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PREPRODUCTION MODELS OF SURFACE-VESSEL BATHYTHERMOGRAPHS.(U)
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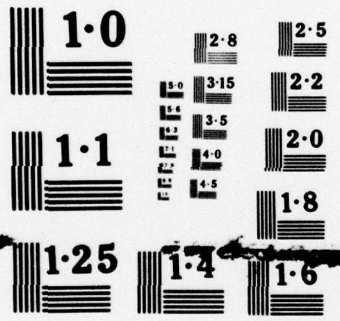
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SERVICE TEST REPORT: PREPRODUCTION MODELS OF SURFACE-VESSEL BATHYTHERMOGRAPHS.

(ENGINEERING LABORATORIES, INC.)

Good 237

(10) G. D. SHIPWAY AND H. G. MURRAY, ENGINEERING SERVICES DIVISION

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U.S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIFORNIA

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statement of problem

BuShips problem ST-3 (NEL 4G9): Conduct engineering tests and evaluation of bathythermographs to determine acceptability for Naval use.

conclusions

The bathythermograph in its present form, as manufactured by Engineering Laboratories, Inc., does not meet military specifications.

recommendations

The following improvements are recommended to correct the major deficiencies found in the equipment:

1. Use a more accurate method of measuring the water temperature when calibrating the instruments.
2. Use a stiffer pen arm and a short stylus point.
3. Use a snug fit between the body tube and the locating screws.
4. Use a denser coating on the slides.

work summary

The instruments were inspected, checked for calibration and speed of element response, and given sea trials to determine their compliance with the equipment specifications and their suitability for Naval use.

Acknowledgment is made to the Photography Section for their suggestions and assistance with the response movies, and to J. S. Black, who assisted on the sea tests. Others who assisted with the tests were R. J. Palk, A. J. Baranoff, M. H. Hamilton, and W. E. Benton.

This report covers work to 6 February 1951.

contents

illustrations

INTRODUCTION

This report covers the testing of six preproduction-model surface-vessel bathythermographs manufactured by Engineering Laboratories, Inc., Garland, Texas, under contract NObsr 52002. Quality of construction, operational performance, and ease of servicing in the field were evaluated. Suggestions have been incorporated in the recommendations to improve the operational performance and serviceability of the instrument, based on consultations with oceanographic and maintenance personnel.

DESCRIPTION OF EQUIPMENT

The bathythermograph (fig. 1) is essentially a tube, weighted on the front end and containing a pressure element and a pressure and temperature recording device in the center portion and a thermal element on the tail, protected by six stabilizing fins. The function of the equipment is to obtain the relationship of temperature with depth.

INSPECTION

One each of the 200- and 900-foot units was disassembled and inspected for compliance with references 1 and 2. The discrepancies are as follows:

1. Excessive clearance exists between the body tube and the locating screws, causing the calibration to be destroyed when the instrument is disassembled.
2. No port is provided at the forward end of the body tube to prevent the trapping of air inside the tube.
3. The slides furnished transmit 75 per cent of incident light instead of the 10 to 20 per cent specified.
4. The grid lines on the slides are unnecessarily heavy and can hide the stylus traces. The spacing of the pressure lines is not uniform.
5. The tweezers furnished (fig. 2) will not hold the slides securely.
6. The swivel attached to the towing fins has 165 degrees of freedom in the plane through itself and the axis of the instrument but binds in the groove between the two towing fins. When subjected to a 300-pound load, the swivel can be turned by hand only with difficulty. No damage to the swivel was noted with a 1000-pound load.

CALIBRATION

The instruments were calibrated two at a time in the calibration tank, which was accurate to ±0.05° F and to ±4 per cent in depth.

A typical calibration cycle is shown in figure 3. A comparison of the manufacturer's grids and the calibration slides is shown in figure 4 for the two extreme cases. All the other curves lie between the two shown and have the same slope. Temperature scales of the grids are inaccurate in span, the low temperatures reading high and the high temperatures reading low. The variation of error between instruments could have been caused by their having been disassembled. The flat portion of the curves at the low-temperature end was probably due to hysteresis as the lowest temperature was marked going down and all others were marked going up. The pressure calibrations were satisfactory.

