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Report on

Installation and Operation

of Mark 4 Mod. 1 Serial 285 Radar Equipment

on the USS MURPHY, DD603

by

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NAVAL RESEARCH LABORATORY

WASHINGTON, D. C.

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NAVY DEPARTMENT

Report on
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APPENDICES

1. Authorization. Arrangements and authorization for the installation of the equipment on the USS MURPHY were outlined in references (a) to (c). References relating to the Mark 4 improvement program are listed as references (d) to (k). Reference (l) discusses the cause and remedy of a defect noted on the Model BK Radio Equipment.

References:
(a) BuOrd conf. ltr S67(Re4f) dated 5 Jan 1944.
(b) NRL ltr to BuOrd, C-S67-7, dated 7 Jan 1944.
(c) CO DD603 conf. ltr, DD603/A2-14/P16-3/LL, Serial 125, dated 21 Mar 1944.
(d) BuShips ltr C-NOs-83608, Serial C-917-4591, dated 17 Dec 1942.
(e) NRL ltr to BuOrd, C-S67-7(384), dated 5 Nov 1943.
(f) NRL ltr to BuShips, C-S67-7(380-GBG), dated 16 Jul 1943.
(g) NRL report R-2146 dated 28 Aug 1943.
(h) NRL report R-2157 dated 13 Sept 1943.
(i) NRL ltr to BuShips, C-S67-7(384), dated 13 Oct 1943.
(j) NRL ltr to BuShips, C-S67-7(384), dated 7 Oct 1943.
(k) NRL ltr to BuOrd, C-S67-7(384), dated 30 Oct 1943.
(l) NRL ltr to BuShips, S67/21(384), dated 22 Jun 1943.

2. Introductory. During the period from 1 March 1943 to 1 September 1943 modifications of the Mark 4 Radar Equipment to increase its resistance to shock and vibration were made at the Naval Research Laboratory. References (f) to (k) are reports covering this work. The Laboratory requested in reference (e) that the modified equipment be installed aboard a Naval vessel in order to evaluate the merit of the modifications. Accordingly, the equipment, with an Automatic Gain Control unit, was installed on the USS MURPHY (DD603) under the supervision of a representative from the Naval Research Laboratory. During the shakedown cruise of this vessel which took place from 5 April 1944 to 1 May 1944, operation of the equipment was observed by a representative of the Naval Research Laboratory.

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I. INSTALLATION

3. Mounting. The Main Frame, Regulated Rectifier, Control Indicator, and the Train Indicator were installed essentially as recommended in NRL reports R-2146 and R-2157, references (g) and (h). The AGC (Automatic Gain Control) unit and its associated Train and Elevation Meters were installed in accordance with the manufacturer's recommendations. The Elevation Indicator, new and unmodified, was supported in the manner recommended by the Electrical Division of the Bureau of Ships.

4. Location of Units. The following is a description of the location and mounting of the individual units of the equipment.

4.1. Main Frame. The Main Frame was located in the after starboard corner of the Radar Transmitter Room adjoining the CIC (Combat Information Center). Two flat brackets were welded to the deck to support the front and rear shock mount channels of the Main Frame. This unit was mounted facing the port bulkhead. No support was provided for the top of this unit. A 3-foot section of RG 35/U solid dielectric coaxial cable was installed between the Main Frame and the rigid gas-filled 7/8-inch concentric transmission line. A special combination end seal and pressure gauge coupling designed and approved by the Radio Materiel Office at the New York Navy Yard was installed between the gas-filled line and the solid dielectric cable. Brackets were provided near the ends of the solid dielectric coaxial cable to relieve any stress on the end couplings. The radius of curvature of the cable is approximately 15 inches. Plate 2 is a photograph of the installation as viewed from the CIC.

4.2. Regulated Rectifier. The Regulated Rectifier and its associated blower was installed to the left of the Main Frame, and directly under the Model BM Radio Equipment. The blower motor and air filter assembly is solidly secured to the deck. It was necessary to modify the two supporting plates for the Regulated Rectifier shock mounts to provide the necessary clearance for the added air filter chamber. The shock mounting characteristics were unaffected by this change. Plate 12 is a drawing of the modified supporting plate, and Plate 3 is a photograph of the unit installed.

4.3. Automatic Gain Control. The AGC unit was located on the port side of the Radar Transmitter Room directly above the Model BN Equipment and between the director cable trunk and the Model SG Radar Transmitter. Ample

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[redacted]

clearance was provided around the unit. The pins securing the heads to the knurled thumb screw for the front panel were too small and sheared off. They were replaced with larger pins. Plate 4 is a photograph of the installation. The unit may also be seen in Plate 2.

4.4. Control Indicator. The Control Indicator is mounted horizontally in a "blister" on the after starboard side of the Main Battery Director near the top. The unit is supported on four 90-pound Lord shock mounts with limiting washers, two at the front top and two at the rear bottom, and four 45-pound Lord shock mounts with limiting washers, two at the front top sides and two at the rear bottom sides. The shock mounting Plan V-3, as recommended on page 29 of reference (g), was not practical in this installation. Vibration tests of the mounting used are described in Plan V-4 on page 23 of reference (g). The associated blower motor is mounted directly to the director bulkhead below the Control Indicator. The cathode-ray tube of the unit is at the eye level of the operator. The cable retaining clamps shown in the photographs of the unit are being replaced by a type which permits rapid removal of the unit for servicing or for replacement. Plates 5 and 6 are photographs of the installation.

4.5. Range Unit. The Range Unit and Range Transmitter were mounted vertically on the after bulkhead of the director using the shock mounts provided with the Range Transmitter. The Range Unit is at a height permitting good visibility of the range dial. The range crank is easily rotated. A photograph of the installation is shown in Plate 6.

4.6. Train Indicator. The Train Indicator was supported vertically in a framework, on eight 45-pound Lord shock mounts with limiting washers; two mounts on the top rear sides, two mounts on the top front, two mounts on the bottom front sides, and two mounts on the bottom rear. Vibration tests of this mounting are described in Plan V-12 on page 8 of reference (g). Shock tests of this mounting method are described in Plan S-4 on page 11 of reference (g). The rear top of the supporting framework was secured to the director bulkhead by two brackets, and also secured at the bottom to the director deck. Plate 7 is a photograph of the installation.

4.7. Elevation Indicator. The Elevation Indicator was supported vertically in a framework by means of four Barry mounts; two at the rear top and two at the front bottom, as recommended by representatives of the Electrical Division of the Bureau of Ships. The supporting framework was secured to the starboard director beam. Plates 7, 8, and 9 are photographs of the installation.

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4.8. Train and Elevation Meters. The Train and Elevation Meters were secured to the vertical panel of the optical shelf directly below their complementary optical telescopes. The meters were supported on four Lord plate type shock mounts supplied by the manufacturer. Plates 7, 8, 9, 10, and 11 are photographs of the installation.

4.9. Service Scope. The Service or Test Scope was mounted vertically, face up, in a framework which was secured to the after bulkhead of the Radar Transmitter Room. The installation, not shown in the photographs, is located between the Main Frame and the Emergency Handlight shown in Plate 2. No shock mounting was provided during the original installation; however, the mounting was modified at sea using three 6-pound Lord shock mounts located on the bottom of the unit and a strip of packing rubber inserted between the top support clamp and the case of the unit.

5. Spare Units. A spare Control Indicator was provided, and installed on the bulkhead in the barbette below the director in a completely enclosed metal box. By raising the lid of the box the spare unit may be lifted out face up. The case for the spare Control Indicator was supported in the metal box on eight 45-pound Lord shock mounts, four on the top sides and four on the bottom sides. A spare Train or Elevation Indicator also was provided and installed on the bulkhead in the barbette below the director in a completely enclosed metal box. The case of the Train or Elevation Indicator was supported in the metal box on eight 45-pound Lord shock mounts, four on the top sides and four on the bottom sides. By raising the lid of the metal box, the spare unit may be withdrawn face up. Both spare units have been modified in accordance with reference (g).

6. Electrical and Mechanical Modifications. Certain mechanical and electrical modifications were made to the equipment during the installation to increase its reliability and performance.

6.1. Modulation Generator. Field modifications were made on the Modulation Generator as follows:

6.11. Western Electric Field Modification 1-06 in which the keyer tube bias was stabilized by:

a. Reducing the load on the rectifier tube.

b. Providing additional taps on the bias voltage divider.

c. Connecting the voltmeter M-2 to measure the keyer tube bias voltage.

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6.12. Western Electric Co. Field Modification 1-07 requiring that ten 1-inch holes be drilled in the rear of the unit and a new lower cover installed to provide additional ventilation.

6.13. Western Electric Co. Field Modification 1-08 in which the screen voltage on the 807 amplifier tubes was reduced.

6.14. Inspection of the Modulation Generator upon arrival at the Shop revealed several mechanical failures. Four capacitor clamps for the type TJH capacitors were loose. All capacitor clamps in the unit were removed from the unit, the solder and rivets removed, and the spade lugs spot welded to the clamps as recommended in reference (h). In addition the lead from the keyer tube bias resistor mounting strip to capacitor C24 was broken due to fatigue. This was a solid conductor and was replaced with a section of flexible conductor having ample slack.

