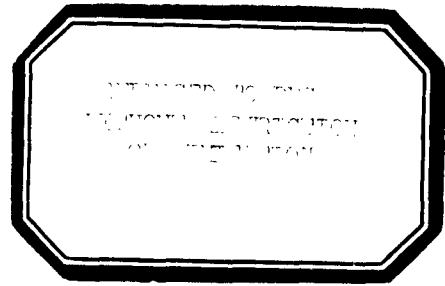


63 4-

409471



CATALOGED BY DDC

AS AD No.

409 471

Monthly Progress Report

P-B1980-9

HERO SUPPORTING STUDIES

by

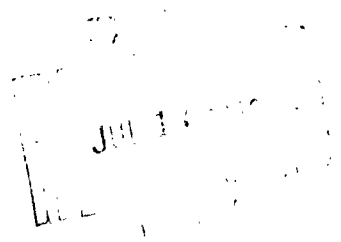
Norman P. Faunce
Paul F. Mohrbach

March 1963

Prepared for

U. S. NAVAL WEAPONS LABORATORY
Dahlgren, Virginia

Contract No. N178-8102



THE FRANKLIN INSTITUTE
LABORATORIES FOR RESEARCH AND DEVELOPMENT
PHILADELPHIA PENNSYLVANIA

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

Monthly Progress Report

P-B1980-9

HERO SUPPORTING STUDIES

by

Norman P. Faunce

Paul F. Mohrbach

March, 1963

Prepared for

U. S. NAVAL WEAPONS LABORATORY
Dahlgren, Virginia

Contract No. NL78-8102

ABSTRACT

Checks are under way to determine the cause of an abnormally high functioning level of RF protected MARK 7 MOD 0 ignition elements at 1 Gc.

In preparation for tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element at 3 and 10 Gc, special mounting hardware is in development. The new mount is for waveguide adaption, but conforms in general style to the mount used for lower frequency tests.

Additional evaluations of a tantalum feed-through capacitor have been made. Tests have been performed to determine the loss contributed by a system comprising the capacitor surrounded by a medium of salt water in varying concentrations. Results are not too conclusive, but they suggest that the loss for this system will increase with increasing conductivity of the surrounding medium.

Development of a one-ohm self-indicating load and a three-voltmeter power measuring arrangement are discussed. The latter incorporates an UHF vacuum thermocouple for an ungrounded voltmeter.

SUMMARY

The HERO test schedule outlined for the protected MARK 7 MOD 0 ignition element included evaluations at 3 Gc. Because of the relative insensitivity of the component these tests could not be performed. Consequently, a shift to 1 Gc was agreed upon.

Attempts were made to conduct 1-Gc tests during this period. Preliminary trials to find the range of functioning powers upon which to base a Bruceton schedule suggested that the 50% firing level would be exceedingly high. The level appeared to be up by at least 3 db compared to predictions based upon loss measurements, and from a previous test of the identical lot at 900 Mc.

A number of experiments were conducted to check out the evaluation system. Additional experiments are in process to determine if the item's sensitivity has been changed. Although the evidence so far does not reveal any clue to the cause for this deviation, we believe that it will be resolved during the next period. In next month's report we will present the results collected this period, together with final test data to be obtained during the early part of next month.

Tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element are next in line after we conclude the program on the MARK 7. Anticipating performance of the tests during this period, we had a suitable mount designed. Because these elements are to be tested at 3 and 10 Gc we will be working in waveguide systems. Suitable parts have been designed to adapt our basic waveguide mounts to accommodate these elements. These parts allow the items to be mounted in a manner similar to that used with the coaxial system at lower frequencies.

Evaluation of the tantalum capacitors has continued. Measurements of worst-case loss was made on systems comprising the capacitor surrounded by salt water solutions; three concentrations were employed. The data suggests that the system loss is related to the surrounding medium's conductivity; the limited data available, however, do not appear to indicate an optimum conductivity. Uncertainty of the measurements, brought about by the low impedance of the system, precludes any firm conclusions. Effort to improve accuracy should precede any further analysis of this system.

To facilitate measurements of terminated power loss (TPL) a one-ohm self-indicating load, and a vacuum thermocouple voltmeter have been developed. The one-ohm load was made to fill a void in our measuring systems. Development of the thermocouple voltmeter was prompted by an interest to expedite low frequency terminated power loss measurements.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.	i
SUMMARY	ii
1. RF TESTS OF MARK 7 MOD 0 IGNITION ELEMENT	1
2. RF TEST OF MARK 1 MOD 0 SQUIB AND MARK 2 MOD 0 IGNITION ELEMENT	2
3. TESTS OF TANTALUM CAPACITOR	5
4. INSTRUMENTATION	8
4.1 An UHF Vacuum Thermocouple As a Self-Indicating Load .	8
4.2 Three-Voltmeter Method for Measuring Power to an Arbitrary Load	10
ACKNOWLEDGEMENTS.	14

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-El 980-9

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
2-1	Cross Section of Firing Mount.	3
4-1	RF Thermocouple Assembly (One Ohm Load).	9
4-2	Thermocouple Assembly and DC Output Meter.	11
4-3	1-Ohm Load Calibration	12
4-4	Three-Voltmeter Power Measuring Circuit.	13
4-5	10 Kc Test Arrangement	13

LIST OF TABLES

<u>Table</u>		<u>Page</u>
3-1	Loss Measurements on Salt Water-Tantalum Capacitor Systems.	6

1. RF TESTS OF MARK 7 MOD 0 IGNITION ELEMENT

Contained in the last report was a summary discussion of all test data collected to substantiate the RF protection afforded in the protected MARK 7 MOD 0 ignition element. Missing from the summary were data to be obtained from tests at 3 Gc; these tests were not performed because the required power was greater than our testing system could produce. It was decided instead to attempt tests at 1 Gc.

