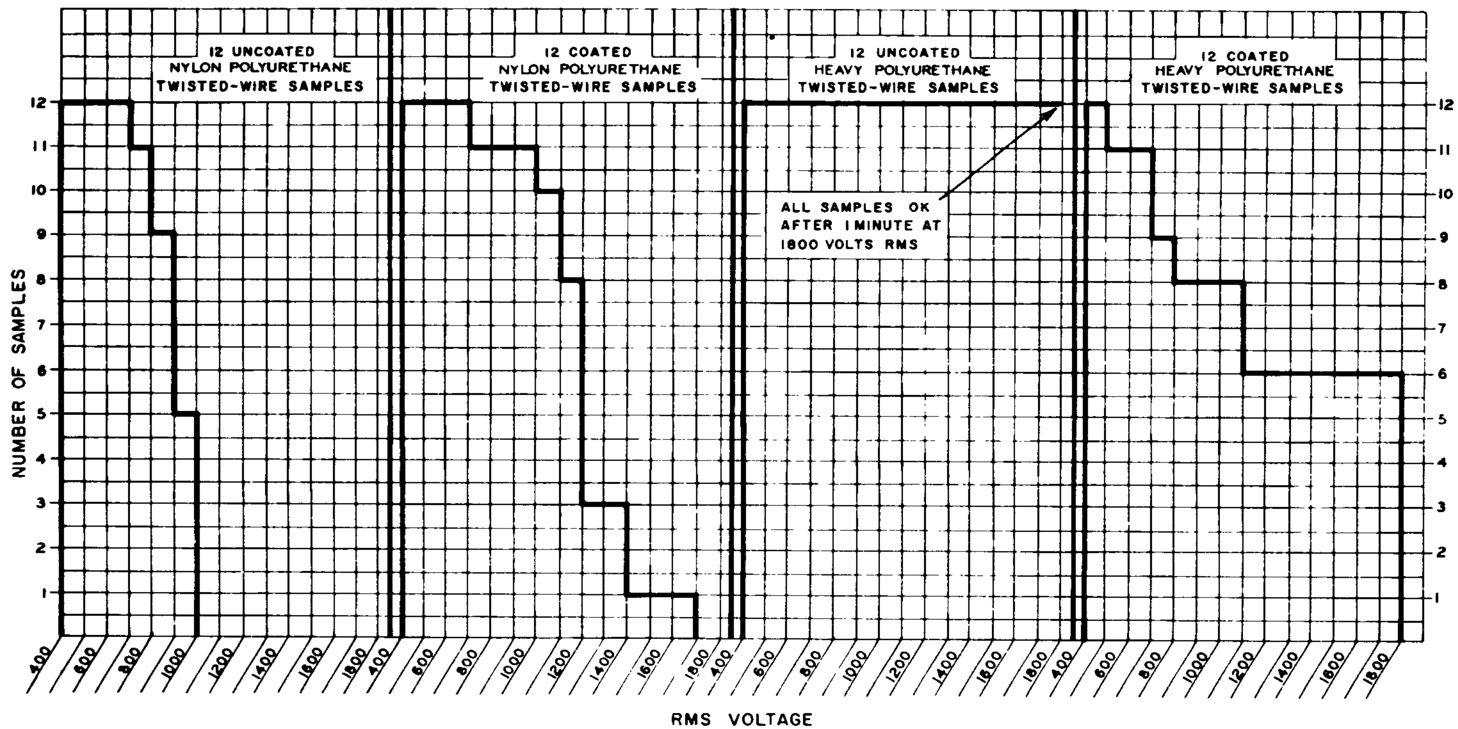
DESCRIPTION	VALUE	OUTPUT AMPLITUDE (p-p volts) SEC 1	SEC 2	RISE TIME (μ sec) SEC 1	SEC 2	FALL TIME (μ sec) SEC 1	SEC 2	OVER-SHOOT (%)	DROOP (volts) SEC 1	SEC 2	BACK SWING (volts) SEC 1	SEC 2	RECOVERY (μ sec) SEC 1	SEC 2
Measurements on 14 unencapsulated units prior to Life Tests [a]	Max	1.04	1.00	.075	.10	.038	.026	2.0	.22	.02	.25	.25	4.0	4.2
	Avg	1.003	1.00	.070	.096	.036	.024	1.43	.20	.193	.25	.22	3.54	3.75
	Min	1.00	1.00	.070	.08	.032	.024	1.0	.20	.18	.25	.21	3.2	3.5

MT-144

(a) All test measurements made by Aladdin.

shown in Figure 3. 2. 3-2. The uncoated heavy-polyurethane wire test samples were superior to all other combinations. The remaining 52 samples will remain in the life test oven to 2000 hours.

As a result of these evaluations, the Aladdin 01-717 design has been modified to insure that the encapsulation epoxy does not degrade the wire insulation. This change involves impregnating the wound bobbin and sleeve assembly with a material that will not degrade the heavy-polyurethane wire insulation.



ML-401

Figure 3.2.3-2. Dielectric-Strength Test Results of 48 Insulation Wire Samples

Aladdin Final Report

Aladdin submitted its final report on the pulse transformer subtasks. This report was reviewed at RCA, Somerville, and was forwarded to Surf Com with minor revisions and comments.

Aladdin indicates that their microelement pulse transformers, made with heavy-polyurethane insulated wire and the construction technique established during this task effort, will pass life-test requirements specified for these microelements. RCA, Somerville, concurs with this conclusion. Aladdin has agreed to prepare a limited quantity of new samples for further Group-C testing at no expense to RCA.

3.2.3.2 Collins Radio - Medium-Frequency Fixed-Inductor Microelements

This task involves the construction of range, prototype, and final-grade samples of medium-frequency inductor microelements.

During this quarterly period, Collins resubmitted 20 prototype samples and a test report. The samples were 455-kc I-F transformers designed to meet the requirements of RCA Purchase Drawing A-2016903.

Materials — The metalized ceramic substrates were supplied by Coors Porcelain. These substrates were made in accordance with Collins drawing 495-9500-300 except for solder coating which was done by Collins. A new substrate design will assure against any marginal notch dimensions.

The pot-cores supplied by Indiana General did not meet the dimensional requirements of Collins Drawing 490-7404-500/508 and 401/403. These units had to be ground so that they could fit into the substrates. The center-post profile is still applied by a separate grinding process.

Process — The coils were wound directly on a special mandril with A. W. G. #41 heavy Solvar wire; no bobbin was used. Eastman 910 adhesive was applied at winding intervals to produce a self-supporting coil. The primary winding is made with a total of 138 turns and tapped at 48 turns. The secondary was wound directly over the primary with 11 turns. The coil was assembled into the pot-core.

The pot-core was held together with nonmagnetic, nonconductive clips while it was adjusted for the proper inductance value. Then the coil was secured with Eastman No. 910 cement. The transformer was mounted into the substrate and held by Eastman 910 cement.

After the leads were placed at the proper lug locations, the lugs were crimped. The connections were then soldered, and the lugs were trimmed and bent flush.

The assemblies were then preheated for three hours at 120°C and filled with degassed Sylgard 182 in a vacuum foaming process. They were cured for two hours at 120°C.

Mechanical Dimensions

All 20 prototype samples passed the pin-gauge test. The thickness varied from .137 to .139 inch; the maximum thickness was .140 inch. The width dimension varied from .307 to .314 inch; the requirement for this dimension is .310 ± .004 inch. The workmanship was very good. There were, however, bubbles in the Sylgard at the corners, but the top and bottom surfaces were clear and well sealed.

Electrical Test Results

All 20 samples withstood 140 rms volts for a period of more than three seconds; 100 volts are required. The minimum insulation resistance, between coils was 30 x 10^4 megohms, and 6 x 10^4 megohms minimum between adjacent notches. These results are well above the required minimum value of 1000 and 10,000 megohms respectively.

Figure 3.2.3-3 shows the distribution of inductance for the 20 units. Nineteen of the 20 microelement inductors were within a tolerance of ±5 percent of the required inductance value that resonated with 220 pf at the test frequency of 455 kc.

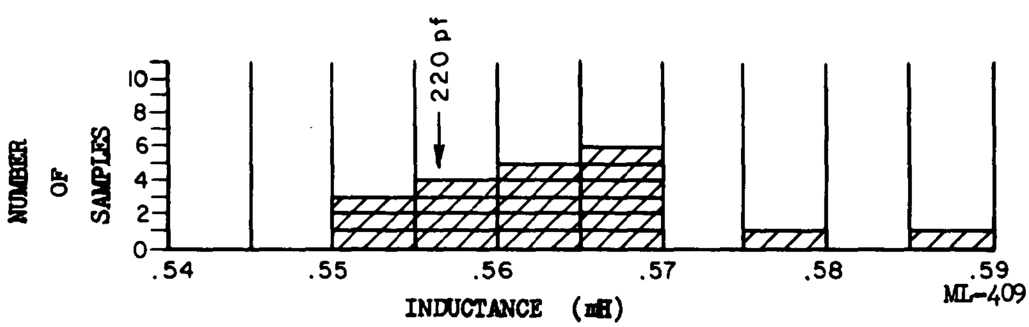


Figure 3.2.3-3. Inductance Distribution of 20 Prototype Microelement Inductors

The self-resonant frequency of the tuned-inductor winding averaged 3.63 Mc for all 20 units, and all were within the required ±15 percent of this average. The distribution of self-resonant frequency is shown in Figure 3.2.3-4.

The average primary reflected impedance was 21.8 kilohms; the specification requirement is 21.5 kilohms. The minimum and maximum values of 19.8 and 23.3 kilohms respectively, represent a maximum variation of ±8.2 percent. The average secondary reflected impedance was 830 ohms; the requirement was 1000 ohms.

The average unloaded Q was 116 against a minimum requirement of 105. The minimum and maximum values were 103 and 122 respectively, or a spread of ±8.5 percent; the uniformity tolerance is ±10 percent. The distribution of Q for the 20 samples is shown in Figure 3.2.3-5.

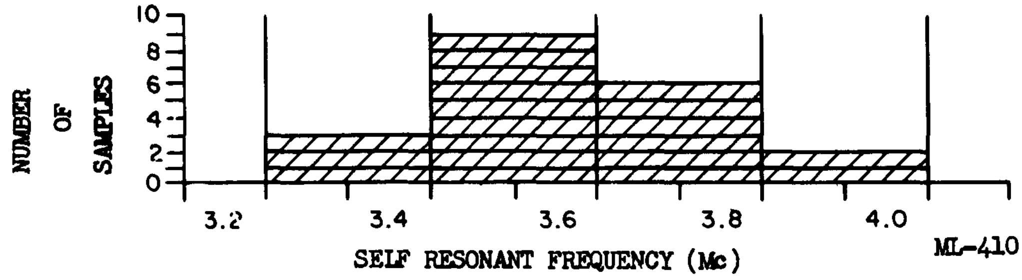


Figure 3.2.3-4. Distribution of Self-Resonant Frequency of 20 Prototype Microelement Inductors

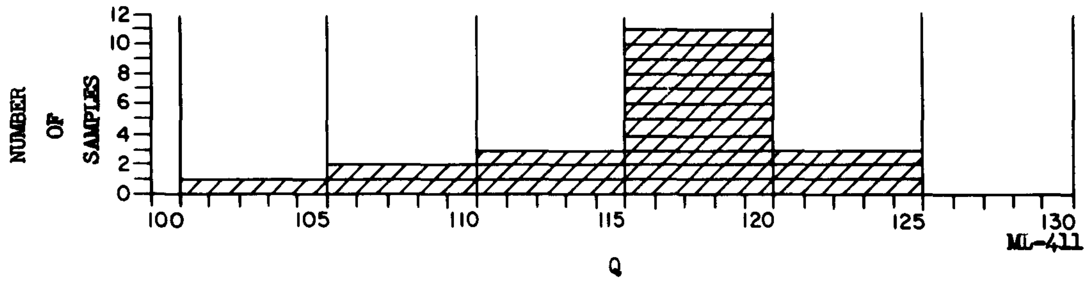


Figure 3.2.3-5. Distribution of Quality Factor of 20 Prototype Microelement Inductors

All of the prototype samples had coupling coefficients that exceeded the 0.9 minimum requirement. The average value was 0.974, and the variation in values for the 20 units was from .970 to .978. The bandwidth, when measured in the circuit shown in Figure 3.2.3-6, averaged 10.17 kc, and the variation in values for the 20 units was from 9.71 kc to 10.67 kc. The specified requirement is from 8.7 kc to 11.7 kc. The bandwidth distribution of the 20 samples is shown in Figure 3.2.3-7.

