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Test of XBC Radio Beacon Equipment

NAVAL RESEARCH LABORATORY

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Report on

Test of XBC Radio Beacon Equipment

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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AUTHORIZATION

1. In accordance with references (a) and (b), the XBC Experimental Radio Beacon Equipment was installed and tested on board the USS HARRY LEE (AP17) and associated landing craft.

Reference:
- (a) BuShips ltr C-S67/52(480-H) of 28 May 1942 to Naval Research Laboratory.
- (b) Navy Dept. ltr FF1/S67/S82-3 of 5 December 1942 to Comdr. Amphibious Force U. S. Atlantic Fleet.
- (c) NRL ltr C-S67/S24 of 26 May 1942 to BuShips.
- (d) BuShips memorandum (480-H) of 21 August 1942 to (470).
- (e) NRL ltr C-S67/S24(381) of 10 November 1942 to BuShips (925).
- (f) NRL ltr C-FE25/380 of 24 November 1942 to BuShips (925).

INTRODUCTORY

2. The XBC Experimental Radio Beacon Equipment was designed for navigational guidance and control of landing craft. This equipment consists of:

(a) A radio transmitting system with a dual beam antenna installed on a ship from which landing operations are to be made.

(b) A radio receiving system installed in the landing craft.

3. The radio transmitting system is illustrated in Plates 1 and 2. The various units comprising the transmitting equipment are shown in Plates 3 to 16. The Model YG Transmitter used in the equipment has an output power rating of 25 watts at 246 mc. The total weight of the assembled equipment as shown in Plates 3, 4, and 5 is 925 pounds. When necessary the equipment can be disassembled into the component units shown in Plates 7, 11, 14, and 15. The greatest weight of any one component unit would then be 180 pounds. A brief description of the principles of operation of the subject XBC equipment is given below. The XBC transmitting equipment consists of a YG transmitter, a radio range keyer, a link circuit relay, a "U" section, phasing section, and an antenna. A block diagram of the equipment is shown in Plate 1. The radio range keyer automatically keys the link circuit relay to transmit A's and N's interlaced on the dual beam antenna. In addition, it automatically transmits an identification

signal periodically on both the A and N beams. The "U" section of line is shorted at either point A or the point N at all times. If the short is at N, then the right hand part of the "U" section presents a high impedance at both the points O and H. Hence, the r-f power from the YG transmitter flows through the OAG part of the "U" section. At the point G the power divides, with half of it going directly to antenna B, while the other half passes through the phasing section and then to the antenna C. Thus, the antenna current in antenna B leads that in antenna C by the electrical length of the phasing section. The center of the beam is no longer at right angles to the antenna but is shifted to the right by an angle θ, as is shown in Plate 2. Similarly, if the contacts A were shorted and N were open, one would obtain the N beam in Plate 2. Thus, one has a dual beam antenna. The link circuit relay is activated by the radio range keyer so that an A is transmitted on the A beam and an N on the N beam. These signals are interlaced, so, if a receiver is to the right of the line OP (see Plate 2), an A is heard in the receiver; if the receiver is to the left of the line OP, then an N is heard, and if the receiver is on the line OP a steady signal is obtained. The width of this steady signal beam is less than one degree, but the beam width of the combined A and N signals is about 45 degrees.

4. The radio receiving system consists of a standard Navy Model RU Aircraft Communication Receiver with a Model ZB Homing Adapter and a directive antenna having an angle of reception of 130 degrees at half power (see Plate 18). The Model RU Receiver has a sensitivity of 2 to 5 microvolts per meter. The RU-ZB receiver combination has an overall sensitivity of approximately 40 microvolts per meter. Any other receiver having operating characteristics similar to the RU-ZB combination could be substituted. The total weight of the receiver (Plate 17) is 30 pounds. The 130-degree beam antenna shown in Plate 18 weighs 9 pounds, and the antenna mast approximately 50 pounds. A waterproof box would be required to house the receiver in a permanent installation.

5. Since this radio beacon system employs the aural method of guiding the receiver operator, the coxswain in the landing boat need only wear a set of headphones. When once properly installed and tuned to the operating frequency of the transmitter, the only receiver controls which will need to be operated by the coxswain for cw reception will be the on-off switch and the volume control; thus his hands will be relatively free for maneuvering the boat.

6. With an aural type of beacon such as the XBC equipment the accuracy with which the proposed landing point can be located depends upon the following factors:

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(a) Response characteristics of receiver.

(b) Aural characteristics of receiver operator.

(c) Distance between landing point and ship.

(d) The field strength pattern of the dual beam transmitting antenna. In other words, the accuracy with which a proposed objective can be located at distances near the maximum useful range of the on-course signal will be less than at shorter distances.

7. Certain fundamental facts which have an important bearing on the successful operation of this equipment are given below:

(a) The deck or platform on the ship on which the transmitting equipment is installed must be at least 30 feet above the water line; this will give an antenna height of at least 40 feet above the water line (see Plate 20).

(b) The location of the transmitting equipment must be such that a clear view horizontal angular range of at least 270 degrees is available; by clear view angular range is meant a view entirely free from obstructions such as masts, stacks, guys, stays, and the like. Such obstructions can seriously distort the radio beam from the XBC equipment.

(c) Provisions must be made which will enable the transmitter operator to make accurate corrections in the bearing of the radio beam to compensate for changes in the ship's heading. This is of vital importance, since the whole success or failure of the landing operation depends upon the accuracy of this bearing. Because of the time lag inherent in the use of a telephone system, it is recommended that a gyro-compass repeater be installed alongside the XBC equipment for this purpose.

(d) The receiving element of the receiving antenna must be shielded to such an extent as to preclude reception of reflected signals. The angle of reception of the receiving antenna, however, must be wide enough to compensate for variations in the course or heading of the landing boat.

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(e) The height of the receiving antenna above the water line must be at least 15 feet to insure reception of a usable signal in the on-course beam at a distance of nine nautical miles. The results of the tests described herein indicated that a height of 15 feet is adequate with the 130-degree beam antenna for the above range.

8. The purpose of this project was to determine the following factors under simulated actual operating conditions:

(a) The maximum useful range of the on-course radio beam.

(b) The accuracy with which landing craft can locate a proposed objective by following the on-course signal.

(c) The approximate width of the on-course beam.

(d) The effect of another ship passing through the radio beam between the transmitting and receiving antennas.

(e) The effect of directing the radio beam toward reflecting objects, such as high cliffs on the shore line, other ships, or the operating ship's own superstructure.

(f) The usefulness of voice modulation on the radio beam.

(g) To gain as much information as possible, from a practical viewpoint, relative to location and installation of the transmitting equipment aboard ship and the receiving equipment on the landing craft.

LANDING PROCEDURE

9. Ship's officers experienced in actual landing operations gave the following information in regard to the general procedure carried out:

Landings are usually made under cover of darkness with all lights on ships and boats completely blacked out. If the sea is rough, as many boats as desired are lowered into the water on the lee side of the ship and loaded. The ship is then turned 180 degrees to enable the remainder of the boats to be lowered and loaded on the lee side. While this activity is taking place, the loaded boats circle around off to one side of the ship in what is termed a "rendezvous." When all of the landing boats are ready to go ashore, they are directed to the "debarkation line," from whence the invasion landing is made.

MEASUREMENTS AND RESULTS

10. Ten test runs were made to determine the factors listed in paragraph 8. The participating personnel conducting the tests were as follows:

Lt. Comdr. A. C. Stocker, RMO of Atlantic Fleet Amphibious Force.
Lt. C. A. Burmister, U.S.C.andG.S.
Lt. C. L. D. Allen, NRL.
Ensign Baxter, Boat Officer, USS HARRY LEE.
Three Seamen, USS HARRY LEE.
A. A. Cory, Senior Radio Engineer, RMO Office, Norfolk Navy Yard.
L. G. Robbins, Associate Radio Engineer, NRL.
W. A. White, Contract Employee, NRL.
R. P. Hunter, Contract Employee, NRL.

The USS HARRY LEE was anchored at a point 5.5 miles north of Cove Point Light, Md., and about 1.5 miles off shore.

11. The XBC transmitting equipment was installed on the 20 mm anti-aircraft gun platform above the 5-inch gun platform on the after deck of the USS HARRY LEE (see Plate 20). Certain modifications to the anti-aircraft gun platform were necessary in order to make the installation. A detailed description of these modifications is given in paragraphs 4 and 5 of Appendix A. As indicated in Plate 20, the resulting antenna height above the water line was 44 feet. This location provided a clear view horizontal angle of approximately 300 degrees. Officers on board ship who were experienced in landing operations were of the opinion that this angular range was adequate for almost any landing operation. The ship's telephone system was utilized in relaying from the bridge to the XBC operator each one-half degree change in ship's heading.

12. The receiving equipment was installed in a 36-foot Eureka personnel boat (LCP(L)) as shown in Plate 21. No attempt was made to simulate a permanent installation of the receiver for these tests. A detailed description of the proposed permanent installations of the receiving equipment aboard various types of landing craft is given in paragraphs 18 to 25 of Appendix A. Unless otherwise indicated, the 130-degree beam receiving antenna was mounted on a 15-foot mast. The total height of the antenna above the water line was approximately 16 feet.

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Maximum Useful Range

13. The 130-degree receiving antenna was mounted on a 20-foot mast. The XBC radio beam was trained on a buoy 11 miles distant toward Barren Island. The simulated landing party followed the on-course signal reliably for a distance of 9.9 nautical miles. At this distance the signal level was approximately at receiver noise level so that increasing concentration on the part of the coxswain would be necessary to hear the signal.

14. Because of poor visibility it was impossible for the landing party to see the ship beyond three miles. There were other ships in the vicinity also, making it difficult to determine which one was the USS HARRY LEE. However, on the return trip, by following the on-course signal, the coxswain was soon able to distinguish between ships. The identification feature of the XBC equipment would enable the coxswain to distinguish between ships if more than one XBC equipment were in operation at the same time.

15. During the course of this run the telephone line on the ship, used to communicate changes in ship's heading to the transmitter operator, became inoperative for 10 minutes. During this time the bearing of the radio beam was uncorrected. The landing party was eight miles out at the time and was forced to cruise on the "N" side of the on-course signal. When the bearing of the radio beam was finally corrected on the ship a change of 15 degrees was made. The landing party then found itself on the "A" side of the on-course signal. By reversing the boat's course the coxswain soon picked up the on-course signal without further difficulty.

16. Since the signal became unreliable while the boat was still a mile short of its objective, no attempt was made on this run to obtain an approximation of the on-course beam width.

17. The receiving antenna mast was not provided with guys for additional support against whipping. A fairly heavy sea was running during this test and, as a result of the violent whipping, the mast sustained a 10-degree bend just above the upper support (see Plate 21). It was evident that a 20-foot mast would require additional support.

Landing Accuracy at Maximum Useful Range

18. The radio beam was trained on a buoy 9.6 nautical miles from the ship. The maximum range attained with a usable cw on-course signal was nine nautical miles. By increasing the height of the antenna mast from 15 feet to 20 feet, the

above maximum reliable range was increased to 10 miles; this checked the results given in paragraph 13. At this distance the receiver noise was beginning to obscure the desired signal. This noise is inherent in the receiver, and is not atmospheric or man-made interference.

19. An attempt was made here to determine the width of the on-course beam. The receiving boat arrived at a point about 100 yards to the east of the buoy (9.6 miles from the ship). This point was well within the on-course beam. By running at right angles across the beam a rough estimate of 750 yards (2°) was obtained as the apparent beam width. This cannot be construed as the true beam width because:

(a) The measurement was made at the maximum usable range of the on-course signal.

