9 March 1938

NRL Report No. R-1430
BuEng. Problem M3-12

FR-1430

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test

of

Weston Wire Wound Voltmeter

Multiplier Resistors.

NAVAL RESEARCH LABORATORY
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WASHINGTON, D.C.

Number of Pages: Text - 5 Tables - 2 Plates - 2

Authorization: BuEng.ltr. S67/22 (1-7-W8) of 14 January 1938.

Date of Tests: 2 - 24 February 1938.

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Distribution:
BuEng. (5)

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AUTHORIZATION

1. The work reported on herein was authorized by Bureau of Engineering letter, reference (a). Other pertinent correspondence is listed as references (b) to (d).

Reference: (a) BuEng.ltr. S67/22 (1-7-W8) of 14 January 1938.
(b) Specifications for Electrical Indicating Instruments, 17-I-12a.
(c) Weston Electrical Instrument Corp. ltr. of 21 December 1937 to BuEng.
(d) NRL Report No. R-1120, "Report of Tests of Weston Replacement Voltmeter for Models RAA and RAB Receivers."

OBJECT OF TEST

2. The objects of the test were to determine whether the 3 voltmeter multiplier resistors submitted by the Weston Electrical Instrument Corporation comply with specifications, reference (b), and are suitable for Naval use.

ABSTRACT OF TEST

3. The multiplier resistors were tested to determine the following:

(a) Temperature coefficient of resistance.

(b) Temperature rise at maximum rated voltage.

(c) Temperature rise at 50% voltage overload.

(d) Protection afforded against humidity effects.

(e) Capability of insulation to withstand voltage overload.

CONCLUSIONS

(a) These voltmeter multiplier resistors comply with the applicable requirements of specifications, reference (b), except for minor constructional details.

(b) These units are well protected against the effects of excessive humidity.

(c) These units of both the tubular and the box type of mounting are considered suitable for Naval use as voltmeter multipliers at the voltages at which they are rated by the manufacturer.

RECOMMENDATIONS

(a) It is recommended that the 3.5 kilovolt tubular resistor, if applied to Naval use, be provided with ferrules having a diameter of 13/16" instead of 9/16", since the larger mounting clip will give increased spring tension for withstanding excessive vibration.

(b) Since these multipliers are totally enclosed in waterproof cases for humidity protection and since no overheating occurs, it is recommended that the construction of these multipliers be considered to conform to the essential requirements of reference (b), Paragraph 5(a)(5)(a) even though no perforated guard is employed.

(c) It is recommended that the phenolic insulation employed in the tubes of the tubular resistors be considered satisfactory. (See paragraph 5(a)(5)(b), reference (b)).

(d) It is recommended that these wire wound, wax impregnated, totally enclosed voltmeter multipliers of both the tubular and the box type be considered suitable for Naval use.

(e) It is recommended that the Weston Electrical Instrument Corporation be requested to consider the feasibility of applying similar humidity protection to the self-contained multipliers for meters, such as Type 22124 (250 volt, 2-1/2" diameter), even if it should be necessary to increase the space required to house the multiplier resistor.

MATERIAL UNDER TEST

4. The material under test consisted of 3 wire wound resistors submitted by the Weston Electrical Instrument Corporation for use as voltmeter multipliers in conjunction with indicating instruments drawing a current of 1 milliampere at full scale deflection, thus constituting a voltmeter of 1,000 ohms per volt at full scale on the meter. Two of the samples are of the tubular type; that is, the resistance elements are mounted in a bakelite tube which is filled with Superla wax for protection against humidity effects, while in the third sample the resistor units are mounted in an iron box which is also filled with the wax. Plates 1 and 2 show the type of construction and approximate size of these units. The several samples shall be identified in this report by the following numbers:

Unit No. 1 is a 750 volt tubular type multiplier (750 kilohms). See Plate 1.