6.15. The oven for the Modulation Generator oscillator was not installed. The original ovens first installed were not satisfactory, and since have been replaced with new ovens using selected capacitors.

6.2. Receiver. The following modifications were made to the Receiver:

6.21. Western Electric Co. Field Modification 32 requiring that the resistor R28 in the plate of the local oscillator be replaced by two 3000-ohm 2-watt resistors in parallel.

6.22. Western Electric Co. Field Modification 1-03 requiring that the 2000-ohm potentiometer R46 in the monitor video output be replaced by a 5000-ohm potentiometer in order to increase the signal height on the Test Service Scope.

6.23. Western Electric Co. Field Modification 1-36 requiring that a degeneration network be inserted in the cathode of tube V6 to make it unnecessary to select special detector tubes, and that a mica capacitor be installed between one lead of the sensitivity control and ground to reduce any tendency toward oscillation.

6.24. The oscillator injection r-f voltage was reduced slightly to eliminate a double peak in the cathode tuning.

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6.3. <u>Control Indicator</u>. The following modifications of the Control Indicator were made:

6.31. Western Electric Co. Field Modification 19 requiring separate fusing of the lobe switch motor. Upon testing the equipment it was found that the 3-ampere fuses supplied would open circuit due to the starting surge current. Five-ampere fuses were substituted. These fuses were later replaced by 1-ampere Super-Lag type fuses.

6.32. Western Electric Co. Field Modification 1-42 which requires that a high-pass filter network be inserted in the input circuit of the second video stage. This is designed to overcome certain types of jamming. A switch was installed on the front panel to permit the selection or rejection of the filter network.

6.4. <u>Train or Elevation Indicators</u>. Modifications were made on the Train or Elevation Indicators as follows:

6.41. Western Electric Co. Field Modification 26 requiring that a resistor be inserted in the primary of the filament transformer to slightly reduce the filament voltage of the tubes in the Indicators.

6.5. <u>Replacement of 2X2 Tubes</u>. All 2X2 tubes in the equipment were replaced by type 3B24 tubes and held in place with Birtcher tube clamps.

6.6. <u>Fusing</u>. A supply of 1-ampere Super-Lag type fuses was obtained from a tender during the shakedown cruise. These 1-ampere fuses were installed in the lobe switch motor circuit and in the Train and Elevation Indicator power circuits replacing the 3 and 5-ampere fuses supplied.

7. <u>Cable Connectors</u>. Type AN size 18 cable connectors were installed on all the director-mounted units, including the spare units. These connectors were inserted in the individual cables at a distance of 3 to 4 feet from the units. The Train Indicator, the Elevation Indicator, and the spare Train or Elevation Indicator are readily interchangeable. The Control Indicator and the spare Control Indicator are also readily interchangeable. All spaces inside the connectors were filled with "Ignition Sealing Compound - No. 4" manufactured by the Dow-Corning Company. The compound was spread over the two halves of each connector at the joint to prevent moisture creepage to the connector pins.

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II. OPERATION

8. The following adjustments were made to the equipment prior to operation.

8.1. Repetition Rate. Prior to shipping the equipment from the Laboratory, the "AUDIO FREQ" dial was locked on 50 and the Modulation Generator frequency adjusted to 1639.2 cycles per second by beating its 180th harmonic with a 295.056 kc signal. A Type LM Frequency Calibrator was used for this purpose. The frequency standard used to adjust Modulation Generators at the New York Navy Yard indicated that a setting of 46.8 on the "AUDIO FREQ" dial was correct. This setting was used throughout the cruise. However, it was noted that the repetition rate of vessels adjusted at Casco Bay was different by about 1 cycle per second from those adjusted at New York. An "AUDIO FREQ" setting of about 42 was required for synchronism with other vessels.

8.2. Zero Range. After the equipment was placed in operating condition it was necessary to obtain a Zero Range correction value and align the radar antenna with the optical system. The first Zero Range calibration was made while anchored in Gravesend Bay. A range of 5980 yards was measured to a lighthouse by the usual navigational methods. The radar Zero Range correction knob was adjusted so that the echo from the lighthouse was in the notch with the range scale set at 5980 yards. By then setting the transmitted pulse in the notch, a Zero Range value of minus 200 yards was obtained. While at sea a double echo check was obtained by ranging on a cruiser. Table 1 lists the values obtained. The estimated average Zero Range correction was minus 50 yards. Variations in values probably arose because the two ships were not broadside to and therefore the ranges varied during the interval required to shift from the echo to the double echo. Subsequent firing indicated that a Zero Range correction of minus 50 yards was correct. The Zero Range correction value now used is minus 50 yards.

8.3. Antenna Train. The antenna was adjusted for a correct train indication at Gravesend Bay by training the optical system on the center line of a lighthouse 5980 yards distant, and then adjusting the antenna so that the train pips were matched and the train meter indication was zero.

8.4. Antenna Elevation. Previous empirical data obtained from the Radio Materiel Office, New York Navy Yard, indicated that the correct adjustment of the antenna when

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elevated on airborne targets is obtained when the antenna is set 80 minutes low on surface targets. Accordingly, the radar antenna was set 80 minutes low on the lighthouse. No airborne targets were in the vicinity and a check could not be obtained. During anti-aircraft firing practice it was found that the antenna elevation did not agree with the optical elevation. The antenna was adjusted for agreement with the optical system on a plane at a range of 2500 yards and an elevation of 6000 feet. A subsequent check on a tug at 2000 yards indicated close agreement with the optical system. This indicated that the first method of adjustment did not agree with practice.

9. Ship Characteristics. Measurements of vibration and shock characteristics of the ship were obtained during cruising, full power runs, and firing. Data obtained from the Engineering Manual of the ship indicated that similar conditions may be encountered aboard all vessels of the DD598 to DD617 class.

9.1. Vibration. At a speed of 20 knots the entire ship vibrated at a frequency of approximately 560 cycles per minute as measured with a Westinghouse Reed Vibrometer. The propeller shafts' speeds were approximately 186 r.p.m. The propellers were three bladed. These data indicated that the ship vibration frequency was equal to the product of the shaft's speed in r.p.m. and the number of blades on the screws. From the ship's Engineering Manual data were computed giving the relationship between ship's speed and vibration frequencies. These data are presented in Table 2 and are shown graphically in Plate 1. The most severe vibration amplitudes occurred at a speed between 17 and 20 knots. At speeds greater than 30 knots there was little vibration. The amplitudes of vibration constantly varied, possibly due to slight differences between the two shaft speeds. It was apparent to an observer that the amplitude was modulated by approximately a 5-second beat. There was little or no vibration generated by sources other than the propellers. Because of the low frequencies encountered, and the constant variation of amplitude, measurements of amplitude and acceleration were not satisfactory. The total displacements did not exceed 1/16 inch. The bulkheads of the Radar Transmitting Room are made of sheet aluminum with vertical stiffeners. Relative motion between the bulkheads and the deck was observed both during vibration and shock.

9.2. Shock. Shock measurements were made during firing runs on both airborne and surface targets. Buchanan cells and associated indicating equipment were used to measure the momentary peak acceleration. A total of 58 rounds of 5 inch 38 caliber ammunition was fired during one run,

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of which 17 rounds were fired from No. 2 gun. Data were obtained in the Radar Transmitting Room and in the Main Battery Director during this firing.

9.21. Radar Transmitting Room. Cell holders were attached solidly to the deck adjacent to the Mark 4 Main Frame so that shock in vertical and port-to-starboard directions could be measured. Shocks having a momentary peak acceleration of between 10 and 24 g in a vertical direction were measured at the base of the Main Frame, and between 16.7 and 29 g in a port-to-starboard direction. The most severe shock occurred when gun No. 2 was fired.

9.22. Main Battery Director. Cell holders were attached to the top right side of the "blister" which contained the Control Indicator so that shock in a vertical and port-to-starboard directions could be measured. Shocks having a momentary peak acceleration of between 29 g and 35 g in a vertical direction, and between 16.7 and 24 g in a port-to-starboard direction were measured at the base of the shock mounts supporting the Control Indicator. The most severe shock came from gun No. 2 when firing during AA practice.

9.3. Temperature. During General Quarters all ventilating equipment was secured. With an outdoor temperature of 51°F, the temperature in the Radar Transmitting Room increased to 97°F, a differential of 46 degrees, at the end of three hours. A fan on the bulkhead was kept running to prevent higher hot spot temperatures. Temperatures above 138°F or 58°C are anticipated if the outdoor temperature should rise to 90°F. Heaters are provided in the Main Battery Director so that the ambient temperature did not fall below 50°F when the external temperature was below freezing.

9.4. Humidity. Because of the heat developed in the Radar Transmitter Room no humidity problem is anticipated. However, it was observed that surface condensation and dripping was common in the Main Battery Director. Waterproofing of the cable connectors is considered essential.

