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Quarterly Progress Report

Q-B1805-4

PRECISION RF SENSITIVITY STUDIES

(Evaluation of MARK 1 MOD 0 Squib
and MARK 2 MOD 0 Ignition Element)

by

Paul F. Mohrbach
Robert F. Wood

1 August to 1 November 1961

Prepared for

U. S. NAVAL WEAPONS LABORATORY
Dahlgren, Virginia
Code WHR

Contract No. N178-7830

THE FRANKLIN INSTITUTE

LABORATORIES FOR RESEARCH AND DEVELOPMENT
PHILADELPHIA PENNSYLVANIA

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ABSTRACT

RF systems for firing the MARK 2 MOD 0 ignition element and the MARK 1 MOD 0 squib are discussed. Emphasis is placed on theoretical means for matching at 5 and 30 megacycles. Some specific details of practical systems are given.

The adaption of the MARK 2 firing mount to accommodate the MARK 1 squib is described. A unique adjustable shorted stub, developed in our laboratory, was completed and utilized for firing at 250 megacycles.

A method for the determination of system loss factor is briefly presented. The systems for firing the MARK 1 squib and the MARK 2 ignition element were calibrated to obtain these losses at frequencies of 5, 30, and 250 megacycles.

Bruceton tests were conducted with both the squib and ignition element at 5, 30, and 250 megacycles.

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1. INTRODUCTION

The Franklin Institute, under contract with the Naval Weapons Laboratory, has been engaged in a program of precision RF sensitivity studies of the MARK 1 MOD 0 squib and the MARK 2 MOD 0 ignition element. The sensitivity levels are to be determined with an error of less than 5%. The present phase of the program is to fire the squib and ignition element, using Bruceton tests, and knowing accurately the system loss factor. If no other factors are involved, application of the system loss factor to the mean firing level will yield the RF sensitivity of the device in terms of power delivered to its input leads.

In the early phases of the program, considerable effort was directed toward evaluation of losses in various matching devices. These losses were investigated over a frequency range of 250 to 500 megacycles. Experimental tests were supplemented with theoretical studies of impedance matching which led to the conclusion that large system losses are inevitable when matching into loads having a small resistive component. Large reactive components in the load will also produce large system losses. On the basis of unavoidable system losses of 50 per cent or more, we proceeded to assemble and test a practical system for firing the MARK 2 MOD 0 ignition element at 250 megacycles.

Calibrated RF thermocouples were used in the first attempts to evaluate system losses. These thermocouples were useful for comparing the relative losses of different matching systems; we realized, however, that a better way to determine absolute system loss would involve determination of the RF power actually reaching the bridgewire of the ignition element or squib under test. This has been done by means of infrared detectors and photoconductive cells mounted above the bridgewire of the ignition element.

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The system loss evaluation technique described above has one inherent source of error, in that the losses in the base of the ignition element are included in the loss factor obtained. Base losses, if present, should not be included in the loss factor.

Several experiments were made to determine the loss in the base of the MARK 2 MOD 0 ignition element at 250 megacycles. No numerical values for the losses were obtained since they were too small to measure.

All of the previously mentioned work was performed prior to the present quarterly report period. During the present period, we fired the MARK 2 MOD 0 ignition element in precision Bruceton tests at additional frequencies of 5 and 30 megacycles. Evaluation of the MARK 1 MOD 0 squib was then initiated. Bruceton tests were fired with this item at frequencies of 5, 30, and 250 megacycles.

2. RF FIRING SYSTEMS FOR MARK 2 MOD 0 IGNITION ELEMENT AND MARK 1 MOD 0 SQUIB

Contributor: John P. Warren

A block diagram of the basic firing system is shown in Figure 2-1. Manufacturer and model number have not been indicated for some of the components, since they varied according to the test frequencies used.

The RF generator is isolated from the firing system by a 10 db pad. A coaxial relay admits the RF power into the firing system when the firing switch is closed. A 50-ohm 5-watt dummy load terminates the system properly when the relay is in the off position. A second 10 db pad reduces the power to a safe level to prevent initiation of the EED during the matching procedure. This pad is removed from the system after each matching routine.

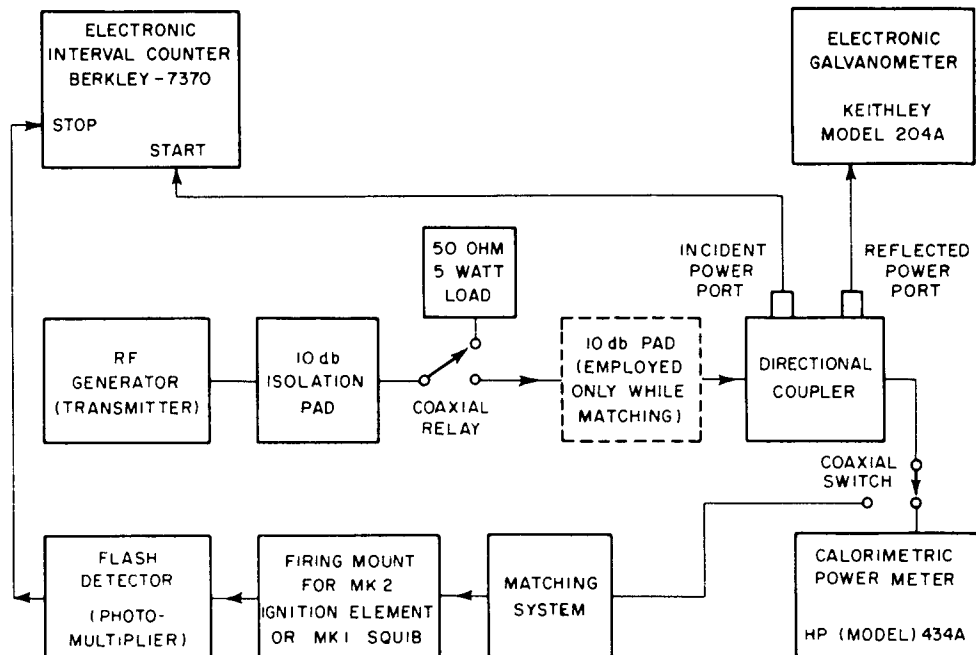


FIG 2-1 BLOCK DIAGRAM OF BASIC FIRING SYSTEM

The directional coupler serves a dual purpose. It provides an indication of impedance match when the output from its reflected power port is minimum, and the output of the incident power port provides a start signal for the chronograph used to measure functioning time. A flash detector produces an output signal when the EED ignites, which stops the interval timer.

2.1 5 and 30 Megacycle Systems

Distributed constant matching systems, which are used at 250 megacycles, are not practical at 5 and 30 megacycle because of the length necessary. In this low frequency range, lumped constant networks consisting of inductors and capacitors are used. The principles involved can be found by reference to any standard text on circuit theory.

At frequencies of 5 and 30 megacycles, our impedance measurements show that we may assume that the real part of the impedance of the

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MARK 2 ignition element corresponds to the dc resistance of the bridge-wire. The bridgewire which is nominally 0.1 ohms when cold is about 0.14 ohms when heated to a dull red.

Figure 2-2 is a theoretical circuit for matching a MARK 2 ignition element to a 50-ohm line. The values of reactance required for matching were obtained by substitution in equations (2-1) and (2-2).

$$X_2 = \sqrt{Z_o R_a - R_a^2} \quad (2-1)$$

$$X_1 = \frac{Z_o R_a}{X_2} \quad (2-2)$$

These equations yield almost equal values of 2.65 and 2.64 ohms for X_1 and X_2 . At 5 megacycles, a capacitor of 0.012 microfarads and an inductor of 0.082 microhenries are required for the calculated reactances of 2.65 ohms. At 30 megacycles, the component values are 0.002 microfarads and 0.0136 microhenries.

The equations from which we calculated X_1 and X_2 assume that the load has no reactance. The load in Figure 2-2 is therefore denoted

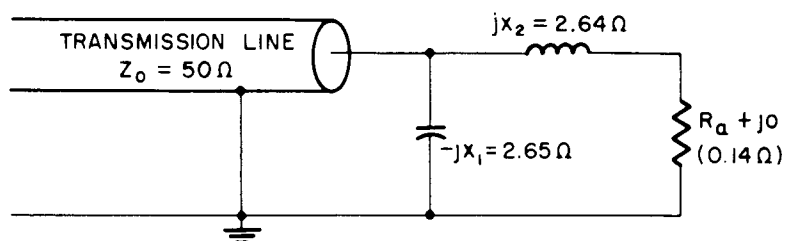


FIG.2-2. THEORETICAL CIRCUIT FOR MATCHING MK 2
IGNITION ELEMENT AT LOW FREQUENCIES

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as $R_a \pm j0$ which in the case of the MARK 2 element is approximately 0.14 ohms. The net reactance of the load will modify the calculated value of X_2 , however, this will not be considered here since the exact value of X_2 will be obtained empirically in actual practice.

Similar calculations may be made to determine the theoretical values of components required for matching the MARK 1 MOD 0 squib at 5 and 30 megacycles. The nominal dc resistance of the squib bridge wire is 1 ohm (cold) and about 1.4 ohms when heated to a dull red. The calculated values for X_1 and X_2 are 8.49 and 8.24 ohms respectively. At 5 megacycles, these reactances may be obtained with a capacitor of 0.00375 microfarads and an inductor of 0.262 microhenries. At 30 megacycles, these values become 0.000625 microfarads and 0.0436 microhenries.

The matching networks used in the firing of the squib and ignition elements were simple combinations of inductive and capacitive elements mounted in an aluminum box as shown in Figure 2-3. Here can be seen a variable 1000-picofarad tuning capacitor, a fixed shunt capacitor, and a series tuning inductor. The fixed capacitor and the series inductor are removable so that other values may be substituted according to the frequency and the impedance of the item under test.