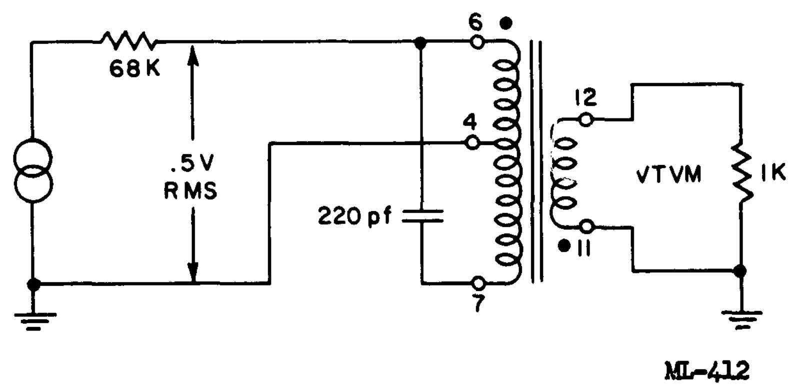


Figure 3.2.3-6. Test Circuit for Bandwidth Measurement

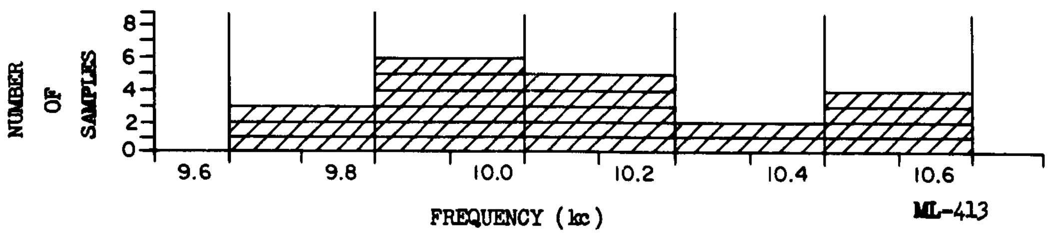


Figure 3.2.3-7. Distribution of Bandwidth of 20 Prototype Microelement Inductors

Eight of the 20 units were measured for temperature coefficient. The curves of the fractional change in inductance (PPM) vs. temperature for most stable inductor (No. 749) and the most erratic inductor (No. 733) are shown in Figure 3.2.3-8.

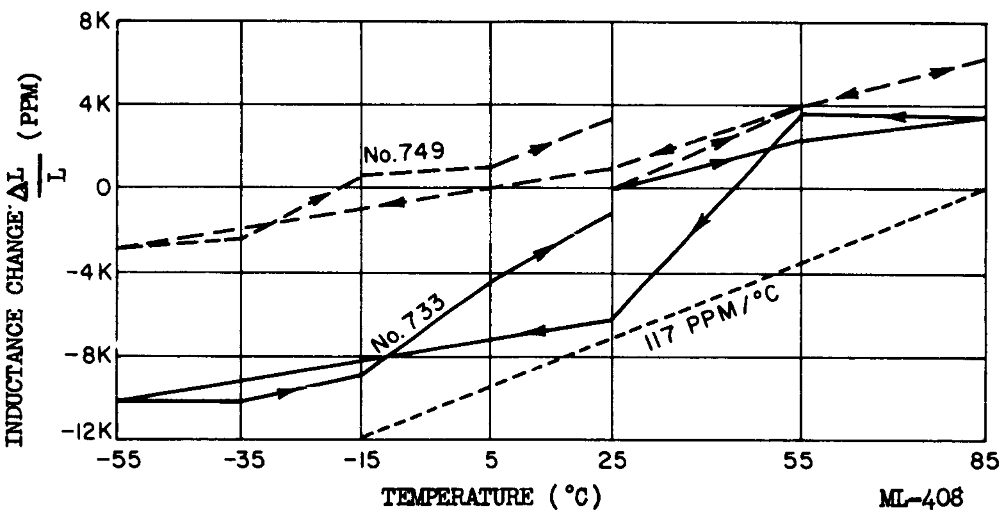


Figure 3.2.3-8. Temperature Coefficients of the Most Stable and Most Erratic Prototype Inductors

Drive sensitivity of the 20 prototype samples varied from 0.3 to 3 ppm/mv. All units exhibited a stability corresponding to less than 0.5 percent change in inductance with 100 ma, dc, flowing through the primary. The dc current resistance of the primaries average 1.66 ohms over a variation in values of 1.61 to 1.88. This represents a uniformity tolerance of ±8 percent against the requirement of ±15 percent.

As a result of the above test results, Collins was granted approval on January 14, 1963, to proceed with construction of final-grade units.

3.2.3.3 Radio Industries — I-F Microelement Trimmer Inductors

Microelement trimmer inductors are made in two cup-core designs. One is a 455-kc I-F transformer for coupling between transistor stages. This design will be subjected to environmental and life testing. The other unit is a 15-Mc, 2-microhenry inductor intended to demonstrate the high-frequency capability of the cup-core design.

455-kc Trimmer Inductor — The prototype 455-kc microelement inductors are built around a commercial ferrite. Because of its closed magnetic structure, the microelement does not meet requirements of SCL-6342 for precision inductors. Tests indicated that these units have a high and irregular temperature coefficient of permeability at low temperatures.

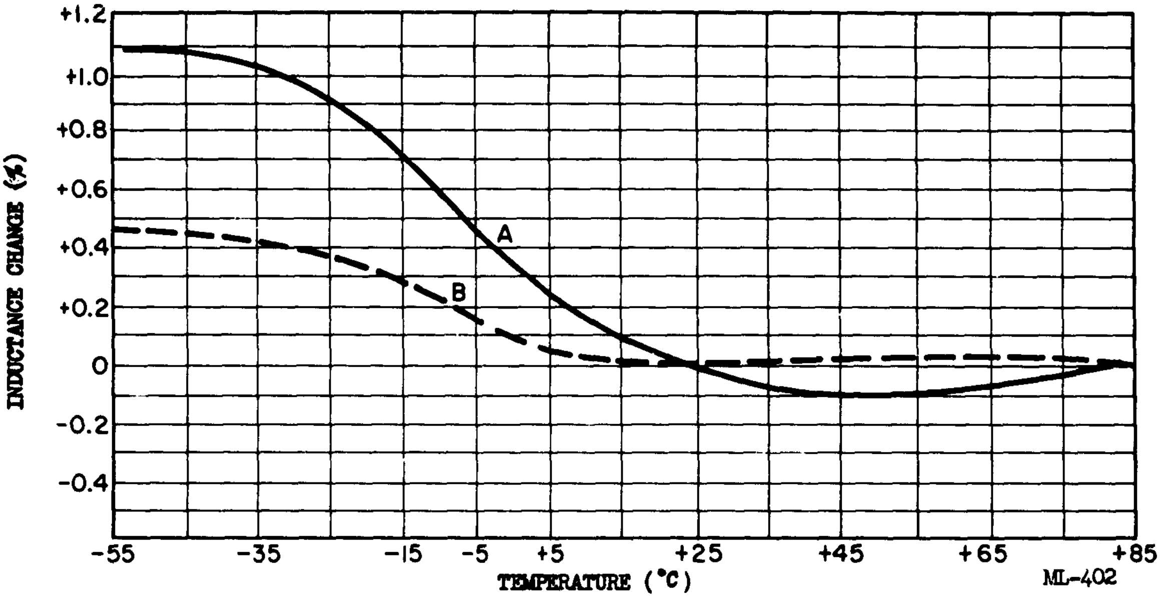
Since the prototype versions of this design were submitted for evaluation, Radio Industries received type TC-3 and TC-4 temperature-compensated ferrites from Indiana General Corporation, and submitted samples of inductors made from these materials. The TC-3 material was rough and abrasive to the inductor leads, and had relatively high conductivity. Inductors made with TC-4 material had very good inductance characteristics at room temperatures, and had unloaded Q's close to 100. The temperature coefficients of inductance were low, negative and nonlinear. High-Q inductors made with TC-3 material displayed the same temperature behavior. Temperature cycling and sealing of the trim cap with a thixotropic epoxy lowered the temperature coefficient and flattened out the nonlinear part of the curve.

Figure 3.2.3-9 shows the temperature behavior of a unit made with TC-3 material. Behavior was checked both before and after temperature cycling and sealing. Although the lower temperature coefficient was negative, it was considered acceptable in view of the state-of-the-art.

Radio Industries made 24 final-grade microelements with TC-3 cup cores in deep glass-mica substrates. They had apparently resolved the insulation-abrasion problem by coating the cup with Goodyear Pliolite. During fabrication, however, it was discovered that processing temperatures reduced insulation resistance between coils to 0.2 megohms on some units. Again, the TC-3 material had abraded insulation. Consequently, it was considered inadvisable to start the 2000-hour life tests, and Radio Industries agreed to replace the 24 units with inductors made with TC-4 cup cores.

15-Mc Trimmer Inductors — Radio Industries successfully completed development of the 15-Mc microelement trimmer made with TC-4 material supplied by Indiana General Corporation. Ten final-grade microelement samples were delivered. These units had electrical characteristics as described in Table 3.2.3-9. The performance objective was a Q of 100 for a 2-microhenry inductor at 15 Mc.

These units were made with cup-core center posts of carbonyl SF material; cups and screw caps were made of TC-4 material. This combination resulted in a lower and more linear temperature coefficient of inductance than units made entirely of TC-4 material.



A - Behavior of 455-kc transformer when trimmed to nominal inductance, and before temperature cycling and sealing of the trimmer cap.

B - Behavior after 12 temperature cycles and sealing of the trimmer cap with thixotropic epoxy.

Figure 3.2.3-9. Temperature Coefficient of Inductance of Assembled 455-kc Microelement Trimmer After Temperature Cycling and Sealing of the Trimmer Cap with Epoxy Cement

To meet the high Q required at 15 Mc, Radio Industries developed a special nylon-covered litz wire. Figure 3. 2. -10 shows the performance of units wound with this wire. The Q curve peaks around 9 Mc, indicating potentially good performance at the most-used intermediate frequencies of 10. 9 and 11. 5 Mc. The curve indicates that the Q objective of 100 is best achieved at these frequencies, and that useful designs (Q=70) can be achieved at 15 Mc if the required inductance is not too low. Effort to further increase Q was unsuccessful.

Typical temperature behavior of the 15-Mc cup-core trimmer is shown in Figure 3. 2. 3-11. A typical drive characteristic is shown in Figure 3. 2. 3-12.

TABLE 3.2.3-9.
PERFORMANCE DATA FOR 10 HIGH-FREQUENCY MICROELEMENT TRIMMERS MADE BY RADIO INDUSTRIES
These Demonstration Trimmers are Mechanically Identical to 2016904

UNIT SERIAL NO.	NOMINAL INDUCTANCE AT 7.9 Mc (μh)	Q AT 7.9 Mc AND NOMINAL INDUCTANCE	Q AT 15 Mc AND NOMINAL INDUCTANCE
28	2.4	80	70
30	2.4	95	68
31	2.5	90	63
32	2.4	93	69
33	2.5	87	67
34	2.4	93	69
35	2.4	95	70
36	2.4	95	70
37	2.45	97	70
40	2.4	87	69

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The effect of a steady external-magnetic field on the 15-Mc inductor was checked by use of a permanent magnet calibrated to 50 ±5 oersteds. The inductor was mounted on busses on a Boonton 260 Q-meter, and tuned at 2 x Q drive. The magnet was brought toward the inductor from the side, top, and bottom. The inductor was detuned approximately 0.2 percent, as indicated by a drop in Q of about 8 percent, when the inductor was approached from the side and bottom. The Q under these circumstances was approximately 3 percent lower than the initial value. When the magnet was removed, the inductor Q returned to its initial value. The effect of the magnetic field at the top of the inductor was the same, except that the inductance did not return to its initial value by a margin of 0.05 percent when the magnet was removed.