9.5. Line Voltage Variation. The line voltage Transtat Control in the Main Frame was adjusted for an average line voltage of 117 volts. It was observed that the line voltage would fluctuate between 110 and 120 volts. Occasionally a surge which lowered the line voltage to 100 volts was observed. No surges above 120 volts were observed. The line frequency was maintained within 1/4 cycle of 60 cycles.

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A deviation to 58 cycles was observed, but the generator immediately lost its load. The most violent fluctuations occurred immediately after gunfire.

10. <u>Failures During Shakedown Period</u>. The following is a list of failures encountered during the shakedown period of 5 April 1944 to 1 May 1944.

10.1. <u>Director-Mounted Units</u>. The director-mounted units were energized for approximately 413 hours during the cruise. One type 6AG7 tube and one type 6SJ7 tube were replaced in the Control Indicator. It was later discovered that a cable connector had not been tightened completely, permitting an intermittent open circuit. This gave an indication identical to that caused by defective tubes. Tightening the cable connector eliminated the difficulty. No difficulties were encountered in the other director-mounted units.

10.2. <u>Main Frame</u>. The Main Frame was energized for approximately 700 hours during the cruise. Three failures occurred.

10.21. The Transmitter plate capacitor C-4 shorted the first day out. The capacitor was of the type originally supplied with the equipment, and had given at least 15 months service prior to failure. The defective capacitor was replaced by a 20 kv type. No further trouble was encountered.

10.22. The Main Line power switch D-1 in the Control Panel of the Main Frame failed. A new switch was obtained from a tender. No further trouble was encountered.

10.23. The plate current milliammeter M-2 in the Control Panel became erratic in operation due to gunfire. The meter was severely damaged previously during the NRL testing program, and temporary repairs were effected at that time. A new meter was obtained from a tender. No further trouble was encountered.

10.24. The type 702A and the type 316A vacuum tubes in the Receiver required replacement at the end of 200 hours. No failure occurred in this instance, but replacement improved the Receiver efficiency.

10.3. <u>Service Scope</u>. Several failures occurred in the test oscilloscope as a result of shock from gunfire. The first time gun No. 2 was fired a tube was dislodged from its socket. At the end of 10 rounds all remaining tubes were partially dislodged. A brace from the front panel to the chassis had broken loose. Tube clamps were constructed

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in the ship's machine shop similar to Part 26 on Plate 79 of reference (g). The broken brace was secured with machine screws. A shock mounting was provided for the unit. Later the rubber cushion around the cathode-ray tube came loose. It was more solidly secured. After the above modifications were made no further trouble was encountered.

10.4. Regulated Rectifier. No failures occurred in the Regulated Rectifier.

10.5. Automatic Gain Control. No failures occurred in the Automatic Gain Control unit. Minor adjustment was required several times.

10.6. Train and Elevation Meters. The elevation operator accidentally dropped his headphones on the Elevation Meter, cracking the glass. The glass was replaced with a transparent plastic sheet.

11. Operation of Mark 4 Equipment. Operation of the Mark 4 Equipment was observed during conditions of gunfire, cruising, depth charge attacks, and torpedo attacks.

11.1. Gunfire. Approximately 125 firing runs were made during the cruising period, of which approximately 75 employed the 5 inch 38 caliber guns. A total of 1343 rounds of 5 inch 38 caliber ammunition, 2011 rounds of 40 mm ammunition, and 5961 rounds of 20 mm ammunition was expended. Operation of the equipment during gunfire was entirely satisfactory. The trace on the Control Indicator did not flicker or become unsteady during firing, and spotting was possible. Shells were followed out on the Indicator and the splashes observed. Anti-aircraft fire from gun No. 2 was directed at angles which transmitted the maximum blast to the director. No misoperation of the equipment occurred. During AA fire it was possible to continuously range on the target. Firing rates of the 5-inch guns varied from 15 to 20 rounds per minute per gun.

11.2. Vibration. The cruising speed of the ship was between 17 and 20 knots. Maximum vibration occurred at this speed. At about 15 knots the Main Frame exhibited a front-to-back rocking mode having a displacement of 1/16 inch at the top. No vibration was observed on any other Mark 4 Units. Receiver frequency drift was negligible. The Receiver maintained its adjustment during three days of gunfire and cruising. The reliable range on the target towing plane was 25,000 yards. Ranges of 25,000 yards were consistently taken on cruisers. Land echoes were observed at 70 miles.

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11.3. Depth Charge Attacks. Two depth charge attacks were simulated. On the first attack six 300-pound charges were fired from the depth charge guns and set to detonate at a depth of 200 feet. On the second attack six 300-pound charges were fired from the depth charge guns and three 600-pound charges were dropped from the stern, all set to detonate at a depth of 250 feet. No misoperation of the equipment occurred. The shock delivered to the Mark 4 Equipment was not as severe as that caused by gunfire. Three torpedoes were fired. The shock produced was minor, and operation of the equipment was satisfactory.

12. Operation of Other Equipments. While the attention of the observer was primarily directed to the operation of the Mark 4 Radar Equipment, there were opportunities to observe the operation of other equipments during similar conditions of shock and vibration. Following are comments on other equipments.

12.1. SC-3 Radar Equipment. The SC-3 radar equipment did not operate satisfactorily until near the end of the cruise. The grid of one r-f amplifier in the Receiver was shorted, lowering the sensitivity. The duplexer was extremely critical, requiring frequent adjustment. The antenna alignment section was not satisfactory due to the arcing which took place in its interior. A replacement of the alignment section with a section of solid dielectric flexible coaxial cable was scheduled at the completion of the cruise. Several interlocks opened during gunfire. This was caused by poor alignment of these components during the assembly of the equipment. The neon bulb in the coaxial line at the top of the Transmitter fractured during gunfire. At a ship's speed of 7 knots the Indicator vibrated excessively in a front-to-back rocking mode. Displacement at the top was approximately 1/2 inch. Near the end of the cruise planes were being picked up at 50 to 60 miles.

12.2. SG-1 Radar Equipment. The interlocks on the Main Frame of the SG radar momentarily opened during gunfire. These were then short circuited. A magnetron type 706TY failed after approximately 200 hours of use. It was necessary to clean the air filter approximately every three days. It was difficult to obtain bearings on a cruiser at 1000 yards because of minor lobes and mast reflections. The Modulation Generator panel vibrated excessively at 27 knots. Some confusion resulted when operators shifted from SC-3 operation to SG-1 operation because of the difference in bearing indicator dials. Operation of the equipment was very satisfactory, in spite of the above-mentioned difficulties. The equipment was in use 415 hours during the

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cruise. The detection of a submarine periscope and a buoy was reliable at 5000 yards. Surface ship detection was reliable at 25,000 yards. Land detection was reliable at 75,000 yards.

12.3. Model BM Radio Equipment. The Model BM Radio Equipment vibrated excessively in a vertical direction at a speed of 25 knots. The unit is supported at the bottom on four Lord mounts and at the top by two Lord mounts attached to a bulkhead brace. At 25 knots the Receiver was so erratic that observation of the SC-3 radar indicator to which the BM is coupled was impossible. A different method of shock mounting as well as some improvement in the Receiver is believed to be necessary.

12.4. Model BN Radio Equipment. There was some amplification of vibration on the Model BN Radio Equipment at a ship's speed of 27 knots. However, no difficulty was experienced with the equipment. It was not possible to determine whether Lord 60-pound or 90-pound shock mounts were attached to this equipment.

12.5. Model BK Radio Equipment. The generator field of the motor-generator for the Model BK Radio Equipment would reverse polarity when the equipment was deenergized. Flash excitation of the field from a storage battery was necessary to restore normal operation. It was found necessary to disconnect the leads to the BK equipment before shutting down the motor-generator. A remedy for this defect is outlined in reference (1).

12.6. Dry-Aire 2200 Compressor. The compressor was not satisfactory. At the end of the cruise a complete replacement was planned. The r-f coaxial gas-filled lines did not leak during the entire cruise. However, the compressor would cycle every 15 minutes or thereabouts, finally running continuously.

13. Conclusions. The Mark 4 Mod. 1 Radar Equipment gave entirely satisfactory operation during the cruising period. Some of the equipment is new, and component failures may occur at a later date. However, the operation of the equipment during gunfire gave effective proof of the necessity of the recommended improvement program. The previous history of the Mark 4 Radar aboard the USS MURPHY was particularly bad, and therefore the present performance was gratifying to the ship's personnel. An analysis of the data obtained in the USS MURPHY leads to a number of general conclusions.

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13.1. All shock-mounted equipment should be supported on mounts which are not resonant below 1500 cycles per minute.

13.2. No system of shock mounting will afford protection for equipment that is not inherently mechanically and electrically rugged.

13.3. Additional resilient mounts attached to bulkheads for a deck-mounted unit are undesirable because of the relative motions between these surfaces.

13.4. The slightest deviation from normal operation of the equipment caused by the ship's own vibration or gunfire is not permissible for most effective operation. Should momentary failure occur due to gunfire, shell spotting is extremely difficult if not impossible. Any flashing on the cathode-ray tube screen excites the operator, materially lowering his efficiency.