It would ordinarily be assumed that both the series inductor and the shunt capacitor would have to be variable in order to allow for the normal variation in resistance and reactance of the EED being tested. However, it was found that the MARK 1 MOD 0 squibs and the MARK 2 MOD 0 ignition elements were so uniform in their electrical characteristics that a fixed inductance and capacitance in combination with a single variable capacitor was enough to produce an acceptable match for any item in a group under test.

Figure 2-4 represents a typical firing system for the Bruceton tests at 5 and 30 megacycles. The values of the components in the matching network were, of course, changed according to the frequency and the item being tested.

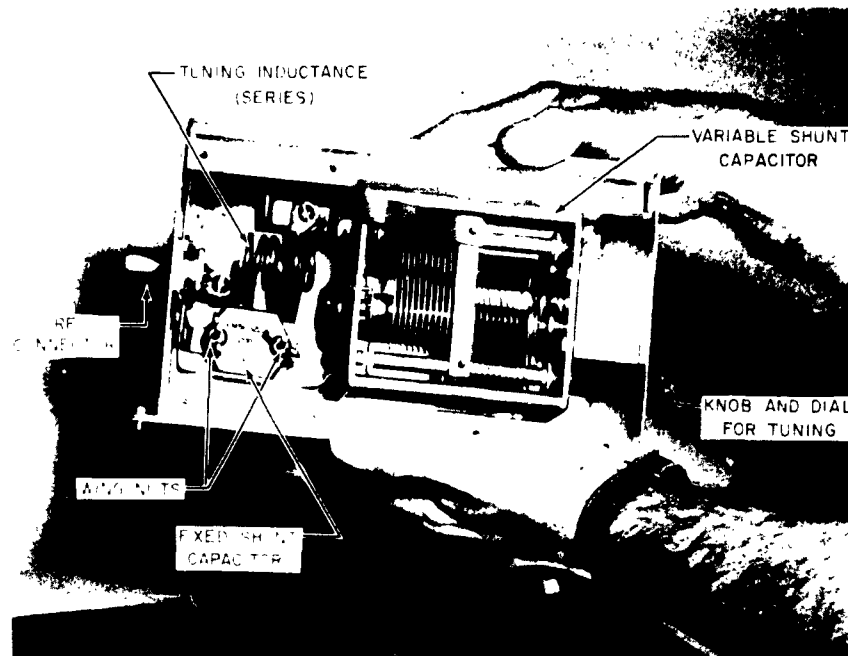


FIG 2-3 A TYPICAL LUMPED CONSTANT MATCHING NETWORK

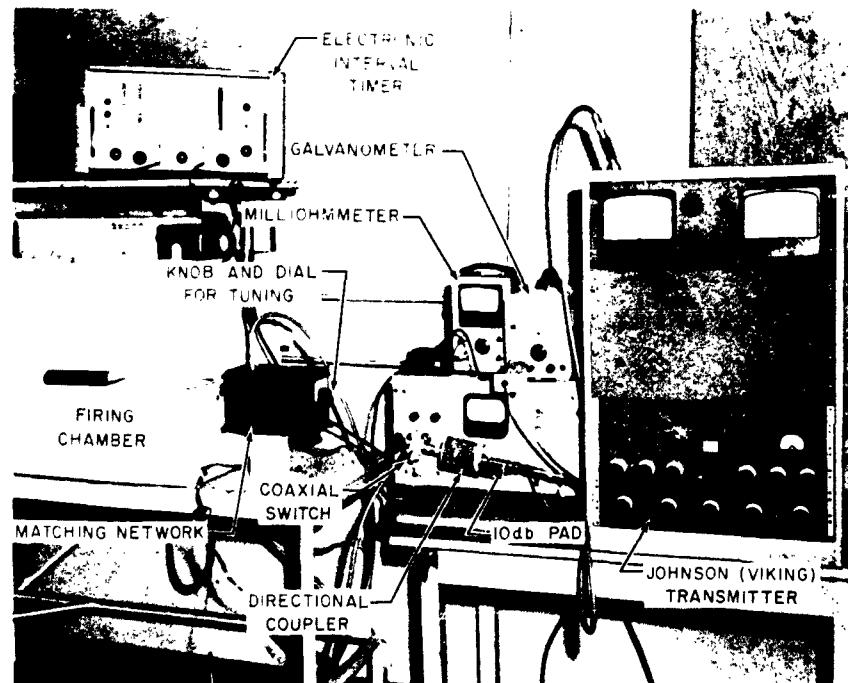


FIG 2-4 TYPICAL FIRING ARRANGEMENT FOR 5 AND 30 MC TESTS

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2.2 250 Megacycle System for the MARK 1 MOD 0 Squib

The matching system for the MARK 2 MOD 0 ignition element at 250 megacycles was described in the previous quarterly report, Q-B1805-3, in Section 3. The system for evaluating the MARK 1 MOD 0 squib is identical except that an adjustable shorted line was available in place of the fixed short used in the previous test.

Although the resistance of the squib bridgewire is 10 times as large as that of the ignition element, physical lengths of the coaxial tuning elements were approximately the same. The adjustable shorted line developed in our laboratory was employed for matching.

Figure 2-5 is a close-up view of the impedance matching components for the MARK 1 squib at 250 megacycles. Figure 2-6 shows the entire firing system including the matching elements. Details of the shorted stub will be given in Section 2.4.

2.3 Adaption of the MARK 2 MOD 0 Ignition Element Firing Mount to Accommodate the MARK 1 MOD 0 Squib

The firing mount designed for the MARK 2 MOD 0 ignition element proved satisfactory. Therefore, rather than design a new mount, a series of adaptor parts were made to accommodate the MARK 1 squib in the same mount. Figure 2-7 is a view of the firing mount and photocell housing as adapted for the squib. The changes are not very easily seen in this picture.

Figure 2-8 shows the actual parts which were made to accommodate the squib. The leads of the squib must be precut to exact length and shaped before installation in the mount. This is done with a special holding and stripping device, not shown. A precut and dressed squib is in the foreground of the picture, which also shows another squib mounted in the center conductor. A hex-socket head screw is turned to fasten one of the leads in the center conductor. A slot is provided in the collet to force the ground lead against the bottom edge of the outer case of the squib. The