The change in calibration after exposure to 135° F and 125 per cent of pressure is shown in figure 5 for instruments number 5 and 6, which were subjected to the complete cycle of conditions together. The small fluctuations of each curve could be due to errors in reading the slides, but the spread between the curves, possibly caused by flexibility in the pen arm, exceeds the requirements of reference 2, paragraph 3.3.3.5.

The pressure deflections at 40° and 80° F were measured from the calibration slides. The variations were 1 per cent or less of full range in all cases. The zero-pressure lengths of number 2 and 6 pressure elements (fig. 6) were measured at 30° and 90° F; the length changed a maximum of 0.009 inch, or 1.3 per cent of full depth.

SPEED OF RESPONSE

thermal elements

Figure 7 shows the test setup used to measure the speed of response of the thermal elements. The elements were lowered into water at approximately 85° F and stabilized at that temperature. They were then raised out of that water and lowered into water at approximately 40° F as rapidly as possible. The background was used to check the speed of immersing the elements. The film speed was measured and found to be 19 frames per second. Zero time was taken as the frame before the first frame to show movement of the pen.

Figure 8 shows the temperature response curves for the fastest and the slowest elements. The latter moved the required two-thirds of its travel in 0.41 second and reached the end of its travel within 3 seconds. Most of the variation between the curves was due to the difference in the speed of immersing the various elements.

pressure elements

Figure 9 shows the test setup which was used to check the speeds of response of the pressure elements. The element was photographed through the two windows of the pressure chamber, one of which had lines engraved on it. Pressure was applied through a hand-operated globe valve, which introduced considerable variation in the speed of application of the pressure. The film speed of 20 frames per second was measured by photographing a stop watch for about 15 seconds. Zero time was taken as the frame before the first frame to show movement of the element.

Figure 10 shows the curves for the fastest and the slowest pressure elements. The average time for the required two-thirds travel was 0.18 second and the average time to finish travel was 0.6 second. The specifications, reference 2, paragraph 3.2.4.2., require two-thirds travel in 5 seconds and complete travel in 15 seconds.

SEA TRIALS

Sea trials were made to test the towing qualities and to check for hysteresis. The towing tests were made at speeds up to 10 knots and showed no discrepancies. The trials with the deep-diving attachment showed that the solder shear pin (fig. 1) would break with the slightest tension in the cables, usually upon first hitting the water.

The instruments were lowered with the ship at rest, for the hysteresis tests. The instruments had a maximum pressure hysteresis of about 2 per cent of full depth, in excess of the permissible maximum of 1 per cent. The temperature hysteresis was as much as 0.2° F in some cases, also in excess of specifications. This latter was possibly due to flexibility in the pen arm.

Three of the stylus points corroded severely; the others were unaffected (fig. 11). The corroded points were apparently steel instead of Monel. The springs on the 900-foot pressure elements rusted at the ends.

The automatic pen-lifter mechanism is a new and simple design. Figure 12 is a view of the mechanism with the tail piece revolved to show the parts more clearly. The follower, part a, rides in the grooves on the arm, part b.

CONCLUSIONS

The Engineering Laboratories preproduction models of the bathythermograph in their present form do not meet military specifications.[2] The major discrepancies are:

1. The method of temperature measurement is inaccurate.

2. All showed excessive temperature and pressure hysteresis.

3. There was excessive clearance around the locating screws.

4. The slide coating is of insufficient density to eliminate the specified amount of incident light.

RECOMMENDATIONS

To correct the major deficiencies and enable the instrument to meet the specifications, the following improvements are recommended.

1. Use a more accurate method of measuring water temperature when calibrating the instrument.

2. Use a stiffer pen arm than was furnished and a stylus point as short as possible, to reduce the temperature hysteresis.

3. Use a snug fit between the body tube and the locating screws in the pressure element and the tail piece.

4. Use a denser coating on the slides. Slides that transmit about 35 per cent of incident light were used for these tests with good results.