13.5. It is possible to design and construct equipment which will operate perfectly during the worst conditions from ship's own gunfire. Good engineering, good workmanship, adequate testing, and correct installation are necessary.

14. Acknowledgment. The Naval Research Laboratory desires to express its appreciation for the excellent arrangements made by officers and engineers of the New York Navy Yard, and to the officers and men of the USS MURPHY for their cooperation in facilitating the work during the period from 1 April to 1 May 1944.

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TABLE 1

RANGE ZERO CHECK
DOUBLE ECHO METHOD

Range* (Yards)	Double Echo Range (Yards)	True Range (Yards)	Error (Yards)
1270	2580	1310	+ 40
1300	2530	1230	- 70
1300	2530	1230	- 70
1310	2500	1190	-120
1330	2560	1230	-110
1220	2490	1270	+ 50
1230	2490	1260	+ 30

* With Range Zero set on zero yards.

Weighted average error = -50 yards.

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TABLE 2

Speed (Knots)	Shaft R.P.M.	Vibration Frequency (C.P.M.)
9	81	243
12	108	324
15	137	411
20	186	568
25	243	729
30	304	912
35	358	1074
Flank	388	1164

[redacted]

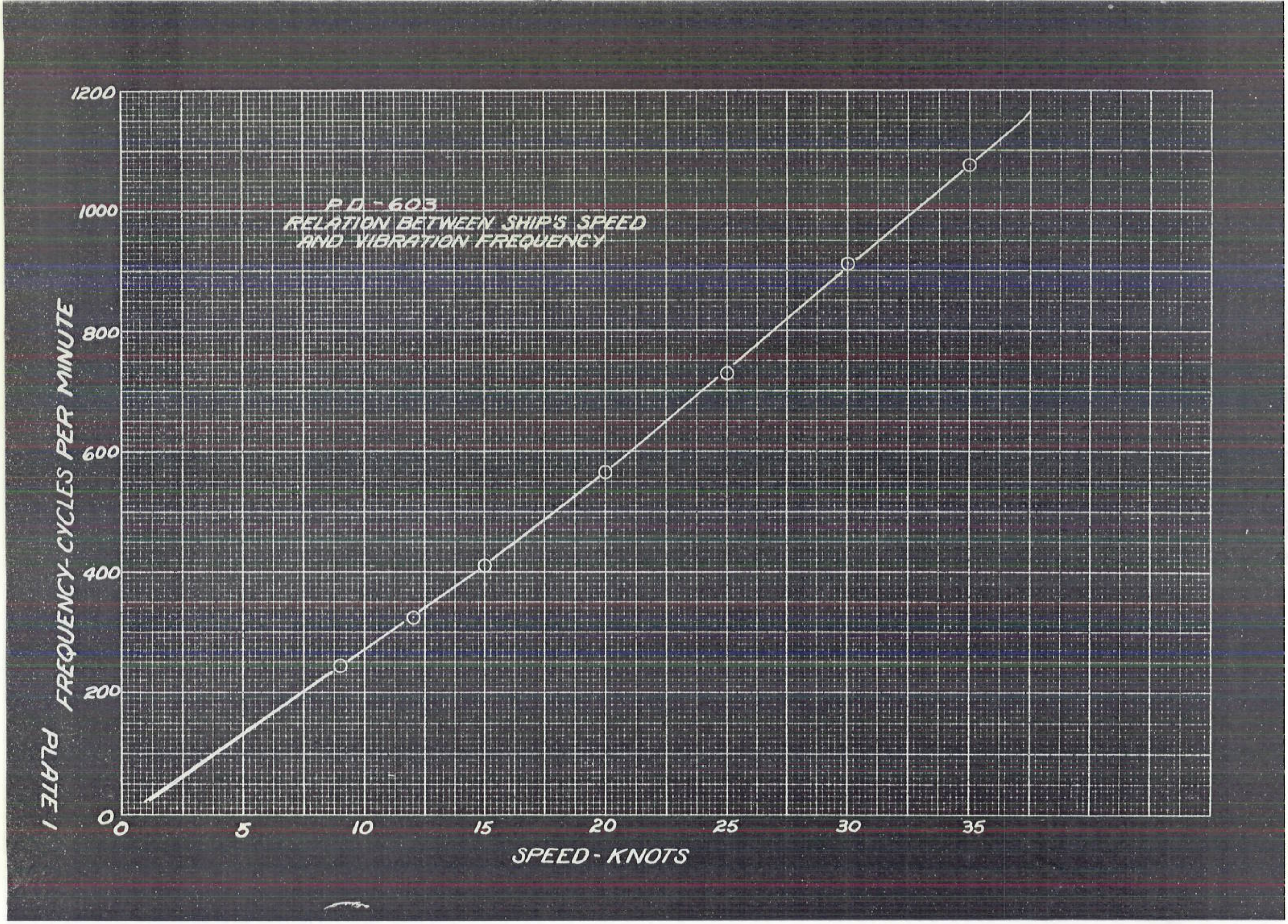
P.D. - 603
RELATION BETWEEN SHIP'S SPEED
AND VIBRATION FREQUENCY
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
FREQUENCY-CYCLES PER MINUTE
SPEED - KNOTS

PLATE I

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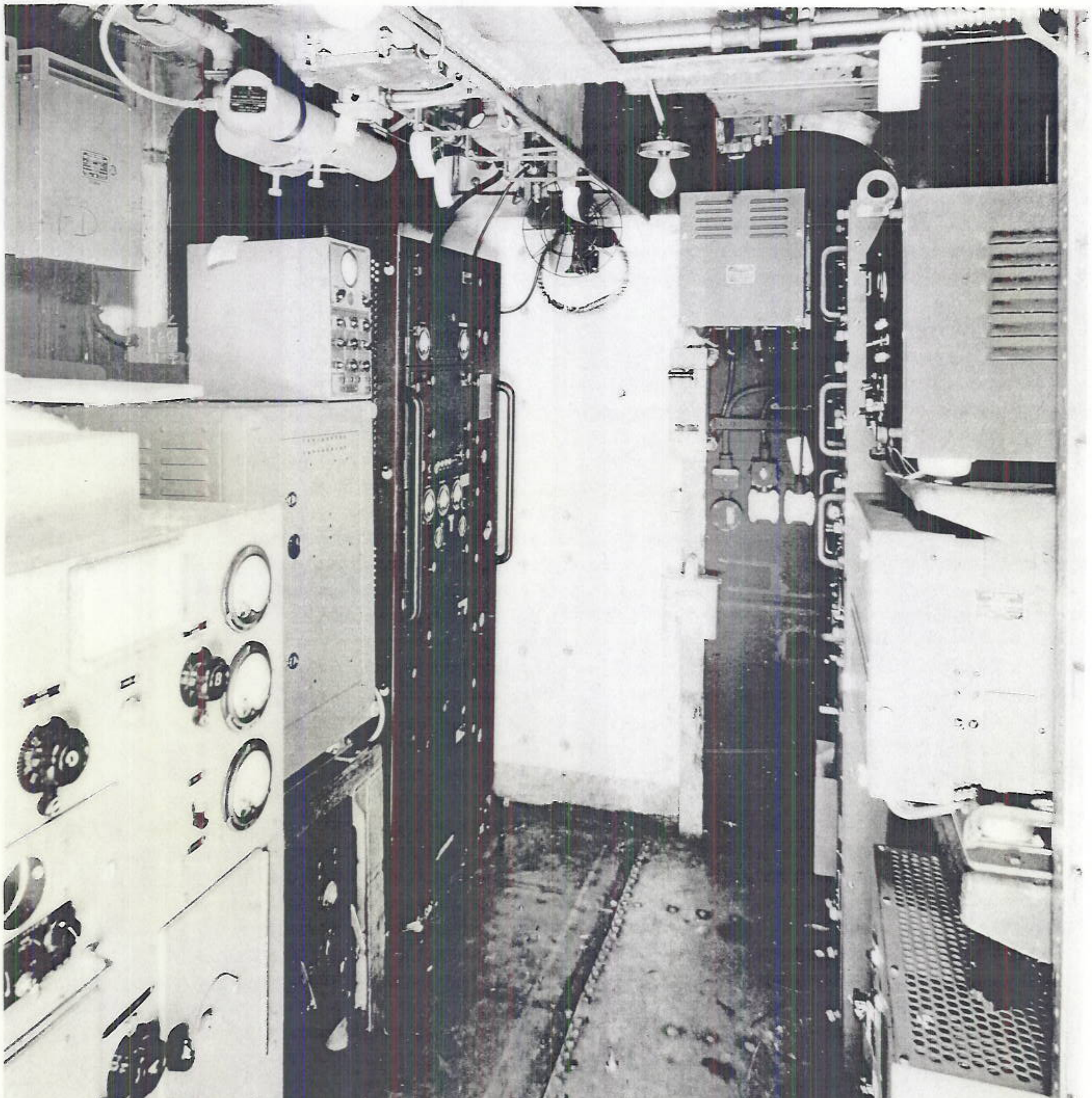
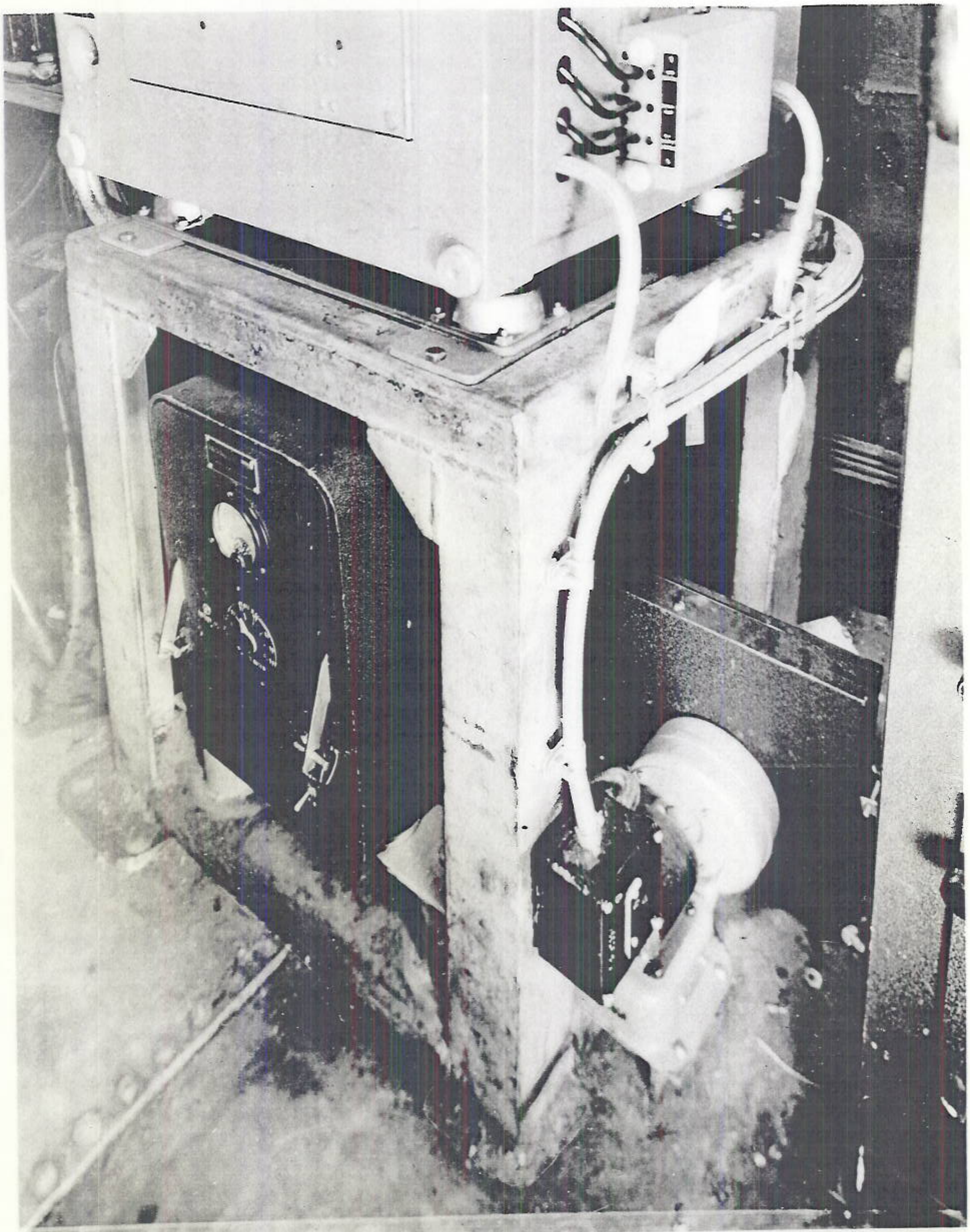