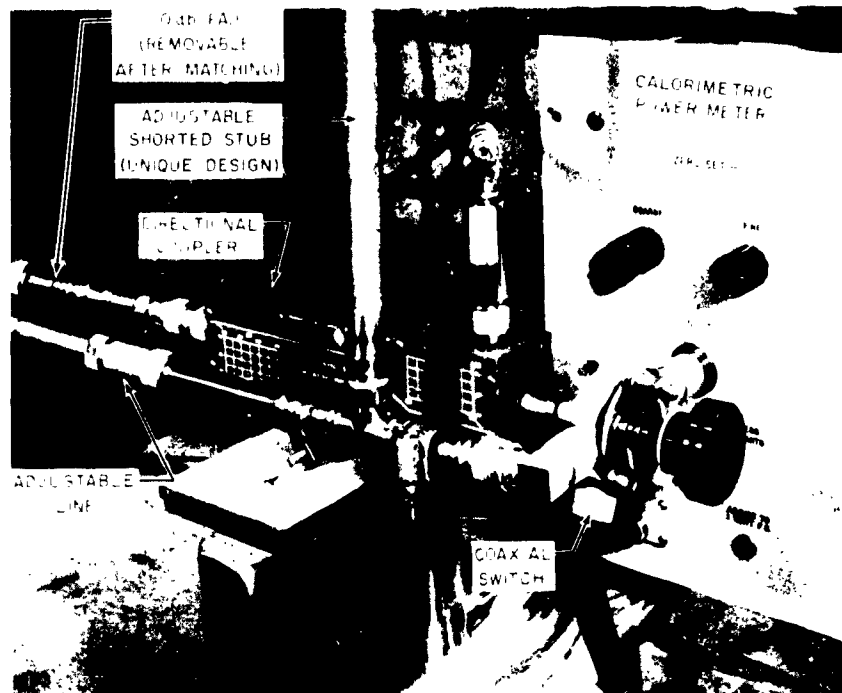


FIG 2-5 COMPONENTS FOR MATCHING MARK I MOD 0 IGNITION ELEMENT AT 250 MC

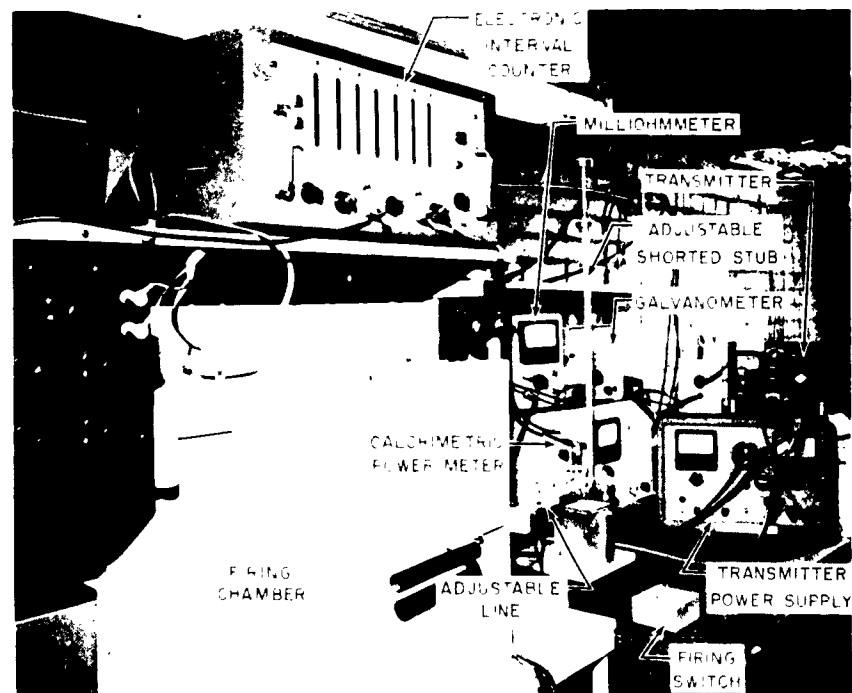


FIG 2-6 FIRING SYSTEM FOR MARK I MOD 0 IGNITION ELEMENT AT 250 MC

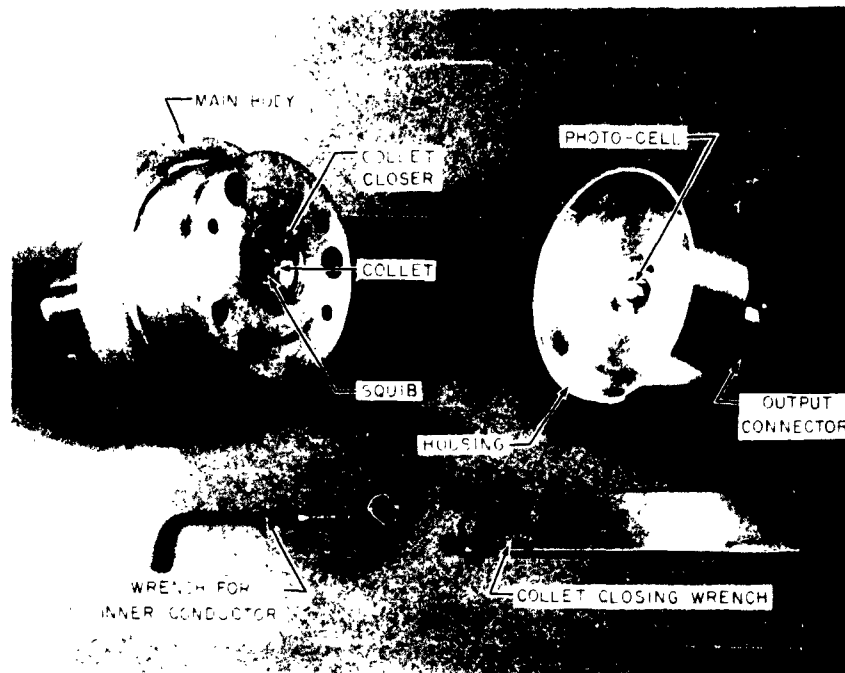


FIG.2-7 FIRING MOUNT AND PHOTO-CELL HOUSING (ADAPTED FOR MARK I MOD O SQUIB)

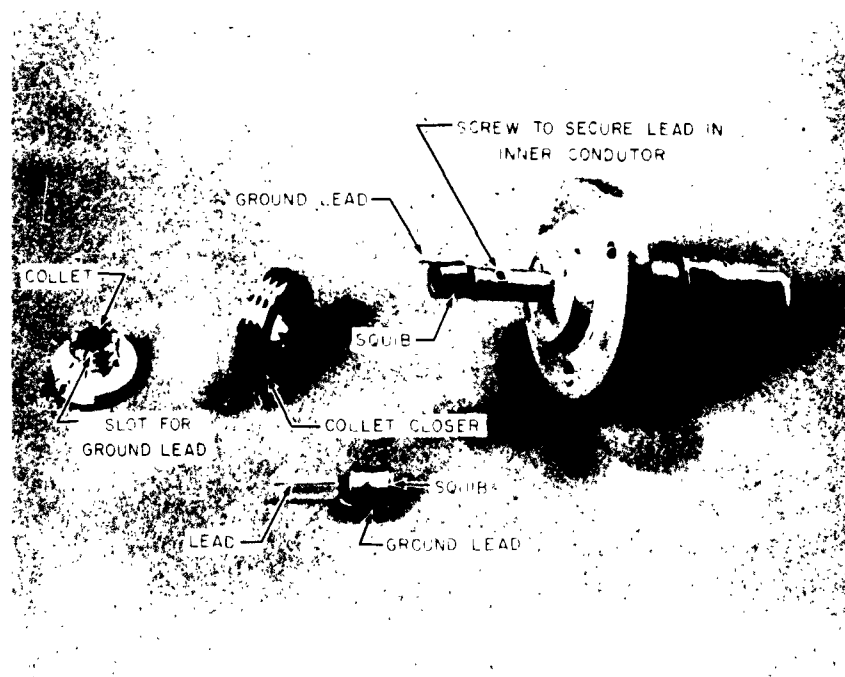


FIG.2-8 ADAPTER PARTS FOR ACCOMMODATING MARK I MOD O SQUIB

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collet-closer brings the collet into intimate contact with the bottom circumference of the squib case. The screw that tightens the center conductor is reached by a special wrench inserted through a hole in the main body of the mount.

2.4 A Novel Adjustable Shorted Stub

Contributor: R. R. Raksnis

We have developed a novel adjustable shorted stub for use with 50-ohm coaxial air lines. Commercially available devices of this character are limited in respect to the minimum length of adjustment for the shorted stub. Shorted stub lengths of one centimeter or less are desirable for matching the MARK 2 MOD 0 ignition element. Otherwise, an additional half-wavelength of air line must be included in the stub length. This half wavelength of line has been shown experimentally to contribute an additional 25 percent to the total losses in a system for matching the MARK 2 element at 250 megacycles.

The novelty of our shorted stub lies first in the fact that it may be adjusted to a length approaching zero and second in the unusual arrangement of collets which provide the actual short circuiting conductance across the line. A third feature is the provision of an external knob which allows the collets to be positively locked in any desired position. A micrometer adjustment for fine positioning is also included.

Figure 2-9 is a view of the adjustable shorted stub, partially disassembled to expose some of the inner constructional details. The instrument consists basically of a 70 cm length of coaxial air line (outer and inner conductor) and an assembly containing the shorting slug which is inserted within the coaxial line. The 70 cm line is so constructed that it may be attached to the junction port of a coaxial tee fitting in such a way as to form a smooth continuation of the outer and inner conductors of the tee.

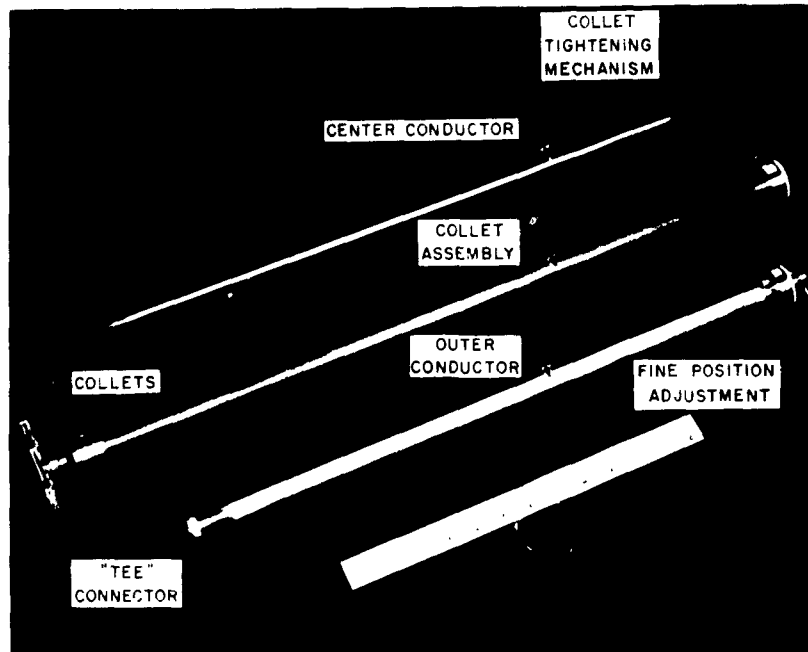


FIG 2-9 ADJUSTABLE SHORTED STUB - DISASSEMBLED

The shorting slug consists of two concentric silver plated collets. The outer collet has an internal taper which is a mating fit with the external taper of the inner collet. When the inner collet is drawn up into and flush with the outer collet, the locking action forces the contacting fingers against both the inner and outer conductor. The intimate contact between the tapered surfaces of the collets combines with finger spreading collet action to create a plane of high conductance across the line at the junction of the coaxial tee. Figure 2-10 is a close-up view of the collets in the condition just described.

Figure 2-11 is a view of the completely assembled shorted stub with a section of adjustable air line attached for matching the MARK 1 MOD 0 squib at 250 megacycles. A longer adjustable line is shown just below the main assembly. The short adjustable line at the bottom of the figure will be used for matching the squib and ignition element at 1000 megacycles and above.