(b) The distances between audible "A" and audible "N" were rough estimates by the boat personnel.

(c) The signal level at which the receiver operator considered the A and N characters audible was also an estimation.

(d) During this test the ship's head was changing as much as 1 degree every 15 seconds for which corresponding corrections in the on-course beam bearing had to be made.

Previous measurements at ranges up to 7.5 nautical miles have indicated an on-course beam width of approximately 0.6 degree (see reference (f)).

20. Voice modulation was also used intermittently in this test. The apparent maximum range for understandable voice communication with the XBC equipment as it is now designed is 6.5 to 7 nautical miles. Further details in regard to this test are given in paragraph 27 of Appendix A.

<u>Landing Accuracy at 5.5 Miles</u>

21. A run was made with the radio beam directed on a buoy 5.5 miles distant. The purpose of this run was to determine the accuracy with which an objective can be located by following the on-course cw signal, and to check the operation of the voice modulation feature incorporated in the equipment.

22. The coxswain followed the on-course signal to the buoy, arriving at a point about 100 yards (1/2°) to the east side. This point was on the "A" side of the on-course beam,

indicating that the center of the beam was considerably less than 100 yards from the buoy.

23. The voice modulated signal at a distance of 5.5 nautical miles was understandable but of only fair quality.

Distortion of the On-Course Beam Produced by the Ship's Superstructure

24. The radio beam was trained on a buoy 6.4 miles distant on a bearing such that the on-course beam was aimed directly at the ship's superstructure. It was observed in the receiving boat that the beam width was somewhat narrower than that observed when the beam was unobstructed. A maximum on-course range of only 4 miles was attained indicating a high degree of attenuation by the obstruction. By following the boat's magnetic compass bearing on beyond this range, the coxswain brought the boat to a point about 50 yards to the east of the objective. Apparently, in this particular case, the on-course beam was not distorted by the ship's superstructure. This was an exception as proved by subsequent tests.

25. Conditions were the same as described in paragraph 24, except that the beam was directed on a buoy whose bearing was 10 degrees west of the previous course. Thus, the beam was aimed about 10 degrees off the ship's port bow, but was still passing through cargo booms, boat davits, and rigging. On this run the objective was missed by 3/4 mile, indicating a decided distortion of the on-course beam due to the influence of the ship's superstructure.

Reflection of the Beam Caused by the Ship's Superstructure.

26. The boat circled the ship at a distance of about one mile. The radio beam was directed toward the ship's superstructure. The receiving antenna was trained toward the ship at all times. Numerous false on-course signals and reflections were observed around the circle. These results proved the necessity of locating the XBC transmitting equipment on the ship so as to provide the greatest possible clear view horizontal angle.

Width of On-Course Beam

27. This test was made in an attempt to determine the effect of the ship's superstructure on the width of the on-course beam. The boat circled the ship at a distance of one to one and one-half miles at idling speed. The beam receiving antenna was trained on the ship at all times. The XBC beam was turned in a clockwise direction in 20-degree increments from bearing 030 degrees to 330 degrees (the clear view angle

[redacted]

of the beam) and in 10-degree increments from 330 degrees to 030 degrees (the obstructed angle). As the boat moved toward the on-course signal, a letter "A" was flashed to the ship by blinker tube when the "A" signal was considered by the receiver operator to be on the edge of the on-course beam. The boat then moved through the on-course beam until the letter "N" was just audible; "N" was flashed to the ship at this point. An operator on the ship took bearings on the two flashed signals by means of a sextant. Hence, the approximate width of the on-course beam was determined for any direction in which the beam may be aimed.

28. The data thus obtained are shown in Table 1, and indicate a considerable variation in beam width, even in the clear view angle. It is granted that there is considerable possibility of error in this method of measurement. By considering only the readings in the clear view angle and discounting those readings that are believed to be in error, an average beam width of 41 minutes or 0.67 degree is obtained. This is the beam width at distances for which the receiver noise level is low as compared to the desired signal, or for distances less than about 7 miles.

Effect of Another Ship Passing Through On-Course Beam.

29. This run was made with a view to determining the effect of another ship passing across the beam between the transmitting and receiving antennas. The boat proceeded on the on-course beam to a distance of about 4 miles and allowed a collier to cross the beam about one-quarter mile distant. No distortion of the on-course signal was observed, but as various parts of the ship's superstructure crossed the beam, definite shadowing or fading of the signal was noted. The signal did not disappear completely, but decreased from a very strong signal to one that was too weak to be usable.

Effect of High Cliffs on Landing Accuracy

30. This run was made to ascertain whether or not spurious signals could be received when the beam was directed toward high cliffs. The USS HARRY LEE was anchored about one and one-half miles from several high cliffs. The angle between the X3C on-course beam and the cliffs was about 110 degrees. The landing boat followed the on-course signal toward the cliffs as far as the depth of the water would allow. No deviations, reflections, or abnormal effects were observed as long as the receiving antenna was directed toward the ship, or even 90 degrees away from the ship. When the receiving antenna was turned toward the cliffs, however, and the boat's course changed to parallel the shoreline, numerous false on-course signals and spurious characters were noted

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such that it was impossible to locate the true course. The moment the receiving antenna was turned back toward the ship, all reflections disappeared completely and the coxswain soon picked up the true on-course signal. It was also noted that the reflected signals were considerably weaker than the direct beam. This test definitely proved the necessity of using a directive receiving antenna.

Inherent False On-Course Signals

31. The on-course beam was trained directly astern of the ship. The receiving boat circled the ship at a distance of about 500 yards with the receiving antenna trained toward the ship at all times. The true on-course signal was picked up directly astern of the ship as expected. Continuing on around the port side, the normal character "N" was heard until, at a point about 35 degrees off the true on-course beam, a false "on-course" signal was received, after which the character "A" was heard. This is a normal condition resulting from the secondary side lobe of each main lobe of the beam. This is shown in the field strength pattern, Plate 25. The character "A" continued to be heard with gradually diminishing volume until the boat was directly off the ship's bow. There another false "on-course" signal much weaker than the true on-course signal appeared. "N" was then heard in gradually increasing volume around the starboard side to a point about 35 degrees off the true on-course beam. At this point the false "on-course" signal corresponding to that on the port side was heard; from there on the character "A" persisted until the true on-course beam was again heard astern of the ship.

32. False "on-course" beams are obtained at approximately 35 degrees on each side of the true on-course beam as shown in Plate 26. Thus, if the landing boat is within 0.6 mile of the true on-course beam when at a distance of 1.0 mile from the ship no trouble should be encountered in finding the true on-course beam. However, if the landing boat were off of the true on-course beam more than 30 degrees before proceeding to the debarkation point, there would be danger of the coxswain proceeding on a false "on-course" beam. A study of Plate 26 reveals that the "A" and "N" signals are on the <u>right and left sides</u> respectively of the false "on-course" beams and on the <u>left and right sides</u> respectively of the true on-course beam. The directive receiving antenna in the landing boat will automatically guide the coxswain to direct the landing boat toward the beach. If the landing boat is on a false "on-course" beam, the coxswain will observe that the "A" and "N" signals are reversed from those for the true on-course beam and can thus recognize the fact that he is on a false "on-course" beam. It is still necessary for him to know whether he is on the right or left side of the true

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[redacted]

on-course beam. If he follows a course in the direction away from the true on-course beam when leaving a false "on-course" beam, he will observe a steady decrease in signal instead of a steady increase, as would be obtained when proceeding toward the true on-course beam.

33. It is evident from the above discussion that the coxswain on the landing boat can have trouble finding the true on-course beam if he is more than 30 degrees off the beam. It may be possible to overcome this difficulty by rotating the on-course beam through 360 degrees and periodically giving directions on the voice modulation to the coxswains. For example, if the landing boat were at the point B in Plate 26 and the XBC transmitting antenna were rotated counter-clockwise through an angle of 90 degrees, the coxswain would observe the false "on-course" beam (3), the true on-course beam (1), and possibly the false "on course" beam (2). The XBC operator will then inform all coxswains who heard at least two beams as to their positions relative to the true on-course beam. This operation may be repeated for the other three quadrants. After the true on-course beam is again properly directed, the XBC operator will instruct all coxswains to proceed to the true on-course beam. Weak pulse on-course beams in the back radiation (angle θ in Plate 26) may be observed. No trouble should be encountered in distinguishing between these weak pulse signals and the beams 1, 2, and 3 (see Plate 26).

Interference Produced by XBC Equipment

34. The 246 mc carrier of the XBC transmitter is modulated at a radio frequency between 540 and 830 kc. The modulation frequency used during these tests was 735 kc. This frequency was picked up by the ship's RAS-2 communication receiver and the DP12 and DP13 direction finders. The field strengths at the direction-finder loops was estimated to be the order of 30 to 40 microvolts per meter. Other field strength measurements at the Laboratory have given field strengths of the same order of magnitude. The radiated power is of the order of 10^{-8} watts.

35. A filter was inserted in the power line in the XBC cabinet but there was no appreciable reduction in signal as received by the DP12 direction finder. This test together with other measurements that have been made at the Laboratory indicate that the greater part of the power is radiated from the XBC structure with possibly some radiation from the power line. It should be noted that a radiated power of 10^{-8} watts will produce a field strength of only one microvolt per meter at a distance of 0.5 mile.

[redacted]

36. The 735 kc interference signal was picked up on the RU-4A receiver which was circling the USS HARRY LEE at a distance of about 100 yards. The receiver gain control was set at approximately the maximum position and the noise level was relatively high, but a readable signal was obtained.

Vibration Test of XBC Equipment

37. The entire first day, after leaving the Norfolk Navy Yard, was occupied with full speed test runs on the ship's turbines. This offered an opportunity for observing vibration of the XBC transmitting equipment. Although the 20 mm anti-aircraft gun platform on the after deck provided the greatest clear view angle, it was one of the poorest locations on the ship from a standpoint of vibration. This vibration was objectionable, however, only during full speed operation of the ship. While at two-thirds or half-speed operation, the vibration was just perceptible. During the times of severe vibration of the XBC equipment the entire gun platform was also vibrating with considerable amplitude. The equipment withstood eight hours of severe vibration on the USS HARRY LEE without damage.

38. Vibration amidships or forward is much less than near the fantail. Suitable locations for the equipment near the forward part of the ship may be available in some cases; however, this would be an exception, judging from observations made on several ships at the Norfolk Navy Yard.

39. The XBC transmitting equipment was mounted on the shock and vibration table at the Naval Research Laboratory. No key clicks or other undesirable operating characteristics were observed during the shock and vibration tests. The following changes were made in order to reduce vibration of the component parts of the equipment.

(a) The maximum total amplitude of vibration of the antenna structure was reduced from about 3/8 inch to 1/16 inch by mounting several vibration dampeners on the antenna structure.

(b) The base of the keyer-modulator unit was strengthened in order to reduce vibration of the keyer motor.

(c) The vibration of the transmitter unit was less for the rigid mounting than when rubber mountings were used.

(d) The mounting brackets of the power transformer in the transmitter unit broke during the vibration tests. These mounting brackets were strengthened and no subsequent failure was observed.

[redacted]

OPERATIONAL FACTORS

40. The tests on the USS HARRY LEE and other operational tests at the Laboratory Annex have brought out the following operational characteristics of the XBC Experimental Radio Beacon Equipment. These operational characteristics, including all of the observed limitations, are tabulated below.