Radio Industries supplied a brief report and data for the 15-Mc trimmer, and delivered samples for forwarding to the Signal Corps. This delivery marked completion of the 15-Mc trimmer-inductor task.

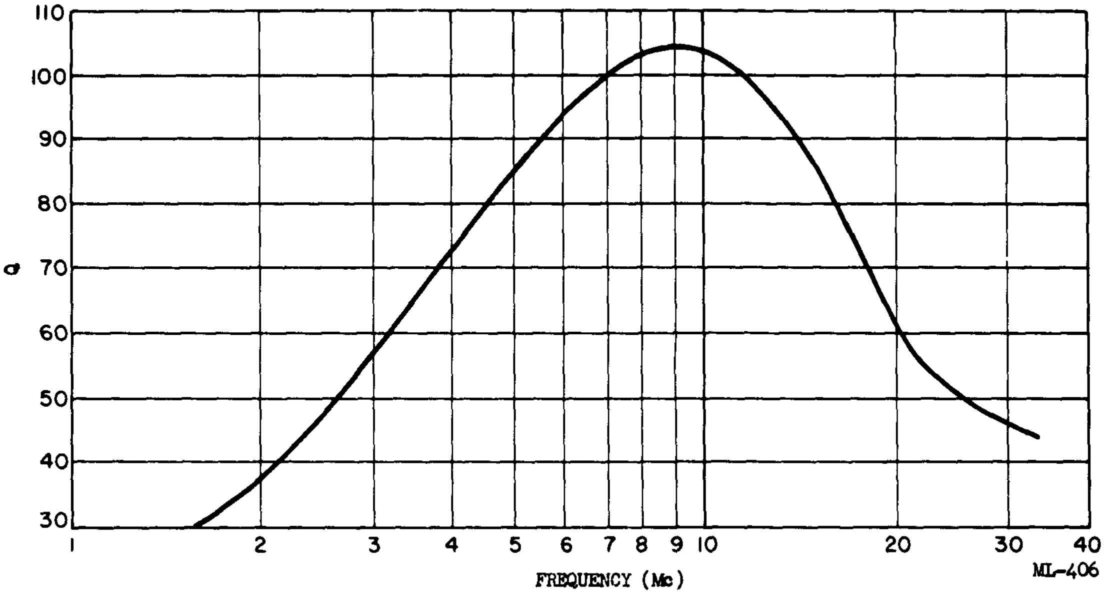


Figure 3.2.3-10. Typical Q Curve for High-Frequency Microelement Trimmer Inductor Developed by Radio Industries

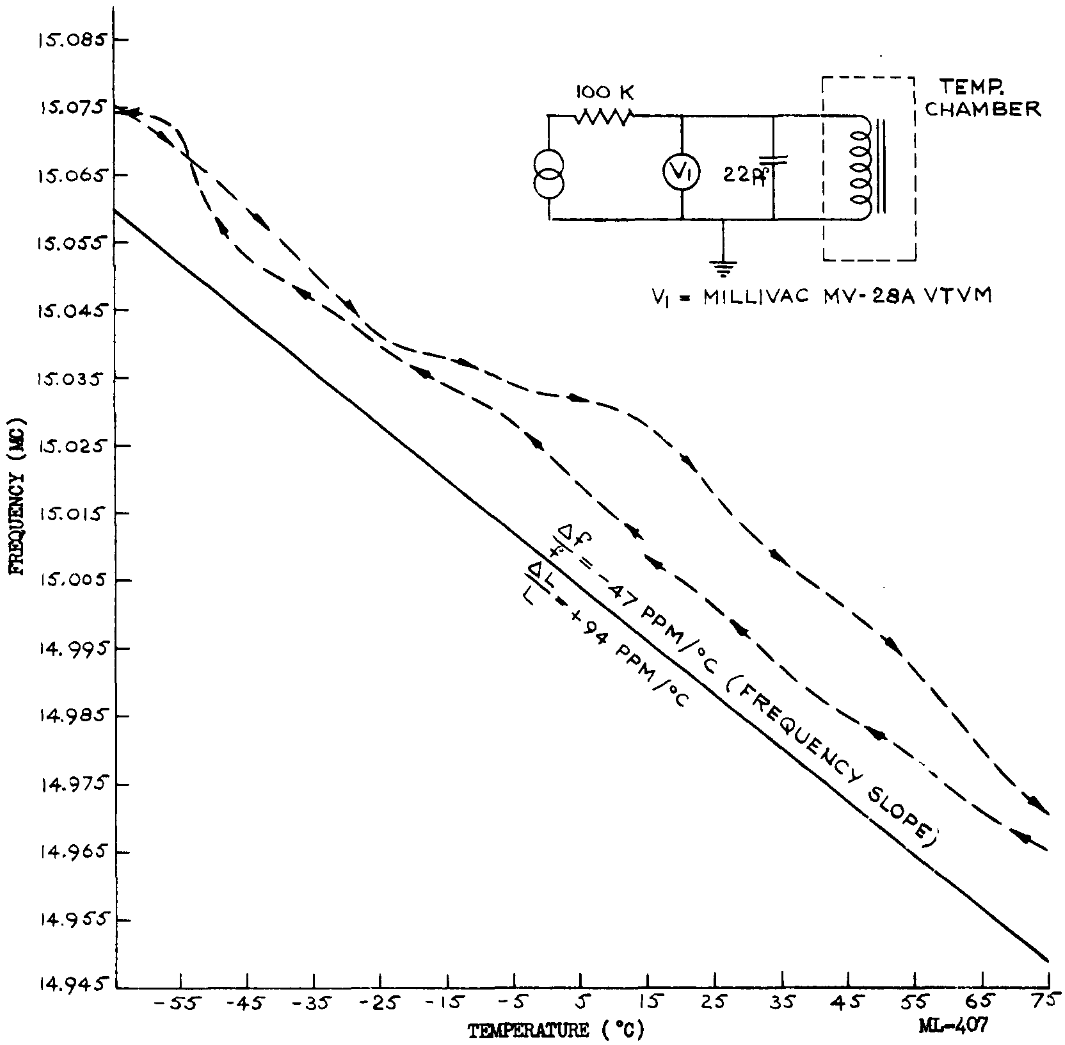
3.2.3.4 Collins Radio — High-Frequency Microelement Inductors

The final-grade demonstration microelement inductor required for this task (RCA Drawing 2016905) is a 2-microhenry carbonyl-iron toroid intended for coupling transistors in a 10.7-Mc I-F amplifier.

Collins Radio received substrate assemblies from Coors Porcelain and solder-coated the notches in accordance with RCA specifications. They assembled their final-grade toroid assemblies into them by using the terminating tools described in the 19th Quarterly Report. Collins delivered 75 final-grade 2016905 microelement transformers to RCA in February. All units passed visual and mechanical inspection, and were processed into test modules at RCA, Somerville.

Testing of Final-Grade Microelement Inductors

These microelements were subjected to a 100 rms volt dielectric-voltage test, and no failures occurred. The insulation resistance between notches to which primary and secondary coils were terminated averaged 4×10^5 megohms; a few units ran as low as 2×10^5 megohms. The specified minimum limit is 10^3 megohms.



NOTES:

1. Inductor element held at temperature extremes for 20 minutes for stabilizing.

2. Cup - TC4; Cap - TC4; Core - Sf Carbonyl.

Figure 3.2.3-11. Temperature Coefficient of Resonant Frequency for Radio Industry's High-Frequency Microelement Trimmer Inductor

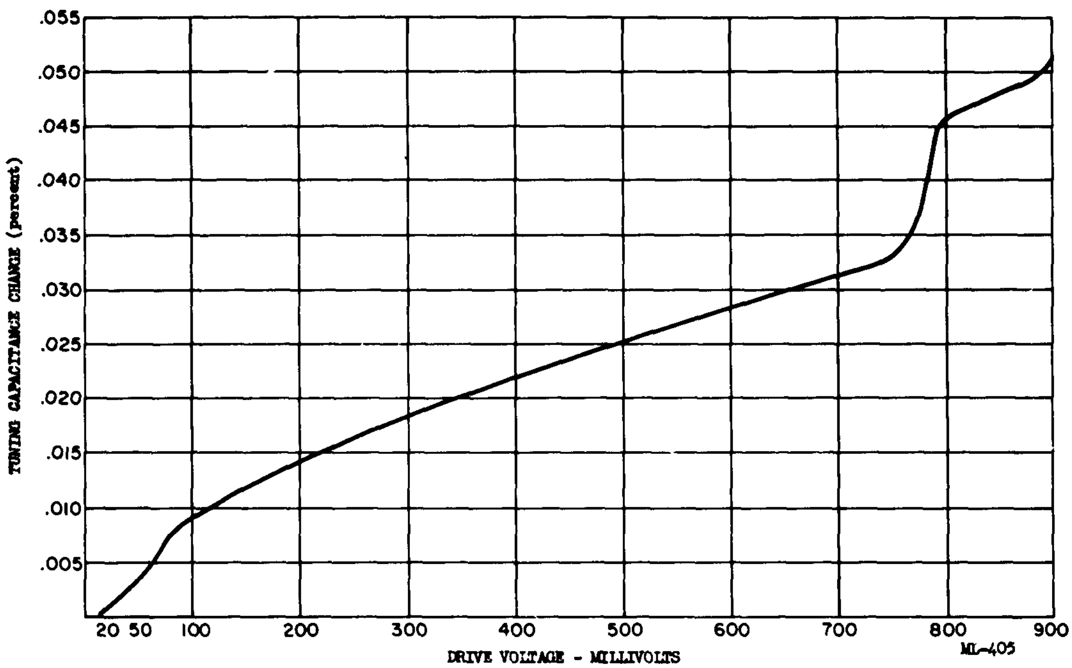


Figure 3.2.3-12. Typical Drive Characteristic of Radio Industry's 15-Mc Microelement Trimmer Inductor

The effective inductance of the primary at the notches, as indicated by the capacitance needed to tune the inductors to 10.7 Mc on the Boonton 260A Q-meter, averaged 106 picofarads. The maximum was 111 pf; the minimum was 102. This spread is ±4.5 percent effective inductance, and is within the ±5 percent uniformity requirement in the RCA-2025985 capability specification.

Unloaded Q's averaged 86, with a minimum of 80 and a maximum of 92. The Q's did not completely reach the 2016905 target of 100, but exceeded the uniformity requirement of ±10 percent.

Test Modules

The demonstration microelement transformers were assembled into test modules for environmental and accelerated-life testing in accordance with RCA specification 2025985. Units intended for environmental testing were assembled, one each, into individual test modules terminated so that microelement notch numbers and micro-module terminal numbers corresponded. Units intended for life test were assembled two per module. All test modules were sent to Collins Radio for environmental and life tests.

3.2.3.5 Cambridge Thermionic — HF and VHF "D"-Core Microelement Inductors

The microelement inductor for this task is a 0.215 microhenry reactor for operation at 88 megacycles. It is made with a 16-turn "D" core mounted in a deep, glass-mica substrate. In the previous quarterly report, Cambridge Thermionic had encapsulated final-grade "D" core microelements into test modules for both environmental and life tests.

Cambridge Thermionic completed environmental testing of nine microelement inductors with no failures. Three of the units were subjected to thermal cycling as specified in MIL-STD-202-102A-D. After temperature cycling these units were measured for inductance and Q. The measurements for these parameters were the same as those prior to the test (within the accuracy of the 88 megacycle Q meter measurements). The temperature coefficient of inductance of the three units was measured by mounting them on a Boonton 190 Q meter within a temperature controlled oven. The averaged TC's, between -55°C and +85°C, were +93, +109, and +63 PPM/°C. These values were within the ±30 percent uniformity requirement.

Six inductor test modules were subjected to the following environments:

a. Vibration as per MIL-STD-202-201A

b. Vibration as per MIL-STD-202-204A-C

c. Shock as per MIL-STD-202-202A

d. Barometric Pressure as per MIL-STD-202-105B-C

e. Immersion as per MIL-STD-202-104A-B

f. Moisture Resistance as per MIL-STD-202-106A

Measurements of effective inductance and unloaded Q were made between these environments; as well as a dielectric-strength test at 100 rms volts on adjacent terminals, and a leakage resistance test at 100 dc volts between adjacent terminals. Comparative inductance measurements were all within the ±1 percent measurement accuracy. A loss of unloaded Q (between 1 and 4 percent) resulted after immersion and moisture resistance tests. The leakage resistance, between adjacent terminals decreased to 3000 megohms after moisture resistance, but increased again with time.