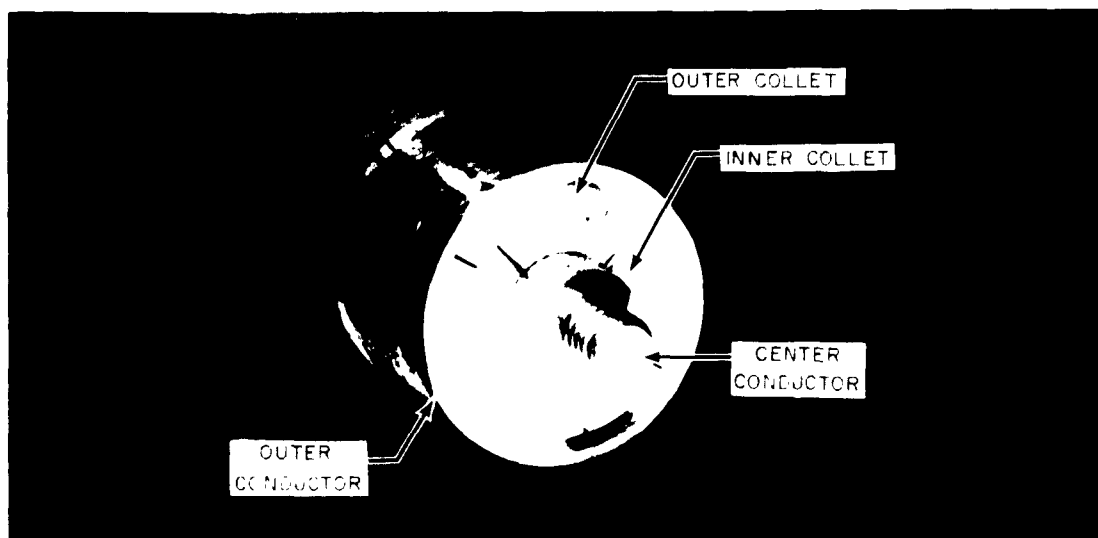


FIG 2-10. CLOSE-UP OF COLLETS FOR ADJUSTABLE SHORT

3. DETERMINATION OF SYSTEM LOSS FACTOR

Contributor: John F. Warren

We have standardized the method which will be used for system loss evaluation up to and including 1000 megacycles; see Figure 3-1 for block diagram. The principles involved are described in previous reports and will not be repeated here. However, one feature of the established technique not used or described in previous reports will be briefly discussed.

When adjusting for impedance match, the power is always reduced to not over 10% of the firing levels. This means that matching takes place when the item is cold. The dc resistance of bridge wires made from 90% platinum - 10% iridium, increases approximately 40 percent when the temperature of the wire is raised from ambient (20°C) to a dull red heat. We therefore reasoned that it would be advisable to lower the power by a factor of ten, by the use of an attenuating pad when matching for system loss evaluation. However, preliminary tests

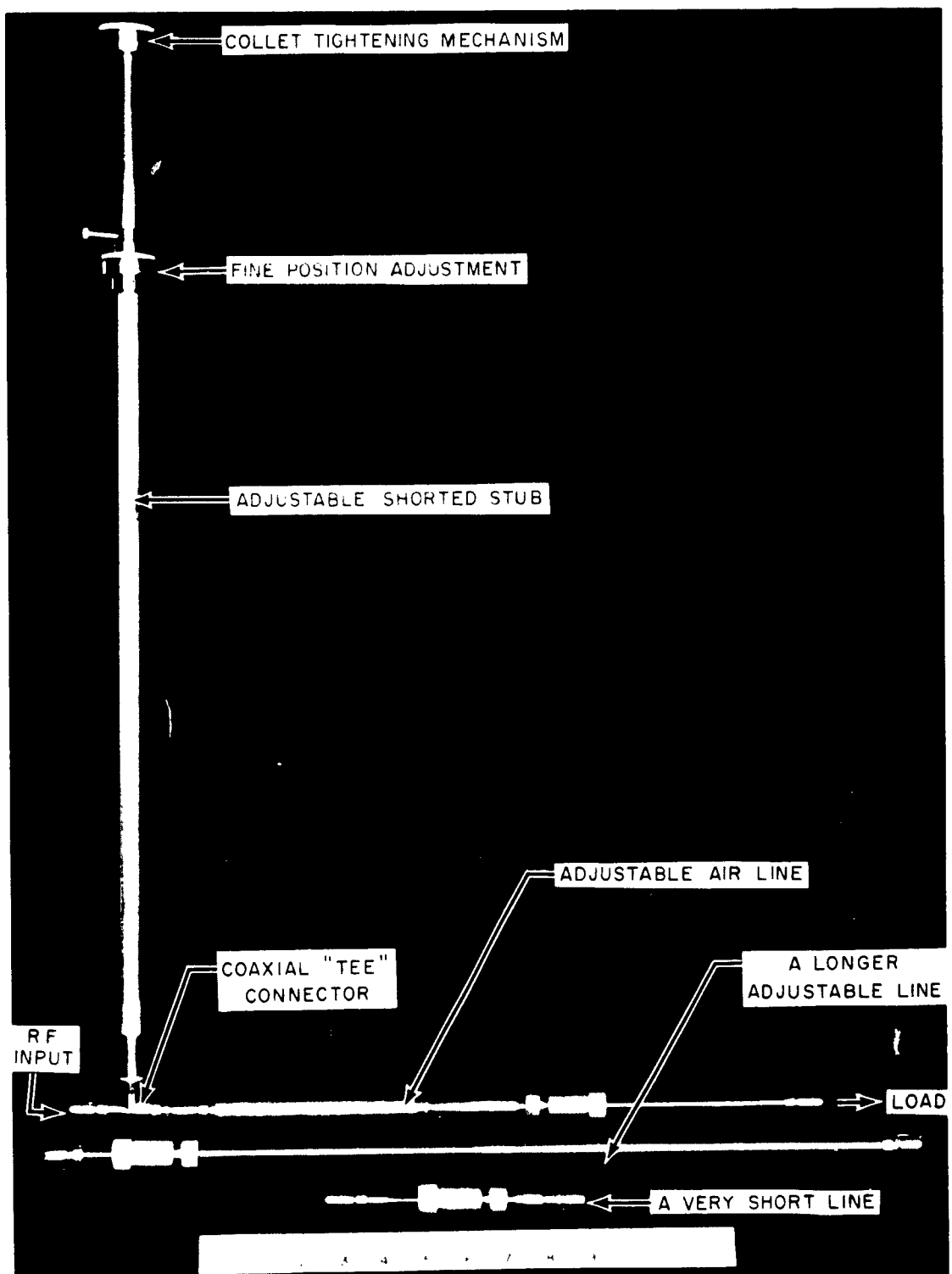


FIG. 2-11 IMPEDANCE MATCHING NETWORK EMPLOYING THE SHORTED STUB
AND A SECTION OF ADJUSTABLE AIR LINE

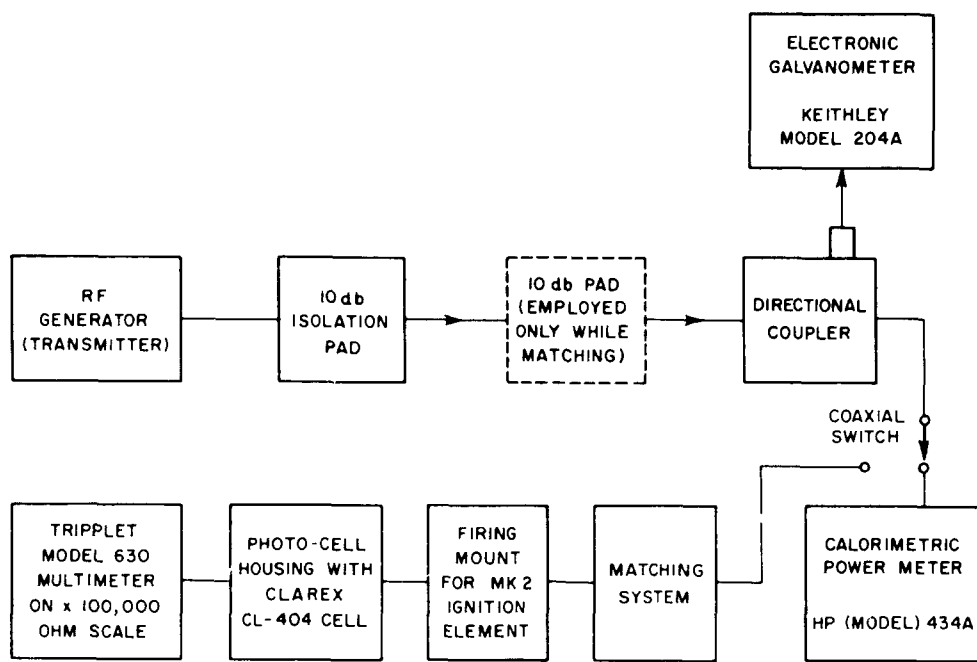


FIG 3-1 BLOCK DIAGRAM OF TYPICAL SETUP FOR SYSTEM LOSS EVALUATION

showed little difference in results whether the pad was used or not. The pad was used for the firing system evaluations made during the present period.

The MARK 2 MOD 0 and the MARK 1 MOD 0 systems were evaluated for losses at 5 and 30 megacycles. Data resulting from these tests is given in the Appendix, Tables A-1 to A-5. Average loss factors are given in Table 3-1 for all of the items tested on this program to date.

Table 3-1

SYSTEM LOSS FACTOR

<u>Device</u>	<u>Frequency (Mc)</u>	<u>System Loss Factor (Average)</u>	<u>Efficiency (Percent)</u>
MARK 1 MOD 0	5 Mc	0.94791	94.79%
MARK 1 MOD 0	30 Mc	0.71770	71.77%
MARK 1 MOD 0	250 Mc	0.80997	80.99%
MARK 2 MOD 0	5 Mc	0.69620	69.62%
MARK 2 MOD 0	30 Mc	0.42258	42.26%
MARK 2 MOD 0	250 Mc	0.41210	41.21%

4. BRUCETON SENSITIVITY TESTS

Contributor: John P. Warren

The RF sensitivity of the MARK 2 MOD 0 ignition at 250 Mc was established by means of a Bruceton test of 100 elements during the previous report period. Additional tests on the MARK 2 were made at 5 and 30 megacycles during the present period.

The Bruceton tests were continued and 100 firings were completed for the MARK 1 MOD 0 squib at 5, 30, and 250 megacycles. The Bruceton analysis sheets for all of the tests are given in the Appendix, Tables B-1 to B-12.

The system input power for the 50-percent fire level was derived from these Bruceton tests and then multiplied by the system loss factors obtained in Section 3. This gave the power input to the bridge wire if no losses in the base of the items are present. However, no tests for base loss have been made on the MARK 1 MOD 0 squib, and figures for the actual sensitivity are reserved until a later date.