Unit No. 2 is a 3.5 kilovolt tubular type multiplier (3.5 megohms). See Plate 1.

Unit No. 3 is a 3.5 kilovolt box type multiplier (3.5 megohms). See Plate 2.

METHOD OF TEST

5. The temperature effect on the resistance of the units was determined by measuring the resistance at a number of temperatures between -12° and $+52^{\circ}$ C., in each case after the temperature in the compartment had been held constant over a period of 2 hours. The temperature rise at maximum rated voltage and at 50% voltage overload was determined by applying the thermocouple of a resistance thermometer to the surface at the mid point, after the proper voltage had been applied for approximately 2 hours. The protection afforded against excessive humidity was determined by heating the units in salt water for 4 hours at 75° C., rinsing in fresh water, drying the surface, and measuring the resistance. The ability of the insulation to withstand a voltage overload was determined by applying two times the maximum rated voltage plus 1,000 volts between each terminal and the case and noting whether breakdown occurred.

DATA RECORDED DURING TEST

6. The data recorded during the tests are given under "Results of Test" and in the appended tables.

PROBABLE ERROR OF RESULTS

7. The error in the measurement of the resistance values is less than $\pm$ 0.15%. The error in the measurement of the temperature of the units is less than 2° C. The error in the measurement of the applied voltage during the voltage overload tests was less than $\pm$ 2%.

RESULTS OF TEST

8. Construction. These wire wound resistors for use as voltmeter multipliers are mounted in watertight cases for protection against humidity. As mentioned in reference (c), the resistance elements are wound on insulating spools which are mounted in a bakelite tube, in the case of the tubular style, and in an iron box, in the case of the so-called box type. The resistors are embedded in Superla wax to provide protection against humidity. At the upper part of Plate 1 are shown two resistor spools connected together by a threaded stud. The spool at the left is covered by the protective cup-shaped metal shield; that at the right has had the shield removed (which is shown above it) and also the layers of wax coated tape and a layer of insulated wire from one-half of the unit. The resistance of these particular unmounted spools which were furnished to show the construction of the resistance elements, is 1 megohm each. The size of the wire in these unmounted spools is approximately 0.001". The completed units which were tested were not disassembled for examination. It is presumed that the short tubular unit No. 1 contains one 750 kilohm spool and that unit No. 2 contains 5 spools of 700 kilohms each, in series. The resistance of the units at 20° C. was measured to be as follows:

Unit No.	1	747 kilohms
	2	3500 "
	3	3500 "

9. Temperature Effect on Resistance. The temperature coefficient of resistance (per cent change in resistance per degree Centigrade change in temperature) was measured to be as follows:

Unit Number	Temperature Coefficient
1	0.019 per cent
2	0.009 " "
3	0.009 " "

10. Temperature Rise. The temperature rise on the surface at maximum rated voltage and at 50% voltage overload were as follows:

Unit Number	Temperature Rise at Rated Voltage	Temperature Rise at 50% Voltage Overload
1	10°C.	20°C.
2	17	26
3	*	*

* Temperature rise less than 5°C.

Specifications, reference (b), paragraph 5(a)(2)(b) state that the temperature rise shall not exceed 75° C. in a 750 volt unit at full

rated voltage and shall not exceed 75° C. in 3.5 kilovolt units at 80% of full rated voltage. The temperature rise in these units was satisfactorily low and far within the specification allowance.

11. Humidity Test. All three of the resistors were fully immersed in salt water and heated to 75° C. After 4 hours the units were removed, rinsed in distilled water, the surfaces wiped with a dry cloth, and their resistances measured two minutes after removal from the salt water bath and again after one hour with the following results:

Unit No.	Resistance in Kilohms after Salt Water Bath		Resistance before Immersion
	Two minutes out of water	One hour our of water	
1	736	747	747
2	3060	3480	3500
3	3500	3500	3500

It will be noted that the immersion in salt water had a very slight effect on the resistance of the 2 tubular resistors as measured after one hour's drying and that there was no observed effect on unit No. 3 in the iron box even immediately after removal from the bath. These resistors of both the tubular and the box type are considered to be adequately protected against humidity effects.