F644C5763 NAVY YARD, NEW YORK MARCH 17, 1944
U.S.S. DD 603, MK 4 RADAR INSTALLATION.
RADAR ROOM, C.I.C.

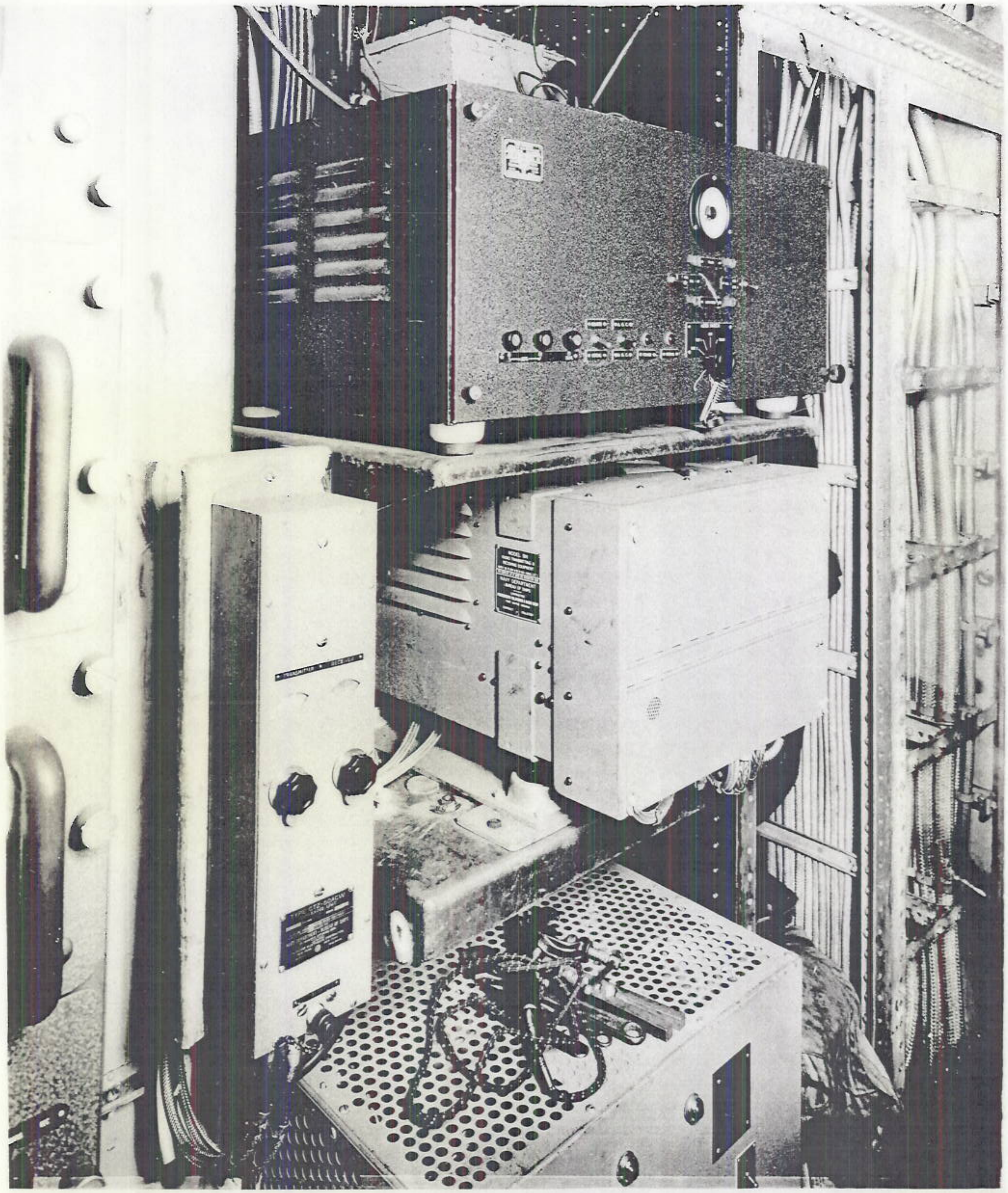
DECLASSIFIED

PLATE 2



F644C5765 NAVY YARD, NEW YORK MARCH 17, 1944
U.S.S. DD 603, MK 4 RADAR INSTALLATION.
REGULATED RECTIFIER AND BLOWER MOTOR.