Though a functioning test had already been performed at 900 Mc it was decided to perform a test at 1 Gc, which was then regarded as a repeat test. The previous test, under our old procedure, did not include adjustment for systems losses. By repeating a test at a frequency not too distant we assumed that we would have a reasonable basis for a comparison between old and new data.

Because we chose to test at a slightly higher frequency we anticipated a slight increase in the 50% functioning level as well as in the Bruceton levels required to perform the test. The increase, however, turned out to be far beyond our expectations. A series of experimental checks were begun to determine the cause for this apparent anomaly. By the close of the reporting period the problem had not been solved. Anticipating the emergence of a reasonable explanation from additional experiments, we will postpone discussion of this work done in this period. Results to be presented in April's report should conclude the initial outline of tests for this element.

2. RF TESTS OF MARK 1 MOD 0 SQUIB AND
MARK 2 MOD 0 IGNITION ELEMENT

RF tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element were performed on a previous contract. This work, detailed in final summary report (F-B1805), represents an attempt to determine with reasonable precision the RF functioning sensitivity of EED's. As a consequence, a procedure was developed for precision testing within the 1 Mc to 1 Gc frequency spectrum, and tests of both the squib and ignition element were performed.

Techniques developed on the present program permit the precision evaluation of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element to be extended to 10 Gc. Tests at 3 and 10 Gc have been planned to attain this objective.

The lower frequency tests were made in especially developed coaxial firing mounts, having an unusual collet device with contacting fingers. The new tests planned at 3 and 10 Gc will be made in waveguide systems, for which the coaxial mounts are not adaptable. Accordingly, new mounts were designed.

For both 3 and 10 Gc we have on hand one basic waveguide mount which is made to accommodate various types of devices. This is achieved by means of adapter plates and interchangeable probes which are individually constructed for each type of device. For the sake of expediency, the adapter hardware is usually made as simple as possible for routine tests. However, a mounting assembly consistent with that designed for the lower frequencies was considered necessary for the precision firing tests of the squib and ignition element.

In Figure 2-1, a cross section of the 3 Gc waveguide mount developed this period for firing the MARK 2 MOD 0 ignition element is shown. The basic waveguide mount includes the waveguide section and