(a) The maximum useful range of the XBC equipment is 9 nautical miles for transmitting and receiving antenna heights above the water of 44 feet and 15 feet respectively. This maximum useful range will be less than 9 miles if the height of either antenna is less than given above.

(b) The width of the on-course beam is about 0.6 or 0.7 degree for distances at which the receiver noise level is negligible, or for distances less than about 7 miles with the antenna heights given in paragraph 40(a). The width of the on-course beam increases for distances greater than about 7 miles and is of the order of 1.0 to 1.5 degrees at the maximum useful range.

(c) If the landing craft is off the on-course beam less than 30 degrees, then either an "A" or an "N" signal is heard and thus the coxswain will know the direction to the on-course beam.

(d) The XBC equipment can be used for cw radio communication to the landing craft for distances up to the maximum useful range or about 9 miles. (A keying arrangement can be provided to accomplish this.)

(e) The XBC equipment can be used for voice modulated radio communication to the landing boat for distances up to about 6 to 6.5 miles.

(f) The coxswain in the landing boat observes the on-course beam signal aurally and thus is relatively free for other activities.

(g) The directive receiving antenna enables the coxswain to determine whether he is going toward or away from the ship from which the landing operations are being made.

(h) The radio-frequency modulation of the ultra-high frequency signal in the XBC transmitting equipment

[redacted]

makes it possible to operate any number of XBC transmitters up to 10 and possibly 30 in the same area without interference.

(i) Each XBC transmitting system automatically sends an identification signal at the will of the operator. This will enable the coxswain to tune his receiver and to know at all times during the landing operations that he is tuned to the desired transmitting system.

(j) This system can be used for guiding the landing craft back to the same ship from which the landing operation was made.

(k) The landing point was never missed by more than 100 yards during the landing accuracy tests on the USS HARRY LEE.

(l) Reflections from cliffs at the landing point and other ships in the vicinity did not interfere with the normal operation of the equipment.

(m) The true bearing of the landing point must be known.

(n) If the position of the ship changes appreciably during the landing operation then continuous data on the true bearing of the landing point must be available to the XBC operator.

(o) The operator of the XBC transmitting equipment must be provided with continuous data on the ship's heading. A gyro repeater could be used for this purpose.

(p) The 246 mc carrier frequency of the XBC transmitting system is modulated by a radio frequency between 540 and 830 kc. The radiated power at the modulation frequency is in the order of 10^{-8} watts. The field strength at 0.5 mile from the ship will be in the order of one microvolt per meter for this radiated power. However, some interference is produced in the ship's receivers and the direction finders, if the ship's receivers are tuned to the modulating frequency.

(q) The on-course beam of the transmitting antenna cannot be trained in any direction in which obstructions such as guys, booms and stacks are in the propagation path of the radio waves.

[redacted]

Officers familiar with landing operations have indicated that an obstruction angle of 60 degrees or less along the center line of the ship should not appreciably impair the operation of this guiding equipment. An obstruction angle of 60 degrees corresponds to a clear view angle of 300 degrees. The clear view angle on the USS HARRY LEE was 300 degrees.

(r) False "on-course" beams are obtained at approximately 35 degrees on each side of the true on-course beam as is shown in Plate 26. If the landing boat is within 0.6 mile of the true on-course beam at 1.0 mile from the ship or within 3 miles at a distance of 5 miles, no difficulty should be encountered by the coxswain in finding the true on-course beam. If the landing boat were off the true on-course beam more than 30 degrees before proceeding to the debarkation point, then there is a danger of the coxswain proceeding on a false course. Methods for distinguishing between the false and true courses and of finding the true on-course beam are given in paragraphs 32 and 33.

CONCLUSIONS

41. The operational tests of the XBC Experimental Radio Beacon Equipment on the USS HARRY LEE demonstrated that it is a usable system for guiding landing craft to the landing point provided that the distance from the ship to the landing point is no greater than 9 nautical miles and that precautions are taken to avoid using false course indications. It is believed that instruction and training will largely overcome these inherent defects.

[redacted]

APPENDIX A

1. In the following paragraphs a detailed description is given of various factors relative to the installation of the XBC equipment aboard the USS HARRY LEE and associated landing craft. These factors are of interest mainly from a mechanical viewpoint and have a direct bearing on the successful operation of the equipment. Much of the information given herein was obtained through observations made on the USS HARRY LEE and other ships of transport class which were docked at the Norfolk Navy Yard. Since most ships vary considerably in details of construction, each installation of the XBC equipment would be an individual problem. Hence, the installation on the USS HARRY LEE served only as an example.

Location of Transmitting Equipment

2. The primary factors to be considered in selecting a location for the XBC transmitting equipment on board ship are as follows:

(a) Must provide a clear view horizontal angle of at least 270 degrees.

(b) Must provide a height of the center of the antenna of at least 40 feet above the water line.

(c) Must not interfere with activities on the ship such as gun fire, movement of the boat davits, cargo booms, and landing craft.

(d) Should not necessitate any major modification of the ship's superstructure.

3. The following points were observed during an investigation of all possible locations for the equipment on the USS HARRY LEE:

(a) The clear view angle for most positions ranged from 45 degrees to 135 degrees, and this for one side of the ship only. This would require an equipment on both sides of the ship to be useful for landing operations in a very limited angular range. These conditions prevailed for all locations forward of the 20 mm anti-aircraft gun platform above the 3-inch and 5-inch gun platform on the after deck of the ship.

[redacted]

(b) This 20 mm anti-aircraft gun platform satisfactorily fulfilled all the conditions listed in paragraph 2 above on the USS HARRY LEE after a few minor modifications of the gun platform were made. The same could be made to hold true for several other ships observed.

(c) The clear view horizontal angle obtained in this location was about 300 degrees. Complete clear view angle can only be obtained by installing the XBC antenna on top of the mainmast. It is not believed that the gain of about 60 degrees in unobstructed view thus obtained would justify the complications involved in such an installation.

(d) Plate 20 shows that the XBC equipment, as it was installed for the tests described herein, would obstruct gunfire through a horizontal angle of about 40 degrees and a vertical angle of about 70 degrees for this 40-degree sector. To avoid this condition in a permanent installation, the position of the XBC equipment and the four ammunition lockers on the forward side of the platform could be interchanged. This would allow the anti-aircraft guns their normal clear view coverage and still provide a clear view angle of 300 degrees for the XBC radio beam.

Modifications of Ship Necessary for Installation

4. Plate 19 shows the 20 mm anti-aircraft gun platform as originally built on the USS HARRY LEE. Plate 20 shows the modifications that were necessary in order to install the XBC equipment. These modifications involved:

(a) Removal of a section of splinter shield.

(b) Addition of a new triangular section of deck.

(c) Addition of a new straight section of splinter shield.

(d) Addition of a stanchion and other supports under the new section of deck.

(e) Removal of two gun-barrel cooling tanks and a ditty box to another location on the splinter shield.

This modification increased the total area of the platform by approximately 5 square feet. Although this area is not as great as the area of the base of the equipment (about 8.7 sq. ft.),

[redacted]

it allowed the equipment to be placed in a position such that the guns could be swung around without interference.

5. The most convenient source of 110-volt a-c power was a 5 kva generator in the emergency generator room. To bring this power to the XBC transmitting equipment required the installation of a new cable from the distribution panel in the generator room to a junction box under the gun platform. This distance, through bulkheads, down below decks, through ducts, etc., was about 200 feet. Power was then brought into the XBC equipment from the junction box by means of a flexible, rubber covered cable provided with a waterproof plug which fitted into the cabinet. The rubber covered cable was looped up and over the splinter shield and left sufficiently long to permit one complete revolution of the equipment. In a permanent installation a flexible shielded cable and suitable outlet could be provided on the platform.

Transportation and Installation of Transmitting Equipment

6. When completely assembled as shown in Plates 3, 4, and 5, the transmitting equipment is one self contained unit. Transporting or lifting the equipment completely assembled is inadvisable due to the possibility of damaging the antenna. A means is provided for readily removing the antenna structure from the waterproof cabinet so that they can be moved separately. If dock cranes are available at the time of installation, the equipment can be lifted aboard ship in two sections as shown in Plates 6, 7, and 11; that is, the antenna structure as one section, and the cabinet and base, with transmitter and keyer-modulator units installed, as the other section. These sections weigh 145 and 780 pounds, respectively. Lifting eyes are provided in the base assembly to facilitate lifting the cabinet-base section. The equipment was lifted from the pier to the gun platform on the USS HARRY LEE in the above manner.

7. If dock cranes are not available, the ship's cargo booms can be used to lift the two sections described in paragraph 6 from the dock to the main deck. On some ships, as in the case of the USS HARRY LEE, the cargo booms are not long enough to reach directly over the gun platform. In such cases the general procedure given below will have to be followed:

(a) Break the cabinet section down into the component units shown in Plates 12, 13 and 14.

(b) Construct a temporary platform to bridge between the splinter shield of the gun platform and the gunwale of the last barge (a distance of about 8 feet).

[redacted]

(c) Lift the various units of equipment onto this temporary platform by means of the cargo boom.

(d) Move the individual units onto the gun platform by hand.

The weights of the component units are as follows:

Antenna Structure.	145 Lbs.
Waterproof Cabinet	160 Lbs.
Rotary Base, Less Base Plate	175 Lbs.
Base Plate	180 Lbs.
Transmitter Unit	180 Lbs.
Keyer-Modulator Unit	85 Lbs.

Thus, any one unit can be handled by two men.

8. The steel base plate (see Plate 14) may either be bolted or welded to the platform. Welding is preferable, since it prevents water from creeping under the platform and rusting the deck. The remainder of the base assembly is then secured to the base plate by means of stud bolts. In the experimental installation, the base plate was tack-welded to the gun platform in six places around its circumference.

Operational Tests on Transmitting Equipment

9. The following preliminary operational tests were made on the transmitting equipment after installation was completed:

(a) Checked for proper operation of transmitter and keyer-modulator units.

(b) Measured standing wave ratio of the antenna system.

(c) Listened to the output signal with a receiver set up nearby.

Item (a) was determined by adjusting the transmitter output frequency to 246 mc, as indicated by the wavemeter supplied with the equipment, and then ascertaining that all readings of voltage and current on the transmitter meters were normal. The listening test, item (c), was made to determine whether or not key clicks were present in the output signal. If key clicks had been heard, adjustment of the lobe-switching contacts, shown in Plate 10, would have been necessary.

10. The standing wave ratio of the antenna system, item (b) of paragraph 9, was measured by the slotted line--probe voltmeter method. The slotted line was inserted between

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the transmitter r-f output terminal (see Plate 12) and the input terminal of the U-section (see Plates 1 and 9). The probe voltmeter indicated the standing wave ratios to be: A beam E_{min}/E_{max} = 0.85; N beam E_{min}/E_{max} = 0.81. Values of this order of magnitude and as well balanced, indicated satisfactory operation of the lobe switching mechanism and proper alignment of the antenna structure and radiating elements. Had these standing wave ratios been of appreciably lower value or unbalanced, then the indication would have been poor contact at the lobe-switching points, or loose or misaligned antenna elements and feeders. This constitutes a simple and definite method for determinining and correcting faults of this kind in the XBC antenna system.

11. Although considerable wet weather was encountered after installation of the transmitting equipment, no leaks were found in the weatherproof cabinet. Certain modifications in the present method of mounting the antenna structure on the cabinet are being made to simplify the process of assembly or disassembly of the two units. On opening the cabinet on cold mornings, condensation was noticeable on the surface of metal parts. Turning the heaters on (one 150-watt heater in the transmitter unit and one 150-watt heater in the keyer-modulator unit) for a couple of hours before actual operation started eliminated this moisture.