Fifty life-test units have completed 1500 hours with no failures in an 85°C oven and a dc current of 0.50 milliampere. Cambridge Thermionic anticipates completing this test and submitting a final report during next quarter.

3.2.3.6 United Transformer — Audio Transformer and Choke Top-Elements

The audio top-element demonstration unit is a high-impedance isolation transformer with primary and secondary center taps. The leads come through a split bobbin shell and are soldered into the hole terminals of a Mitronics substrate.

During this quarter, United Transformer shipped 24 final-grade top-element transformers. All of the units passed the microelement pin-gauge test, and averaged 0.394-inch high. Some of the solder thickness on the under side of the wafer could be removed and thereby reduce the height by at least .010 inch.

All units successfully withstood the 100 volt (rms) dielectric-strength test. The average inductance of the primary windings was 2.23 henrys over a range of values from 1.74 to 2.72 henrys; 1.4 henrys is the minimum specified. The direct-current resistance of the primaries averaged 953 ohms for values from 845 ohms to 1070 ohms; this result was within the 970 ±20 percent specified.

The secondaries were wound over the primaries and had an average direct-current resistance of 1210 ohms over a range of values from 1090 to 1330 ohms; the requirement for this parameter is 1220 ±20 percent.

The average low-frequency response measured at 400 cps was down 1.2 db from the reference frequency of 1000 cps. Unit to unit variations were -.8 to -2 decibels against a -3 decibel limit.

The average high-frequency response measured at 20 kilocycles per second was up one decibel from the reference frequency of 1000 cps. The range of values for the 24 units varied from +.5 to +1.3; the limit specified was +3 decibels.

The average distortion at 1000 cycles over all the units was 0.66 percent with a 10 mw coupling. Unit to unit variation was from 0.4 percent to one percent against a limit of five percent. These units will couple 100 mw at frequencies down to 400 cps at unity power factor before approaching the five percent distortion limit.

RCA Somerville encapsulated six of the 24 transformers into test modules and delivered them to United Transformer for Group-B environmental tests.

The six test modules were subjected to environmental tests. No measurable changes of characteristics resulted. The low-frequency response was down 1.5 decibels at -55°C as compared with a decrease of 1.3 decibels at +85°C.

United Transformer anticipated submitting a final report on the top-microelement audio inductor by the end of this quarter.

3.2.3.7 RCA Inductor Packaging Development

Ten test modules were constructed with seven I-F microelement inductors mounted on glass-mica deep substrates and three similar inductors mounted on thin alumina wafers. These 10 modules were subjected to environmental tests to determine if there were any differences between inductors mounted on glass-mica deep substrates and those mounted on thin alumina substrates; also, to determine if there were any differences resulting from the pre-encapsulation of the core and coil in Sylgard 182 previous to module encapsulation.

After initial measurement of characteristics the units were subjected to the same environmental tests listed previously in this report.

Measurements of Q and insulation resistance were repeated between each environmental test. Up until the immersion test was made, there were no measurable changes in Q and insulation resistance on any of the test modules. There was also no mechanical damage. The results of the immersion tests are shown in Table 3.2.3-10. The test modules designated with numbers contained inductors mounted on glass-mica substrates, and the test modules designated with letters are the inductors mounted on alumina substrates. The first four samples, 10, 14, 17, and 20 had lower Q's and higher insulation resistance than samples 22, 34, and 54 because the former samples were previously on life test.

Excluding the abnormal degradation of microelement No. 51 (although it still passed MIL-C-15305, little difference between the two methods of mounting toroid inductors was shown, as far as moisture resistance is concerned. Any advantage gained in encapsulating the inductors with deep, glass-mica substrates has apparently been sacrificed because of the increased surface area and decreased surface resistance when moisture enters through the module encapsulant.

The above test results, and the life-test results reported in the last quarterly report show that deep, glass-mica substrates are compatible with current micro-module assembly techniques. In addition, microelement toroid inductors mounted on deep substrates are compatible with almost any method of mechanized production.

TABLE 3.2.3-10.

COMPARISON OF Q AND INSULATION RESISTANCE OF TOROID INDUCTORS MOUNTED ON DEEP, GLASS-MICA SUBSTRATES WITH THOSE OF TOROID INDUCTORS MOUNTED ON THIN ALUMINA SUBSTRATES

	TEST MODULE DESIGNATION	BEFORE IMMERSION		AFTER IMMERSION		2 HOURS AFTER MOISTURE RESISTANCE		24 HOURS AFTER MOISTURE RESISTANCE
		Q	IR (megohms)	Q	IR (megohms)	Q	IR (megohms)	IR (megohms)
Inductors mounted on deep, glass-mica substrates	10	89	7.10^6	89	7.10^6	89	12.10^3	13.10^3
	14	88	6.10^6	88	6.10^6	88	8.10^3	15.10^3
	17	88	5.10^6	88	40.10^5	88	4.10^3	12.10^3
	20	90	7.10^6	90	8.10^6	90	15.10^2	6.10^3
	22	96	50.10^5	95	45.10^5	91	24.10^2	8.10^3
	34	94.5	50.10^5	94	45.10^5	93	6.10^3	11.10^3
	51	99.5	50.10^5	99	50.10^5	97	10	300
Inductors mounted on thin alumina substrates	A	93	20.10^6	92	20.10^6	90.5	20.10^3	25.10^3
	B	95.5	20.10^6	94.5	20.10^6	94	10.10^2	13.10^2
	C	96.0	20.10^6	95	20.10^6	95	10.10^3	35.10^3

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3.3 SEMICONDUCTOR DEVICES

Objective and Status

Program Extension II PEM for semiconductor devices will establish capability for manufacturing a broad-line of microelement transistors and diodes. The tasks consist of the following three phases:

Phase I - Demonstration of package hermeticity and compatibility with module processing techniques. This phase has been completed.

Phase II - Demonstration of ability to meet electrical performance requirements and establishment of device specifications. Two hundred units of each type will be supplied.

Phase III - Demonstration of facilities in a preproduction run. Three hundred units of each type will be supplied.

The status of the above program is as follows:

Texas Instruments and Sperry Semiconductor have completed all the microelement transistor requirements of Phase I and Phase II. These vendors have completed all Group-A tests associated with the Phase III testing program. Storage and operating-life tests are in progress.

Philco and General Electric have completed all the microelement transistor requirements of Phase I. These vendors have completed all Group-A tests associated with the Phase II testing program. Storage and operating-life tests are now in progress.

RCA has completed all the microelement transistor requirements of Phase I. All of the technical requirements of the Phase II program, except for establishing a final specification, have been completed.

Fairchild, MicroSemiconductor, and Hughes have completed all the microelement diode requirements of Phase I and Phase II. These vendors have completed the fabrication of the devices required for the Phase III test program; these devices have been placed on 1000-hour temperature aging.

The Program Extension II, PEM for semiconductor devices consists of two additional tasks as follows:

1. The Diode Mounting Task (MMDP 32-4) which is concerned with establishing a capability of attaching diodes to ceramic wafer by welding.

2. The Ultrasonic Cleaning Task (MMDP 31-7) which is concerned with establishing a capability of ultrasonically cleaning semiconductor devices without degrading the electrical characteristics of the elements.

3.3.1 TRANSISTORS

3.3.1.1 PROGRAM EXTENSION II, PEM

2N705 Germanium Mesa Transistor

Texas Instruments completed fabrication of a sufficient number of these transistors to supply the 300 test elements required for Phase III; these units were subjected to 100°C temperature aging for 1000 hours.

All Group-A and -B tests have been completed on these devices. During the week of March 11, the 1000 hour operating and storage-life tests were initiated.

2N328A Silicon-Alloy Junction Transistor

Sperry Semiconductor completed the 1000 hour temperature aging on a sufficient number of transistors to supply the 300 test elements required for Phase III.

All Group-A and -B tests have been completed. The 1000-hour operating and storage-life tests will be completed on March 19. Four electrical failures have occurred during the operating-life test. They are:

One V_{CE} short after 256 hours

One catastrophic I_{CBO} failure after 265 hours

Two degradational I_{EBO} failures after 488 hours

The four failures noted above were within the failure allowance of the specification. These failures are attributed to an increase in operating-life power requirements over those specified in Phase II. The specifications will be modified so that the operating-life power requirements are in accordance with the device capability.

No failures occurred during the storage-life test.

2N501A Germanium and 2N495 Silicon Transistors

Philco fabricated a sufficient number of transistors to supply the 200 germanium-type test elements and 50 silicon-type test elements required for Phase II; these units were subjected to 1000-hour temperature aging. The acceptance-test program for the 2N501A was initiated on February 11; all Group-A and -B tests have been completed. The 500 hour interim-life test measurements were taken on both the operating and storage-life elements on March 11; there were no failures.

The acceptance-test program for the 2N495 was initiated on March 8. All Group-A electrical testing was completed, and Group-B testing is now in progress. The operating and storage-life tests will be initiated by March 25.

Silicon VHF Power Transistor; TA-2029 and TA-2229 Germanium Transistors

During this quarterly period, all Group-A, -B, and -C tests on these types of transistors were completed. A meeting of the Signal Corps and RCA was held to negotiate the Phase III specification. RCA suggested the following specification changes:

a. Oscillator power output to be 250 mw minimum rather than the previous 400 mw.

b. Power gain to be minimum 10 db rather than the previous 12 db.

c. Over-all microelement height to be increased to 0.120 inch over the previous 0.090 inch.

d. Thermal resistance from the junction to the case increased to 75°C per watt over the previous 50°C per watt.

The above changes are being reviewed by the Signal Corps, and a decision is expected next quarter. If approval is granted, the final specification will be formalized.

RCA fabricated and subjected to 1000 hour, high-temperature aging a sufficient number of transistors to supply the 200 test samples of the TA-2029 type required for Phase II. All Group-A test data has been taken; Group-B testing is in progress, and Group-C operating and storage-life tests have been initiated.

RCA fabricated and subjected to 1000-hour temperature aging approximately 270 test elements of the TA-2229 type. Of this number, 105 transistors were Group-A tested and were found to meet all the electrical requirements. An additional 120 elements were tested which failed to meet the r_{bb}' and noise level requirements. All Group-B tests, and Group-C operating and storage-life tests were completed.

2N335 Grown-Junction Silicon Transistor

General Electric completed 1000 hours temperature aging on a sufficient number of transistors to supply the 200 test elements required for Phase II. All Group-A and -B mechanical and environmental testing have been completed. The 500-hour life-test measurements on both the operating and storage-life elements were scheduled for completion before the end of March.

Ultrasonic Cleaning

The detailed test program for ultrasonic cleaning has been written and submitted to Signal Corps. This test program utilizes the ultrasonic cleaning equipment which was developed under the PEM program.

The procurement and subsequent testing of 25 samples of each of the following transistor and diode types will be included in the program:

a. 2N709 NPN, Silicon Planar High-Speed Transistor

b. 2N995 PNP, Silicon Planar High-Current Transistor

c. TA-2229 PNP, Germanium Mesa Transistor

d. 2N501A PNP, Micro-Alloy Diffused-Germanium Transistor

e. 1N747 Silicon-Alloy Junction Zener Diode

All parts required in this task have been received, except for the 2N995 PNP, silicon planar, high-current transistors.

3.3.2 DIODES

3.3.2.1 PROGRAM EXTENSION II, PEM

1N650 General-Purpose Silicon Diode

Fairchild fabricated and has placed a sufficient number of diodes to supply the 300 test elements required for Phase III and has placed them on 1000-hour temperature aging. The shock and vibration tests necessary to fulfill the technical requirements of the Phase II test program have been successfully completed and the 15 test modules together with data have been transmitted to Signal Corps. A final specification for Phase III has been negotiated and approved.