Table 4-1 is a summary of pertinent data obtained to date. It will be noted that the calculated powers to the bridge wire of the MARK 1 MOD 0 squib have a spread of less than 2% over the range of 5 to 250 Mc. The spread for the MARK 2 MOD 0 element is around 8%. This spread is higher than expected. This may be attributable to the fact that ignition elements for the 30 Mc test were taken from a different lot. This was discovered when an inventory disclosed that we had not fired as many times from the new lot as we thought.

The average sensitivity of the MARK 1 squib for 5, 30, and 250 megacycles is 0.091 watts at the input of the bridge wire. The average sensitivity of the MARK 2 MOD 0 element, over the same frequency range, is 0.893 watts. It is interesting to note that the MARK 1 squib is approximately ten times as sensitive as the MARK 2 element. The sensitivities of the two devices are in approximate ratio with their dc bridge wire resistances. (0.1 ohm - MARK 2 - 1.0 ohm MARK 1).

Table 4-1

INPUT POWER TO BRIDGE WIRE

<u>Device</u>	<u>Freq. (Mc)</u>	<u>System Input Power For 50% Fire P_1 (Watts)</u>	<u>System Loss Factor F</u>	<u>Calculated Input To Bridge Wire $P_B = P_1 \times F$ (Watts)</u>	
MARK 1 MOD 0	5	0.096556	0.94791	0.09153	} average = .09105
MARK 1 MOD 0	30	0.12504	0.71770	0.08974	
MARK 1 MOD 0	250	0.11343	0.80997	0.09187	
MARK 2 MOD 0	5	1.2260	0.69620	0.85354	} average = 0.89278
MARK 2 MOD 0	30	2.2051	0.42258	0.93183*	
MARK 2 MOD 0	250	2.1650	0.41210	0.89219	

* The items used in this test are believed to have been taken from a different lot from those used for the other tests.

5. CONCLUSIONS AND FUTURE PLANS

With the completion of Bruceton tests at 5, 30, and 250 megacycles, we are in a position to draw limited conclusions regarding the sensitivity of the MARK 2 ignition element. The loss in the base of this item is considered to be negligible at frequencies of 250 megacycles and below. Therefore, the figure obtained for sensitivity at the bridge wire is the sensitivity at the base of the item. The average sensitivity of the MARK 2 element over the range of 5, 30, and 250 megacycles is, then, 0.893 watts. This figure should correspond very closely with the dc firing level.

Bruceton tests have also been completed for the MARK 1 MOD 0 squib at 5, 30, and 250 megacycles. However, no tests for determination of the loss in the base have been made. If we assume that the loss in the base of the squib is negligible in this case, also we may quote a tentative figure of 0.0910 watts for the sensitivity of the item. We do not have figures for the equivalent dc sensitivity of this item, but we would assume it to be very close to the RF value of 0.0905 watts.

While a considerable part of the original aims of the program have been accomplished, several complications arose during the study which were not fully expected. As a result the funds and original time allotted have been used up. It should be understood, however, that these complications have not been just lost ground, but have in nearly every case further extended the present state of knowledge in this field. These complications can be divided into two major categories; RF power detection at the base of the EED and impedance matching.

With regard to power detection, it was indicated from the preliminary studies that vacuum thermocouples of varying resistances could be used to obtain a calibration of the system losses as a function of terminating resistance. However, while this still remains a possibility, it was found that the thermocouples when mounted represented impedances

that were so different from the actual EED's that it was decided to go to a different system. The system now in use for the lower frequencies consists of an infrared detector which detects the energy dissipated in the bridge wire. This system works very well at the lower frequencies, but is valid only so long as the RF energy is dissipated only in the bridge wire and there is no direct RF interaction with the detector. Both of these points are questionable at high frequencies.

The more direct and most useful approach to this problem is to measure the impedance and the voltage at the base of the plug and to determine the power directly at this point. As the wavelength becomes shorter this is more and more difficult to do, but during this study equations and techniques have been worked out which should make these measurements possible.

With regard to matching techniques, great strides have been made. It was determined during this study that system losses are almost entirely a function of the degree of mismatch between the generating system and the termination and the physical length of the system from the matching device to the EED. For the tremendous mismatches which normally occur between a typical 50 ohm system and an EED these losses can become quite large; so large in fact, that situations can occur which make it impossible or extremely difficult to obtain a match. The development of theory with supporting equations indicated that present commercially available matching systems were not adequate and indicated the necessary direction in which to go to develop more effective matching devices. These devices have subsequently been developed and proven in use. This then brings us to the present status of the contract. At this time the following items have been accomplished.

- a) Development of firing instrumentation for all six frequencies (5, 30, 250, 1,000, 3,000, and 10,000 Mc).
- b) Development of system loss calibration techniques for 5, 30, and 250 Mc and actual calibration of these firing systems.

- c) Development of refined matching systems for 5, 30, 250, and 1,000 Mc. The 3,000 and 10,000 Mc systems will use waveguide rather than coaxial lines and the techniques are worked out.
- d) Evolution of theory and equations for system losses as a function of terminating impedance for any system. These equations should be of considerable value in the future when they are completely established.
- e) Completed firing tests for both the MARK 1 MOD 0 squib and the MARK 2 MOD 0 ignition element at 5, 30, and 250 Mc. These tests have been very successful.
- f) Attenuation and impedance measurements of the EED's at 5, 30, and 250 Mc.

These following tasks remain to be done.

- a) Final refinement of firing systems at 1,000, 3,000, and 10,000 Mc.
- b) Final development of the power detection system at 1,000, 3,000, and 10,000 Mc. This is done when the systems are set up and ready to go in final form.
- c) Attenuation and impedance measurements at 1,000, 3,000, and 10,000 Mc.
- d) Calibration of systems losses at 1,000 3,000 and 10,000 Mc.
- e) Firing tests at 1,000, 3,000, and 10,000 Mc.

There is also the possibility that a constant current firing test on the MARK 1 MOD 0 will be required if this information does not already exist. Because testing at three of the six frequencies remains to be done it might appear that the remaining tasks represent half of the project; this is not so since the solution of problems that came up in the early studies will greatly simplify the remaining tasks. Many of the problems that arose, where not completely unexpected, were of greater number and complexity than originally estimated. On the other hand the solution of these problems has yielded knowledge and techniques beyond the original scope of the contract and this knowledge will be of considerable future

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value. Furthermore, the sensitivity information obtained so far is of immediate value and also applicable to future studies of RF sensitivity to pulsed power. On the above bases we are requesting that the present contract be extended four months with additional funds.

Paul F. Mohrbach

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Project Engineer

Approved by:

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Applied Physics Laboratory

Francis L. Jackson

Francis L. Jackson
Director of Laboratories

APPENDIX A

- Table A-1 Efficiency of RF Matching System and Firing Mount for MARK 2
MOD 0 Ignition Element at 5 Megacycles
- Table A-2 Efficiency of RF Matching System and Firing Mount for MARK 2
MOD 0 Ignition Element at 30 Megacycles
- Table A-3 Efficiency of RF Matching System and Firing Mount for MARK 1
MOD 0 Squib at 5 Megacycles
- Table A-4 Efficiency of RF Matching System and Firing Mount for MARK 1
MOD 0 Squib at 30 Megacycles
- Table A-5 Efficiency of RF Matching System and Firing Mount for MARK 1
MOD 0 Squib at 250 Megacycles

Table A-1

EFFICIENCY OF RF MATCHING SYSTEM AND FIRING MOUNT FOR MARK 2 MOD 0 IGNITION ELEMENT AT 5 MEGACYCLES

Element Number	RF Power Input (Watts)	Light Cell Resistance (Ohms)	DC Calibration with L & N "K" Pot			$I_H = \frac{E_R}{R_C}$ (amps)	Heater Power (dc) $P_{dc} = E_H \times I_H$ (Watts)	RF system Efficiency $= \frac{P_{dc}}{P_{rf}}$	RF Freq. (Mc)
			E_R (volts)	E_H (volts)	R_C (ohms)				
1	1.54	500K	1.39632	0.38024	0.5	2.79264	1.06187	0.6895	5
3	1.63	500K	1.44192	0.38514	0.5	2.88384	1.11068	0.6814	5
4	1.59	500K	1.37102	0.41072	0.5	2.74204	1.12621	0.7083	5
8	1.45	500K	1.28854	0.39794	0.5	2.57708	1.02553	0.7072	5
1	1.54	500K	1.39651	0.37918	0.5	2.79302	1.05905	0.6876	5
4	1.55	500K	1.36494	0.39238	0.5	2.72988	1.07115	0.6910	5
8	1.45	500K	1.29371	0.39704	0.5	2.58742	1.02730	0.7084	5

Highest Efficiency = 0.7084

Average Efficiency = 0.6962

Lowest Efficiency = 0.6814

Table A-2

EFFICIENCY OF RF MATCHING SYSTEM AND FIRING MOUNT FOR MARK 2 MOD 0 IGNITION ELEMENT AT 30 MEGACYCLES

Element Number	RF Power Input (Watts)	Light Cell Resistance (Ohms)	DC Calibration with L & N "K" lot		$I_H = \frac{E_H}{R_S}$ (amps)	Heater Power (dc) $P_{dc} = E_H \times I_H$ (watts)	RF system Efficiency $= \frac{P_{dc}}{P_{rf}}$	RF Freq. (Mc)
			E_H (volts)	R_S (ohms)				
1	2.54	500K	1.35830	0.38121	2.7166	1.03559	0.40771	30
4	2.62	500K	1.35239	0.42303	2.7047	1.14416	0.43670	30
8	2.33	500K	1.27418	0.41029	2.5483	1.04554	0.44872	30
1	2.62	500K	1.38182	0.38424	2.7636	1.06188	0.40529	30
4	2.60	500K	1.34920	0.40837	2.6984	1.10195	0.42383	30
8	2.32	500K	1.27218	0.40854	2.5443	1.03945	0.44804	30
Low Loss Simulant	2.63	500K	1.37928	0.39253	2.7585	1.08279	0.41171	30
Low Loss Simulant	2.68	500K	1.37284	0.38913	2.7456	1.06842	0.39866	30