5. Provide a better type of tweezer for holding the slides, such as shown in figure 13.

6. Place an additional small port near the forward end of the bellows to prevent the trapping of air and to facilitate draining the body tube.

7. Make the groove between the towing fins deeper to eliminate the binding of the swivel.

8. Improve the plating on the 900-foot-range pressure spring to minimize corrosion.

9. Use Monel for all stylus points.

Based on the experience of men who have serviced and extensively used bathythermographs, the following additional improvements are recommended to obtain an instrument more suitable for naval use.

1. Replace the swivel anchor pin with a ¼-20 fillister-head brass machine screw to facilitate swivel replacement.

2. Provide a tapped hole in the forward end of the pressure element to facilitate removal when corroded.

3. Strengthen the tail-fin joints by brazing instead of soldering with soft solder.

4. Use as close a fit as practical between the nose piece and body tube to reduce the load on the holding screws.

5. Provide an adjustable reference edge for the slide in the grid holder to permit matching the pressure lines of grid and calibration slide.

6. Cut off the low-pressure, low-temperature corner of the slides for easier orientation when handling.

7. Provide 1/32-inch-wide shoulders on the viewing side of the grid holder to support all edges of the grid.

8. Write the grid nameplate data (serial number and date) on transparent material (fig. 14) so that the grid lines will show through when photographed.

9. Make the lines on the grids narrower and more evenly spaced.

10. Pack the grids in small wooden boxes instead of wrapping them in tissue paper.

11. Pack the viewer with the grids in the instrument box, since they are normally used together.

12. Supply the lacquer in a can with a wide mouth suitable for dipping the slides.

REFERENCES

1. *Bureau of Ships Specification, Electronic Equipment, Naval Ship and Shore*: General Specification 16E4(SHIPS), 1 August 1949.

2. *Military Specification, Bathythermographs, Surface Vessel*, MIL-B-15237(SHIPS), 15 March 1950. Amendment 1, 15 May 1950; Amendment 2, 15 November 1950.

Figure 1. Bathythermograph.

Figure 2. Tweezers supplied.

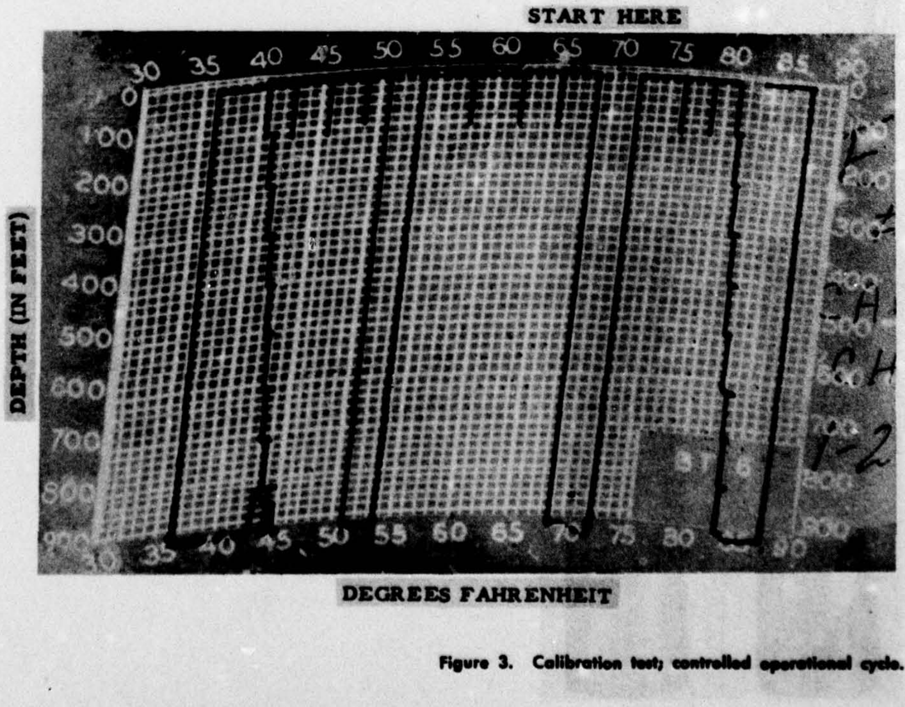


Figure 3. Calibration test; controlled operational cycle.