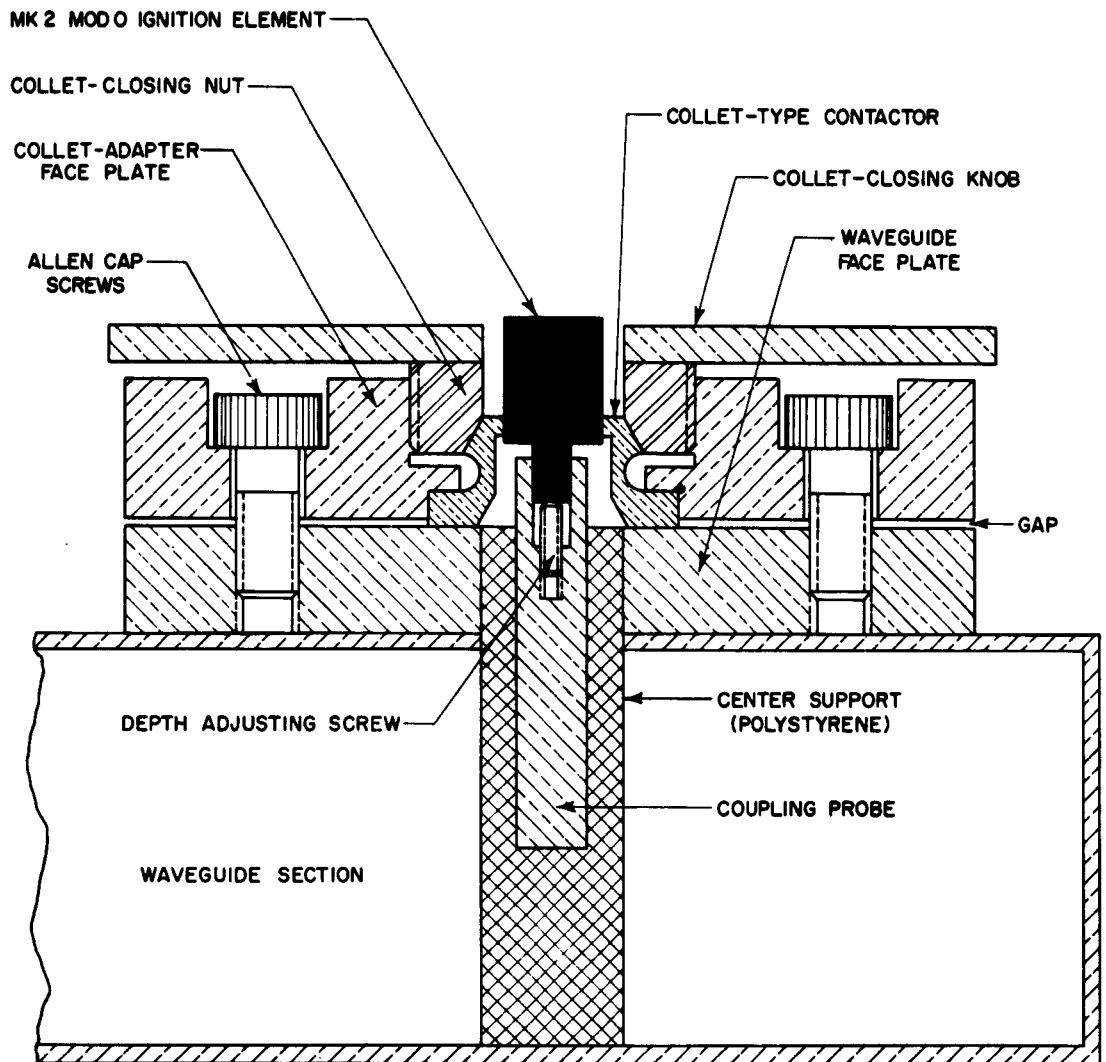


FIG. 2-1. CROSS SECTION OF FIRING MOUNT

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

the attached face plate. The added parts were especially designed for mounting the ignition element as it had been for low frequency tests. The following brief discussion will explain some of the features of this new mount.

RF power is taken from the waveguide by means of a coupling probe. The probe extends to the center of the waveguide and is rigidly held by a polystyrene support. Contacting fingers at the upper end engage the center conductor of the ignition element. An adjustment screw, in the center of the probe, is set to fix the depth of insertion of the elements.

A clearance gap of .002 inch between the two face plates insures positive contact and an RF seal will be made at the base of the collet contactor. When the knob is turned, the collet-closing nut bears against the collet; this forces the contacting fingers to engage the base of the ignition element, providing both the electrical and mechanical attachment necessary.

The adapter parts shown in the figure will also fit the basic 10 Gc firing mount. A shorter probe and polystyrene support are required because the 10 Gc waveguide is smaller in cross section. Many of these parts are also used to mount the MARK 1 MOD 0 squib. However, the collet and center conductor for this device differ in design, to accommodate the twin leads.

This new mount has not been tested, but appears to be superior - mechanically, at least - to previous ones. Tests planned at 10 Gc for the squib and ignition element will prove its worth.

3. TESTS OF TANTALUM CAPACITORS

Data collected in the past several weeks indicate that a particular type of tantalum capacitor might possibly provide a reasonable level of dissipative loss at lower frequencies. Though it may be shown that these items will fail in respect to power handling capability, our interest has been in exploring their lossy character in some detail.

Because these feed through capacitors bear, in part, a resemblance to a proposed model for an optimum lossy medium, the Naval Weapons Laboratory has encouraged us to extend our study of them. It has been recommended that we explore the systems comprising the feed through capacitor surrounded by various concentrations of salt water.

Results have been obtained from measurements of three units, each surrounded by salt water solutions in three concentrations. These concentrations of salt water were made by combining respectively 100, 250 and 400 grams of sodium chloride in one liter of water, resulting in solutions with conductivities of 0.0268, 0.0666 and 0.0725 mhos per centimeter.

The loss was found from measurements of the system's input impedance with different terminating impedances, our standard procedure for low frequency evaluation of worst case (matched) attenuation. Table 3-1 contains the resulting data, which is shown in contrast to the loss attributed to the capacitor by itself. Entries missing from the table are due to "blow-ups" in the computer program used to process the measured values, to give the worst case loss. When these data are important they can be extracted by introducing minimal changes in the input data.

Table 3-1

LOSS MEASUREMENTS ON SALT WATER-TANTALUM
CAPACITOR SYSTEMS

	Frequency (Mc)	db loss for capacitor			
		alone	in 100 g/l salt sol'n	in 250 g/l salt sol'n	in 400 g/l salt sol'n
Capacitor No. 1	.520	6.90	2.18	3.45	3.52
	1.0	-	1.50	-	4.99
	5.0	-	4.34	15.75	9.01
	10.0	6.06	4.33	6.72	6.73
Capacitor No. 2	.520	9.11	3.42	-	-
	1.0	2.75	2.87	-	2.86
	5.0	8.53	3.88	9.19	4.05
	10.0	12.75	4.05	2.04	6.89
Capacitor No. 3	.520	8.22	0.73	3.73	-
	1.0	2.45	2.81	0.45	2.28
	5.0	14.43	4.55	6.79	4.07
	10.0	0.87	3.55	7.63	5.86

• Because of the characteristic low impedance of the systems being evaluated, little confidence is given to these data. Very slight errors in measurements can account for wide variations in determined loss. The uncertainty of the results induced us to make a few check measurements. These results indicated that the data are at best accurate to within 10% of the tabulated value, but may in many cases deviate by 20 to 30%.

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

In view of these uncertainties,, there is little to be learned from the results. Indications are that the system comprising salt water medium and a capacitor becomes more lossy as the concentrations of the solutions increase,. The data do not support the conjecture that an optimum loss will be obtained for a specific conductivity of surrounding medium, other than to indicate that optimum loss occurs when the surrounding medium is the normally "good" coaxial outer conductor. Additional experiments with solutions of higher conductivity would be in order if the measurement could be made more accurately. Attention will be given to improving the evaluation of this sort of component, and when improved techniques become available we will return to this investigation.