12. Insulation Voltage Test. The samples were subjected to a dielectric voltage test in which a potential of two times the rated, or normal maximum voltage, plus 1,000 volts was applied from each terminal of the units to the case. This potential was 2500 volts for the 750 volt unit and 8000 volts for the 3.5 kilovolt units. In the test of the tubular units a metal band was clamped around the tube and the voltage applied between the terminal and the band. In the case of the unit mounted in the iron box the potential was applied between a terminal post and the box at a point at which the insulating coating had been removed.

All of the units withstood the insulation test without any breakdown. This test is prescribed in reference (b), paragraph 5(a)(5)(b).

13. Insulation. The insulation between the terminals of the tubular resistors consists of a bakelite tube which the manufacturer states in reference (c) has been sprayed with Glyptol. This insulation is considered satisfactory on the basis of the results of the salt water immersion test and the dielectric voltage test described above. In reference (b), paragraph 5(a)(5)(b) it is stated that Class B insulation (inorganic) shall be used unless otherwise specified. Class B insulation (ceramic material) is used in the box type unit No. 3.

14. Power Consumption. Since these resistors are intended for use with electrical indicating instruments having a full scale current

of 1 milliampere, the voltmeter formed by the use of these multipliers with such a meter would have a resistance of 1,000 ohms per volt at full scale. Therefore, the power consumed in the multiplier when its associated instrument indicates full scale would be 1 watt per thousand volts (1 watt per megohm of multiplier resistance).

15. Dimensions and Weight. The exact maximum overall dimensions of the 3 units tested are given in Table 2, together with their weights. In Plates 1 and 2 the style of the terminal construction provided is shown. The box type unit is offered by the manufacturer as stated in reference (c) "to meet certain space requirements on replacement jobs." This unit is quite heavy; its weight is more than 11 times that of the tubular unit of the same value of resistance. The weights of all the samples is given in the last column of Table 2. The ferrule of the 3.5 kilovolt tubular resistor has a diameter of 9/16". It is believed that the use of a 13/16" diameter ferrule with the corresponding mounting clip is decidedly preferable to guard against dislocation of the units under conditions of excessive vibration. This proposed value is the diameter of the ferrule of the Navy 60 watt resistor.

CONCLUSIONS

16. These voltmeter multiplier resistors comply with the applicable requirements of specifications, reference (b), except for minor constructional details.

17. These units are well protected against the effects of excessive humidity.

18. These units of both the tubular and the box type of mounting are considered suitable for Naval use as voltmeter multipliers at the voltages at which they are rated by the manufacturer.

Table 1

Summary of Test Data

Sample	Rated Voltage Volts	Rated Resistance Kilohms	Resistance at 20°C. Kilohms	Temp.Coeff. % Resistance Change per °C.	Resistance after salt water test Kilohms: 2 min. out of water	Resistance after salt water test Kilohms: 1 hr. out of water	Temp.Rise - °C.: Rated Voltage	Temp.Rise - °C.: 50% Voltage Overload
1	750	750	747	0.019	736	747	10	20
2	3500	3500	3500	0.009	3060	3480	17	26
3	3500	3500	3500	0.009	3500	3500	*	*

* Temperature rise less than 5°C.