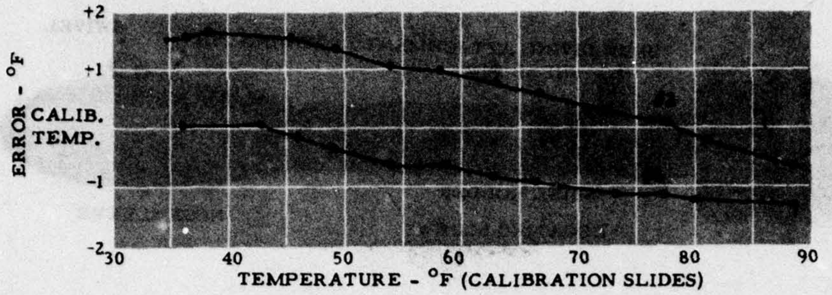


Figure 4. Temperature calibration curves.

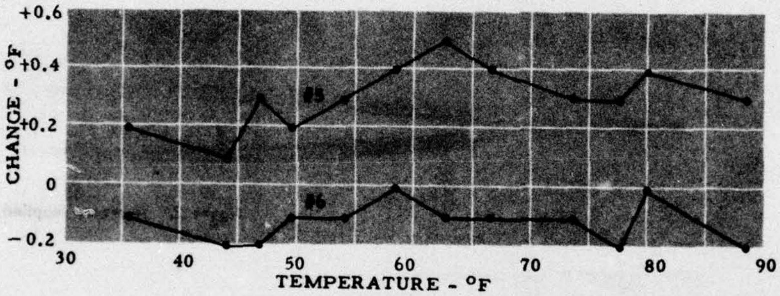


Figure 5. Change of temperature calibration curves.

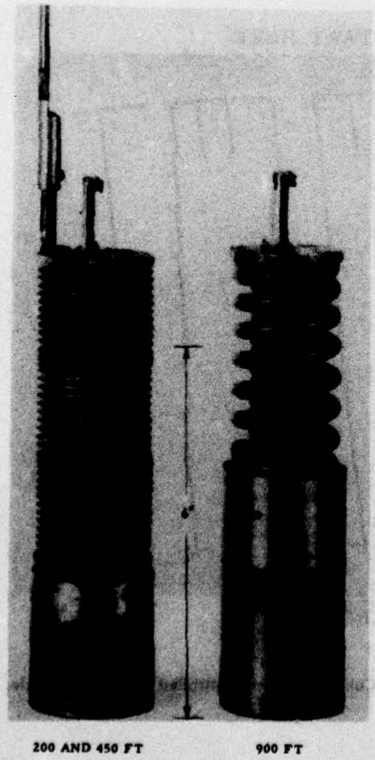


Figure 6. Pressure elements.

Figure 7. Thermal response test setup.