4. INSTRUMENTATION

Work was done this month to improve our technique for measuring terminated power loss. Because of the emphasis upon fixes under development to operate into one ohm loads, we prepared a UHF thermocouple as a self-indicating one ohm termination. Additionally, we have looked into a three voltmeter technique for measuring power. This new self-indicating load and power measuring procedure is intended to expedite measurement of terminated power loss (TPL) in the 1 kc to 1 Mc frequency range.

4.1 An UHF Vacuum Thermocouple as a Self-Indicating Load

Several UHF Vacuum thermocouples, were obtained and assembled into a simple mount. A General Radio coaxial RF connector was provided at the input and a BNC connector for the dc output. Figure 4-1 is a view of one of these assembled thermocouples with the cover removed. The few parts required can be clearly seen in the picture. The heavy brass case serves as a common ground for both the RF and the dc circuit. The case is also an efficient shield against ambient RF and temperature effects. A small RF by-pass condenser is connected directly across the thermocouple dc output leads.

The particular thermocouple shown has a heater resistance of 1 ohm which produces a nominal output of 7 milliwatts for an input of 22.5 milliwatts (150 ma dc). It is possible to calibrate the output to indicate the current, voltage, or power associated with the heater element. A calibration made with dc input is assumed valid for RF inputs up to 35 Mc, the maximum frequency for which the elements are designed.

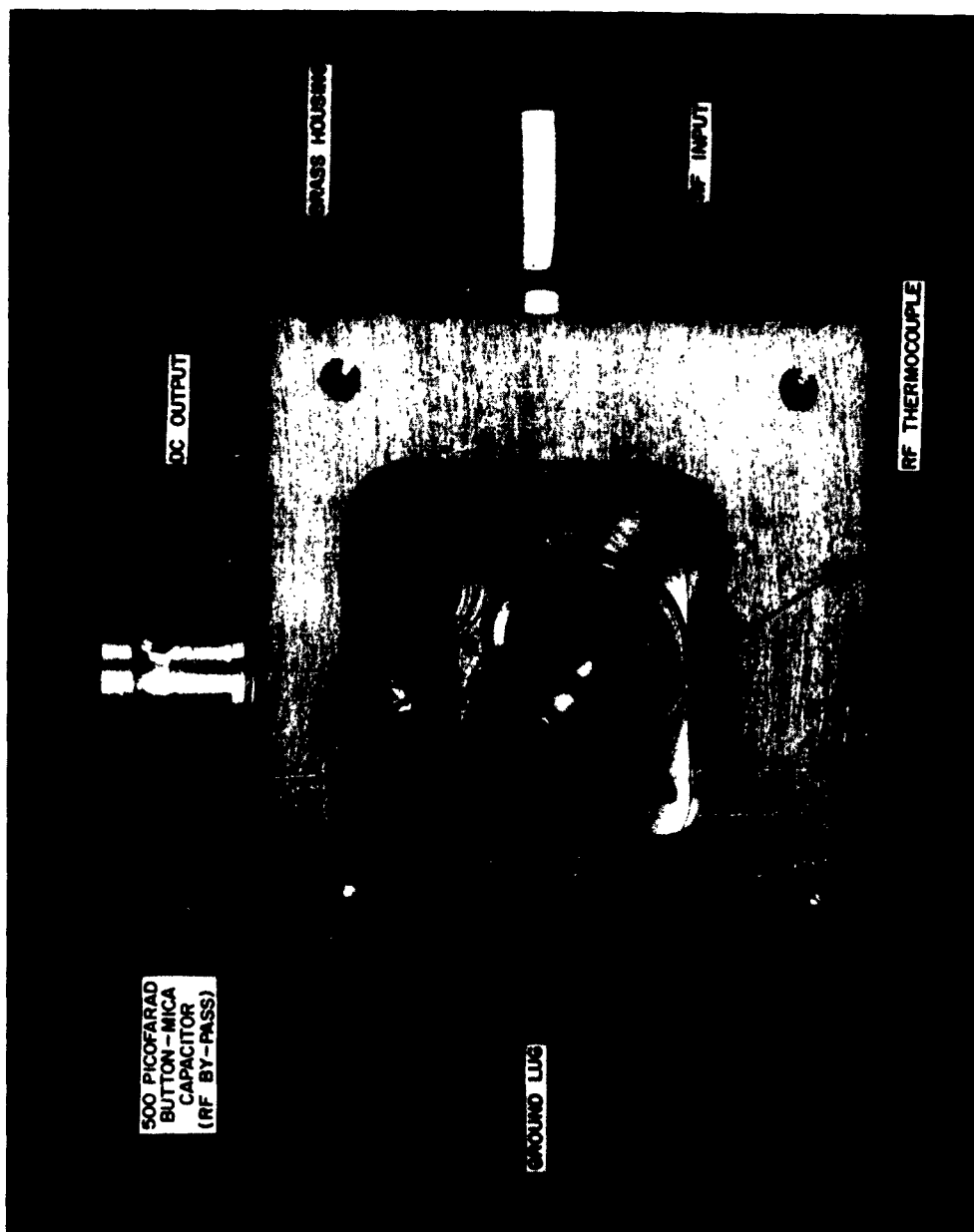


FIG. 4-1. RF THERMOCOUPLE ASSEMBLY (1 OHM LOAD)

In Figure 4-2, the 1-ohm thermocouple is shown connected to a sensitive (0-3 mv) dc millivoltmeter. Such an indicator is preferable to an electronic millivoltmeter when only moderate sensitivity is required, since the possibility of ground loops and direct RF pickup is eliminated. Figure 4-3 is a calibration curve for the thermocouple when connected to this particular meter. Reference to the curve shows that 1 milliwatt of power to the heater gives a readable deflection of 0.28 millivolts. If greater resolution is required, a more sensitive (electronic) meter must be used.