Highest Efficiency = 0.44872
Average Efficiency = 0.42258
Lowest Efficiency = 0.39866

Table A-3

EFFICIENCY OF RF MATCHING SYSTEM AND FIRING MOUNT FOR MARK 1 MOD 0 SQUIB AT 5 MEGACYCLES

Squib Number	RF Power Input (Watts)	Light Cell Resistance (Ohms)	DC Calibration with L & N "K" Pot			Heater Current $I_H = \frac{E_R}{R_S}$ (amps)	Heater Power (dc) $P_{dc} = E_H \times I_H$ (Watts)	RF system Efficiency $= \frac{P_{dc}}{P_{rf}}$	RF Freq. (Mc)
			E_R (volts)	E_H (volts)	R_S (ohms)				
7	0.182	500K	0.34586	0.49772	1	0.34586	0.172141	0.9458	5
6	0.178	500K	0.33797	0.49626	1	0.33797	0.167720	0.9422	5
5	0.181	500K	0.34061	0.50291	1	0.34061	0.171296	0.9464	5
4	0.181	500K	0.34511	0.50423	1	0.34511	0.174015	0.9614	5
3	0.178	500K	0.33649	0.50259	1	0.33649	0.169117	0.9501	5
7	0.180	500K	0.34405	0.49336	1	0.34406	0.169740	0.9430	5
6	0.180	500K	0.33852	0.49773	1	0.33852	0.168491	0.9361	5
5	0.180	500K	0.33992	0.50045	1	0.33992	0.170112	0.9451	5
4	0.182	500K	0.34431	0.50379	1	0.34431	0.173459	0.9531	5
3	0.181	500K	0.33875	0.51078	1	0.33875	0.173027	0.9559	5

Highest Efficiency = 0.9614
Average Efficiency = 0.94791
Lowest Efficiency = 0.9361

Table A-4

EFFICIENCY OF RF MATCHING SYSTEM AND FIRING MOUNT FOR MARK I MOD O SQUIB AT 30 MEGACYCLES

Squib Number	RF Power Input (Watts)	Light Cell Resistance (Ohms)	DC Calibration with L & N "K" Pot			Heater Current $I_H = \frac{E_R}{R_S}$ (amps)	Heater Power (dc) $P_{dc} = E_H \times I_H$ (Watts)	RF system Efficiency = $\frac{P_{dc}}{P_{rf}}$	RF Freq. (Mc)
			E_R (volts)	E_H (volts)	R_S (ohms)				
5	0.235	500K	0.34192	0.50351	1	0.34192	0.17216	0.7326	30
4	0.238	500K	0.34775	0.50446	1	0.34775	0.17542	0.7370	30
3	0.251	500K	0.34245	0.51479	1	0.34245	0.17629	0.7023	30
2	0.249	500K	0.33300	0.51527	1	0.33300	0.17158	0.6890	30
1	0.242	500K	0.33954	0.49101	1	0.33954	0.16669	0.6888	30
5	0.242	500K	0.34396	0.50726	1	0.34396	0.17448	0.7209	30
4	0.240	500K	0.34786	0.50611	1	0.34786	0.17605	0.7335	30
3	0.248	500K	0.34242	0.51466	1	0.34242	0.17623	0.7106	30
2	0.235	500K	0.33222	0.51539	1	0.33222	0.17122	0.7370	30
1	0.232	500K	0.34027	0.49559	1	0.34027	0.17216	0.7326	30

Highest Efficiency = 0.7370

Average Efficiency = 0.7177

Lowest Efficiency = 0.6888

Table A-5

EFFICIENCY OF RF MATCHING SYSTEM AND FIRING MOUNT FOR MARK 1 MOD 0 SQUIB AT 250 MEGACYCLES

Squib Number	RF Power Input P _{RF} (Watts)	Light Cell Resistance (Ohms)	DC Calibration with L & N "K" Pot		Heater Current $I_H = \frac{E_R}{R_S}$ (amps)	Heater Power (dc) $P_{dc} = E_H \times I_H$ (Watts)	RF system Efficiency		RF Freq. (Mc)
			E_R (volts)	E_H (volts)			P_{dc}	P_{RF}	
7	0.212	500K	0.34564	0.49647	0.34564	0.17159	0.8094	0.8094	250
6	0.208	500K	0.34066	0.50206	0.34066	0.17103	0.8222	0.8222	250
5	0.207	500K	0.34195	0.50477	0.34195	0.17261	0.8338	0.8338	250
4	0.217	500K	0.34483	0.50424	0.34483	0.17387	0.8013	0.8013	250
3	0.217	500K	0.33812	0.50806	0.33812	0.17178	0.7916	0.7916	250
7	0.214	500K	0.34457	0.49326	0.34457	0.16996	0.7942	0.7942	250
6	0.208	500K	0.33822	0.49642	0.33822	0.16789	0.8072	0.8072	250
5	0.209	500K	0.34085	0.50125	0.34085	0.17085	0.8175	0.8175	250
4	0.214	500K	0.34346	0.50045	0.34346	0.17188	0.8032	0.8032	250
3	0.212	500K	0.33963	0.51138	0.33963	0.17368	0.8192	0.8192	250

Highest Efficiency = 0.8338
Average Efficiency = 0.80997
Lowest Efficiency = 0.7916

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APPENDIX B

B-1	Bruceton Test MARK I MOD 0 Squib 5 Mc
B-2	Bruceton Test MARK I MOD 0 Squib 30 Mc
B-3	Bruceton Test MARK I MOD 0 Squib 250 Mc
B-4	Bruceton Test MARK II MOD 0 Squib 5 Mc
B-5	Bruceton Test MARK II MOD 0 Squib 30 Mc

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B-1 BRUCETON TEST MK 1 MOD 0 SQUIB 5 MC

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Functioning Levels (ζ)											FUNCTION. TIME		RESISTANCE	ITEM NO.
WATTS	0.721	0.773	0.828	0.887	0.950	1.02	1.09	1.17	1.25	1.34	secs	Ω		
					0						-	0.97	1	
					0	X					0.9561	1.05	2	
					0						-	1.00	3	
					0	X					1.3051	0.98	4	
					0						-	-	5	
					0	X					1.6824	1.07	6	
					0						-	1.11	7	
					0	X					1.7058	1.20	8	
					0						-	1.02	9	
					0	X					0.9210	1.04	10	
					0						-	0.89	11	
					0						-	1.05	12	
						X					0.9581	0.92	13	
						X					0.6939	0.93	14	
					0						-	1.07	15	
					0						-	1.10	16	
						X					0.8630	0.91	17	
						X					0.5868	1.05	18	
											1.6867	1.02	19	
					0						-	0.95	20	
					0	X					1.8088	-	21	
					0						-	1.00	22	
					0						-	0.82	23	
						X					0.9376	0.96	24	
						X					1.2630	0.95	25	
					0						-	1.04	26	
					0	X					2.7346	1.14	27	
					0						-	1.06	28	
					0						-	0.96	29	
						X					0.6590	0.98	30	
					0						-	1.04	31	
						X					1.1086	1.08	32	
					0						-	0.92	33	
						X					0.8547	1.04	34	
						X					1.2789	1.01	35	
											1.427	1.01	36	
						X					2.2124	1.03	37	
					0						-	1.08	38	
					0						-	0.98	39	
					0						-	1.00	40	
					0						-	1.02	41	
						X					0.7459	1.05	42	
					0						-	1.04	43	
					0						-	0.97	44	
						X					0.9475	0.98	45	
					0						-	1.00	46	
						X					0.7641	0.84	47	
					0	X					0.6914	0.97	48	
					0						-	0.94	49	
						X					0.5641	1.04	50	
											n _x =	X		
											n ₀ =	O		
	0	1	1	5	14	4								
	1	1	5	13	4	0								

Functioning Levels (ζ)											FUNCTION. TIME		RESISTANCE	ITEM NO.
WATTS	0.721	0.773	0.828	0.887	0.950	1.02	1.09	1.17	1.25	1.34	secs	Ω		
					0	X					1.4508	1.00	51	
					0						-	0.98	52	
					0						-	1.03	53	
						X					1.2299	1.04	54	
						X					0.4533	0.86	55	
					0						-	1.02	56	
					0						-	0.99	57	
						X					0.7450	1.01	58	
					0						-	0.94	59	
					0	X					0.9335	0.98	60	
					0						0.3523	1.06	61	
					0						-	1.00	62	
						X					0.2586	0.89	63	
						X					0.9780	0.95	64	
						X					2.2787	0.97	65	
					0						-	0.98	66	
					0						-	0.96	67	
						0					-	1.07	68	
						0					-	0.96	69	
						X					0.8392	0.93	70	
					0						-	0.98	71	
						X					0.6616	0.97	72	
					0						-	1.00	73	
						X					1.9130	1.00	74	
						X					0.8979	1.01	75	
					0						-	1.01	76	
						X					-	1.00	77	
					0						-	0.98	78	
					0						-	1.00	79	
						0					-	1.06	80	
											-	1.02	81	
						X					0.9062	0.98	82	
					0						-	1.05	83	
						X					0.9181	0.94	84	
					0						-	0.97	85	
						X					1.1642	0.95	86	
						X					0.7915	1.01	87	
					0						-	0.97	88	
					0						-	1.12	89	
						0					-	1.03	90	
											-	1.07	91	
						X					0.6993	1.01	92	
					0						-	1.06	93	
					0						-	1.00	94	
						X					1.0313	1.00	95	
						X					1.1060	1.04	96	
					0						-	1.05	97	
					0						-	1.00	98	
						X					0.8341	1.06	99	
											1.0134	1.10	100	
											n _x =	X		
											n ₀ =	O		
	0	1	1	7	12	4								
	1	1	7	12	7	0								

i	i ²	n _o	n _x	Σ = MW	Probability Levels	Confidence Level
0	0	2	0	77.3	P% = <u>99.9</u>	X% = <u>90</u>
1	1	2	2	82.8	100-P% = <u>.1</u>	
2	4	12	2	88.7		
3	9	26	12	95.0	m = <u>1.98478</u>	k _p ^② = <u>3.090</u>
4	16	8	26	102.0	σ = <u>.04274</u>	k _x ^② = <u>1.282</u>
5	25	0	8	109.0	d = <u>10.3</u>	G ^③ = <u>.965</u>
6	36				S = $\frac{g}{d}$ = <u>1.425</u>	G ² = <u>.93122</u>
Totals: N _o = 50 N _x = 50					N = <u>100</u>	H ^③ = <u>1.54</u>
					n ^① = <u>50</u>	H ² = <u>2.37160</u>