MicroSemiconductor submitted the required 50 microelement diodes to demonstrate a capability to mount its 1N658 diodes on ceramic wafers. Thirteen of the 50 microelement diodes were placed in an oven to determine how temperature affected the assemblies. After 200 hours at 200°C, four units had loose diode leads and their metalization had been lifted away from the ceramic. In a further effort to resolve the problem, MicroSemiconductor obtained some ceramic wafers from Ceramics for Industry (CFI) which consisted of a nickel strap brazed to moly-manganese metalization. Eleven microelements were assembled with these ceramic wafers, by MicroSemiconductor, and submitted to RCA, Somerville for further evaluation. Ten of these diode microelements were placed in an oven at 200°C. These elements were visually inspected and electrically tested after 400 hours. There were no degradational or catastrophic failures. Based on these results MicroSemiconductor was authorized to proceed with Phase III. MicroSemiconductor fabricated and placed a sufficient number of diodes on 1000-hour temperature aging to supply the 300 test elements required for Phase III.

1N750A Microseal Zener Diode

Hughes fabricated and has placed a sufficient number of Zener diodes on 1000-hour temperature aging to supply the 300 test elements required for Phase III.

The four Phase II test elements which exceeded the maximum Zener-voltage limit after completing 1000 hours of storage-life test were analyzed; internal failures were discovered. Hughes performed a failure analysis on these elements and ascertained that the increased Zener voltage and the accompanying increase in dynamic impedance were caused by the development of high internal resistance paths. As part of their recommended corrective action, Hughes indicated it would perform a dynamic forward test on each diode to measure the current carrying capability. This procedure would eliminate those diodes exhibiting poor internal contact. On the basis of this failure analysis and subsequent recommended action, Hughes was authorized to proceed with Phase III.

Diode Mounting

During this quarterly period, weld settings and welding techniques were developed and test samples were fabricated.

Effort was directed toward establishing wafer metalization requirements. Best results have been obtained when the substrates were metalized with a molymanganese base plate, an over-plate of nickel, and finally a gold flash. Weld settings have been established for wafers with standard plating, i.e., the nickel plating that is provided with the standard microelement product. Wafers with additional nickel plating (approximately .002 inch) have also been procured and are presently being evaluated. The additional nickel plating is believed to enhance the welding characteristics of the wafer. Test samples are presently being fabricated for verification.

A pull-strength-measuring technique was established to evaluate the bond strength; pull strength samples of the four diode types under evaluation were fabricated and tested with the following results:

Texas Instruments, TI 254 Micro "G" Diode — A weld pull-strength of four pounds resulted with optimum welding parameters.

Transitron, TMD 20 Micro-Diode — The weld pull-strength was measured at 2.2 pounds which is approximately equivalent to the strength of the .004 inch palladium, ribbon lead material.

Pacific Semiconductor, 1N2206 Micro-Diode — An average weld pull-strength of four pounds was obtained.

Samples of five diode types have been successfully welded to ceramic wafers. A brief status of these diode types follows:

Texas Instruments, TI 254 Micro "G" Diode — Diodes with gold plated rodar leads have been procured. Difficulties were previously encountered in welding the round rodar lead which is standard for this diode type. Fabrication of the test samples will start in the next quarterly period.

Transitron, TMD-20 Micro-Diode — The 150 test diodes have been welded to 50 ceramic substrates (3 diodes per substrate). These samples are currently being subjected to mechanical and environmental tests.

Pacific Semiconductor 1N3206, Micro-Diode — Fabrication of the 150 test diodes has been initiated and is 50 percent complete.

MicroSemiconductor, 1N3206 Micro-Diode — Initial effort was expended in establishing parameters for welding the silver leads on this diode type. Consistent welds were not obtained, and it was decided to specify a diode lead material which could be welded more consistently. These diodes are now being procured with gold-plated Kovar leads. During the next quarterly period, pull-strength tests will be performed to establish the optimum welding parameters; assembly of the test diodes will then be initiated.

Clevite 1N277 (equivalent) Micro-Diode — Although not a part of the prescribed test program, this diode type with round Dumet leads was evaluated and welding parameters were established. Test samples were fabricated, and a pull-strength of four pounds resulted. This evaluation demonstrates the broad capability of the welding techniques as developed under this program.

3.4 CRYSTALS

The purpose of the crystal Production Engineering Measure under Program Extension II is to develop sources of microelement crystals and to resolve processing problems associated with crystal production. The first PEM phase was an analysis phase in which three suppliers (Midland, Bulova, and McCoy) produced and tested sample microelement crystals to demonstrate capability. Samples were encapsulated in test modules and evaluated. Each supplier submitted a process analysis report, including test data. The reports and test results were used to determine the extent of production facilitation required.

A pre-implementation phase was established to incorporate and demonstrate design revisions suggested during the analysis phase. Midland has successfully completed the pre-implementation phase and is proceeding with the implementation phase.

3.4.1 MIDLAND MFG. CO.

Midland has completed the fabrication of the required 63 preproduction samples. A purchase order for preproduction testing was issued to Victor Electronics; Group-A, -B, and -C tests have been started. It was decided to introduce an additional electrical measurement after 30 days of life test. The reason for this action is to expedite the early approval of pilot-run fabrication.

Midland has resolved the problems experienced in the crystal blank-tabbing process. Rayon silk screens have been replaced by stainless steel screens supplied by RCA along with complete instructions on the screening process. Crystals with low-equivalent series resistance now can be fabricated by this process. A change in the Hanovia silver firing process was necessary to assure uniform adherence. This action was prompted by the low yields obtained resulting from poor adherence of the metalization. The firing process now provides a free flow of oxygen which is necessary for proper firing of the Hanovia silver.

Midland has planned to seal the crystal cavities by means of a solder-seal process involving resistance heating. This method did not produce satisfactory results. Contact resistance, nonuniform heating, and the need to use flux resulted in flux deposits, solder splashes on the crystal, and caused changes in frequency and other operating parameters after final adjustment.

Midland also sealed crystals by means of induction heating. An induction-heating coil, designed by RCA, was made available to Midland for use in this process. This heating was done in a vacuum chamber to reduce the equivalent series resistance. In addition, the oxidation of the solder was reduced by providing a forming-gas atmosphere, which eliminated the need to use flux. Because of the limited availability of the induction heating equipment, Midland has reverted to the use of an earlier sealing process. This method involves placing the crystal package on a hot-plate under atmospheric conditions.

The packages were tinned with the use of a water-soluble flux which was boiled-off after tinning in distilled water. The boiling of the flux in distilled water caused adverse solder conditions, and the process was changed to ultrasonic cleaning in PC Freon.

Close quality control was introduced during the early process stages to eliminate the possibility of obtaining unreliable crystals. These controls were primarily instituted to assure good adherence of the Hanovia silver.

Mitronics experienced an extremely low yield in its crystal package fabrication. A meeting between RCA and Mitronics was held to improve this condition. As a result, two design changes were made:

a. The pin location was changed from the vulnerable center notch area to the corner where considerable more wall thickness is available.

b. The thickness at the bottom of the cavity was increased from 0.010 inch to 0.020 inch to facilitate the process of the ceramic substrate.

The above changes will probably result in an over-all microelement crystal height of 0.065 inch instead of the present .060 inch.

3.4.2 BULOVA ELECTRONICS DIVISION

Bulova issued a purchase order to Isotronics, Inc. for ceramic crystal packages. An inspection of some sample packages showed that suitable units could be made with minor process changes. Isotronics will deliver to Bulova, early next quarter, a sufficient number of usable packages for the fabrication of 15 analysis-phase samples.

3.5 MATERIALS AND TERMINATIONS PROGRAM EXTENSION II, PEM

3.5.1 MATERIALS

Objectives and Status

Work is being performed under Program Extension II, Production Engineering Measure on encapsulation, coating, and marking. The object of this work is to develop processes which will minimize cost, improve module yield and reliability, and be adaptable to a high rate of production.

3.5.1.1 ENCAPSULATION

The encapsulation process has been demonstrated, established, and has been incorporated in production. It was found that good encapsulant-adhesion is assured if the surface of the shell is roughened to a dull-matt finish. However, this additional roughening operation is estimated to cost 2 1/2 to 3 cents more in the cost of each shell if done by the vendors.

3.5.1.2 COATING

The coating process has been demonstrated, established, and incorporated in production. A coating specification has been written.

A series of tests were performed with red fluorescent dyes dissolved in methyl ethyl ketone. These solutions were then mixed with DC271M-11. The dyes used in these tests were American Cyanamid:

a. Calcozine Red BX

b. Calco Rhodamine Base

c. Calcozine Red 6GX

Unencapsulated dummy test modules were used containing two coils and substrates. The modules were then coated with the above dye solutions in accordance with Specifications 2025808. After coating, the modules were carefully taken apart and examined under an ultra-violet light. Although, all of the components showed complete coverage, there was evidence of variation in the degree of coverage. This method could be periodically used on control modules; American Cyanamid Calcozine Red BX dye is recommended for this use.

3.5.1.3 MARKING

Some difficulties in marking were encountered because the .003-inch face type did not meet the height specification of .918-inch ±.0005 inch. This type was returned to the Acromark Company for correction. Other changes involved:

a. installation of fire rods to maintain more uniform temperatures.

b. installation of low-pressure regulators for better pressure control and

c. addition of hardened-steel inserts in the type holders.

Twenty-three production modules were marked with good clarity with the following marking parameters; pressure of 10 pounds, a head temperature of 475°F to 525°F, a dwell time of 1.0 to 1.3 seconds on the front stage and 3 to 4 seconds on the back stage and a speed of one-quarter turn.

3.5.1.4 SEALING TRIMMER CAPACITORS

A practical method for sealing trimmer capacitors was established and a manufacturing specification is being prepared. The process involves the following operations:

a. Eccobond #98 (B-stage epoxy resin) powder is poured into annular-ring cavities located in a RTV60 mold.

b. The mold is placed in an 100°C oven until the powder in the ring cavities is melted.

c. The mold is removed from the oven and one end of each of the epoxy glass sleeves is quickly inserted into a cavity.

d. After cooling to room temperature, the sleeves are removed from the mold. The end of the sleeve that was inserted in the melted resin, is checked for the presence of a film of the resin around the perimeter of the sleeve.

e. The trimmer capacitor is then placed face up in the cavity of a jig.

f. The sleeve is placed over the end of a centering pin. The sleeve and centering pin are then slipped over the trimmer, positioned, and the centering pin removed.

g. The jig is then placed in a 100°C oven for five minutes until a bond is made.

h. The jig is removed from the oven, cooled, and then the trimmer assembly removed from the jig.

i. The sleeve is filled with RTV60 and cured to complete the sealing process.

3.5.2 TERMINATIONS

Summary and Status

The work on terminations in the analysis phase of Program Extension II, PEM for micro-modules was divided into four subtasks as follows:

a. Solder-process analysis

b. Cleaning-process analysis

c. Metalizing standardization

d. Post Termination

The tasks on solder-process analysis, metalizing standardization, and cleaning-process analysis of a group of transistors have been completed.

The progress on the PEM solder-process and metalizing standardization tasks is discussed in "Micro-Module Assembly" in Section 3.6.2. The PEM Post Termination task is complete. In this report, the PEM micro-module cleaning task is discussed in detail.

3.5.2.1 FOUR-STAGE ULTRASONIC CLEANING EQUIPMENT

Micro-modules constructed under the PEM Program are cleaned in a four chamber console-type cleaning machine designed and built by the National Ultrasonic Corp. The modules are cleaned in four stages as follows:

a. The first stage consists of mechanical agitation of PC Freon to remove the bulk of the soluble spacers and resin flux.

b. The second stage ultrasonically agitates the modules in PC Freon to loosen and remove minute particles.

c. The third stage consists of spraying PC Freon on the modules to insure removal of any remaining particles.

d. The fourth stage consists of rinsing the modules clean with condensed vapors of TF Freon. The modules leave this operation dry and are ready for encapsulation.

3.5.2.2 PRESENT STATUS OF PEM CLEANING EQUIPMENT

Forty lots of modules, averaging 25 modules per lot, have been processed through the cleaning equipment. Eight lots were rejected because they did not meet the residual-flux specification of 0.01 milligram per element. A 10-element module can contain no more than 0.10 milligrams of residual flux.

Several of the rejected lots have had flux residues as high as 0.34 and 0.82 milligram. In these cases, the modules were left overnight, or over a weekend, before they were cleaned. This time delay before cleaning allows the flux to polymerize and become increasingly insoluble. Specification 2025882 was modified to specify an eight-hour maximum allowance time prior to cleaning.