4.2 Three-Voltmeter Method for Measuring Power to an Arbitrary Load

The power into a load having both real and reactive components determined by the basic three-voltmeter method is given by,

$$P_{in} = \frac{V_1^2 - V_R^2 - V_Z^2}{2R_1}$$

Where the symbols refer to quantities indicated in Figure 4-4.

The circuit given in Figure 4-4 requires that the voltmeter used to measure V_R must be isolated from ground which increases the chances of picking up unwanted signals in the circuit. If we substitute a vacuum thermocouple for all or part of R_1 in the three voltmeter circuit, V_R can be determined with minimum interference since we have maximum isolation of the voltmeter with such a system. Because a dissipative element is placed in series with the load in such a circuit, it is necessary to have relatively large power outputs from the generator if adequate precession is to be obtained. However, the technique has the advantage of eliminating the need for phase measurements and minimizes the pickup problems created by having the voltmeter above ground.

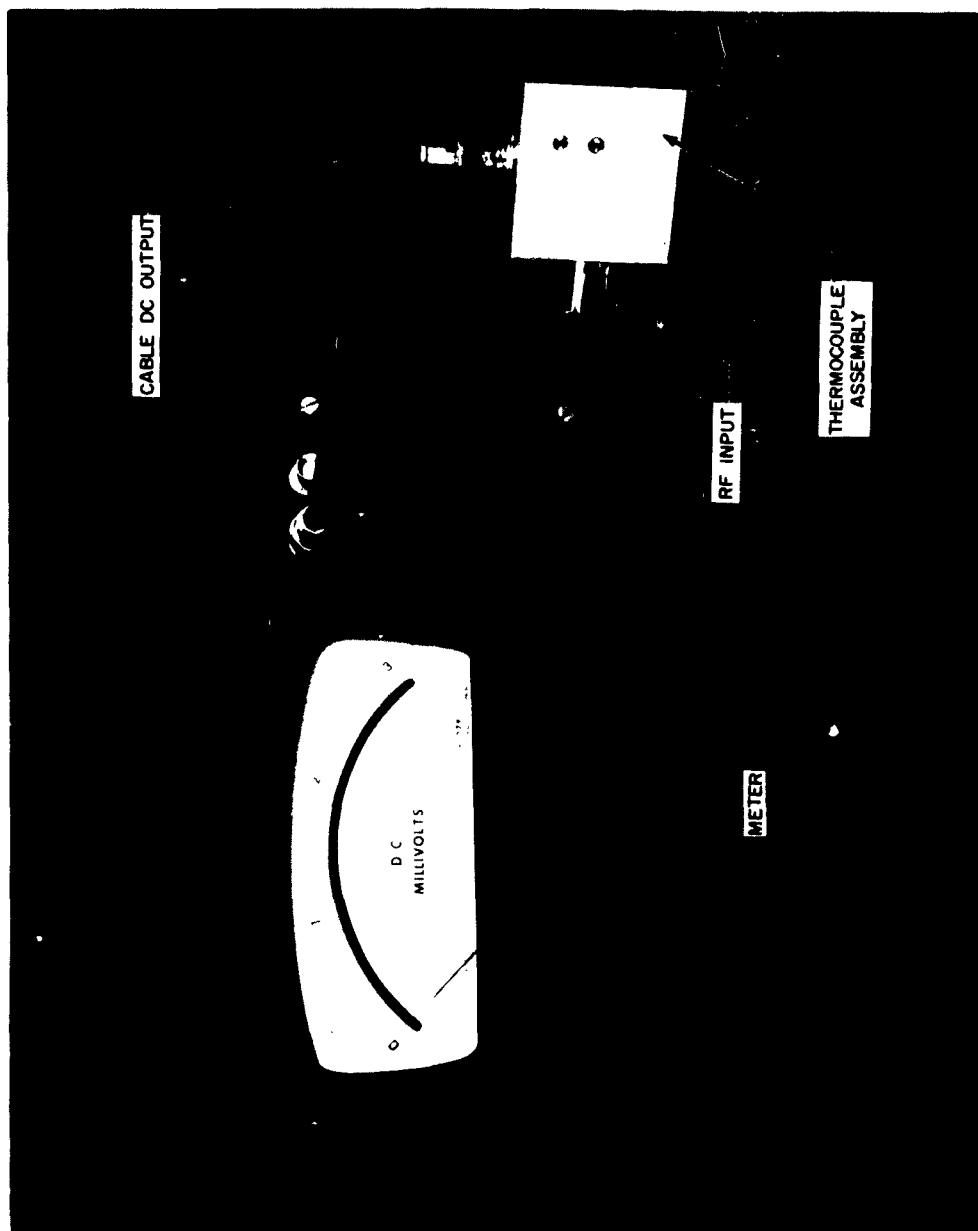


FIG. 4-2. THERMOCOUPLE ASSEMBLY AND DC OUTPUT METER

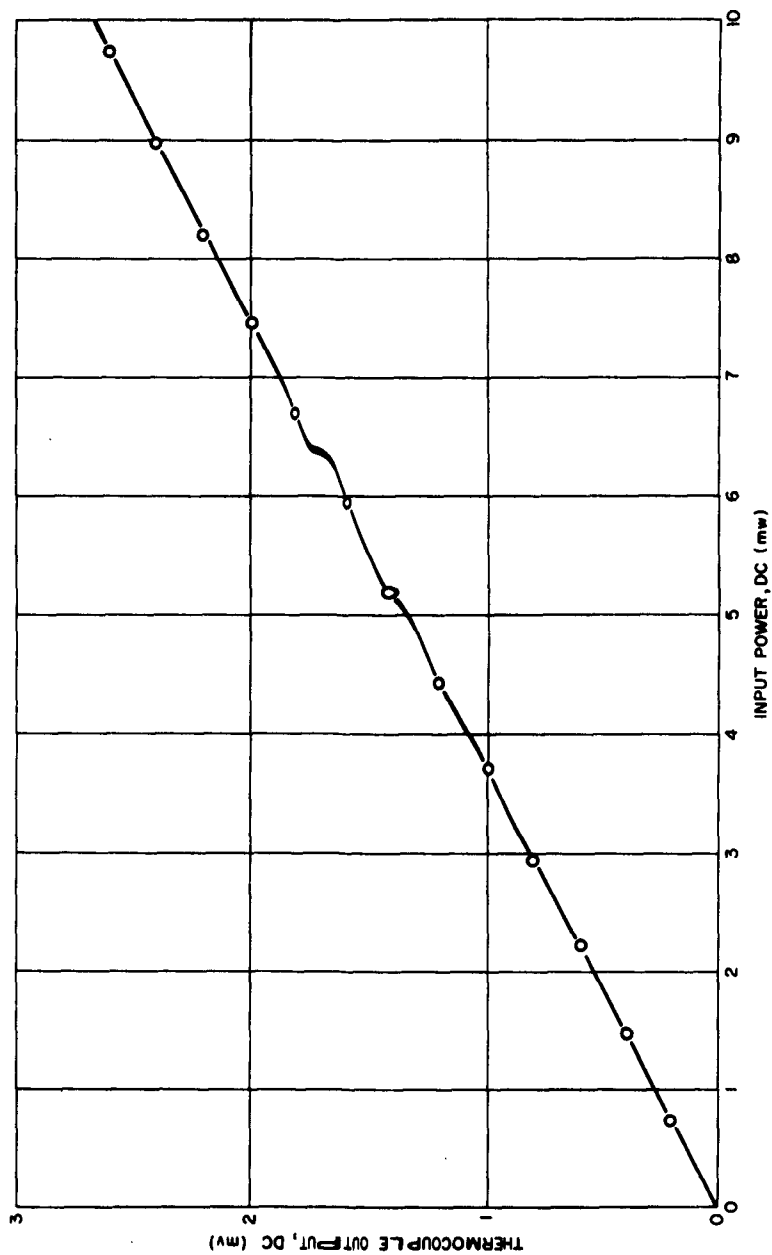


FIG. 4-3. ONE OHM LOAD CALIBRATION

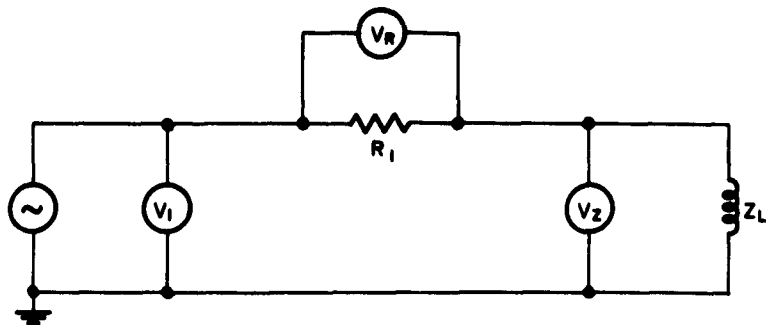


FIG. 4-4. THREE VOLTMETER POWER MEASURING CIRCUIT ARRANGEMENT

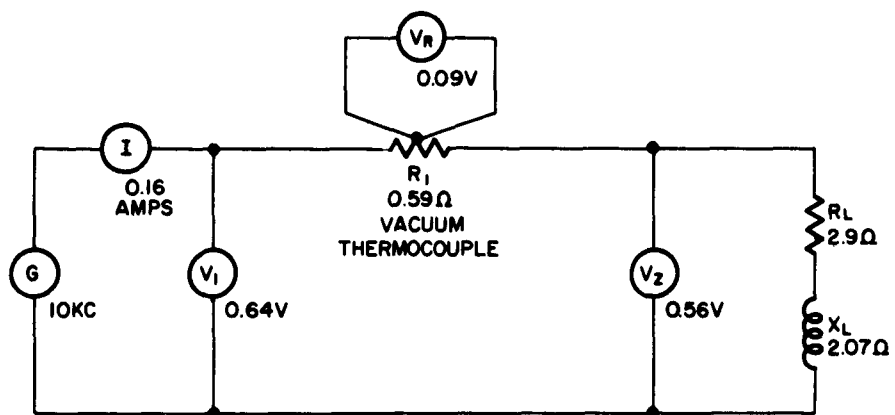


FIG. 4-5. 10KC TEST ARRANGEMENT

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

To verify operation of our newly developed equipment, we set up the circuit shown in Figure 4-5. A low loss RF choke coil was chosen as an arbitrary load, and we set out to measure the power it would dissipate when fed by a 10 kc signal source. The impedance of the load was first determined and the thermocouple voltmeter was calibrated to indicate the series current flow as well. Data shown in Figure 4-5 were then obtained. We may compute power from these data in a number of ways, including the expression for three voltmeter data as well as the technique which uses phase shift. By all means of calculation we obtain a value between .073 and .074 watts.

