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SHIP-SHORE RADIO DIVISION - RECEIVER SECTION

28 November 1945

ELECTRICAL TESTS OF MODEL X-OBS CATHODE RAY OSCILLOSCOPE

By R. G. Hennessy

- Report R-2678 -

[redacted]

* Unclassified *

Approved by:

T. McL. Davis - Head, Receiver Section

L. A. Gebhard
Superintendent,
Ship-Shore Radio Division

Commodore H. A. Schade, USN
Director, Naval Research Laboratory

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NRL Problem S793.1T-C

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ABSTRACT

The Model X-OBS Oscilloscope was subjected to electrical tests to determine its compliance with Navy Specifications RE-9624-B and to check its applicability in calibration of time-sweep circuits of the Model AN/SPA-1 and RDJ Pulse Analyzers. The equipment failed to meet many of the specifications. The design of some of the circuits is unsatisfactory, since the vacuum tube electrode voltages exceed the absolute maximum values as stated in the JAN Tube Specifications. The performance of the equipment is not considered satisfactory. A complete redesign of the circuits is recommended.

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BuShips (6)
NRSL (1)
Op.Nav 413-B2 (1)

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INTRODUCTION

1. The Model X-OBS Cathode Ray Oscilloscope was designed for shipboard use. The Oscilloscope has sweep time durations of 5, 20, 100, 500 and 5000 microseconds which may be externally triggered. There is also an internal oscillator which allows the oscilloscope to be used as a synchroscope. The equipment was submitted for complete electrical and mechanical tests and to determine its applicability in calibration of the time sweep circuits of the Model AN/SPA-1 and RDJ Pulse Analyzers. Investigations of the electrical characteristics were made at the Naval Research Laboratory from 7 August 1945 to 20 September 1945 under authorization of reference 1. The tests made and the results obtained are discussed in this report.

RESULTS OF TESTS

2. Amplitude Variation of Calibration Sine Waves. The amplitude of the one-microsecond sine waves was constant at .2 inch on the 5 and 20 microsecond sweeps. There was a slight variation in amplitude on the 100 microsecond sweep, but the sine waves are not usable on this sweep. The 20 microsecond sine waves have an amplitude of .38 inches on the 100 microsecond sweep. On the 500 microsecond sweep, the amplitude varies from .39 to .35 inches or approximately ten percent. On the 5000 microsecond sweep the variation is much greater and again the sine waves are not usable. The specifications require that the variation in amplitude does not exceed 5%.

3. Accuracy of Sine Wave Frequency. The accuracy of the calibration sine waves was within 3.6% of the desired frequency. This is within the specification requirements of 5%.

4. Sweep Linearity. A Radar Range Calibrator Type CW60ABZ was used to measure the time required for the sweep to cover ten divisions of the scale (on the face of the scope) at the beginning of the sweep, and ten divisions at the end of the sweep. The specifications require the sweep to be linear within 2%. This requirement was not met. The 5 microsecond sweep was linear only within 10%; the ten divisions were covered in 1.1 microseconds at the beginning of the sweep and 1.2 microseconds at the end of the sweep. The 20 microsecond sweep deviated from linearity by 13.3%; the measured portion of the sweep was covered in 3.78 microseconds at the beginning and 4.36 microseconds at the end. The 100 microsecond sweep was linear within 5.8%. On this sweep, ten divisions on the scale equaled 19.5 microseconds at the beginning while the same distance at the end of the sweep was covered in 20.7 microseconds. The 500 microsecond sweep was linear within 26%, the portion of the sweep measured at the beginning being 38.5 microseconds shorter than the portion at the end. The 5000 microsecond sweep deviated from linearity by 15%. The portion of sweep measured at the beginning of the sweep was 70 microseconds shorter than the portion at the end of the sweep.

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5. Effect of Varying Trigger Pulse Width and Repetition Rate on Sweep Length. Varying the width of the trigger pulse had the greatest effect on the five microsecond sweep. The length in inches changed from 3-3/4 inches with a pulse width of 1 microsecond to 4.0 inches with a 5 microsecond pulse width. Above 5 microseconds, the sweep length was not appreciably affected by pulse width variations. The time duration on the sweep changed from 5.1 to 5.4 microseconds when the trigger pulse width was varied from 1 to 5 microseconds. The time duration did not change when the pulse width was increased above 5 microseconds. On the other sweeps, the change in sweep length or duration due to variations in trigger pulse width was negligible.

6. The repetition frequency of the triggering pulse was varied while the pulse width was kept constant at 5 microseconds. There was a 6% change of sweep length on the five microsecond sweep when the repetition frequency changed from 500 to 20000 cycles. The length of the 20 microsecond sweep decreased from 3-7/8 to 3-1/2 inches or 9.6%. The 100 microsecond sweep decreased from 4 inches to 3-1/2 inches over the range of frequencies. The 500 microsecond sweep decreased from 3-11/16 inches to 3-7/8 inches, a 22% change. The 5000 microsecond sweep was jittery above 5000 cycles and dropped from a length of 3-1/8 inches to 1-5/8 inches which is a 48% change.

7. With the internal blocking oscillator triggering the sweep, the length of the 5, 20, 100 and 500 microsecond sweep was fairly constant over the range of frequencies from 60 to 3600 cycles. The 5000 microsecond sweep decreased from 3-11/16 at 60 cycles to 2-7/8 at 3600 cycles, a 22% change.