<u>Method of Directing On-Course Beam on Proposed Objective</u>

12. Training the on-course beam on a proposed landing point is accomplished as follows:

(a) Referring to Plate 24, it is assumed that the bearing of the objective is 110°T.

(b) The ship's heading is assumed to be 330°T.

(c) The pointer on the rotary base assembly indicates the reciprocal of the on-course beam bearing.

(d) The azimuth dial on the rotary base is rotated to read 110° + 180° or 290° as the ship's heading. A fiducial mark on the stationary member of the base assembly indicating the ship's head will be necessary to make this setting.

(e) The transmitter-antenna structure is then rotated until the pointer on the rotatable member of the base is set on 330° on the azimuth dial. The on-course beam bearing will then be 110°T.

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(f) Any corrections in the on-course beam bearing to compensate for changes in the ship's heading can then be made by direct transfer of the gyro-compass repeater readings to azimuth dial on the XBC base.

Receiving Equipment

13. The Model RU Communication Receiver with Model ZB Homing Adapter as shown in Plate 17 was designed for installation in aircraft, hence the extra long interconnecting cables. If this receiver is incorporated as a unit of the XBC equipment, certain of these cables would need to be shortened to facilitate mounting the receiver in as small a compartment as possible. The various units comprising this receiver are as follows:

(a) Model RU Receiver, including a set of coils.

(b) Switch Box, which includes on-off switch, cw-mcw switch, volume control, and phone jack.

(c) Junction Box, from which power distribution is made.

(d) Switching Relay Box, which includes an input alignment control.

(e) Pilot's Control Box.

(f) Model ZB Homing Adapter.

(g) Headphones.

(h) Dynamotor.

(i) Two 6-volt storage batteries.

14. A brief description of the operation of the receiver follows:

With all necessary connections made and the receiver in operation, set the receiver for cw and homing reception. The ZB tuning dial is set at 246 megacycles. The RU tuning control is then adjusted to the modulation frequency (540 to 830 kc) of the transmitter until a signal is heard in the headphones. If the XBC transmitting equipment is operating on cw and transmitting the characters "A" and "N," the receiver operator will hear "A" or "N," depending on which side of the on-course beam the receiving antenna happens to be located. The RU tuning dial should be adjusted to give the desired audio note (the signal heard in the headphones). The operator

[redacted]

should then readjust the ZB tuning dial and input trimmer until maximum signal output is obtained. An alignment control near the RU tuning dial and another on the switching relay box should then be readjusted until maximum signal output is again obtained. The receiver is then adjusted for maximum sensitivity and should not be tampered with further. The only controls that need be operated then will be the on-off switch, volume control, and cw-mcw switch.

15. Plate 18 shows the receiving equipment assembled. The antenna mast when assembled is 15 feet long. This mast, as shown, is composed of two sections, one 10 feet in length and the other six feet (one foot allowed for telescoping joint). The lower section is 1-11/16" O.D. by 1-5/16" I.D. mild steel tubing; the upper section is 1-5/16" O.D. by 15/16" I.D. mild steel tubing. The two sections when joined are locked together by a suitable device. The antenna and transmission line as a unit are demountable from the mast.

16. Plates 27 and 28 show the proposed clamping bracket and step by which the receiving antenna mast is supported when installed in landing craft. The bracket shown in Plate 27 provides for horizontal mounting of the base plate and would be used in a permanent installation on the Eureka boat (see Plate 21). The bracket shown in Plate 28 provides for vertical mounting of the base plate and would be used in a permanent installation on the Ramp boat and Tank Lighter (see Plates 22 and 23). The same base step would be used in all three types of landing craft.

<u>Types of Landing Craft</u>

17. Any one of a dozen different types of landing craft might be provided with the receiving equipment used in conjunction with the XBC Radio Beacon. Some of these craft are listed below:

(a) 30-foot Surf Land (LCP) (personnel)

(b) 36-foot Eureka (LCP(L)) (personnel)

(c) 36-foot Ramp (LCP(R)) (personnel)

(d) 36-foot Vehicle Ramp (LCV) (light tanks or trucks)

(e) 36-foot Support (LCP(S)) (armored cabin)

(f) 45-foot Tank Lighter (LCT) (2)

(g) 50-foot Tank Lighter (LCT) (3)

(h) 105-foot Tank Lighter (LCT) (5)

[redacted]

Inquiry and investigation revealed that the command or guiding boat of a landing party is generally either a Eureka or Ramp boat. These boats are made of 5/8-inch thick plywood, are unarmored, and capable of carrying about 25 men. They are powered generally with a Diesel engine and have a top speed of 18 knots. The tank lighters are made of steel. They carry tanks, motor vehicles, and supplies. They are powered by two Diesel engines and have a top speed of about 12 knots. Plates 21, 22, and 23 show these three types of boats in general outline and construction detail.

Location and Installation of Receiving Equipment

18. The investigation of possible locations of the receiving equipment was confined to the Eureka, Personnel Ramp, and 50-foot Tank Lighter because they were representative of the rest of the group. It is advisable to mount the receiving antenna mast and receiver so that the transmission line is kept as short as possible in order to hold transmission line losses to a minimum. In all cases the receiver must be mounted near the coxswain because it will be necessary for him to operate the on-off switch, volume control, and cw-mcw switch. This can best be accomplished by mounting the receiver in the nearest available space to the coxswain's control panel, then running appropriate cables for these controls to the control panel.

19. The Diesel engines used on these boats require from 12 to 30 volts d.c. (two to five storage batteries) for starting. Since the receiver dynamotor requires only about 5 amperes at 12 volts d.c., it is believed that the boat batteries can also be used to supply the receiver and thereby eliminate another item of equipment. If the boat starting batteries cannot be used to supply the receiver, then provision must be made for installing separate batteries near the receiver as shown in Plates 21, 22, and 23.

Installation on 36-Foot Eureka Boat

20. Plate 21 shows the 36-foot Eureka boat and the location of the receiving equipment during the recent tests. A 1-3/4 inch hole was bored in the forward deck between the machine gun wells. A 4 by 4 inch block was screwed solidly to the deck in the position shown and further reinforced with steel straps. A steel clamping device to prevent the antenna mast from turning was then fastened to the block with lag screws. Another 1-3/4 inch hole was then bored in the gunners' platform directly below the upper hole, and a steel step lag-screwed to a timber just below the platform. This arrangement provided a firm support for the mast, was convenient for plugging the transmission line into the receiver, and provided good footing for the crew when setting up or removing the mast.

[redacted]

The mast had no further support above the upper deck clamp, such as braces or guys.

21. The receiver was merely set down on the gunners' platform and covered with canvas to prevent its getting wet. No attempt was made to simulate a permanent installation. Extra storage batteries were available for the receiver power supply and were also installed on the gunners' platform near the receiver. The boat starting batteries were not used during any of the tests.

22. In a permanent installation the receiver would be installed in a waterproof box and mounted preferably on the under side of the deck between the machine gun wells (see Plate 21). Suitable leads or cables could then be brought out and terminated in the proper plugs, jacks, and controls on the coxswain's control panel to accommodate the following:

(a) R-f input.

(b) On-off switch.

(c) Volume control.

(d) Headphones.

(e) Cw-mcw switch.

(f) Battery plug.

23. It is recommended that these controls be mounted on a subpanel which in turn could be mounted on the coxswain's control panel. In this way the entire receiver could be easily removed from the boat for periodic servicing and maintenance.

Installation on 36-Foot Ramp Boat

24. An actual installation of the receiving equipment was not made in this type of boat. However, a thorough investigation was made of the best locations and methods for installing the equipment. The results are indicated in Plate 22. The waterproof box containing the receiver could be securely mounted between the ribs along the sidewall of the boat behind the coxswain. The same subpanel mounting for receiver controls as used on the Eureka boat could also be applied here. The antenna mast bracket and step proposed for this boat are shown in Plates 26 and 27. The Diesel engine on this boat requires 12 volts d.c. for starting. This supply could also be used for the receiver.

[redacted]

Installation on 50-Foot Tank Lighter

25. No installation was made on this boat, but Plate 23 shows the best location for the receiving equipment. Since this type of boat is all steel, the antenna mast bracket and step could best be fastened in place by welding. The step shown in Plate 26 and the bracket shown in Plate 27 could be used. As indicated in Plate 23, the mast, receiver, and coxswain's control panel are near each other; thus, the same subpanel mounting for the receiver controls could be used here as proposed for use on the Eureka and Ramp boats. This boat is powered by two Diesel engines, each of which requires 30 volts d.c. (five 6-volt storage batteries) for starting. It is believed that these batteries could also be used to supply the receiving equipment.

26. It must be borne in mind that the locations and mountings illustrated and described herein for the XBC receiving equipment are only suggested or proposed for permanent installations. These suggestions are entirely subject to the approval of the Navy Department.

Voice Modulation

27. During the maximum range test on the voice modulated signal, an important factor was brought out. The Model RU-ZB Receiver is provided with a cw-mcw switch. Because the mcw signal level is far below the cw signal level, the receiver output volume must be increased for mcw reception. Since voice modulation is used only intermittently, the receiver will usually be set for cw reception. If the signal becomes voice modulated when the receiver is set for cw, the mcw signal is completely unintelligible because it is weak compared to the cw signal. This is especially true when the receiving boat is in the on-course beam and over 5 miles out, where receiver noise begins to be appreciable. This difficulty could be corrected by modifying the transmitting equipment to send either manually or automatically a cw signal previous to voice modulating the signal. Thus, the receiver operator would be notified as to when the signal is to be voice modulated.

Table 1

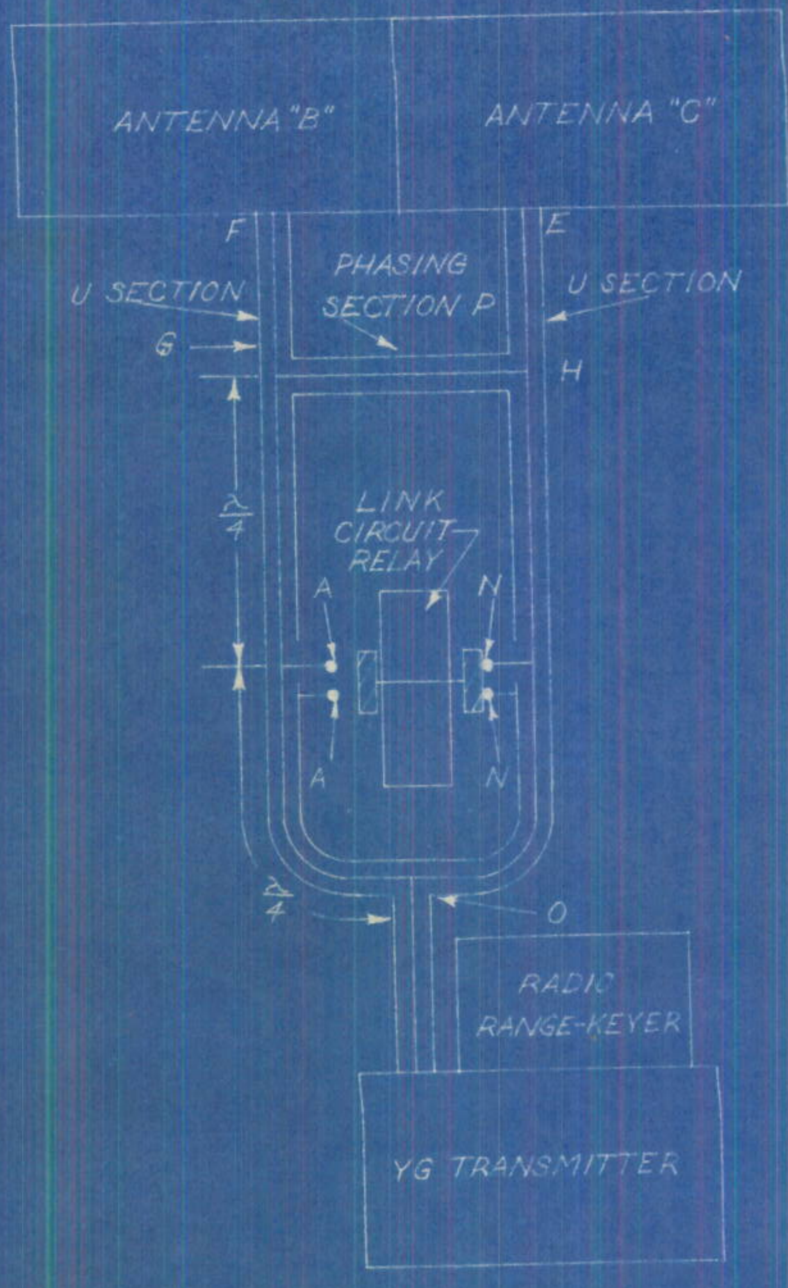
Width of On-Course Beam
of XBC Equipment on USS HARRY LEE