The agreement of the values of net power obtained by these different calculations is considered reasonable proof that the three-voltmeter system employing the vacuum thermocouple as a voltmeter will give accurate results in a practical test.

ACKNOWLEDGEMENTS

Acknowledgement is made of the contribution of John P. Warren to the work and its presentation in Sections 2 and 4.

Paul F. Mohrbach

Paul F. Mohrbach
Group Leader

Norman P. Faunce

Norman P. Faunce
Project Leader

Approved by:

E. E. Hannum

E. E. Hannum, Manager
Applied Physics Laboratory

F. L. Jackson
Francis L. Jackson
Director of Laboratories

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

DISTRIBUTION LIST

Commander U.S. Naval Weapons Laboratory Dahlgren, Virginia Code: WHR (2)	Officer-in-Charge U.S. Naval Explosive Ordnance Disposal Technical Center U.S. Naval Propellant Plant Indian Head, Maryland
Chief, Naval Operations Department of the Navy Washington 25, D.C. Code: OP-411H	Commanding Officer U.S. Naval Underwater Ordnance Station Newport, Rhode Island
Chief, Bureau of Naval Weapons Department of the Navy Washington 25, D.C. Code: C-132 RAAV-3421 RM-15 RMMO-224 RMMO-235 RMMO-32 RMMO-33 RMMO-4 RMMO-43 RMMO-44 RMMP-343 RREN-32 DIS-313 (4)	Director U.S. Naval Research Laboratory Washington 25, D.C. Code: 5410 (2) Commandant of the Marine Corps Washington 25, D.C. Code: AO4C Commander Pacific Missile Range P.O. Box 8 Point Mugu, California Code: 3260 Commanding Officer and Director U.S. Navy Electronics Laboratory San Diego 52, California Attn: Library Commanding Officer U.S. Naval Ammunition Depot Crane, Indiana Code: 34 Commanding Officer U.S. Naval Ordnance Plant Macon, Georgia Code: PD 270 Commander Naval Air Force U.S. Atlantic Fleet U.S. Naval Air Station Norfolk 11, Virginia Code: CNAL-724B Commander Training Command U.S. Pacific Fleet c/o U.S. Fleet Anti-Submarine Warfare School San Diego 47, California
Chief, Bureau of Yards and Docks Department of the Navy Washington 25, D.C. Code: D-200	
Commander U.S. Naval Ordnance Laboratory White Oak, Maryland Code: ED NO LV Technical Library	
Commanding Officer U.S. Naval Ordnance Laboratory Corona, California Code: 561	
Commander U.S. Naval Ordnance Test Station China Lake, California Code: 556 4572	
Commanding Officer U.S. Naval Air Development Center Johnsville, Pennsylvania Code: EL 94	

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

DISTRIBUTION LIST (Cont.)

Commanding General
Headquarters, Fleet Marine Force, Pacific
c/o Fleet Post Office
San Francisco, California
Attn: Force Communications Electronic
Officer

Commander-in-Chief
U.S. Pacific Fleet
c/o Fleet Post Office
San Francisco, California
Attn: Code 4

Commander
Seventh Fleet
c/o Fleet Post Office
San Francisco, California

Commander
New York Naval Shipyard
Weapons Division
Naval Base
Brooklyn 1, New York
Attn: Code 290

Commander
Pearl Harbor Naval Shipyard
Navy No. 128, Fleet Post Office
San Francisco, California
Attn: Code 280

Commander
Portsmouth Naval Shipyard
Portsmouth, New Hampshire

Commander
Naval Air Force
U.S. Pacific Fleet
U.S. Naval Air Station
North Island, San Diego, California

Department of the Army
Office Chief of Ordnance
Washington 25, D.C.
Code: ORDGU-SA
ORDTB
ORDTW

Office Chief Signal Officer
Research and Development Division
Washington 25, D.C.
Code: SIGRD-8

Commanding Officer
Harry Diamond Fuze Laboratories
Washington 25, D.C.
Attn: Harry F. Godfrey

Commanding Officer
U.S. Army Nuclear Weapon
Coordination Group
Fort Belvoir, Virginia

Director
U.S. Army Engineer Research and
Development Laboratories
Fort Belvoir, Virginia
Attn: Chief, Basic Research Group

Commanding Officer
Picatinny Arsenal
Dover, New Jersey
Attn: Artillery Ammunition and
Rocket Development Laboratory
Mr. S. M. Adelman
Attn: Evaluation Unit, Instrumentation
Section, Building 352 -
Mr. Abraham Grinoch

Commanding General
Headquarters 2DRAADCOM
Oklahoma City, A.F.S.
Oklahoma City, Oklahoma

Commanding Officer
U.S. Army Signal Research and
Development Laboratory
Fort Monmouth, New Jersey
Attn: SIGEM/EL-GF

Commanding Officer
U.S. Army Ordnance
Frankford Arsenal
Philadelphia 37, Pennsylvania

Commander
U.S. Army Rocket and Guided
Missile Agency
Redstone Arsenal, Alabama
Attn: ORDXR-R (Plans)

Commanding Officer
Office of Ordnance Research,
U.S. Army
Box CM, Duke Station
Durham, North Carolina
Attn: Internal Research Division

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

DISTRIBUTION LIST (Cont.)