Special Parameters

c = (log ζ)_{i=0} = 1.88818

d = (log ζ)_{i=1} - (log ζ)_i = 10.3

Primary Statistics

A = Σ i in

B = Σ i² n

M = (NR - A²) / N²

m = c + d (AN ± 1) *

τ = 1.62 d (M + 0.029) $\sqrt{\frac{N}{N-1}}$

*Use + for "o's" - for "x's"

**Valid for M ≥ 0.3 only, otherwise consult 'Bruceton Report' (AMP Report No. 101 1R, "Statistical Analysis for A New Procedure in Sensitivity Experiments" July, 1944) File No. Ma-1

For "o's"	For "x's"
A = <u>136</u>	<u>186</u>
B = <u>412</u>	<u>734</u>
M = <u>.84160</u>	<u>.84160</u>
m = <u>1.98478</u>	<u>1.98478</u>
τ = <u>.04274</u>	<u>.04274</u>

Secondary Statistics

m = $\frac{N_o m_o + N_x m_x}{N_o + N_x}$ = 1.98478

σ = $\sqrt{\frac{N_o \sigma_o^2 + N_x \sigma_x^2}{N_o + N_x}}$ = .04274

ζ = Antilog m = .096556 WATTS

Humidity

Temp

Lot No.

Item MK 1 MOD C SQUIB

Type of Test BRUCETON

Frequency 5 MC

Pulse Width 0.4 μ

Rep Rate

Test No.

① n = $\frac{N}{2}$ when N is even integer

n = $\frac{N+1}{2}$ when N is odd integer

② From BF*, p. 19, at given P or X

③ From BF* for G & H versus S. Use Graphs III & IV.

When S ≥ .5, and Graph V

When S < .5

Confidence Interval (Y)

Y = k_x $\left(\frac{n+1.2}{n}\right) \left(\frac{G^2 + H^2 k_p^2}{n}\right)^{1/2}$

= .03853

Final Calculations

(99.9%) (90% Conf) = m + k_p σ + Y

= 2.15537 log units

= .143099 WATTS

(.1%) (90% Conf) = m - k_p σ - Y

= 1.81419 log units

= .06579 WATTS

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B-2 BRUCETON TEST MK 1 MOD 0 QU1B 30 MC

Functioning Levels (Z)											FUNCT. TIME	RESISTANCE	ITEM NO.	Functioning Levels (Z)											FUNCT. TIME	RESISTANCE	ITEM NO.
WATTS	.111	.119	.127	.136	.144	.156	.168	.180	.192	.206				secs	Ω	WATTS	.111	.119	.127	.136	.144	.156	.168	.180			
					X							1.03	1	0											-	1.05	51
				0								1.00	2		X										-	1.06	52
				X							0.3522	1.07	3	0											-	1.01	53
				0							-	0.94	4		X										1.1132	0.98	54
				X							1.07512	0.98	5	0											-	1.07	55
				0							-	0.96	6		0										-	1.02	56
				X							0.5421	1.00	7			X									1.7666	1.10	57
				X							1.3734	0.97	8		0										-	1.06	58
				X							1.9152	1.01	9			X									0.4144	0.98	59
	0										-	0.90	10		0										-	1.01	60
	X										0.9912	1.02	11			X									1.1790	1.01	61
	0										-	0.97	12		0										-	1.03	62
	X										1.0786	0.9	13			0									-	1.00	63
	0										-	0.95	14				X								0.7731	1.05	64
	X										1.8906	1.06	15		0										-	1.01	65
	X										1.0486	1.01	16				0								-	0.95	66
0											-	1.06	17				X								0.7144	0.98	67
0											-	0.90	18			X									0.4012	1.10	68
	X										1.2598	0.98	19			0									-	0.98	69
	0										-	0.98	20				0								-	0.95	70
	0										-	1.02	21					X							0.7245	0.99	71
				X							0.4957	1.03	22				X								0.5179	0.98	72
	X										1.1313	1.04	23				X								1.5015	1.05	73
	0										-	0.92	24		0										-	1.02	74
	0										-	1.03	25			0									-	1.02	75
				X							0.5286	0.97	26				0								-	1.07	76
	X										0.8939	1.05	27					X							0.4001	1.02	77
	X										0.6331	0.95	28				X								0.6254	1.05	78
0											-	0.97	29			X									0.9908	0.97	79
0											-	1.03	30		0										-	1.00	80
	0										-	1.08	31			0									-	0.98	81
				X							0.8389	1.00	32				0								-	1.02	82
	0										-	0.99	33					X							0.4618	1.04	83
				X							0.5546	1.00	34				X								3.5891	0.93	84
	0										-	0.99	35				0								-	0.95	85
				0							-	0.94	36					X							0.8810	0.98	86
				X							0.5385	0.98	37			0									-	1.01	87
	X										1.1909	1.05	38				X								1.4432	0.99	88
	0										-	1.04	39			0									-	0.92	89
	X										1.3588	1.03	40				0								-	0.98	90
	0										-	0.94	41					X							0.5361	0.97	91
	X										0.8192	0.97	42				0								-	0.98	92
	0										-	0.99	43					X							0.4935	0.97	93
				0							-	0.94	44				0								-	0.95	94
				X							0.5691	0.98	45					X							0.6350	0.99	95
				X							1.9441	0.94	46					X							1.1168	0.97	96
	X										0.8049	1.03	47				0								-	0.93	97
0	X										0.4557	0.99	48					X							1.1209	1.01	98
	0										-	0.97	49				0								-	0.93	99
	X										1.3148	1.02	50					X							1.1099	0.97	100
0	4	8	9	6							n _x =		X		0	2	5	10	7					n _x =		X	
3	7	8	5	0							n ₀ =		0		3	6	10	7	0					n ₀ =		0	

i	i ²	n _o	n _x	Σ = MW'
0	0	6	0	111
1	1	13	6	119
2	4	18	13	127
3	9	12	19	136
4	16	0	13	146
5	25			
6	36			
Totals:		N _o = 49	N _x = 51	

Special Parameters

c = (log ζ)₁₌₀ = 2.04532

d = (log ζ)₁₌₁ - (log ζ)₁₌₀ = .03

Primary Statistics

A = 85 in

B = 193 i²n

M = (NR - A²) / N²

m = c + d (A/N ± 1/2) *

σ = 1.62 d (M + 0.029) $\sqrt{\frac{N}{N-1}}$

*Use + for "o's" - for "x's"

**Valid for M ≥ 0.3 only, otherwise consult 'Bruceton Report' (AMP Report No. 101 IR, "Statistical Analysis for A New Procedure in Sensitivity Experiments" July, 1944) File No. Ma-1

For "o's" For "x's"

A = 85 141

B = 193 437

M = .92961 .92503

m = 2.11236 2.08236

σ = .04512 .09805

Secondary Statistics

m = $\frac{N_o m_o + N_x m_x}{N_o + N_x}$ = 2.09706

σ = $\sqrt{\frac{N_o \sigma_o^2 + N_x \sigma_x^2}{N_o + N_x}}$ = .046637

ζ = Antilog m = .12504 WATTS

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Probability Levels

P% = 95
100-P% = 5

Confidence Level

X% = 90m = 2.09706σ = .046637d = .03S = $\frac{q}{d}$ = 1.56N = 100n^① = 50k_p^② = 1.645k_x^② = 1.282G^③ = .957G² = .915849H^③ = 1.59H² = 2.5281① n = $\frac{N}{2}$ when N is even integern = $\frac{N+1}{2}$ when N is odd integer

② From BP*, p. 19, at given P or X

③ From BP* for G & H versus S. Use Graphs III & IV.