To reduce solvent loss, lip-vent seals were designed, built, and are now ready for installation on the machine. A price quotation for the purchase of an explosometer safety device was obtained. A quality control procedure was established for determining the amount of flux residue in a module.

3.5.2.3 TRANSISTOR CLEANING PROGRAM

A cleaning program was conducted to determine if the new ultrasonic-cleaning machine caused any detrimental effects on the microelement transistors.

Twenty of each of two transistor types were mounted on microelement substrates. One type was the 2N917, silicon planar ultra-high frequency transistor mounted in a TO-18 can; and the other, was the 2N1708, silicon planar, epitaxial very-high frequency transistor mounted in a TO-46 can. Each microelement transistor was assembled between two substrates to form a test module (total of 20 modules for each of the ten types).

Data were recorded on each transistor after it was mounted on the substrate, after assembly into a test module, and after cleaning in the new ultrasonic-cleaning equipment. These data are shown in Tables 3.5.2-1 and 3.5.2-2. The cleaning was done in accordance with Specification 2025882; this procedure has not yet been standardized. There was no transistor damage as a result of cleaning the units in this machine.

TABLE 3.5.2-1.
SUMMARY OF DATA ON 2N1708 TRANSISTORS AFTER VARIOUS STAGES OF PROCESSING

TYPE 2N1708	AFTER ASSEMBLY ON SUBSTRATES		AFTER ASSEMBLY IN MODULE		AFTER CLEANING	
	B (Beta)	V_{sat}	B (Beta)	V_{sat}	B (Beta)	V_{sat}
1	58	0.14	91	0.15	95	0.175
2	56	0.16	53	0.17	55	0.16
3	26	0.20	34	0.20	35	0.20
4	71	0.15	71	0.15	67	0.15
5	55	0.18	54	0.19	56	0.18
6	55	0.17	95	0.21	91	0.165
7	100	0.16	100	0.16	100	0.16
8	67	0.16	63	0.16	63	0.16
9	91	0.16	54	0.17	54	0.17
10	77	0.16	74	0.17	74	0.17
11	47	0.19	47	0.20	48	0.18
12	52	0.16	50	0.17	50	0.16
13	56	0.17	54	0.20	53	0.175
14	57	0.17	67	0.19	67	0.175
15	48	0.17	48	0.18	46	0.175
16	57	0.16	62	0.18	61	0.165
17	72	0.16	69	0.18	74	0.16
18	56	0.16	56	0.17	56	0.165
19	56	0.18	54	0.19	53	0.18
20	83	0.14	87	0.16	77	0.15

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TEST CONDITIONS

B at Ic = 10 ma Vce = 1 V

V_{sat} at Ic = 10 ma Ib = 1 ma

TABLE 3.5.2-2.
SUMMARY OF DATA ON 2N917 TRANSISTORS AFTER VARIOUS STAGES OF PROCESSING

TYPE 2N917	AFTER ASSEMBLY ON SUBSTRATES		AFTER ASSEMBLY IN MODULE		AFTER CLEANING	
	β (Beta)	V_{sat}	β (Beta)	V_{sat}	β (Beta)	V_{sat}
1	93	0.12	94	0.14	83	0.12
2	63	0.15	63	0.16	64	0.15
3	24	0.22	24	0.22	24	0.22
4	42	0.14	33	0.16	39	0.16
5	29	0.19	27	0.20	26	0.19
6	71	0.16	39	0.20	68	0.19
7	25	0.21	24	0.23	23	0.20
8	75	0.14	75	0.14	75	0.13
9	38	0.19	68	0.17	64	0.20
10	53	0.14	53	0.16	52	0.15
11	30	0.17	43	0.18	34	0.175
12	26	0.22	28	0.23	24	0.17
13	31	0.20	31	0.21	29	0.18
14	26	0.22	27	0.23	26	0.165
15	33	0.18	33	0.19	33	0.185
16	75	0.14	72	0.15	71	0.18
17	60	0.15	60	0.16	58	0.15
18	108	0.14	107	0.14	116	0.13
19	25	0.22	26	0.23	26	0.23
20	28	0.23	26	0.23	27	0.22

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TEST CONDITIONS

β at Ic = 3 ma Vce = 1 V

V_{sat} at Ic = 3 ma Ib = 0.15 ma

3.6 MICRO-MODULES

3.6.1 RELIABILITY

3.6.1.1 TASK 25A MODULES (RADIO SET AN/PRC-51)

Ninety-nine Task 25A micro-modules were placed on operating-life test with junction temperatures maintained at 85°C. These communications modules have completed a total of 5,554,000 element-hours of test with no catastrophic failures; there have been two degradational failures. One module failed due to a drop in current gain (beta) of a transistor, and the other unit is undergoing further reject analysis. Each of the remaining 97 modules has been on test for 4792 hours. The MTBF for a 10-element Task 25A module is 176,900 hours calculated at a 60 percent confidence level. On a per-element basis, this is a failure-rate of .056 percent per 1000 hours. Life testing on the 97 modules is continuing.

3.6.1.2 TASK 25B MODULES (COMPUTER SET, DIGITAL DATA, GENERAL-PURPOSE MICROPAC)

One hundred and seventy-six Task 25B modules were placed on operating-life test at 90°C and 95°C ambient. This ambient temperature, coupled with the power dissipation of each module, resulted in an average junction temperature of 110°C. These digital modules have completed 16,760,000 element hours of operating-life test. There were two catastrophic failures. One module suffered a catastrophic failure due to a loose diode-to-wafer joint, and another because of an intermittent contact in a Zener diode. The MTBF for a 10-element module is 527,000 hours calculated at 60 percent confidence. On a per-element basis, this is a failure-rate of .018 percent per 1000 hours. All of these modules have been removed from life test.

3.6.1.3 COMBINED RESULTS FOR TASK 25A AND 25B MODULES

Combining the results of the Task 25A and 25B tests, a total of 22,314,000 element-hours have been reached. Two modules suffered catastrophic failure and two modules suffered degradational failure during these tests. The MTBF for a 10-element Task 25 module is 425,800 hours calculated at 60 percent confidence. On a per element basis, this represents a failure rate of 0.023 percent per 1000 hours.

3.6.1.4 SOLDER-JOINT RELIABILITY

Over 250 million joint-hours of test have been logged during micro-module and micro-element operating-life tests. No solder joints have failed during this testing. At a 60 percent confidence level, a solder joint failure-rate of .00036 percent per 1000 hours has been demonstrated.

3.6.1.5 ENVIRONMENTAL TESTS

Forty-eight Task 25 micro-modules have been subjected to environmental tests shown in Table 3.6.1-1.

All 48 modules survived these tests without electrical failure or degradation.

3.6.1.6 REJECTED-MODULE ANALYSIS, MICROPAC SUBASSEMBLY TEST FAILURES

Of the 15 modules returned as failures, 11 were damaged during subassembly tests. Corrective actions have already been taken as a result of the four which failed for other reasons.

TABLE 3.6.1-1.
ENVIRONMENTAL TESTS FOR TASKS 25A AND 25B MICRO-MODULES

NUMBER OF MODULES		TYPE OF TEST	LIMIT	SPECIFICATION
TASK 25A	TASK 25B			
8	8	Shock	50 g	MIL-STD-202A, Method 202A
		Vibration	55 cps	MIL-STD-202A, Method 201A
		Salt Spray	96 hrs	MIL-STD-202A, Method 101A
8	8	Moisture Resistance	10 days	MIL-STD-202A, Method 106A
8	8	Altitude	150,000 ft	MIL-STD-202A, Method 105A
		Vibration	2,000 cps	MIL-STD-202A, Method 204A

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A summary of the reject analysis on these modules follows:

MODULE TYPE	SERIAL NO.	DEFECTIVE COMPONENT
XM-724	52	Shorted Diodes CR1, 2, 3, 4
XM-724	175	Shorted diode CR4
XM-724	43	Shorted diodes CR1, 4
XM-710	81	Burnt-out transistor
XM-708	161	Loose resistor metalization R4
XM-708	165	Punched-through transistor
XM-724	19	Punched-through transistor
XM-724	176	Incorrectly stamped
XM-726	10	Open Diodes
XM-724	70	Shorted diode
XM-741	127	Intermittent diode
XM-741	199	Burnt-out transistor
XM-741	321	Punched-through transistor
XM-1026	108	Two burnt-out transistors
XM-741	204	Open resistor

3.6.2 MICRO-MODULE ASSEMBLY

3.6.2.1 OBJECTIVE AND STATUS

The analysis phase of Program Extension II, PEM for micro-modules had as its objective the development of a module-assembly process suitable for implementation as a micro-module production facility. This phase is complete except for final life test readings of the final-grade I-F module. The implementation phase of this PEM for modules has as its objective the design and procurement of module-assembly facilities in accordance with the above established module-assembly processes. The design of these facilities is complete and their construction and installation are nearing completion.

3.6.2.2 MICRO-MODULE STACKING AND SOLDERING

Microelement handling trays, precision headers, and soluble-spacer fabrication tools have been procured and released to production. The semi-automatic dip-soldering machine has been constructed and released to production. Operating procedures have been written and released.

3.6.2.3 MICROELEMENT TESTING

Design, procurement, construction, and installation of all element test facilities is essentially complete.

Micro-Module Testing

Design, construction, and installation of the digital module test set and the communications module test set are essentially complete; final run-in tests and installation remain to be completed.

3.6.2.4 PROCESS INTEGRATION

A technique for sealing of trimmer capacitors, prior to module assembly, has been established. This technique is presently being evaluated for compatibility with module-assembly process. This method is further discussed in Section 3.5.1 of this report.

Grayhill Moldtronics and Hermitage Plastics have acquired tooling to supply shells for modules. Approval samples from both vendors have been received and are presently being inspected.

Procedures have been coordinated and written for all micro-module assembly operations.

3.6.2.5 MICRO-MODULE SUBCONTRACTORS

Mallory

Design and construction of all module-assembly facilities are nearly complete. Additional fault checking and/or correction is required on the module-stacking machine and on some of the microelement test equipment.

Installation of all equipment is about 90 percent complete.

Paktron

Design and construction of all module-assembly facilities is essentially complete. Minor fault correction still remains on the module assembler and on the riser-wire segment cutter. Installation of equipment is estimated as 90 percent complete.

Pilot-Run Modules (Task 39)

Module types DM-3 and XM-1364 have been established as the types to be produced under this task. Final component drawings and specifications are being prepared.

3.6.3 MICRO-MODULES FOR PROGRAM EXTENSION II EQUIPMENT

3.6.3.1 COMMUNICATIONS MICRO-MODULES (RADIO SET AN/PRC-51) TASK 25A

All of the 99 Group-C test modules were scheduled to complete 5358 hours of life test on March 31. At the 4000-hour check point, two XM-1085 converter modules were found degraded. One failure was caused by the microelement crystal, and the second resulted from transistor degradation. The remaining 97 modules will continue on extended-life tests to 10,000 hours.

3.6.3.2 DIGITAL MICRO-MODULES FOR THE MICROPAC COMPUTER TASK 25B

Life testing on Task 25B is complete. The remaining 17 modules that were still on life test were removed after completing 10,000 hours of operation. Satisfactory operation at room temperature was verified.

There are 40 modules remaining to be delivered against the 162 ordered as spares. Lack of components, particular transistors, has caused a delay in deliveries.

3.7 AN/PRC-51 RADIO SET

This task has been completed except for the submission of the combined final report on this radio set and its micro-modules.

3.8 THE MICROPAC COMPUTER

3.8.1 SYSTEM INTEGRATION AND TEST

During the early part of January, the MICROPAC Computer was returned from the environmental chamber to the laboratory in order to make various modifications. The changes made were as follows:

1. The thermostat in the power supply was set to open at 94°C instead of 81°C.

2. The temperature stability of the -18 v and -9 v special supplies was improved by installing a Zener diode with better stability.

3. L-C type filters were added in each leg of the low power heater supply to reduce radiation.

4. A 500 uuf capacitor was added to the V_T supply to improve its regulation.

A plot of +18 v versus +6 v was made to establish an optimum operating point for the logic circuits. The allowable operating area was quite large, indicating that operation was not marginal from this criteria. A similar plot of drive current versus sense amplifier sensitivity was made. This plot indicated a wide range in the drive current direction and a narrow range in the sense amplifier sensitivity direction. This narrow range was due to low output from the sense windings.