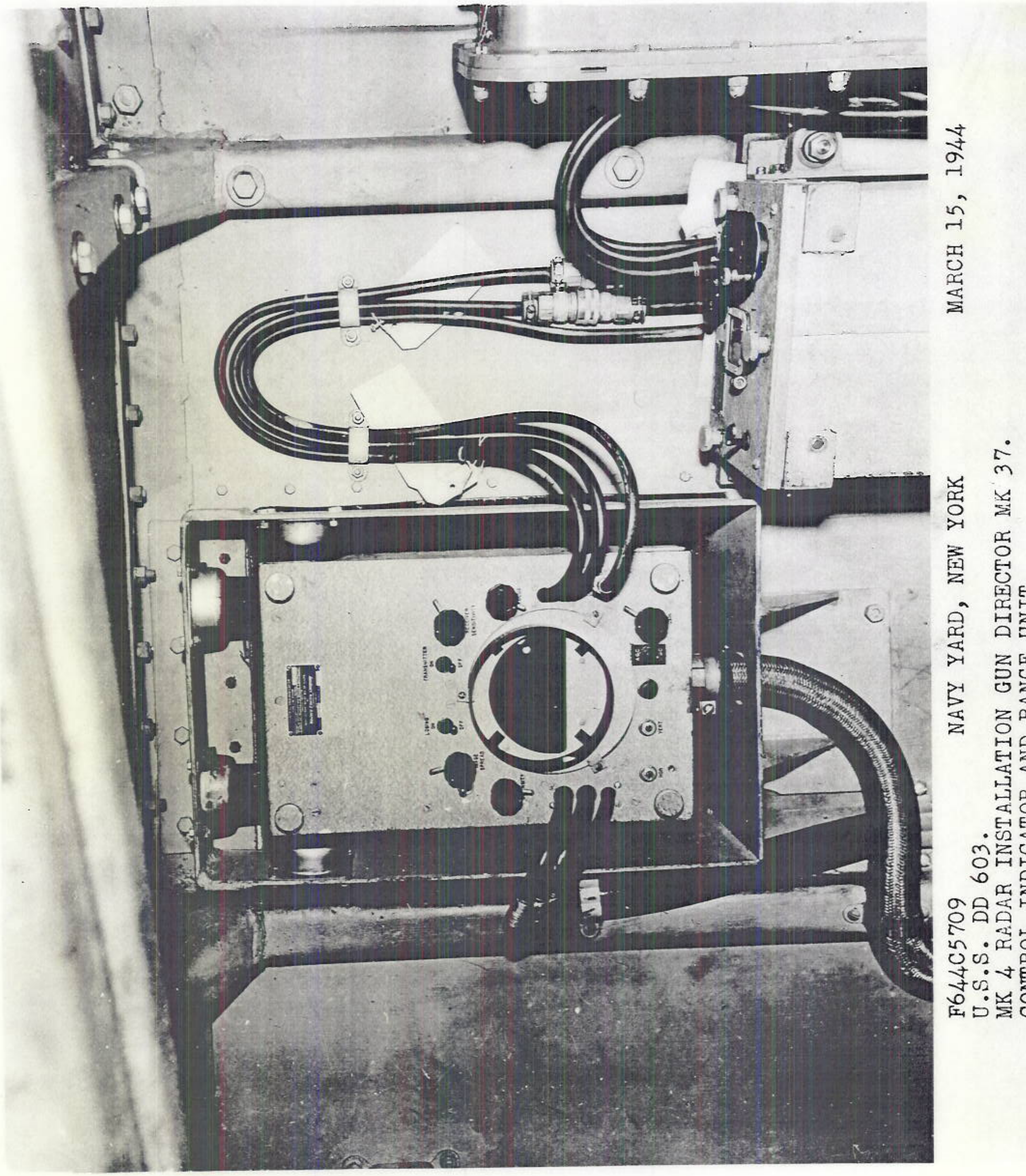
[redacted]



F644C5764 NAVY YARD, NEW YORK MARCH 17, 1944
U.S.S. DD 603, MK 4 RADAR INSTALLATION.
AUTOMATIC GAIN CONTROL UNIT.

DECLASSIFIED

[redacted]



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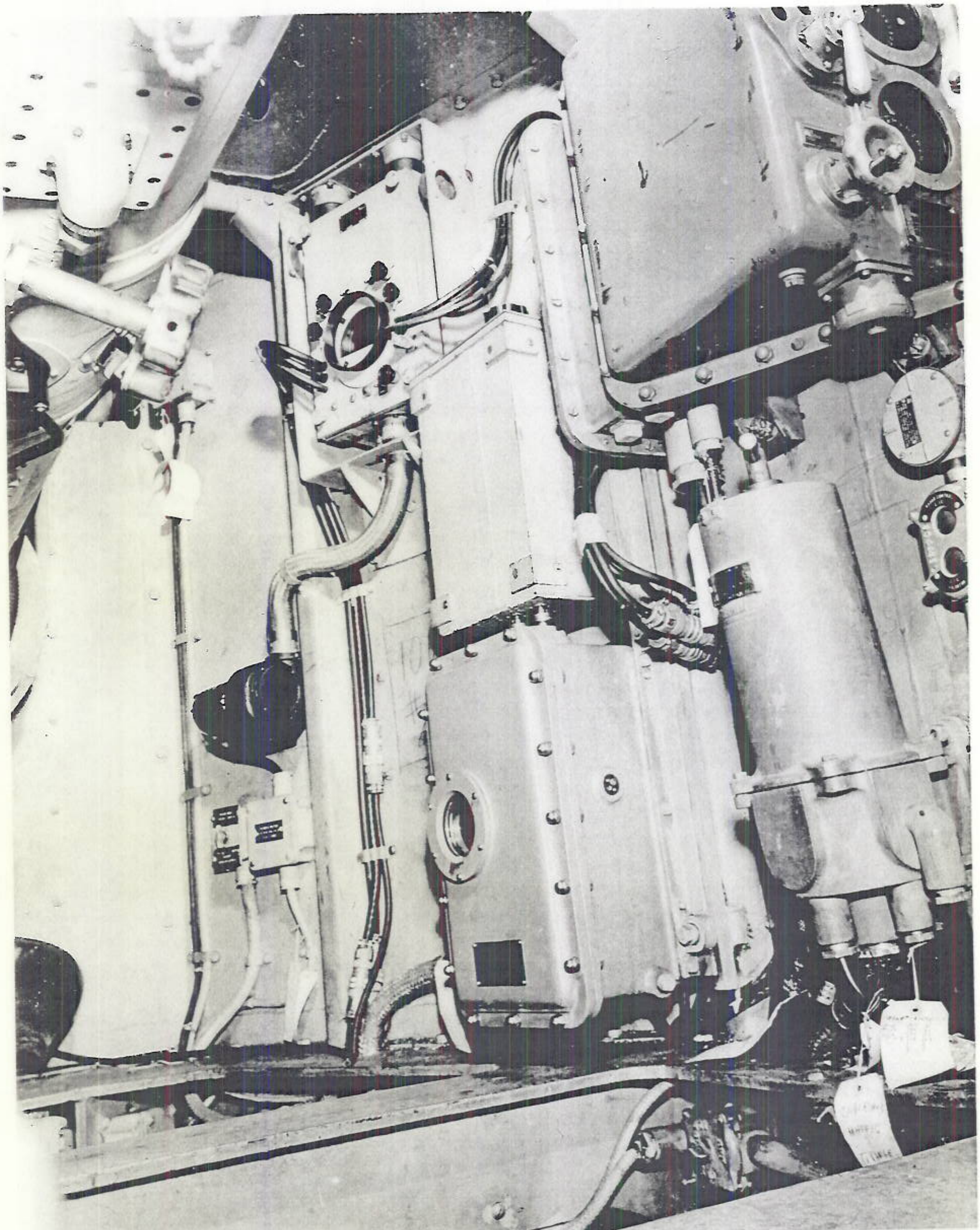

F644C5708 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
CONTROL INDICATOR - RANGE UNIT AND RANGE TRANSMITTER BLOWER FOR INDICATOR.

[redacted]

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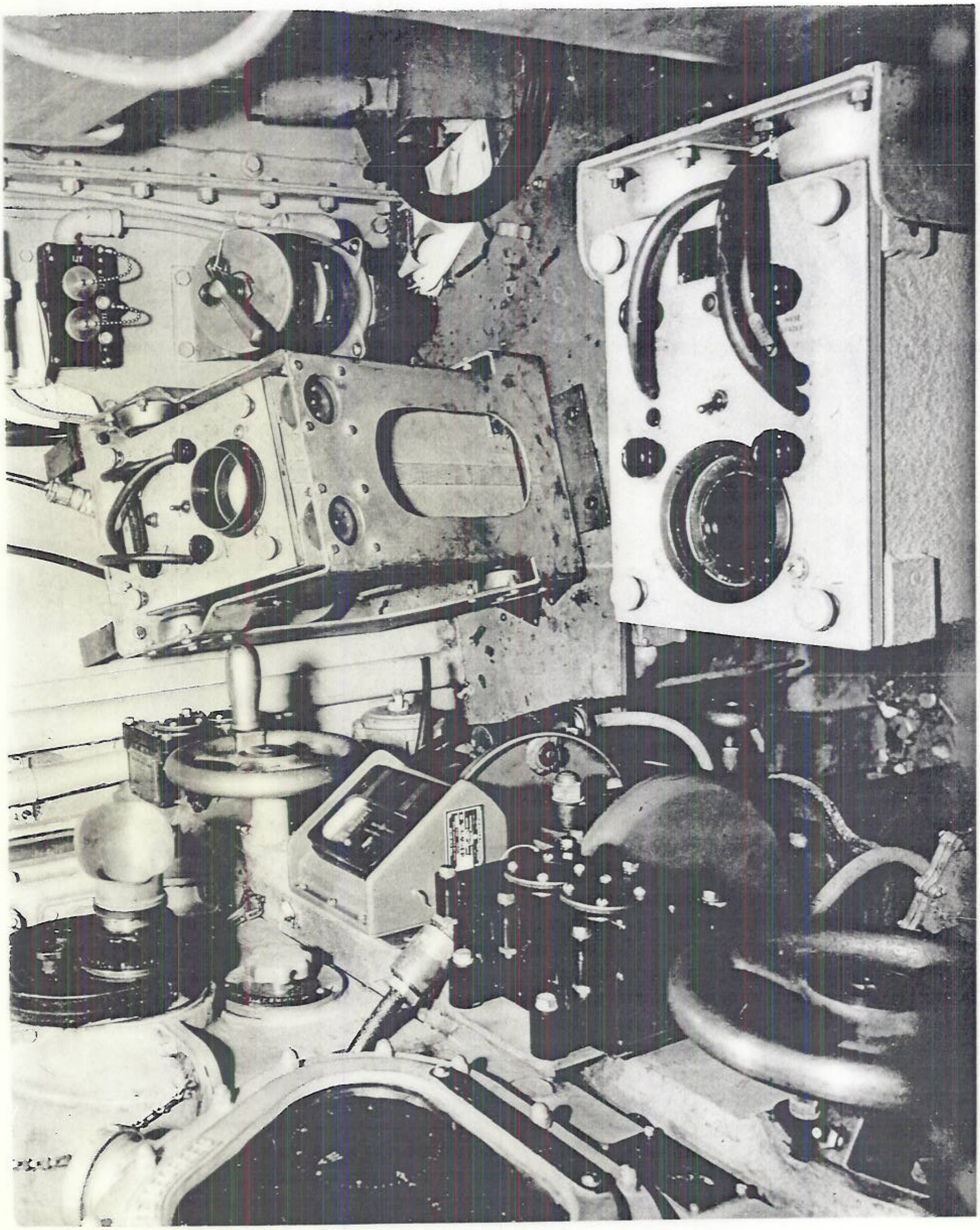
[redacted]