XBC Beam Bearing Relative to Ship's Head (Degrees)	Audible A	Difference	Audible N	Difference	Average	Apparent Beam Width
0 *	359°30'	-0°30'	360°15'	+0°15'	-0° 8'	0°45'
10	9°15'	-0°45'	10° 0'	±0° 0'	-0°24'	0°45'
20	20°20'	+0°20'	21°20'	+1°20'	+0°50'	1° 0'
30	29° 5'	-0°55'	29°35'	-0°25'	-0°40'	0°30'
50	50°30'	+0°30'	50°55'	+0°55'	+0°42'	0°25'
70	68°10'	-1°50'	**			
90	90°25'	+0°25'	**			
110	109°10'	-0°50'	109°55'	-0° 5'	-0°27'	0°45'
130	128°30'	-1°30'	129°36'	-0°26'	-0°58'	1° 4'
150	147° 5'	-2°55'	148° 5'	-1°55'	-2°25'	1° 0'
170	168°10'	-1°50'	168°47'	-1°13'	-1°31'	0°37'
190	188°52'	-1° 8'	189°30'	-0°30'	-0°49'	0°38'
210	209° 5'	-0°55'	209°44'	-0°16'	-0°36'	0°39'
230	228°44'	-1°16'	229°14'	-0°46'	-1° 0'	0°30'
250	248°15'	-1°45'	249°50'	-0°10'	-0°57'	1°35'
270	267°40'	-2°20'	268°30'	-1°30'	-1°55'	0°50'
290	287°32'	-2°28'	288°16'	-1°44'	-2° 6'	0°44'
310	307°20'	-2°40'	307°42'	-2°18'	-2°29'	0°22'
330	329°20'	-0°40'	329°50'	-0°10'	-0°25'	0°30'
340	338°35'	-1°25'	339° 5'	-0°55'	-1°10'	0°30'
350	349° 0'	-1° 0'	**			

* Ship's Head.

** Observer on ship missed second signal flashed from boat.

[redacted]



BLOCK DIAGRAM OF XBC TRANSMITTING EQUIPMENT

[redacted]

PLATE I

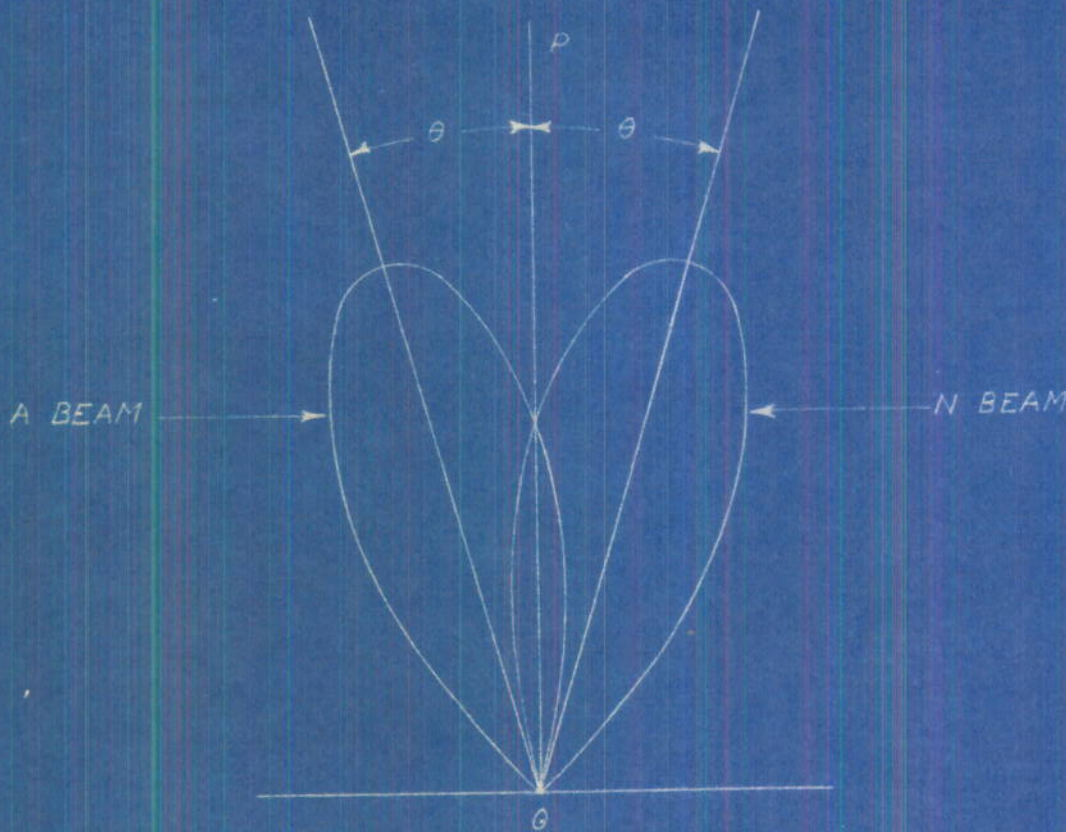
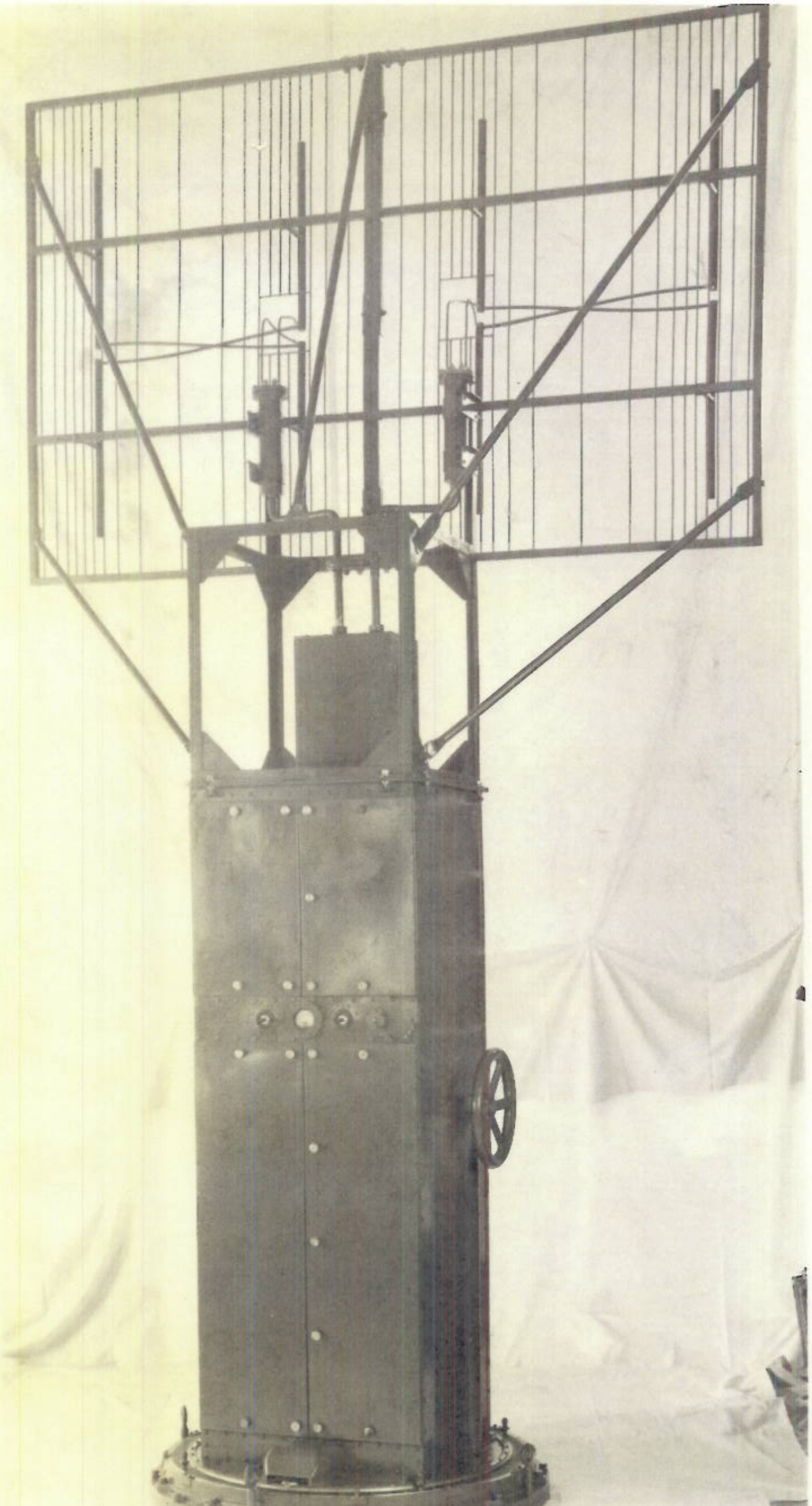