Table 2

Dimensions and Weight

Sample	Dimensions - Inches: Length	Diameter	Width	Height	Diameter of Ferrule	Weight - Pounds
1	4-1/4	1-1/16	-	-	-	0.18
2	9-1/8	1-1/8	-	-	9/16	0.55
3	8-7/8	-	3-9/16	5-3/4	-	6.50

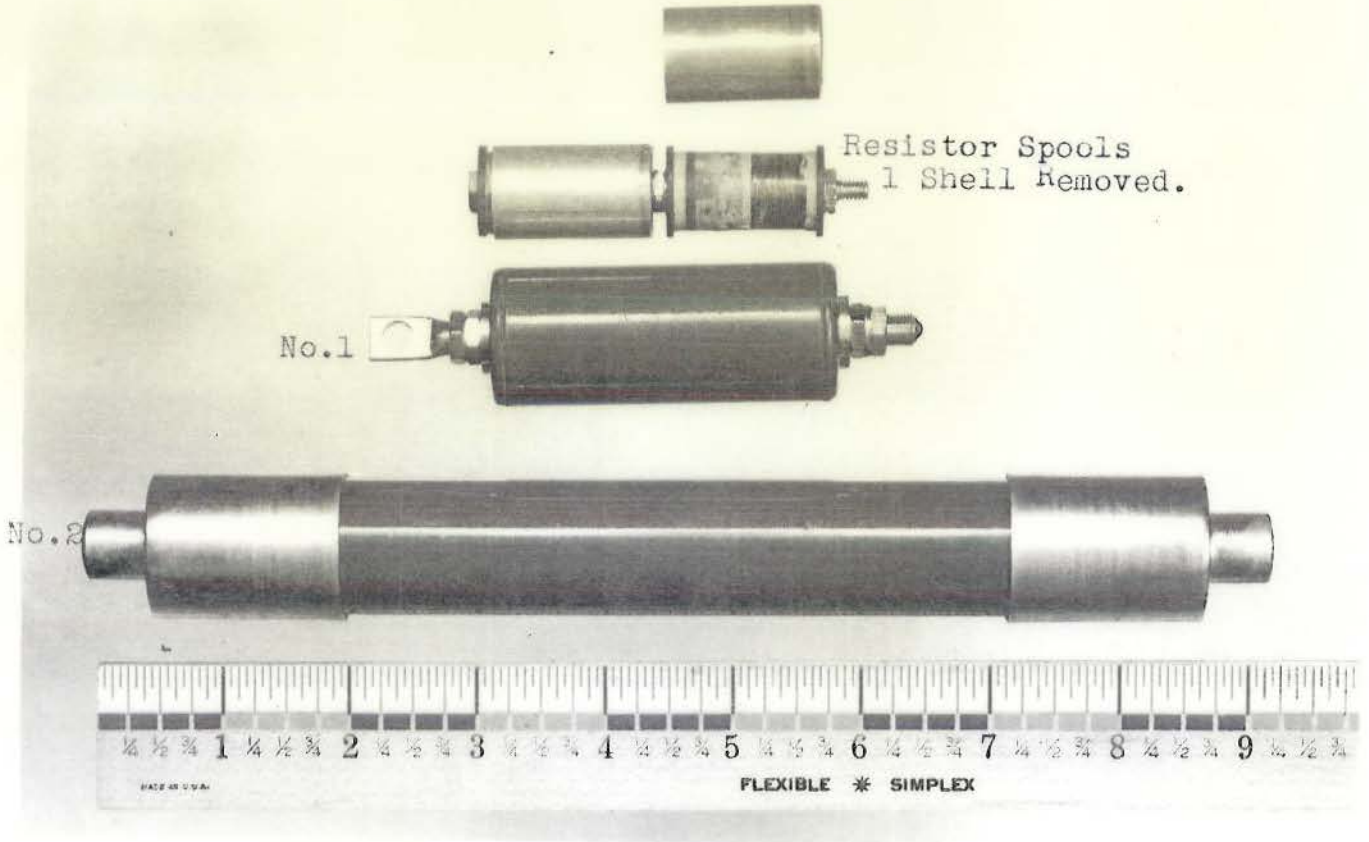

Plate 1.

Tubular Type Multipliers
No.1 - 750 V.
No.2 - 3.5 KV

Multiplier No.3 - 3.5 KV

Plate 2.