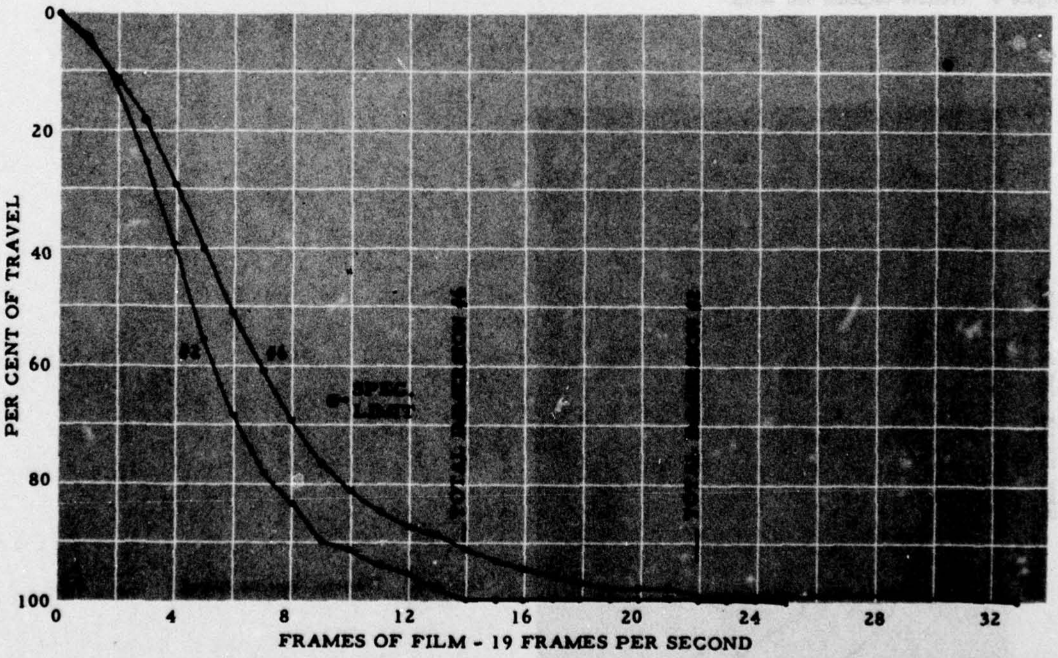


Figure 8. Speed of response of thermal elements.

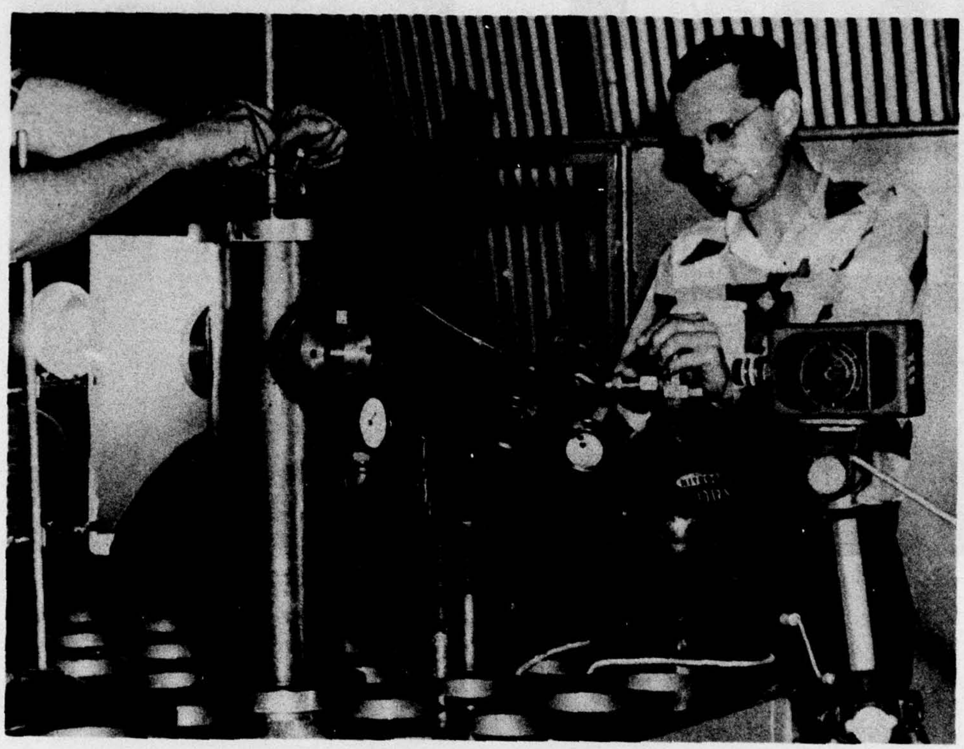


Figure 9. Pressure response test setup.