DIAGRAM OF "A" AND "N" BEAM

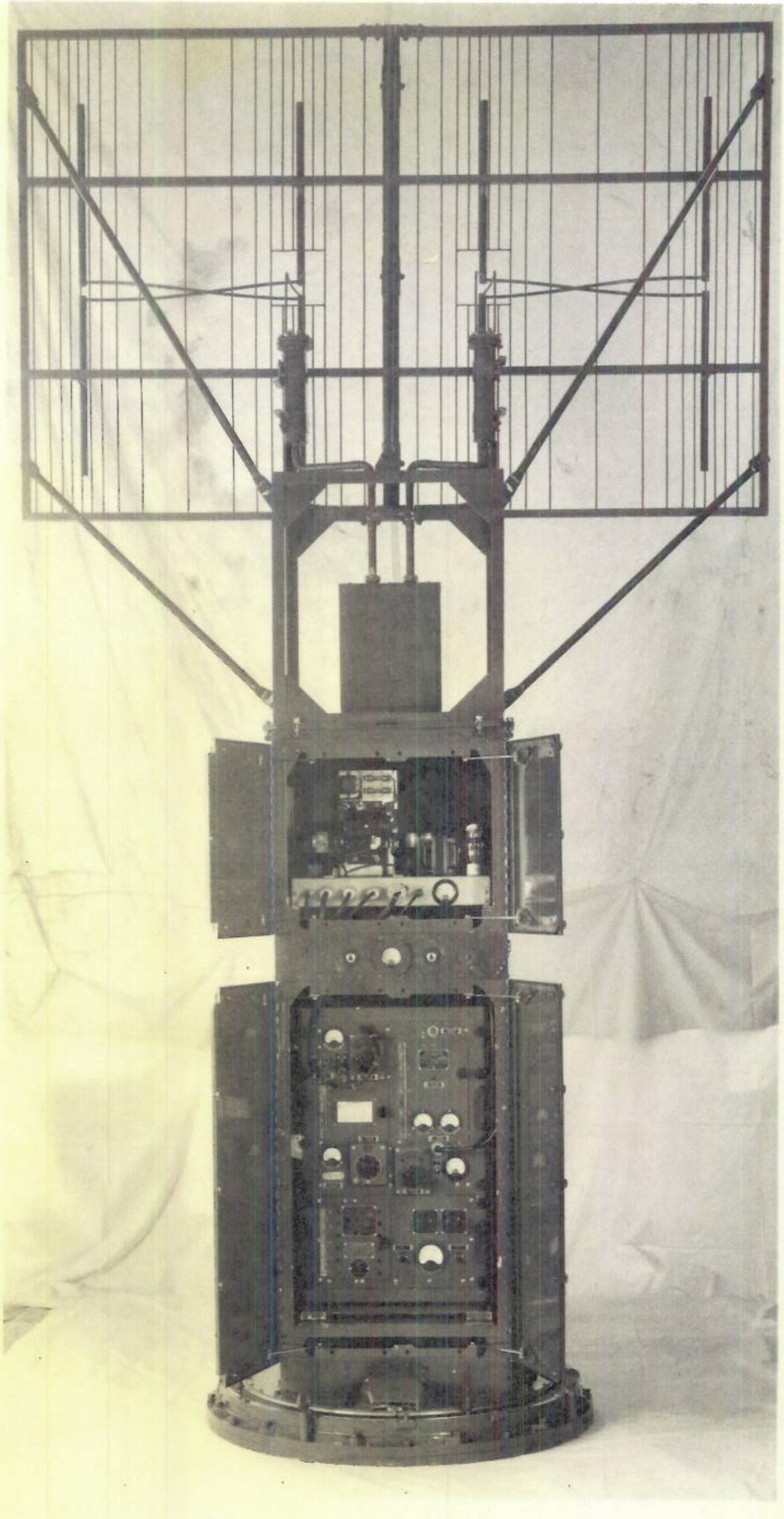
[redacted]

PLATE 2



XBC EQUIPMENT ASSEMBLED - FRONT VIEW DOORS CLOSED [redacted]

PLATE 3



XBC EQUIPMENT ASSEMBLED - FRONT VIEW DOORS OPEN [redacted]

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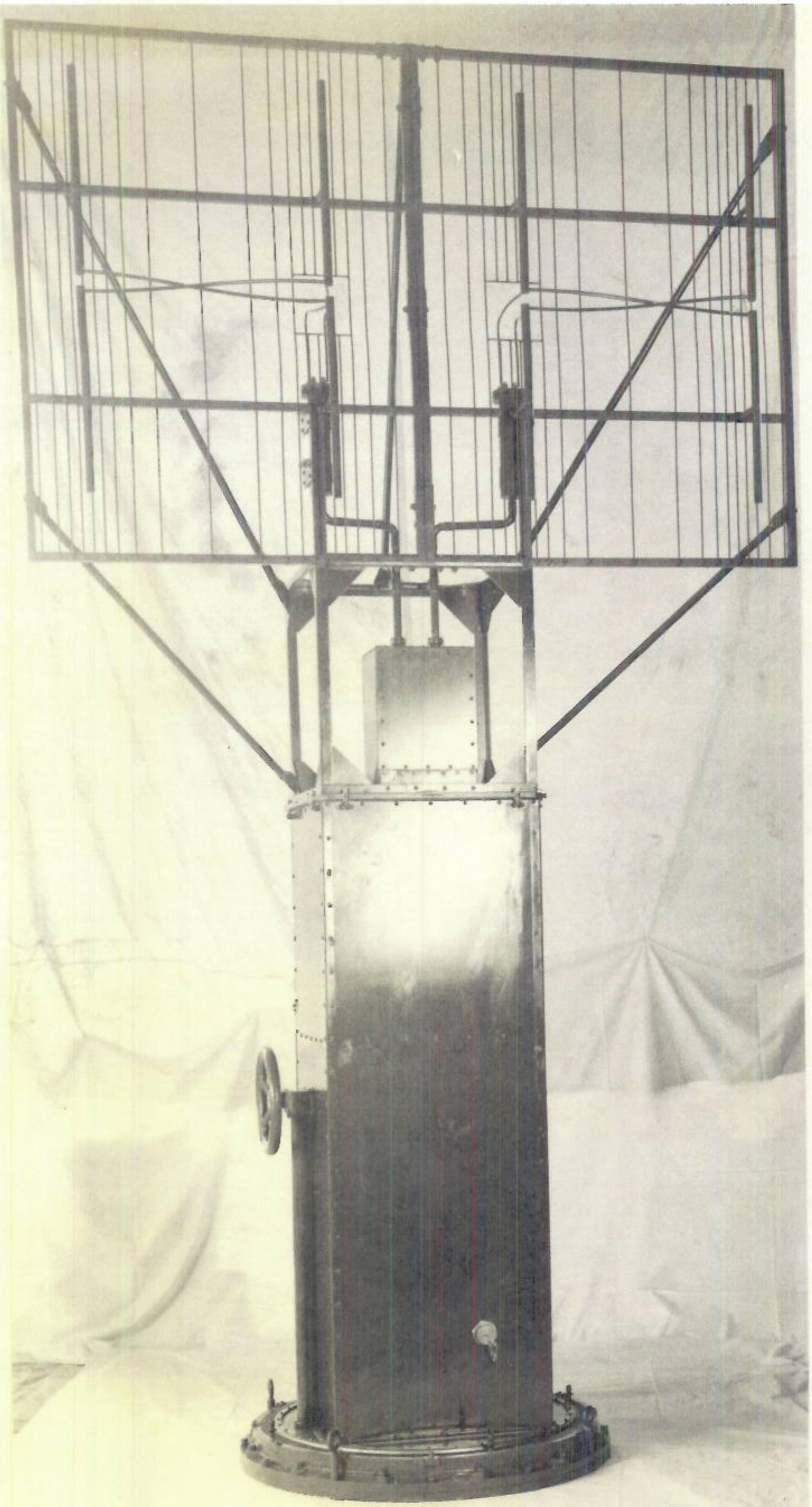
PLATE 4



XBC EQUIPMENT ASSEMBLED – REAR VIEW

[redacted]

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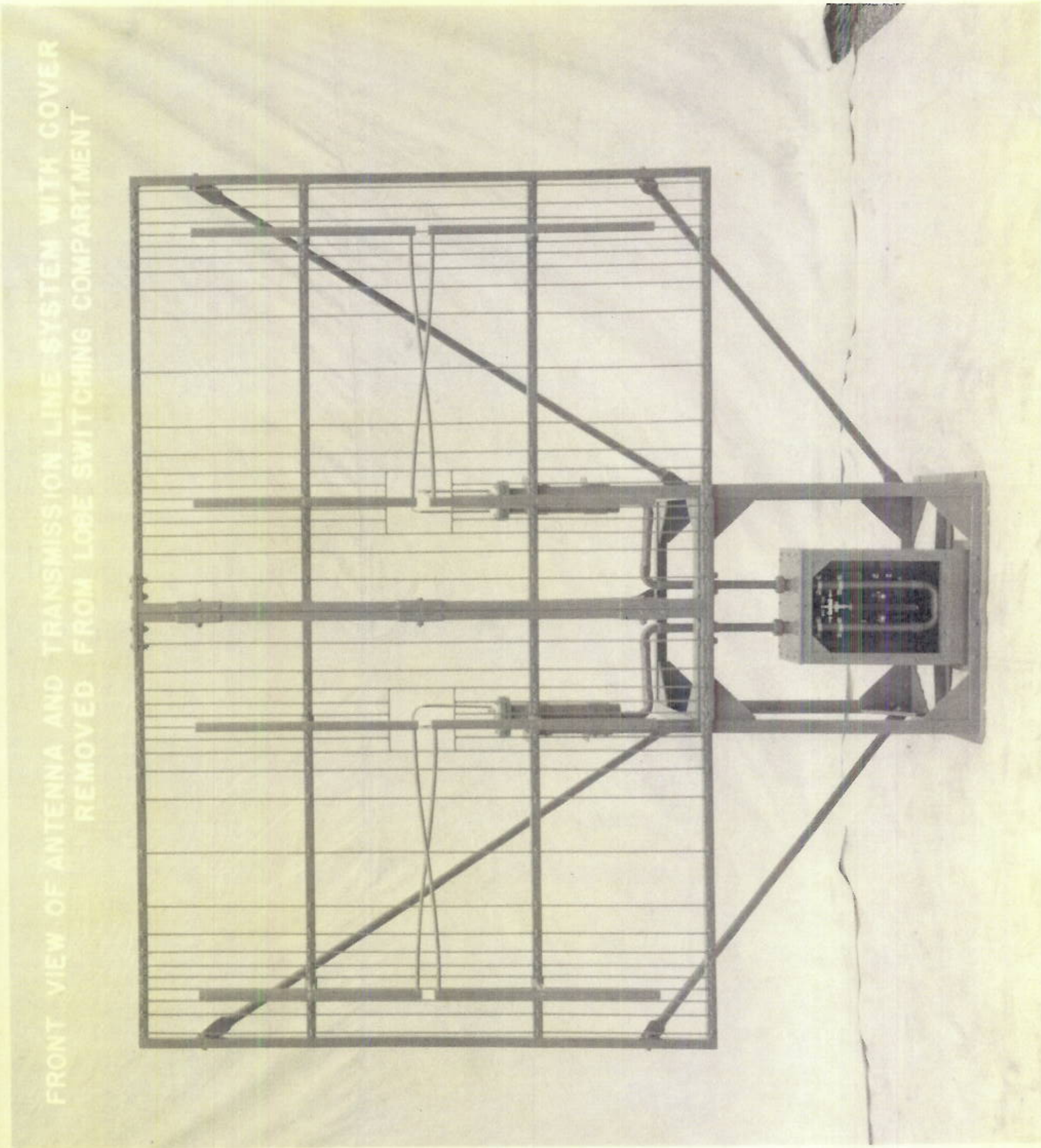
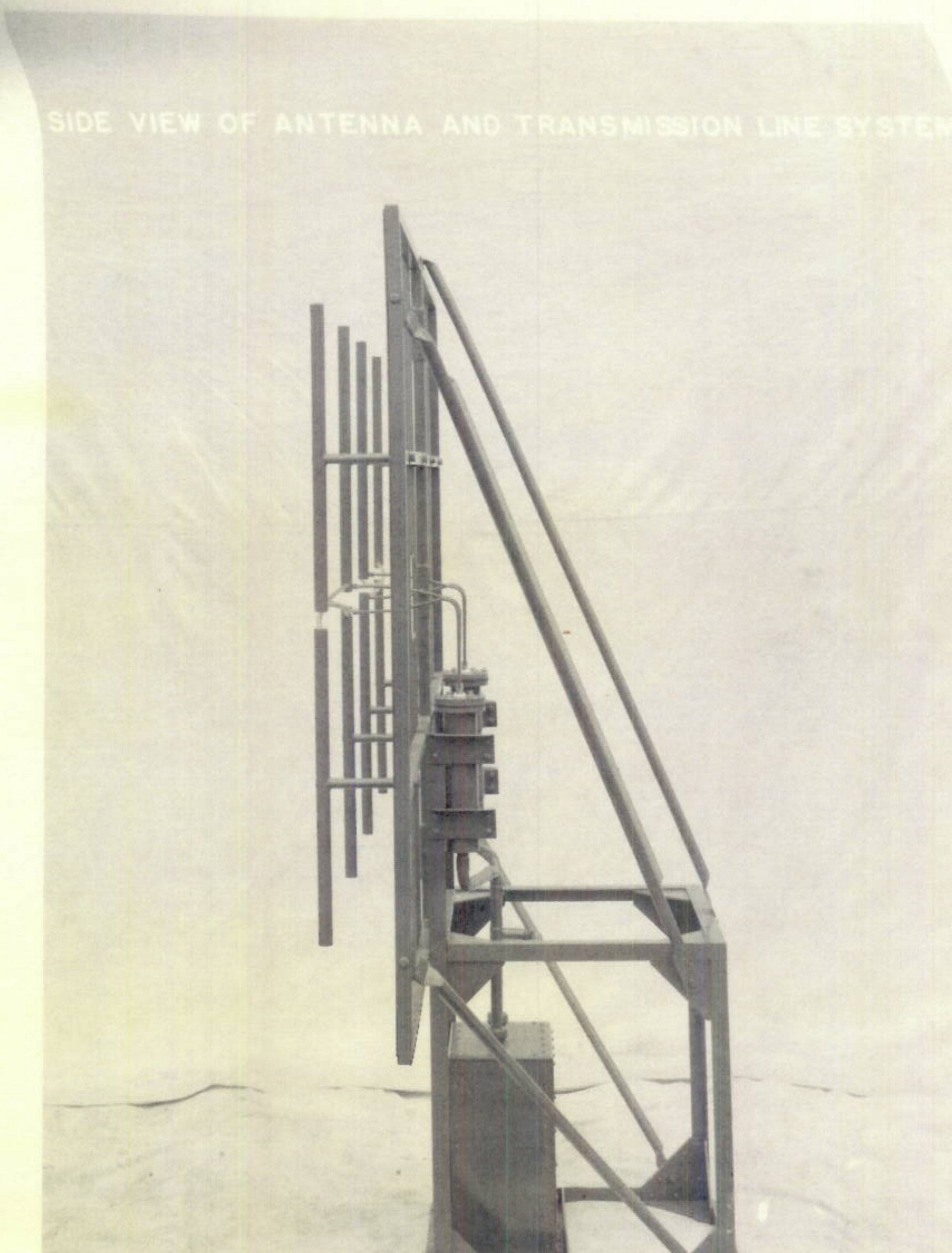
PLATE 5