PLATE 6



F644C5713 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
ELEVATION INDICATOR - SHOWING SHOCK MOUNTING.

[redacted]

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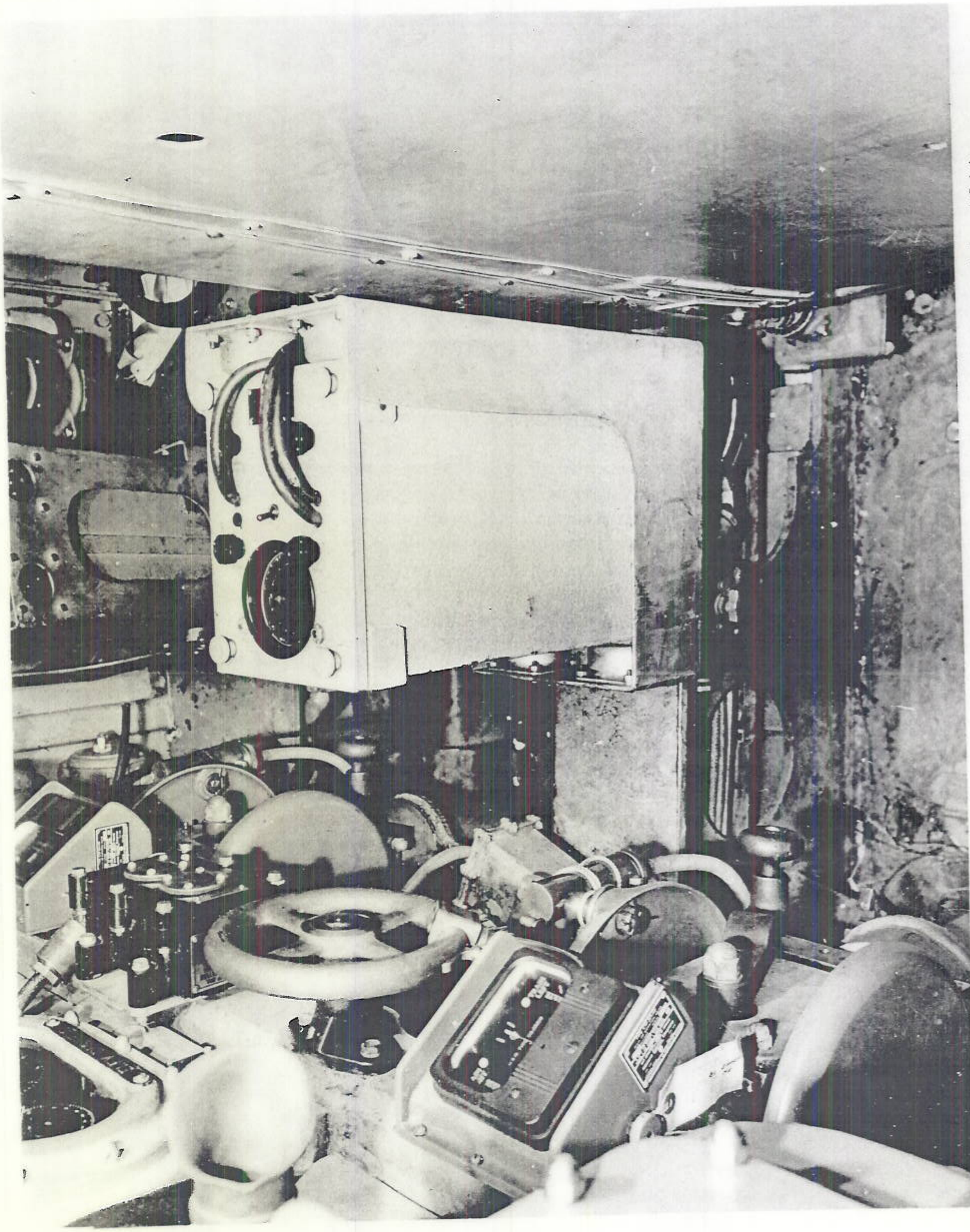
PLATE 7

F644C5711 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
TRAIN AND ELEVATION STATION SHOWING LOCATION OF INDICATOR AND
METERS.

DECLASSIFIED

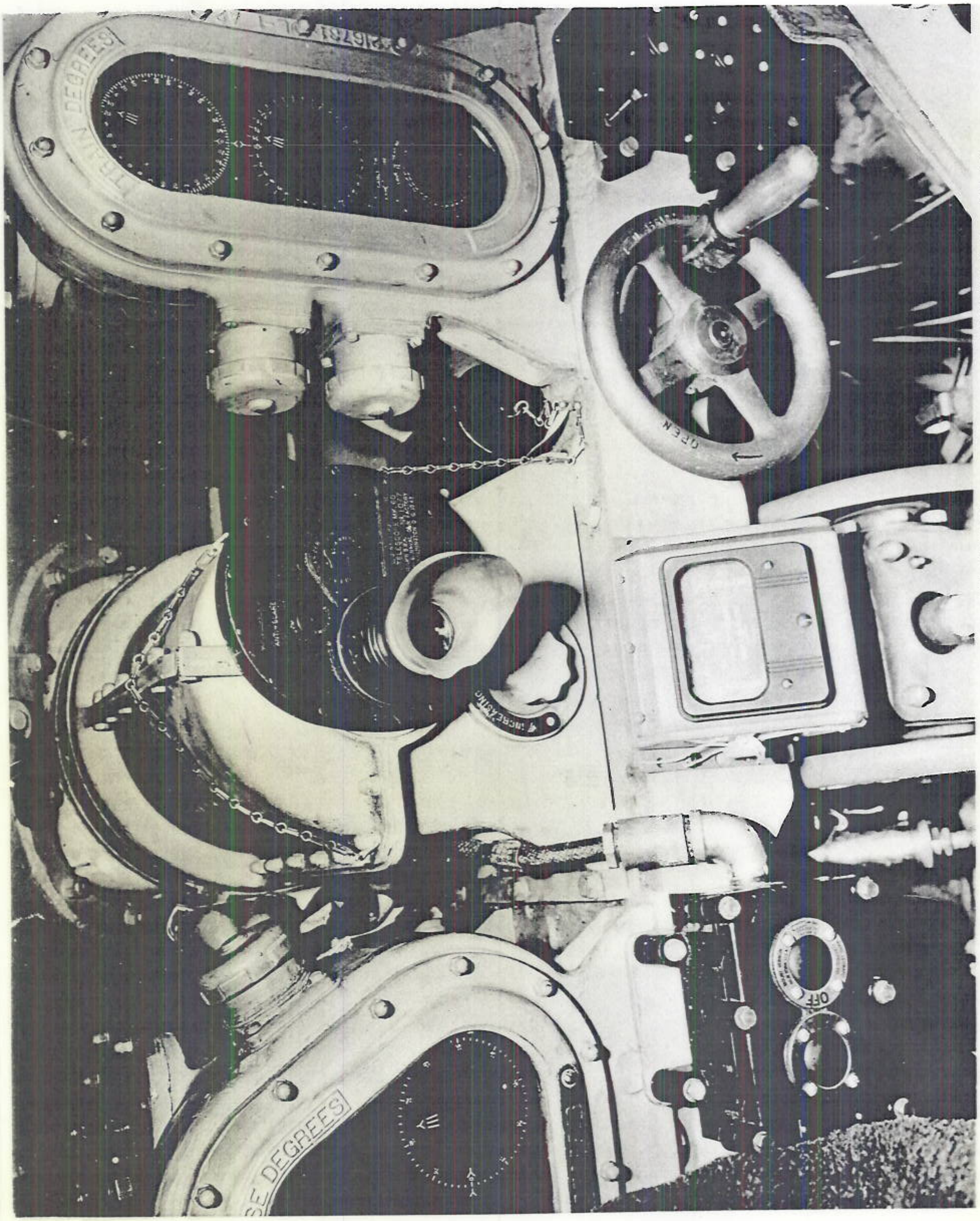
[redacted]



F644C5714 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
ELEVATION INDICATOR - SHOWING SHOCK MOUNTING.