Commanding General White Sands Missile Range New Mexico Code: ORDBS-G3	Commander Griffiss Air Force Base RADC, Rome, New York Attn: RCLS/Philip L. Sandler
Commanding Officer White Sands Missile Range, New Mexico U.S.A. SMSA Code: SIGWS-AJ	Commander Air Force Special Weapons Center Kirtland Air Force Base Albuquerque, New Mexico Attn: SWWSA
Commanding General U.S. Army Electronic Proving Ground Fort Huachuca, Arizona Attn: Technical Library	Director of Missile Safety Research Deputy IG for Safety Norton Air Force Base, California
Director of Office of Special Weapons Developments U.S. Continental Army Command Fort Bliss, Texas Attn: Capt. Chester I. Peterson T S Control Officer	Commanding General Air Fleet Marine Force, Pacific MCAS, El Toro Santa Ana, California
Headquarters Air Research and Development Command Andrews Air Force Base Washington 25, D.C. Code: RDMMS-3	Commanding General Strategic Air Command Offutt Air Force Base, Nebraska Code: DOSIM
Commander Air Force Missile Test Center Patrick Air Force Base, Florida Code: MTRCF	Commander Headquarters Ground Electronics Engineering Installation Agency Griffiss Air Force Base Rome, New York Code: ROZMWT
Director Nuclear Safety Kirtland Air Force Base, N.M. Research Code: AFCNS	Armed Services Explosives Safety Board Department of Defense Rm. 2075, Gravelly Point, Building T-7 Washington 25, D.C.
Headquarters Ogden Air Materiel Area Hill Air Force Base Ogden, Utah Code: OYSS	Commander Hanscom Air Force Base, Massachusetts Codes: AFCCDD/CCEI-1 Attn: Capt. Long
Commander Air Force Missile Development Center Holloman Air Force Base Alamogordo, New Mexico Attn: MDBG	Headquarters Armed Services Technical Information Agency (TIPCR) Arlington Hall Station Arlington 12, Virginia <u>VIA:</u> U.S. Naval Weapons Laboratory Dahlgren Virginia Code: WHR (10)

THE FRANKLIN INSTITUTE • Laboratories for Research and Development

P-B1980-9

DISTRIBUTION LIST (Cont.)

Commander Field Command Defense Atomic Support Agency Albuquerque, New Mexico Attn: FCDR3	Aerojet-General Corporation P.O. Box 296 Azusa, California Attn: Myra Z. Grenier, Librarian
U.S. Atomic Energy Commission Division of Military Application Washington 25, D.C.	Grumman Aircraft Engineering Corporation Weapons Systems Department Bethpage, Long Island, New York Attn: Mr. E. J. Bonan
Defense Research Staff British Embassy 3100 Massachusetts Ave., N.W. Washington 8, D.C. Attn: Mr. G. R. Nice <u>VIA:</u> U.S. Naval Weapons Lab. Dahlgren, Virginia Code: WHR	Jansky and Bailey, Inc. 1339 Wisconsin Avenue, N.W. Washington, D.C. Attn: Mr. F. T. Mitchell, Jr.
Naval Member Canadian Joint Staff 3450 Massachusetts Ave., N.W. Washington 25, D.C. Attn: Staff Officer (Weapons) <u>VIA:</u> U.S. Naval Weapons Laboratory Dahlgren, Virginia Code: WHR	Lockheed Aircraft Corporation P.O. Box 504 Sunnyvale, California Attn: Missile Systems Division, Dept. 62-20 Mr. I. B. Gluckman Attn: Missiles and Space Division, Dept. 81-62 Mr. E. W. Tice Attn: Missiles and Space Division, Dept. 81-71 Mr. R. A. Fuhrman
American Machine and Foundry Company Alexandria Division 1025 North Royal Street Alexandria, Virginia	McCormick-Selph Associates Hollister, California Attn: Technical Library
Atlas Chemical Industries, Inc. Reynolds Ordnance Section P.O. Box 271 Tamaqua, Pennsylvania Attn: Mr. R. McGirr	Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri Attn: Security Officer
The Bendix Corp. Scintilla Division Sidney, New York Attn: R. M. Purdy	RCA Service Company Systems Engineering Facility Government Service Department 838 N. Henry Street Alexandria, Virginia Attn: C. M. Fisher
Bermite Powder Company 22116 West Soledad Canyon Road Saugus, California Attn: Mr. L. LoFiego	Sandia Corporation Division 1262 Albuquerque, New Mexico <u>VIA:</u> Commander, Field Command Defense Atomic Support Agency Albuquerque, New Mexico
Chance Vought Corporation P.O. Box 5907 Dallas 22, Texas Attn: R. D. Henry	University of Denver Denver Research Institute Denver 10, Colorado Attn: Mr. R. B. Feagin

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

P-B1980-9

DISTRIBUTION LIST (Cont.)

Flare Division
Atlantic Research Corporation
19701 W. Goodvale Road
Saugus, California
Attn: Mr. N. E. Eckert, Head,
R&D Group

Vitro Laboratories
14000 Georgia Avenue
Silver Spring, Maryland
Attn: Miss C. Jaques, Librarian

Welex Electronics Corporation
Solar Building, Suite 201
16th and K Streets, N.W.
Washington 5, D.C.

North American Aviation, Inc.
Communication Services
4300 E. 5th Ave.
Columbus 16, Ohio