8. Trigger Sensitivity. With the 'polarity' switch in the positive position, the sweep is triggered by positive pulses of 8.6 or more volts with pulse widths from 1 to 100 microseconds. A negative pulse of 18 volts with a width of 5 microseconds will trigger the sweep. At 25 microseconds and above, a negative pulse of 8.8 volts will trigger the sweep while the 'polarity' switch is still in the positive position.

9. With the 'polarity' switch in the negative position, a negative pulse of at least 14 to 18 volts is necessary to trigger the sweep. A positive pulse of more than 18 volts will trigger the sweep while the 'polarity' switch is in the negative position. Pulses of polarity opposite to that indicated by the 'polarity' switch should not trigger the sweep.

10. Blocking Oscillator. The output of the blocking oscillator is an 85 volt positive pulse or a 14 volt negative pulse at repetition rates from 27 to 3400 cycles.

11. Input Capacity of Input Terminals. The input capacity of the input terminals as measured between input jack to vertical plate and ground was 20.8 micromicrofarads for the top plate and 32.5 micromicrofarads for the bottom plate. These capacitances were measured on a

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"Q" Meter Type 160-A made by the Boonton Radio Company. A maximum of thirty micromicrofarads is allowed in the specifications.

12. Vacuum Tube Electrode Voltages. The vacuum tube electrode voltages were measured with a Precision Vacuum Tube Voltmeter, Pattern EV10 Serial 5158. The voltages on some of the tubes exceeded the absolute maximum allowable value as set forth in the JAN Tube Specifications. The following table lists the overrated tubes and their voltages:

TABLE A

Tube	Type	Eb	JAN (Design) Max. Eb	Ehk	JAN (Design) Max. Ehk
V101	6AG7			130	90
V102	6AC7	353	300		
V103	6SN7			340(Pin 6)	90
V104	6AG7	402	300		
V105	6SN7	383(Pin 2)	300	140(Pin 6)	90
V107	6SN7	400(Pin 5)	300		
		430(Pin 2)	300		
V109	6SN7	390(Pin 5)	300	490(Pin 3)	90
V110	6SN7	395(Pin 2)	300		
		394(Pin 5)	300		
V112	6AG7	332	300		

13. This overrating of tubes is not good design practice and in time may result in failure of the tube. Any vibration would promote failure more readily than if the voltages were within the design limits.

14. Constancy of Sweep Length. The sweep lengths were not constant within 5% when the duty cycle was less than 90% of the sweep time. The 5 microsecond sweep had a variation of 21.8%, from 4 inches to 3-1/8 inches. The 20 microsecond sweep decreased 11% when the duty cycle was increased toward 90%. The 100 microsecond sweep decreased from 4-1/16 inches to 3-1/8 inches as the duty cycle was changed from 1.5% to 90%. The 500 and the 5000 microsecond sweeps also exceeded the 5% variation limit.

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MECHANICAL INSPECTION

15. A mechanical inspection of the Model X-OBS Oscilloscope revealed the following defects:

(a) The mountings for the intensity potentiometer and focus control potentiometer are not satisfactory.

(b) There is no method of locking on the screws holding the bracket on which the 25 watt resistor R108 is mounted.

(c) Many screws do not meet the specification requirements for a minimum of 1-1/2 threads and a maximum of 1-1/2 threads plus 1/8 inch beyond the nuts.

(d) The cable, under the terminal board on which sweep circuit calibration potentiometers are mounted, is not held in place by a clamp.

(e) C-111, a large tubular condenser, is not clamped to board.

(f) The calibration sine wave switch is in an undesirable location on the front panel.

(g) Some pig tail leads on components are longer than 1/2 inch between the case of the component and the terminal stud.

CONCLUSIONS

16. The Model X-OBS Cathode-Ray Oscilloscope did not meet all the requirements of the specifications. It failed to meet the specifications on linearity of sweep, constancy of sweep length with duty cycles less than 90% of sweep time, trigger sensitivity of pulses of polarity opposite to that of the polarity switch, input capacity of input terminals of the vertical plates and JAN Tube Specifications. Many of the tubes were operating at voltages above the absolute maximum value allowed by the JAN specifications. This may lead to tube failure and unsatisfactory operation of the equipment. The equipment is not considered satisfactory for use in conjunction with the Model RDJ pulse analyzer since its calibration circuits are not as accurate as those of the pulse analyzer. However, the sweep calibration frequency constancy meets the five percent requirement of the governing specifications (ref. 2). The subject oscilloscope is suited to provide only a rough check on the sweep frequency calibration of the model RDJ pulse analyzer which has a two-percent constancy requirement.

RECOMMENDATIONS

17. As a result of electrical tests and a mechanical inspection of the equipment it is recommended:

(a) That the intensity and focus control potentiometers be mounted on bakelite strips supported by metal brackets. An insulated coupling

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device should be used to couple the potentiometer shaft to the knob shaft.

(b) That the cabled leads be held in place by cable clamps.

(c) That the calibration switch be located in a more satisfactory position.

(d) That the Oscilloscope X-OBS be completely redesigned electrically, with special attention being paid to operating the vacuum tubes within the voltage limits designated by the JAN Tube Specifications.

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REFERENCES

1. BuShips ltr. C-A22.1(920-Dm), C-920-7407 of 9 July 1945 to NRL. Request for assignment of problem.

2. BuShips Specifications RE9624-B - Specifications for Servoscope.

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