FRONT VIEW OF ANTENNA AND TRANSMISSION LINE SYSTEM WITH COVER
REMOVED FROM LOBE SWITCHING COMPARTMENT

[redacted]

PLATE 6



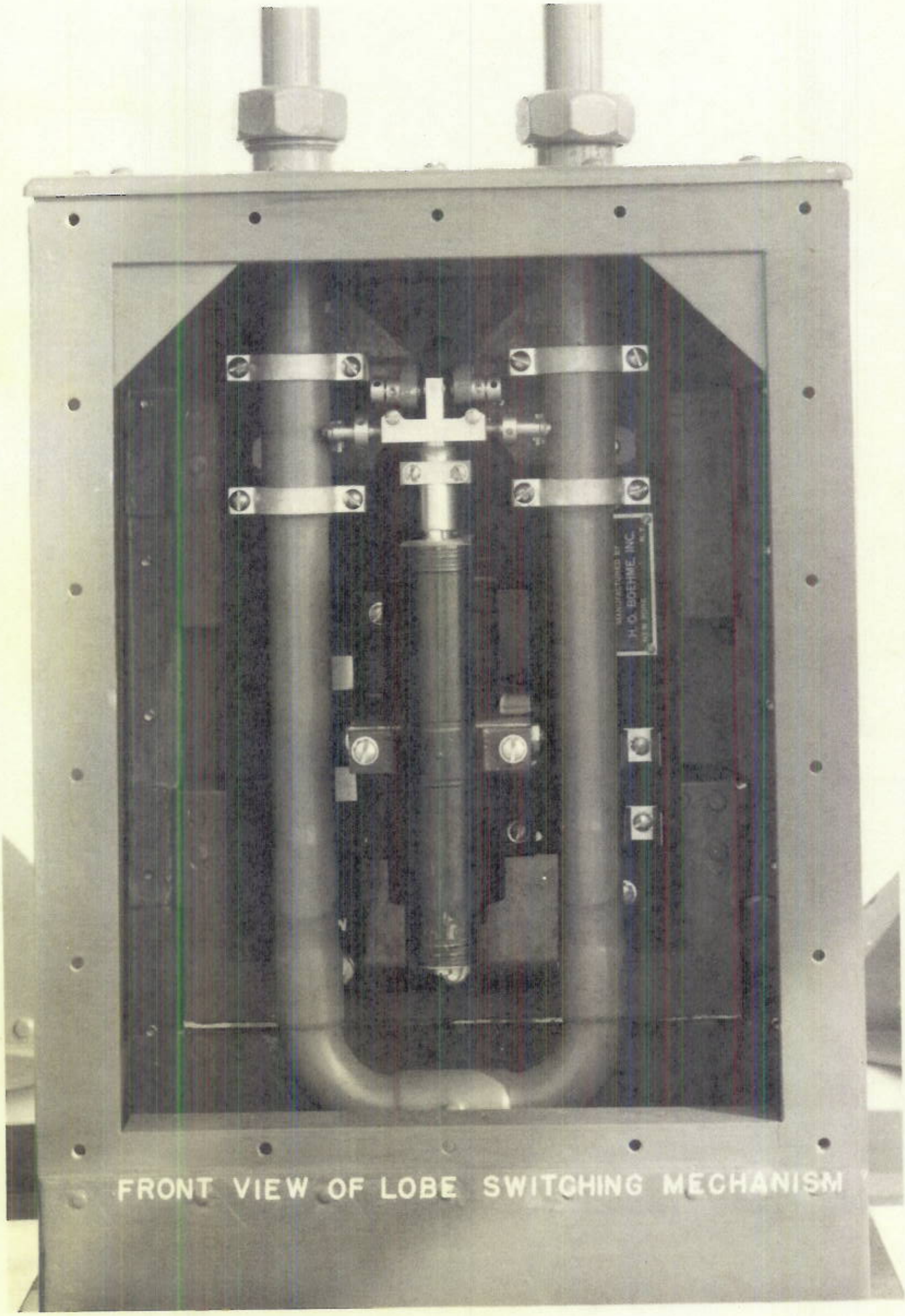
[redacted]

PLATE 7

DISASSEMBLY VIEW OF ANTENNA AND TRANSMISSION LINE SYSTEM

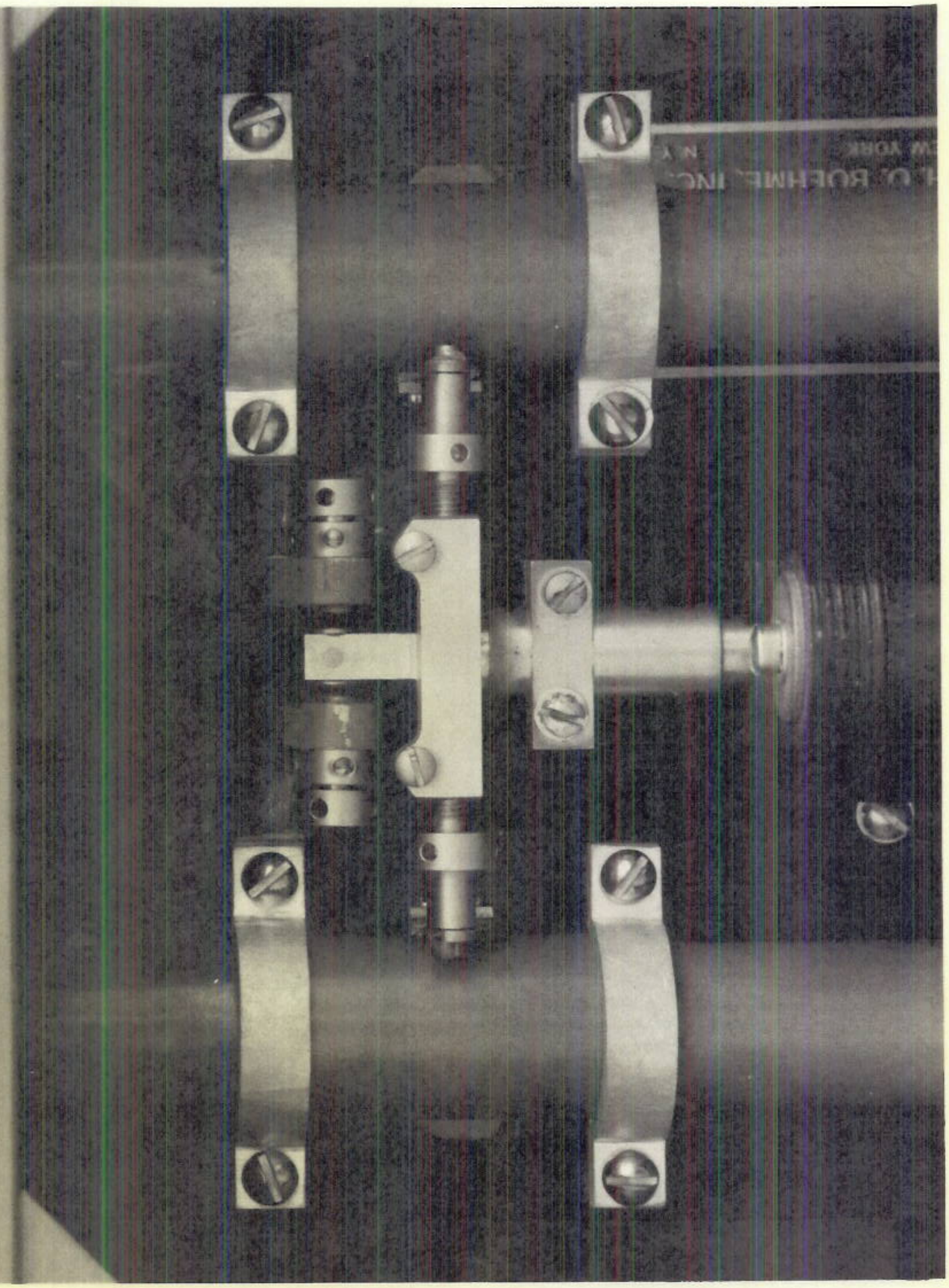
[redacted]