When S ≥ .5, and Graph V

When S < .5

Confidence Interval (Y)

$$Y = k_x \left(\frac{n+1.2}{n} \right) \left(\frac{G^2 + H^2 k_p^2}{n} \right)^{1/2} \sigma$$

= .02299

Final Calculations

(95%) (90% Conf) = m + k_pσ + Y= 2.19677 log units= 157.32 MW
.15732 WATTS(5%) (90% Conf) = m - k_pσ - Y= 1.99735 log units= 99.39 MW
.09939 WATTS

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[illegible]

i	i ²	n _o	n _x	Σ = MW
0	0	10	0	103
1	1	16	10	110
2	4	16	16	118
3	9	8	16	126
4	16	0	8	135
5	25			
6	36			
Totals: N _o = 50 N _x = 50				

Special Parameters

c = (log Σ)_{i=0} = 2.01384

d = (log Σ)_{i+1} - (log Σ)_i = .03

Primary Statistics

A = Σ i n

B = Σ i² n

M = (NB - A²) / N²

m = c + d (A N + 1) / N

σ = 1.62 d (M + 0.029) / √(N-1)

*Use + for "o's" - for "x's"

**Valid for M ≥ 0.3 only, otherwise consult 'Bruceton Report' (AMP Report No. 101 IR, "Statistical Analysis for A New Procedure in Sensitivity Experiments" July, 1944) File No. Ma-1

	For "o's"	For "x's"
A =	<u>72</u>	<u>122</u>
B =	<u>152</u>	<u>346</u>
M =	<u>.96640</u>	<u>.96640</u>
m =	<u>2.05104</u>	<u>2.05104</u>
σ =	<u>.048875</u>	<u>.048875</u>

Secondary Statistics

m = $\frac{N_o m_o + N_x m_x}{N_o + N_x} = \underline{2.05104}$

σ = $\sqrt{\frac{N_o \sigma_o^2 + N_x \sigma_x^2}{N_o + N_x}} = \underline{.048875}$

ζ = Antilog m = .11343 WATTS

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Probability Levels

P% = 99.9100-P% = .1

Confidence Level

X% = 90m = 2.05104k_p^② = 3.096σ = .048875k_x^② = 1.282d = .03G^③ = .954S = $\frac{G}{d} = \underline{1.62916}$ G² = .9011N = 100H^③ = 1.617n^① = 50H² = 2.6146① n = $\frac{N}{2}$ when N is even integern = $\frac{N+1}{2}$ when N is odd integer

② From BP*, p. 19, at given P or X

③ From BR* for G & H versus S. Use Graphs III & IV.

When S ≥ .5, and Graph V

When S < .5

Confidence Interval (Y)

$$Y = k_x \left(\frac{n+1.2}{n} \right) \left(\frac{G^2 + H^2 k_p^2}{n} \right)^{1/2} \sigma$$

= .71924

Final Calculations

(99.9%) (90% Conf) = m + k_p σ + Y= 2.92136 log units= .83424 WATTS(0.1%) (90% Conf) = m - k_p σ - Y= 1.18078 log units= .15167 WATTS

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B-4 BRUGTON TEST MK 2 MOD 0 ELEMENT 5 MC

Functioning Levels (ζ)						FUNCT. TIME	RESISTANCE	ITEM NO.	Functioning Levels (ζ)						FUNCT. TIME	RESISTANCE	ITEM NO.
WATTS	1.03	1.10	1.18	1.26	1.35				secs	Ω	1.03	1.10	1.18	1.26			
						-	.105	1							.228372	.107	51
						-	.110	2							.686500	.096	52
						.1222	.105	3							-	.107	53
						★	.101	4							-	.107	54
						-	.110	5							.218163	.098	55
						★	.100	6							.418044	.110	56
						-	.103	7							-	.091	57
						★	.113	8							-	.101	58
						-	.104	9							.173209	.108	59
						★	.106	10							.461746	.105	60
						-	.106	11							-	.091	61
						.1898	.112	12							-	.108	62
						★	.105	13							.090076	.098	63
						-	.102	14							.978690	.100	64
						★	.103	15							-	.098	65
						-	.107	16							.235854	.095	66
						-	.102	17							-	.112	67
						★	.100	18							-	.105	68
						-	.108	19							.061874	.097	69
						★	.106	20							.688470	.092	70
						-	.105	21							-	.098	71
						★	.098	22							-	.110	72
						-	.105	23							.456157	.111	73
						★	.102	24							-	.112	74
						-	.100	25							.077086	.104	75
						.17832	.095	26							.371377	.103	76
						★	.104	27							.352244	.107	77
						-	.108	28							-	.107	78
						-	.100	29							-	.101	79
						★	.110	30							-	.115	80
						-	.101	31							.115032	.100	81
						★	.1095	32							.312248	.105	82
						.951730	.106	33							-	.100	83
						-	.105	34							.462057	.094	84
						-	.100	35							.645810	.106	85
						.339	.103	36							-	.098	86
						-	.100	37							-	.102	87
						.009705	.090	38							.562393	.094	88
						.664347	.102	39							-	.095	89
						-	.110	40							.203946	.107	90
						.442181	.100	41							-	.110	91
						-	.093	42							.402804	.102	92
						-	.096	43							-	.110	93
						-	.098	44							.258443	.094	94
						★	.095	45							-	.095	95
						★	.093	46							-	.115	96
						-	.108	47							.115653	.102	97
						.173241	.100	48							.1053918	.113	98
						-	.096	49							-	.102	99
						-	.095	50							-	.112	100
	0	6	16	2		n _x = 24		X							n _x = 25		X
	6	17	3	0		n _o = 26		O							n _o = 25		O

i	i ²	n _o	n _x	Σ
0	0	8	0	1.10
1	1	31	8	1.18
2	4	12	30	1.26
3	9	0	11	1.35
4	16			
5	25			
6	36			
Totals: N _o = 51 N _x = 49				

Special Parameters

c = (log ζ)_{i=0} = 0.04139

d = (log ζ)_{i=1} - (log ζ)_{i=0} = 0.3

Primary Statistics

A = Σ i in

B = Σ i² n

M = (N B - A²) / N²

m = c + d (A/N ± 1) *

σ = 1.62 d (M + 0.029) / √(N-1)

*Use + for "o's"; - for "x's"

**Valid for M ≥ 0.3 only, otherwise consult "Bruceton Report" (AMP Report No 101 IR "Statistical Analysis for A New Procedure in Sensitivity Experiments" July, 1944) File No Ma-1

For "o's" For "x's"

A = 55 101

B = 79 227

M = 0.38600 0.38401

m = 0.08874 0.08823

σ = 0.02037 0.02028

Secondary Statistics

m = $\frac{N_o m_o + N_x m_x}{N_o + N_x}$ = 0.08849

σ = $\sqrt{\frac{N_o \sigma_o^2 + N_x \sigma_x^2}{N_o + N_x}}$ = 0.02033

ζ = Antilog m = 1.226 WATTS

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Probability Levels

P% = 95
100-P% = 5

Confidence Level

X% = 90m = 0.08849k_p^② = 1.645σ = 0.02033k_x^② = 1.282d = 0.3G^③ = 1.066S = $\frac{g}{d}$ = 0.677G² = 1.136356N = 100H^③ = 1.26n^① = 50H² = 1.5876① n = $\frac{N}{2}$ when N is even integern = $\frac{N+1}{2}$ when N is odd integer

② From BP*, p. 19, at given P or X

③ From BP* for G & H versus S.
Use Graphs III & IV.

When S ≥ .5, and Graph V

When S < .5

Confidence Interval (Y)

Y = k_x $\left(\frac{n+1.2}{n}\right) \left(\frac{G^2 + H^2 k_p^2}{n}\right)^{1/2}$ = 0.00871

Final Calculations

(95%) (90% Conf) = m + k_p σ + Y= 0.13064 log units= 1.3509 WATTS(5%) (90% Conf) = m - k_p σ - Y= 0.4634 log units= 1.1126 WATTS

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B-5 BRUCETON TEST MK 2 MOD 0 ELEMENT 30 MC

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[illegible]

i	i ²	n _o	n _x	Σ
0	0	3	0	1.91
1	1	18	3	2.05
2	4	26	18	2.20
3	9	3	26	2.35
4	16	0	3	2.52
5	25			
6	36			
Totals: N _o = 50 N _x = 50				

Special Parameters

$c = (\log \zeta)_{i=0} = 0.28103$

$d = (\log \zeta)_{i+1} - (\log \zeta)_i = 0.03$

Primary Statistics

$A = \sum i n$

$B = \sum i^2 n$

$M = (NR - A^2) / N^2$

$m = c + d (A/N \pm 1)$

$\sigma = 1.62 d (M + 0.029) \sqrt{\frac{N}{N-1}}$

*Use + for "o's"; - for "x's"

**Valid for M ≥ 0.3 only, otherwise consult 'Bruceton Report' (AMP Report No. 101 IR, "Statistical Analysis for A New Procedure in Sensitivity Experiments" July, 1944) File No. Ma-1

For "o's"	For "x's"
A = 79	
B = 149	
M = 0.48360	
m = 0.34343	
σ = 0.02517	

Secondary Statistics

$m = \frac{N_o m_o + N_x m_x}{N_o + N_x} = 0.34343$

$\sigma = \sqrt{\frac{N_o \sigma_o^2 + N_x \sigma_x^2}{N_o + N_x}} = 0.02517$

$\zeta = \text{Antilog } m = 2.2051 \text{ WATTS}$

Probability Levels

P% = 95

100-P% = 5

Confidence Level

X% = 90

$m = 0.34343$

$\sigma = 0.02517$

$d = 0.03$

$S = \frac{g}{d} = 0.8390$

$N = 100$

$n = 50$

$k_p = 1.645$

$k_x = 1.283$

$G = 1.030$

$G^2 = 1.0609$

$H = 1.32$

$H^2 = 1.7424$

① $n = \frac{N}{2}$ when N is even integer

$n = \frac{N+1}{2}$ when N is odd integer

② From BP*, p. 19, at given P or X

③ From BR* for G & H versus S. Use Graphs III & IV.

When $S \geq .5$, and Graph V

When $S < .5$

Confidence Interval (Y)

$Y = k_x \left(\frac{n+1.2}{n} \right) \left(\frac{G^2 + H^2 k_p^2}{n} \right)^{1/2} \sigma$

$Y = 0.1123$

Final Calculations

(95%) (90% Conf) = $m + k_p \sigma + Y$

= 0.39606 log units

= 2.4892 WATTS

(5%) (90% Conf) = $m - k_p \sigma - Y$

= 0.29080 log units

= 1.9535 WATTS

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