Full operation in the transit case at room temperature was achieved after providing vents above the memory stack thermo-electric cooling unit and along the side of the power supply. These tests were not witnessed by the Signal Corps. The vents are provided with covers for protection when not operating. Effort was suspended after January 14, 1963 in accordance with a Signal Corps directive.

Work was resumed during the month of March to determine what, if any, mechanical and/or electrical rework is necessary in order for the MICROPAC Computer to be operable over the required ambient temperature range of -30°C to +52°C. Measurements were taken of both temperature and air flow. From these tests the mechanical changes required to obtain satisfactory thermal operation were determined. In addition, it was determined that a worst case temperature differential of ±4.5°C might exist within the memory stack enclosure. It also was found that the sense amplifiers meet all of the requirements and do not require any redesign.

3.9 SPECIFICATIONS, STANDARDS, AND RELIABILITY

3.9.1 SPECIFICATION ACTIVITY

The following table exhibits a summary of actions relative to specifications for the various tasks of the Micro-Module Program through March 31, 1963. In contra-distinction to previous quarterly reports, only those specifications which are still active are included in this table. The cancellation of twenty-eight specifications during the twentieth quarter has reduced the gross number of actions from the 393 mentioned in the nineteenth quarterly report to 214. To this number are to be added the 30 actions which have been taken during the twentieth quarter.

	Specifications Issued	No. of Actions To Date	Actions in 20th Quarter Only
Specifications neither amended nor revised	33	-	-
Specifications revised or amended once	17	17	-
Specifications revised or amended twice	7	14	-
Specifications revised or amended three times	11	33	-
Specifications revised or amended four times	9	36	-
Specifications revised or amended five times	4	20	-
Specifications revised or amended six times	1	6	-
Specifications revised or amended seven times	0	0	-
Gross number of revisions or amendments	—	126	-
Number of original specifications	118	118	2
Gross number of actions on specifications	-	244	30
Number of cancelled specifications	36	-	28

3.10 SUBCONTRACT ACTIVITIES

3.10.1 INTRODUCTION

Subcontract activities include administrative and technical support for the development of microelement and micro-module sources throughout industry. The subcontracting activity is responsible for evaluating both participating and prospective suppliers to insure use of the latest state-of-the-art processes and products.

3.10.2 INDUSTRY LIAISON AND SUBCONTRACT FOLLOW-UP

Supplier liaison activity was provided to assist in resolving various problems in procedure and production facilitation which arose during PEM preproduction and pilot-run programs on microelements and modules. Additional visits were made to coordinate vendor activities and insure proper quality and schedule performance. A tabulation of the various vendor contacts is given below.

An RCA mechanization consultant visited Aerovox, Coors, Mallory and Paktron to assist in assessing the probability of success of these major production facilitation programs. These visits have resulted in a general approval of the methods employed by the subcontractors along with certain recommendations to improve performance. With the exception of Coors, it is anticipated that established schedules can be met.

An informal conference with Mallory and Paktron was held at RCA to review recent revisions in microelement specifications, status of PEM vendors, and general problem areas. While no major problems were disclosed, the conference insured that immediate advantage could be taken of the revised specifications.

Preparations are being made by RCA to release a specially designed notch metalizing machine which will be for sale to the industry, including all vendors involved in the program. This machine is expected to permit cost reduction of microelements and metalized substrates.

3.10.3 PRESENTATIONS

The following Presentations of Micro-module Techniques, Characteristics, and Applications were made by RCA personnel during this quarterly period.

Date	Location and Personnel
January 25	To Lt. Col. Jack Cole and staff of the Electronics Division, U. S. Army Combat Development Command, Fort Belvoir, Virginia, by Messrs. T. J. Tsevdos and D. Mackey of RCA, SurfCom, Camden, N. J.
February 20	To members of the staff of Rome Air Development Center at Rome, N. Y., by D. Mackey and L. Potter of RCA, SurfCom, Camden, N. J.

Date	Location and Personnel
February 27	To Mr. H. Reed of the Naval Ordnance Laboratory, White Oak, Maryland, by R. M. F. Bondy and Mr. S. Stimler.
March 5	To the U.S. Army Missile Command at Huntsville, Alabama, by R. E. Koehler and B. V. Vonderschmitt of RCA, S&MD and M. F. Bondy of RCA, SurfCom.
March 8	To Mr. James Bridges, Department of Defense R&E at Washington, D.C., by D. Mackey of RCA, SurfCom.

3.10.4 TASK MEETINGS

Date	Location	Task Discussed
January 4	RCA, Somerville, N. J.	Micro-modules
January 8	Signal Corps, Ft. Monmouth, N. J.	Resistors
January 30	RCA, Camden, N. J.	Quartz Crystal Elements
February 5	Signal Corps, Philadelphia, Pa.	Capacitors
February 7	RCA, Somerville, N. J.	Passive Parts
February 7	Signal Corps, Fort Monmouth, N. J.	Transistors
February 8	RCA, Camden, N. J.	Semiconductors
February 14	Signal Corps, Philadelphia, Pa.	Capacitor Specifications
February 15	Signal Corps, Fort Monmouth, N. J.	Resistors
March 8	Signal Corps, Philadelphia, Pa.	Module Assembly
March 22	RCA, Camden, N. J.	Semiconductors

3.10.5 COMPANIES VISITED BY RCA PERSONNEL

DATE	COMPANY	TASK DISCUSSED
January 10, 12	Aerovox, Olean, N.Y.	Capacitors
January 11	Philco, Lansdale, Pa.	Transistors
January 14, 18	American Lava, Chattanooga, Tenn. Coors Porcelain, Denver, Colorado	Metalized Substrates
January 21, 24	Midland Mfg., Kansas City, Kan. Radio Industries, Chicago, Ill.	Crystals Inductors
January 21, 25	Sperry Semiconductor, Norwalk, Conn.	Transistors

DATE	COMPANY	TASK DISCUSSED
January 28, 30	General Electric, Syracuse, N.Y.	Transistors
February 7, 9	Microlectron, Santa Monica, Calif.	Resistors
February 11, 15	Philco, Lansdale, Pa.	Transistors
February 18, 22	Coors Porcelain, Golden, Colo.	Metalized Substrates
February 20	Cambion, Cambridge, Mass.	Inductors
February 25	Sperry, Norwalk, Conn.	Transistors
February 25, 27	Texas Instruments, Dallas, Texas	Transistors
February 26	Isotronics, Lodi, N.J. Molecular Dielectrics, Clifton, N.J.	Crystals Inductors
February 28	Paktron, Alexandria, Va.	Module Assembly
March 1	Mallory, Indianapolis, Ind.	Module Assembly
March 8	Philco Lansdale, Pa.	Transistors
March 13	Sperry, Norwalk, Conn.	Transistors

3.10.6 VISITORS TO RCA, SURFCOM, CAMDEN, N. J.

Date	Visitors	Purpose of Visit
January 10	Mr. Kurkjian of Hughes Aircraft Company	To learn of micro-module techniques, characteristics, and applications.
February 18	Captain Balabin, Office of Naval Research	Discussion of microelectronic concepts, techniques and applications.
March 7	Representatives of Fairchild Semiconductor Corp. Mountain View, California	Discussion of integrated circuits and micro-modules.
March 19	Mr. Senicourt of Compagnie, Generale de Telegraphie Sans Fil of France	Discussion of micro-module characteristics and applications.
March 19	Representatives of Motorola Semiconductor Products, Inc. Phoenix, Arizona	Discussion of integrated circuits and micro-modules.

Date	Visitors	Purpose of Visit
March 21	Mr. E. O. Smith of the Department of Canadian Defense Production, Ottawa and Mr. Abby Cohen of RCA Victor, Ltd., Montreal, Canada	Discussion of micro-module characteristics and applications.

3.10.7 VISITORS TO RCA SEMICONDUCTOR AND MATERIALS DIVISION, SOMERVILLE, N. J.

DATE	COMPANY	PURPOSE OF VISIT
December 6	Hughes Aircraft, Santa Monica, Cal.	Discuss Diodes
December 11	Philco, Philadelphia, Penna.	Discuss micro-modules for computer use
December 17	Arvin Industries, Columbus, Ind.	Discuss micro-modules applications
December 27	Motorola, Chicago, Ill.	Discuss micro-modules
January 24	Burroughs Corp., Detroit, Mich.	Micro-Module Conference
January 31	Westinghouse Corp., Baltimore, Md.	Discuss micro-modules

4. CONCLUSIONS

4.1 CAPACITORS

Preporduction delivery requirements of multilayer capacitors were completed by Aerovox. A sufficient amount of test data has been obtained to resolve the moisture resistance problem which was encountered by Aerovox while testing its precision type multilayer capacitors. One lot of these capacitors, coated with phenolic resin and wax impregnated, withstood the moisture test with no failures, in contrast to other lots hasving DC-271 coatings. Analysis of test data is continuing. Results of tests, completed at the end of this quarter, on Aerovox multilayer capacitors having extended temperature coefficients, have been satisfactory.

4.2 RESISTORS

Initial testing of four-element Paktron utility resistor microelements has indicated that they are well within specified noise requirements.

The noise level on 600 type MF3C tubular metal-film resistors, from Electra Mfg. Co., was not as low as on samples measured during the initial screening test. The required extremely thin metal film and the spiraled path cut on the surfaces on these very small resistors, to produce the proper resistance, are given as two probable reasons for the somewhat greater noise level as compared with their very much larger conventional counterparts.

At the 1000 hour test point the maximum change in resistance was 1.5% and the average was 0.4% among the 769 resistance paths in Microelectron semi-precision resistors now on load life test. All units are expected to be within tolerance at the 2000 hour reading.

4.3 INDUCTORS

Test results on 20 prototype medium frequency inductor microelements submitted by Collins Radio were satisfactory.

Tests of Cambridge Thermionic microelement inductors mounted in deep glass-mica substrates are compatible with current micromodule assembly techniques.

It has been concluded that with heavy polyurethane wire insulation, Aladdin transformers can pass the specified life test requirements.

4.4 SEMICONDUCTORS

In the development of diode mounting techniques, best results have been obtained with wafers metalized with a base plate of molybdenum-manganese, an over plate of nickel, and a gold flash.

4.5 MICRO-MODULES

Communication micro-modules now have an indicated mean time-between-failures, (MTBF) of 177,000 hours at a 60% confidence level as a result of completing 5,554,000 hours of life testing during which no catastrophic and two degradational failures occurred.

Digital micro-modules (such as the MicroPac Computer Modules) have completed 16,760,000 hours with 2 catastrophic failures, thus indicating an MTBF of 527,000 hours at 60% confidence.

4.6 THE MICROPAC COMPUTER

Before temporary suspension of work on the equipment on January 14, full operation of the MicroPac Computer in its transit case at room temperature had been achieved after providing vents above the thermoelectric cooling unit in the memory stack and along the side of the power supply.

Upon resumption of work during March it was found that the sense amplifiers do not require redesign since they meet all requirements. Tests indicated that a temperature differential as large as ±4.5°C might exist within the memory stack enclosure under the worst conditions. Tests also indicated what changes in mechanical design were required to obtain satisfactory operation over the stipulated range of temperature.

5. PROGRAM FOR NEXT PERIOD

5.1 ADMINISTRATION

Monitoring of all phases of the PEM Tasks of Program Extension II will be continued. Revisions of design plans of the various tasks will be made when and if required.

5.1.1 PROGRESS CHARTS

The submission of Technical and Financial Progress Charts will be continued on the current monthly basis.

5.1.2 REPORTS

The 20th Quarterly Report, covering the months of January, February, and March, 1963, will be prepared. Monthly Letter Progress Reports for March, April, and May, 1963 will be submitted.

A draft of the remaining two sections of the Micromodule Design Guide will be reviewed by the Signal Corps. Publication of thc Design Guide is anticipated by the end of the next period.

5.2 PASSIVE COMPONENTS

5.2.1 CAPACITORS

Aerovox will complete pilot- run fabrication and Group-A testing; Group-B and -C testing will be started. The moisture-resistance evaluation will be completed. Aerovox will also prepare a final report for submission to RCA.