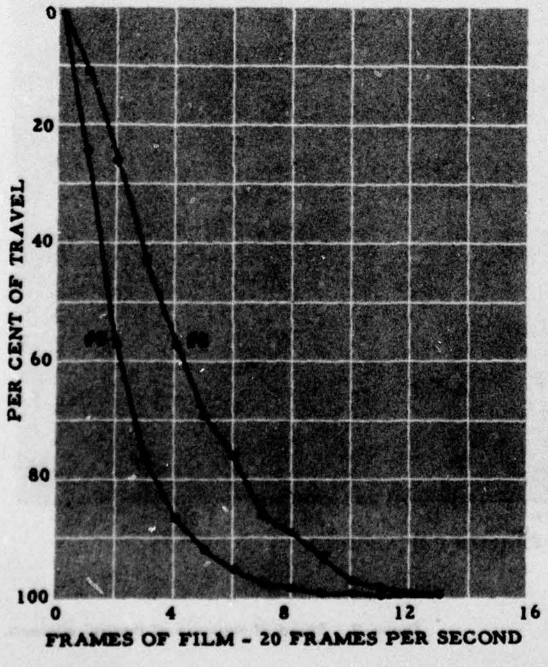


Figure 10. Pressure response curves.

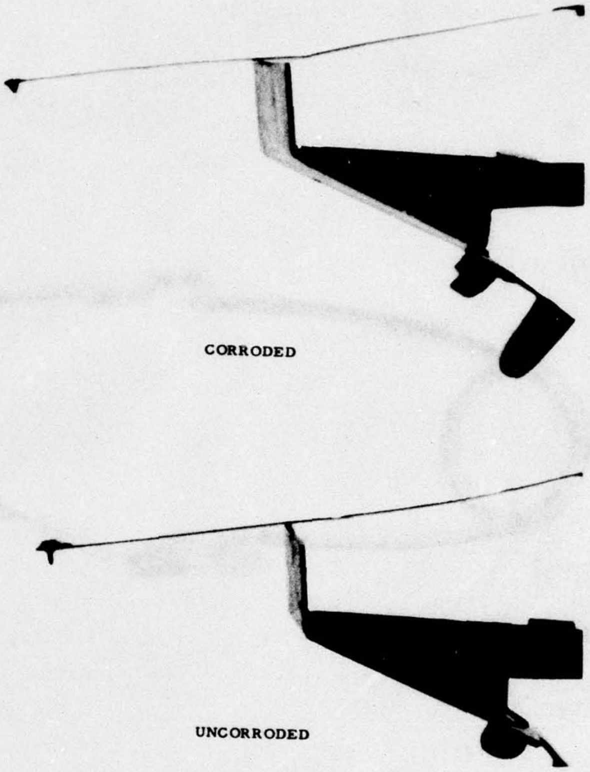


Figure 11. Stylus points, corroded and uncorroded.