[redacted]

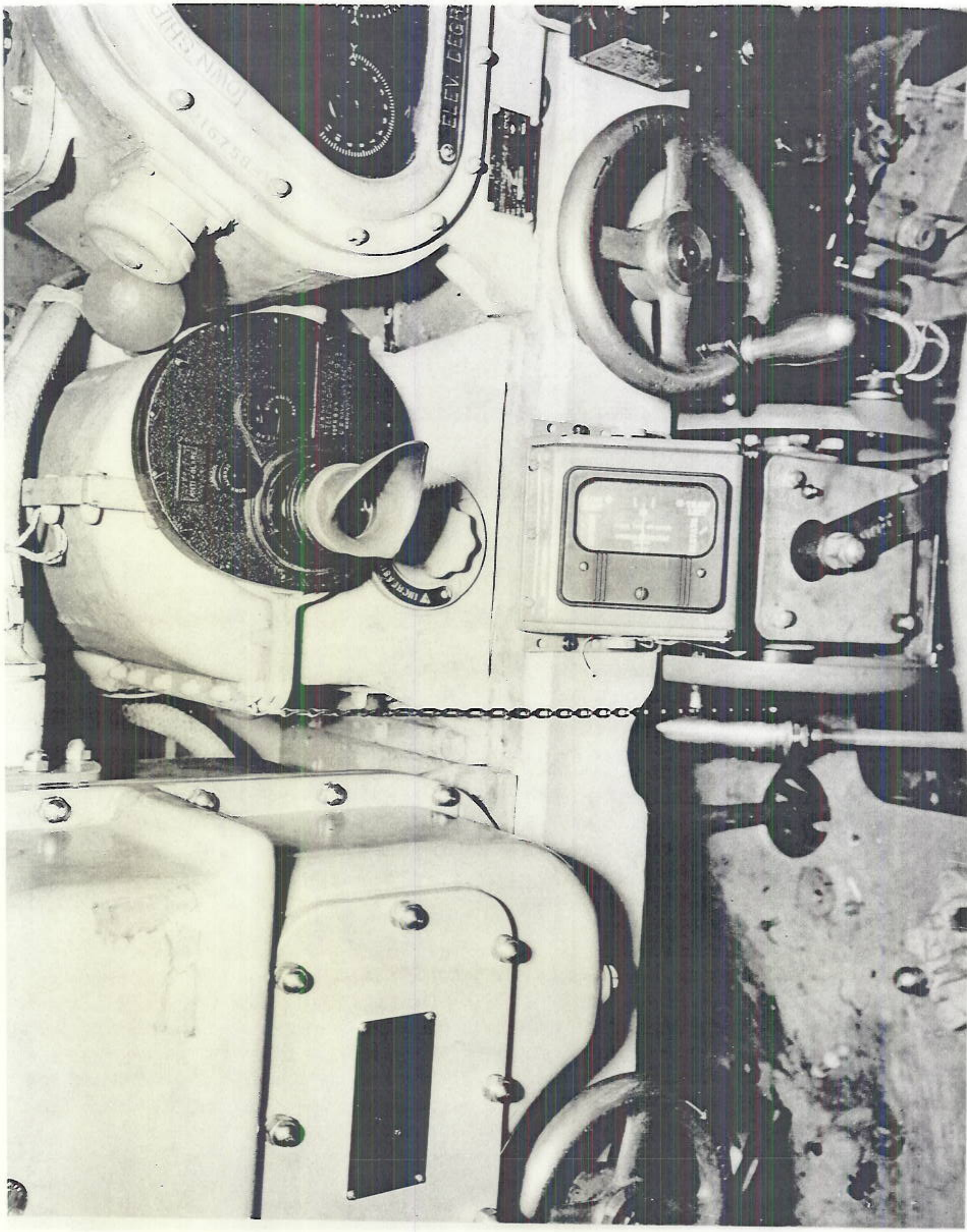
DECLASSIFIED



F644C5712 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
TRAIN OPERATOR STATION SHOWING TRAIN METER.

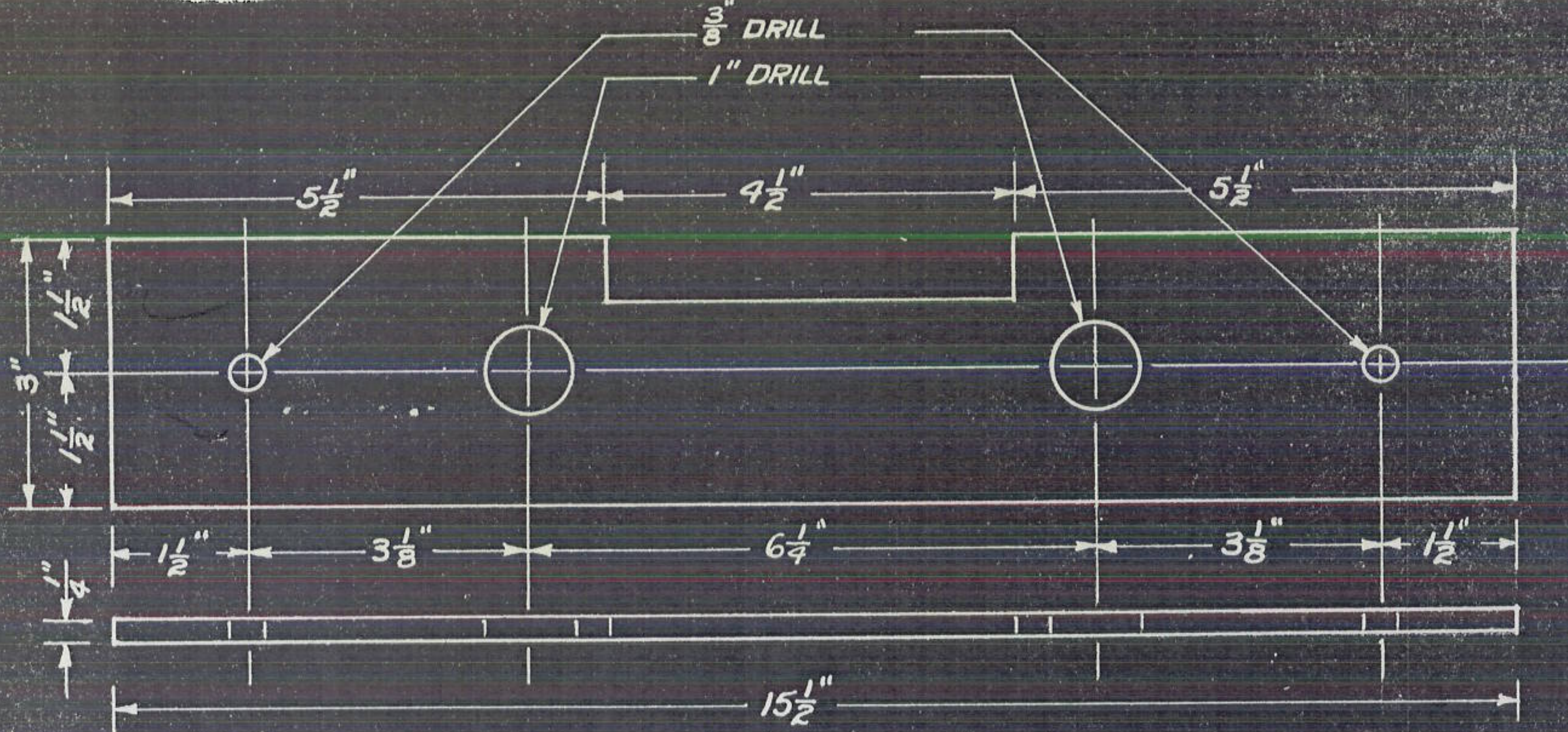
DECLASSIFIED

[redacted]



F644C5710 NAVY YARD, NEW YORK MARCH 15, 1944
U.S.S. DD 603.
MK 4 RADAR INSTALLATION GUN DIRECTOR MK 37.
ELEVATION OPERATOR STATION SHOWING ELEVATION METER.

[redacted]



MOUNTING PLATE

PART 42 (MODIFIED FOR MARK 4 MOD (RADAR EQUIPMENT)

SEE NRL REPORT R-2146 PLATE 85

CONFIDENTIAL

PLATE 12