Cornell-Dubilier will complete fabrication of all pilot-run lots. Group-A tests will be completed and most of the environmental and life tests will be completed. A final report will be submitted to RCA for review.

Astron and Sprague will submit preproduction test data for approval.

Centralab will complete the pilot-run fabrication; Group-A testing, Group-B and -C tests, and the preparation of final report will also be initiated.

Coors will perform its preproduction tests on at least 100 metalized substrates early next quarter. Preproduction and pilot-run fabrication will be completed.

5.2.2 RESISTORS

Group-A and Group-B tests on Electra precision resistors will be completed at RCA, Somerville. Group-C, load-life testing will be started at Electra.

Microlectron will complete its pilot-run tests and submit its final report.

CTS will produce pilot-run parts and begin the pilot-run test program. Preparation of final report will be initiated.

Paktron will build qualification test samples, and begin its test program.

5.2.3 INDUCTORS

During the next quarterly period the following subcontracts for the following items will be completed:

a. Aladdin - Microelement pulse transformer.

b. Cambridge Thermionic - High-Frequency and Very-High-Frequency Microelement Inductor.

c. United Transformer - Top Element Audio Transformer.

Collins Radio will complete Group-B tests and the first 1000 hours of Group-C tests on its medium-frequency and high-frequency microelement inductors. They will also submit a draft of the final report on the high-frequency inductor subtask.

Radio Industries will complete Group-B test and the first 1000 hours of Group-C test. Analysis and improvement of the encapsulation procedure also will be undertaken by this company.

5.3 SEMICONDUCTOR DEVICES

5.3.1 TRANSISTORS

Texas Instruments and Sperry Semiconductor will complete the life testing associated with their Phase III test programs. The test data will be evaluated to demonstrate conformance to the specifications established at the conclusion of Phase II. A final report will be submitted by each of these subcontractors to conclude the Phase III effort.

Philco and General Electric will complete the life testing associated with their Phase II test programs. The test data will be evaluated to determine whether the test elements conform to the respective electrical specifications. Based on the data obtained as a result of the Phase II effort, a final specification will be negotiated. Both companies will submit final reports on their subcontracts.

The major specification changes recommended by RCA, Somerville, for the 70-Mc VHF power transistor will be evaluated; a final specification will be established for this device.

RCA, Somerville, will complete all Phase II Group-B mechanical and environmental tests and Group-C life tests on the TA-2029 germanium transistor. The fabrication of an additional quantity of TA-2229 germanium transistors necessary to supply the 200 test elements required for Phase II will be completed.

The ultrasonic cleaning test program will be initiated. The semiconductor types to be evaluated under this program will be tested, cleaned, and evaluated to determine the effect of ultrasonic cleaning.

5.3.2 DIODE

Fairchild, MicroSemiconductor and Hughes will complete the 1000-hour high-temperature aging on their respective microelement diodes. These subcontractors will start their Phase III acceptance testing programs.

The 200 test microelements to be evaluated under the diode mounting task will be assembled. All mechanical, environmental, and life testing will be performed to evaluate the welding technique.

5.4 CRYSTALS

Midland will complete preproduction testing. Fabrication of pilot-run samples will start after approval of preproduction test samples.

5.5 MICRO-MODULE ASSEMBLY

Procurement and installation of all module-assembly facilities will be completed. Parts procurement for the micromodule pilot run (Task 39) will be started.

5.6 MICRO-MODULES

5.6.1 MODULE CLEANING TASK

The following items will be completed:

a. Procurement of an explosometer for cleaning machine.

b. Installation of lip-vent seals in the cleaning machine.

5.7 AN/PRC-51 RADIO SET

The combined final report for this equipment and its micromodules will be completed and delivered to the Signal Corps.

5.8 THE MICROPAC COMPUTER

During the next quarter the mechanical changes recommended and approved by the Signal Corps will be made.

Further investigations of address circuits, digit driver circuits and sense amplifiers also will be made.

An investigation of the various control currents in the power supply will be made. This will include the possibility of having the low power heaters operated by d-c rather than by phase controlled a-c and the possibility of requiring continuous operation of the cooler in order to have an effective proportional control on the cooler when used in conjunction with the low power heater.

During the latter part of the next quarter, the computer will be reassembled and tests will be run to demonstrate that the computer is operational.

5.9 SPECIFICATIONS, STANDARDS, AND RELIABILITY

During the next quarter, additional microelement and module specifications for the PEM phase of Program Extension II will be issued as required.

5.10 SUBCONTRACTING

Liaison and technical support will be provided to subcontractors in order to expedite completion of PEM subcontracts.

6. PUBLICATIONS AND REPORTS

6.1 MONTHLY LETTER PROGRESS REPORTS

During this quarterly period, the following monthly reports were completed and issued:

Fifty-seventh Monthly Report, December 1962

Fifty-eighth Monthly Report, January 1963

Fifty-ninth Monthly Report, February 1963

6.2 FORMAL REPORTS

The Formal Engineering Reports on Transistors and Diodes (Tasks 18 and 19), respectively, of Program Extension I were printed and distributed.

The Eighteenth Quarterly Report was printed and distributed.

6.3 PUBLICATIONS AND REPORTS

An article entitled, "The Micro-Module: Immediate Miniaturization, Reliability, and Low Cost" by Frank X. Brennan was published in the Field Engineers' Electronics Digest, Vol. 11, PP 2-13, January 1963, a publication of the RCA Service Company.

A paper entitled, "Techniques Associated with the Production of Micro-Modules" was presented by Mr. Paul Nyul of the RCA Semiconductor and Materials Division on January 23 to the New York Metropolitan Chapter of IRE-PGEP.

7. BIOGRAPHIES OF NEW PERSONNEL

7.1 SURFACE COMMUNICATIONS DIVISION, DEP

No new personnel were added during this quarter.

7.2 SEMICONDUCTOR AND MATERIALS DIVISION

MR. JOHN L. SWENTZEL, Publications Engineer.

After graduation with a B.S. degree from the University of New Mexico in 1956, Mr. Swentzel joined the Southwest Potash Corporation in Carlsbad, N. M., as an analytical chemist. After a year in this position, Mr. Swentzel joined the Tennessee Valley Authority as a chemist. In both of these positions he performed chemical analyses.

Accepting a position as Manager, New Products Division, with Aloe Scientific in St. Louis, Mr. Swentzel became responsible for the preparation of all advertising material covering laboratory equipment.

In 1958, he joined the Reaction Motors Division of Thiokol Chemical Corp. as a senior technical editor, where his assignments included reports and proposals related to rocket engine systems.

Mr. Swentzel was next employed by the Astronautics Division of General Dynamics Corp. in San Diego, California, as an engineering writer from 1959 to 1960, where his duties included technical publications covering the Atlas weapon system.

In late 1960, Mr. Swentzel accepted a position as assistant manager of sales promotion with Thermo Electric Co., Inc., Saddle Brook, N. J., where his responsibilities included the preparation of all technical literature covering a complete line of electronic industrial control instruments and systems.

He joined the RCA Semiconductor and Materials Division, Somerville, N. J., in September of 1962, as an Engineering Writer in the Microelectronics Department. He is presently engaged in the preparation of all contract reports under the RCA - U. S. Signal Corps Micromodule Contract.

Mr. Swentzel is a member of the American Chemical Society, and the Society of Technical Writers and Publishers.

8. HOURS OF WORK PERFORMED BY RCA PERSONNEL

8.1 SURFACE COMMUNICATIONS DIVISION

Engineers	January	February	March	Total
F. Brennan	134.0	152.0	152.0	438.0
M. Bondy	148.0	156.0	184.0	488.0
J. Donoghue	136.0	144.0	192.0	472.0
F. Farmer	152.0	140.0	184.0	476.0
S. Heller	152.0	160.0	184.0	496.0
P. Taylor	132.0	139.0	196.0	467.0
K. Weir	96.0	160.0	120.0	376.0
R. Higgins	141.0	160.0	184.0	485.0
Others	861.0	54.0	---	915.0
TOTAL ENGINEERS	1,952.0	1,265.0	1,396.0	4,613.0

Technicians	January	February	March	Total
J. Jackson	72.0	---	---	72.0
R. Moyer	72.0	---	---	72.0
A. O'Hara	128.0	152.0	120.0	400.0
R. Walunkonis	136.0	140.0	200.0	476.0
Others	31.0	36.0	34.0	101.0
TOTAL TECHNICIANS	439.0	328.0	354.0	1,121.0

8.2 SEMICONDUCTOR AND MATERIALS DIVISION

Engineers	January	February	March	Total
D. T. Levy	128.0	151.0	111.0	390.0
J. F. Eisenhardt	176.0	160.0	168.0	504.0
W. F. Paterson	167.0	134.0	164.0	465.0
C. L. Peters	88.0	80.0	108.0	276.0
G. G. Hauser	176.0	160.0	148.0	484.0
H. Keitelman	153.0	128.0	152.0	433.0
I. Hintikki	48.0	144.0	32.0	224.0
T. J. Passwater	168.0	134.0	148.0	450.0
W. L. Oates	104.0	132.0	70.0	306.0
J. H. Sundberg	168.0	142.0	150.0	460.0
D. E. Stubbins	128.0	61.0	63.0	252.0
P. Nyul, Jr.	140.0	132.0	142.0	414.0
R. Fresyzloa	117.0	97.0	29.0	243.0
M. M. Mitchell	92.0	75.0	109.0	276.0
T. S. Spitz	78.0	53.0	83.0	214.0
J. DiMauro	176.0	152.0	168.0	496.0
R. Rosenfield	140.0	132.0	102.0	374.0
J. Pirkey	138.0	126.0	115.0	379.0
Others	459.0	130.0	166.0	755.0
TOTAL ENGINEERS	2,844.0	2,323.0	2,228.0	7,395.0

Technicians				
E. K. Magrosky	163.0	141.0	166.0	470.0
F. L. Schaumberg	123.0	103.0	42.0	268.0
D. W. Hansenzahl	76.0	103.0	80.0	259.0
W. J. Keyzer	84.0	35.0	45.0	164.0
S. D. Peachey	179.0	144.0	72.0	395.0
M. J. Weisberg	161.0	136.0	152.0	449.0
D. J. Stoller	176.0	142.0	161.0	479.0
R. H. Clark, Jr.	131.0	82.0	83.0	296.0

Technicians	January	February	March	Total
S. Shwartzman	134.0	104.0	102.0	340.0
J. Harken	82.0	78.0	90.0	250.0
R. M. Cassaro	162.0	136.0	28.0	326.0
R. F. Monaco	146.0	48.0	---	194.0
J. Charney, Jr.	87.0	78.0	---	165.0
J. L. Swentzel	20.0	112.0	80.0	212.0
W. C. Drake	168.0	164.0	95.0	427.0
Others	459.0	415.0	530.0	1,404.0
TOTAL TECHNICIANS	2,351.0	2,021.0	1,726.0	6,098.0

8.3 HOURS OF WORK

January 1 through March 31, 1963

8.3.1 SURFACE COMMUNICATIONS DIVISION

Engineers	4,613
Technicians	1,121

8.3.2 SEMICONDUCTOR AND MATERIALS DIVISION

Engineers	7,395
Technicians	6,098

8.3.3 TOTAL HOURS 19,227

9. CORRECTIONS FOR NINETEENTH QUARTERLY REPORT

NOTE: The editors would appreciate notification of errors in the latest quarterly report so that corrections may be listed in the succeeding reports. These may be sent to:

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Surface Communications Division
Building 1-4-3
Camden 2, New Jersey
Attention: Dr. P. K. Taylor,
Engineering Editor

9.1 SPECIFIC CORRECTIONS

Page	Location	Nature of Correction
1-3	3rd paragraph, 3rd line	Change "three failures" to "two failures"
3-54	1st paragraph	Omit 2nd and 3rd sentences
3.54	6th line	Omit "also"
3-57	last paragraph, last line	Substitute "glass bonded mica" for "Micalex"
3-58	Table 3. 3. 2-1; 1st column, 6th heading	Substitute "glass bonded mica" for "Micalex"
3-83	Last paragraph, 3rd line	Insert "above 90°C" after "test"
3-83	Last paragraph, 5th line	Replace "therefore very" with "con- "considered" — Insert "For normal operating conditions" before "It is preferable"

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