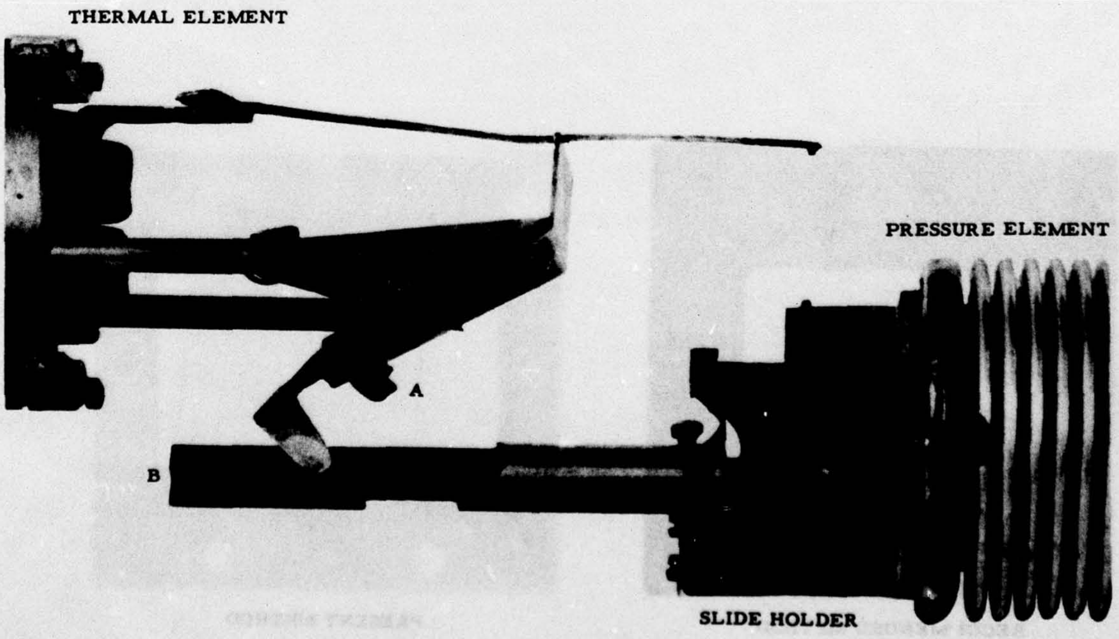


Figure 12. Automatic pen-lifter mechanism.

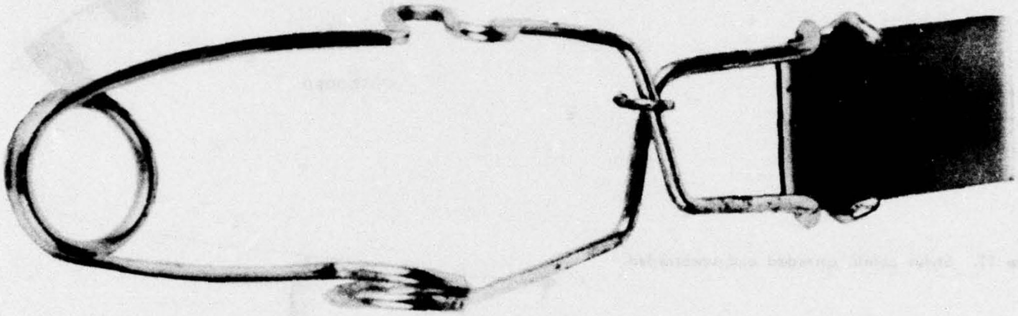
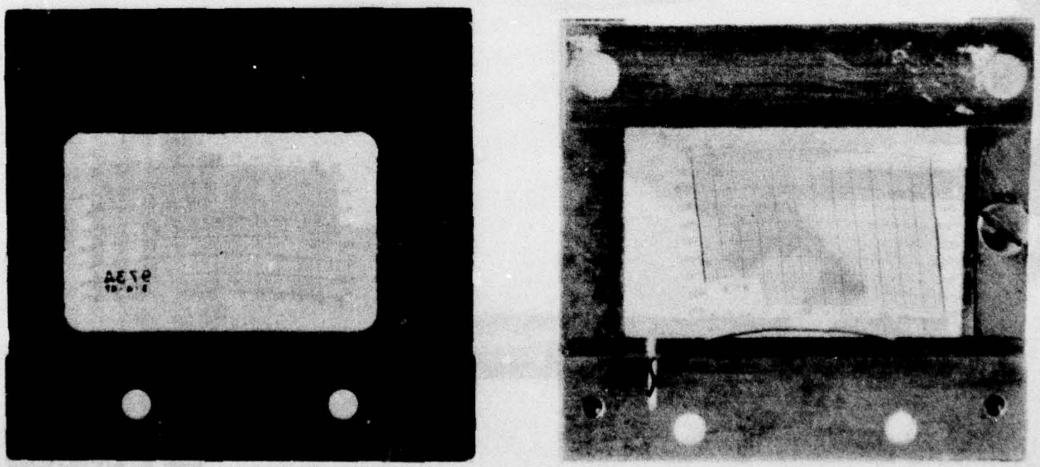


Figure 13. Recommended tweezers.



RECOMMENDED METHOD

PRESENT METHOD

Figure 14. Grid holders, showing present and recommended method of presenting nameplate data.

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