PLATE 8



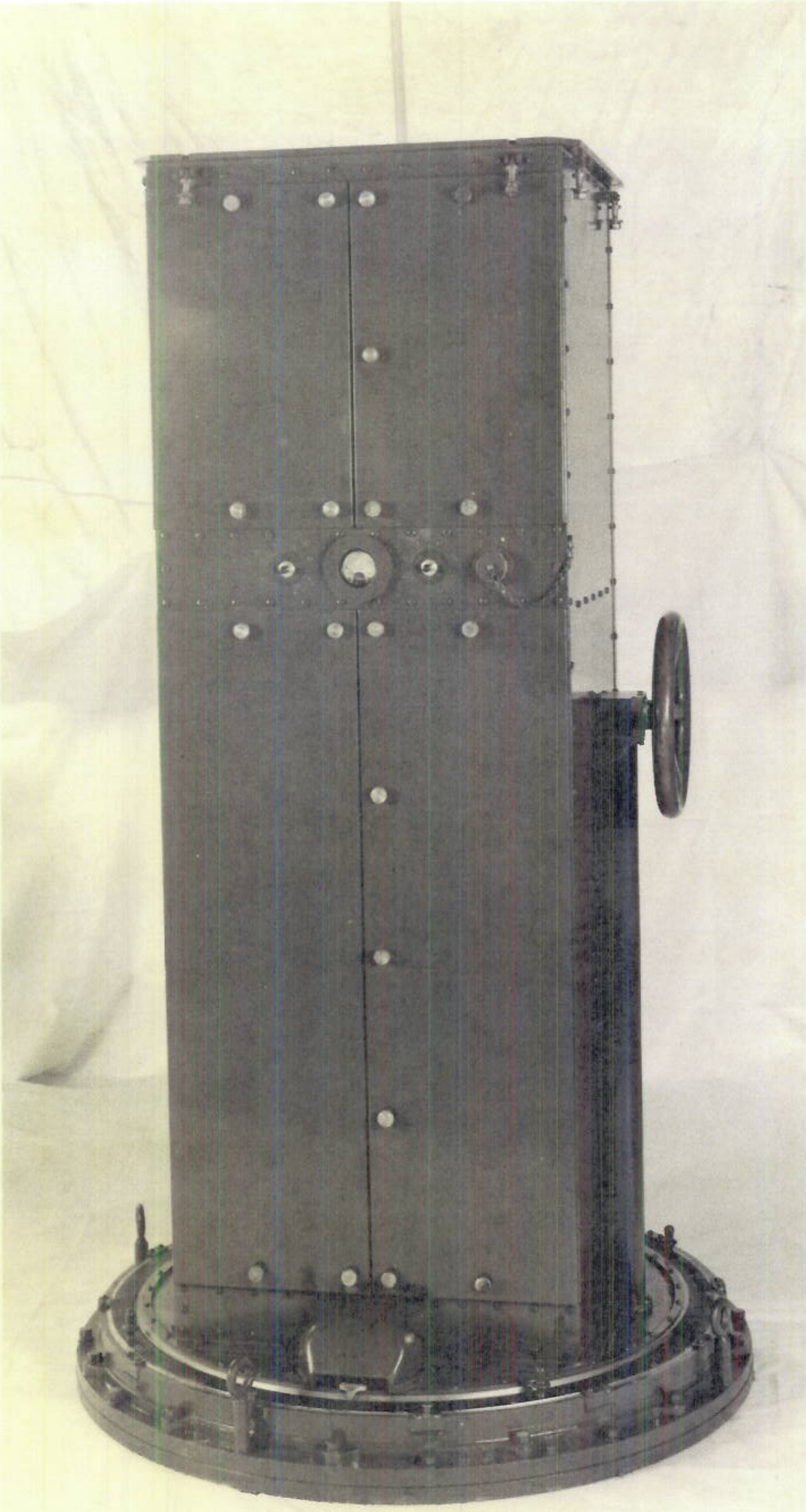
FRONT VIEW OF LOBE SWITCHING MECHANISM

[redacted]



CLOSE-UP OF CONTACTS ON LOBE SWITCHING MECHANISM

[redacted]



CABINET AND BASE-ASSEMBLED

[redacted]

PLATE 11

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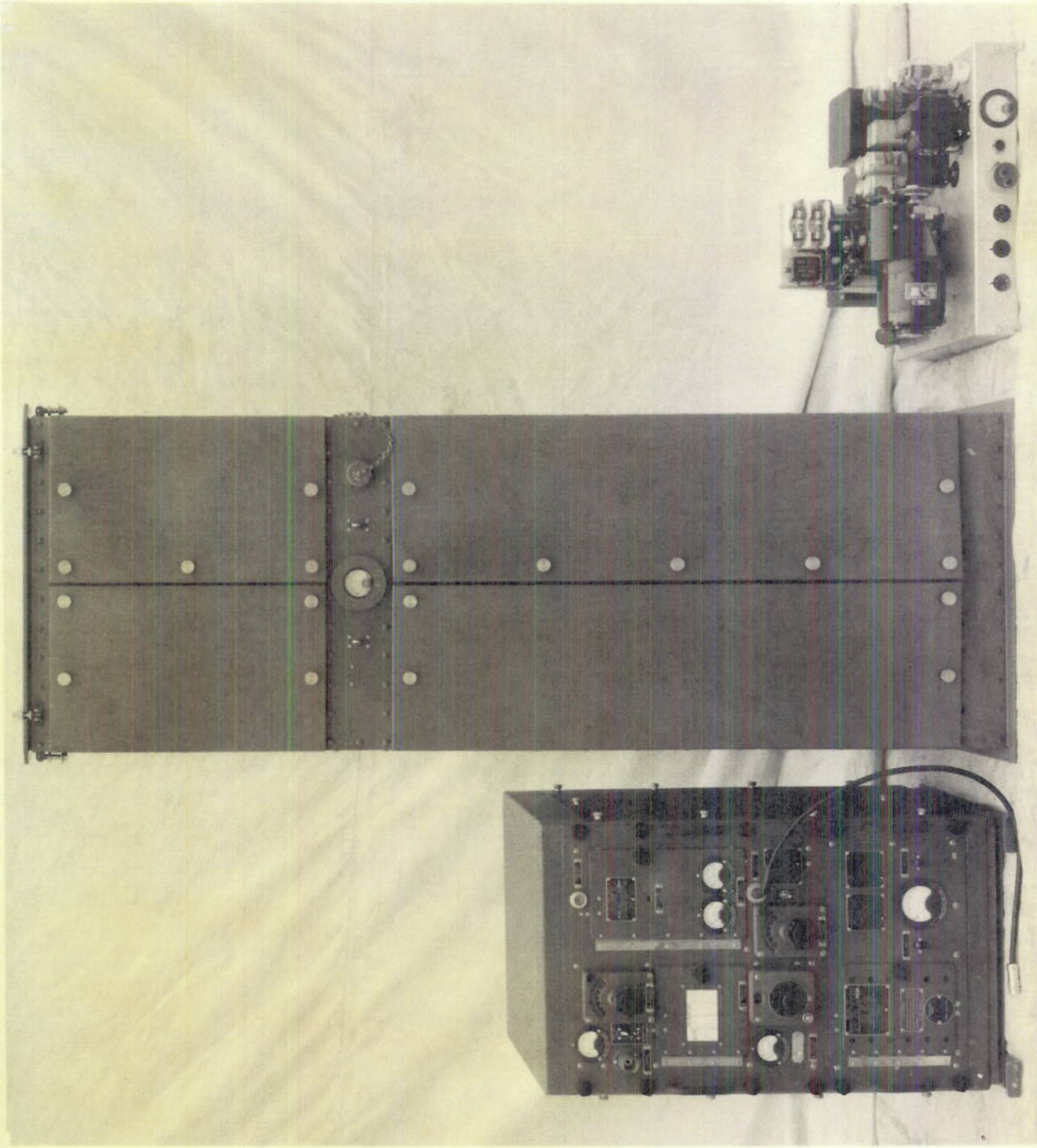
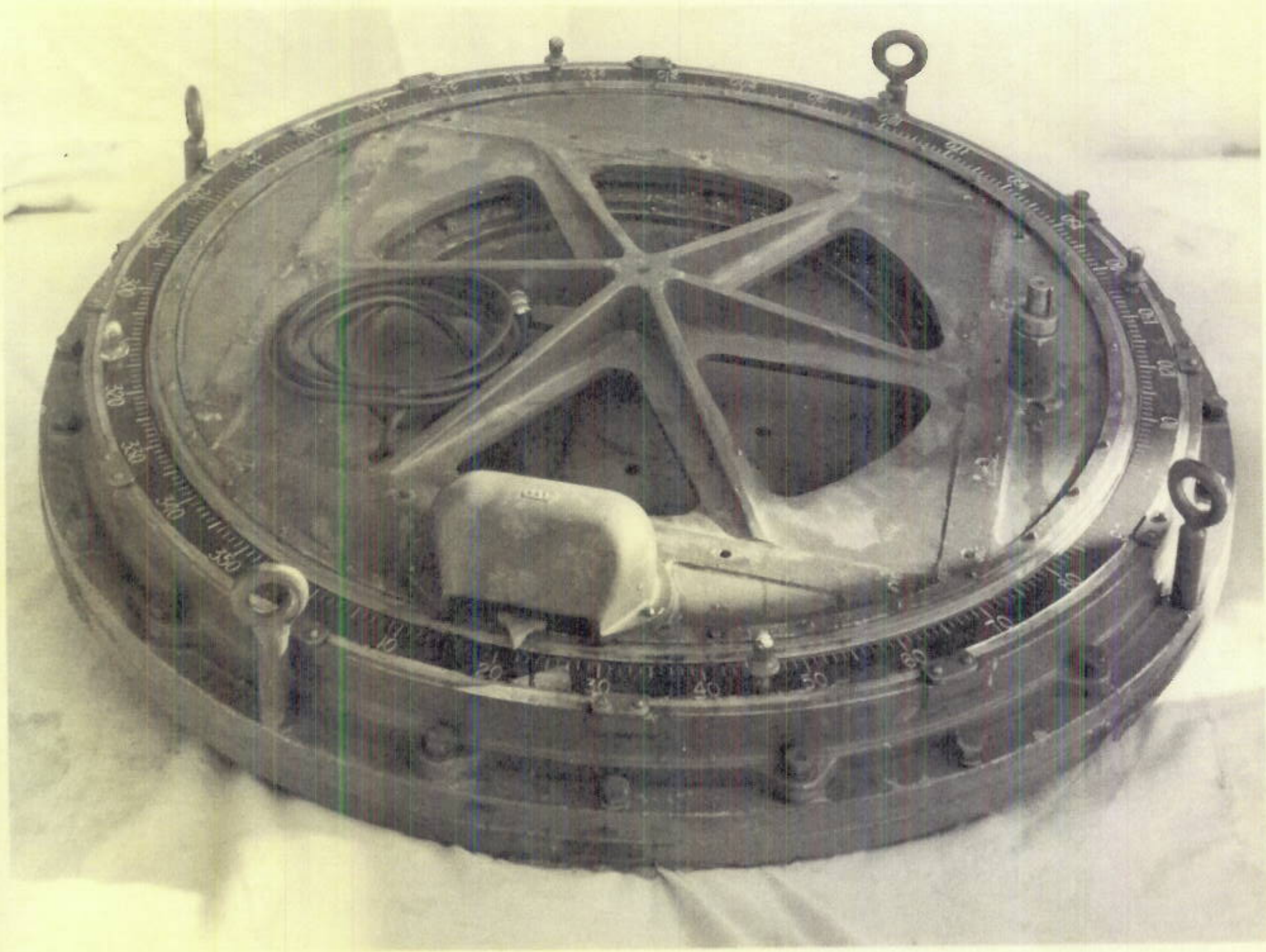


DISASSEMBLY VIEW OF TRANSMITTER, CABINET, AND KEYER
MODULATOR UNITS

[redacted]

DECLASSIFIED

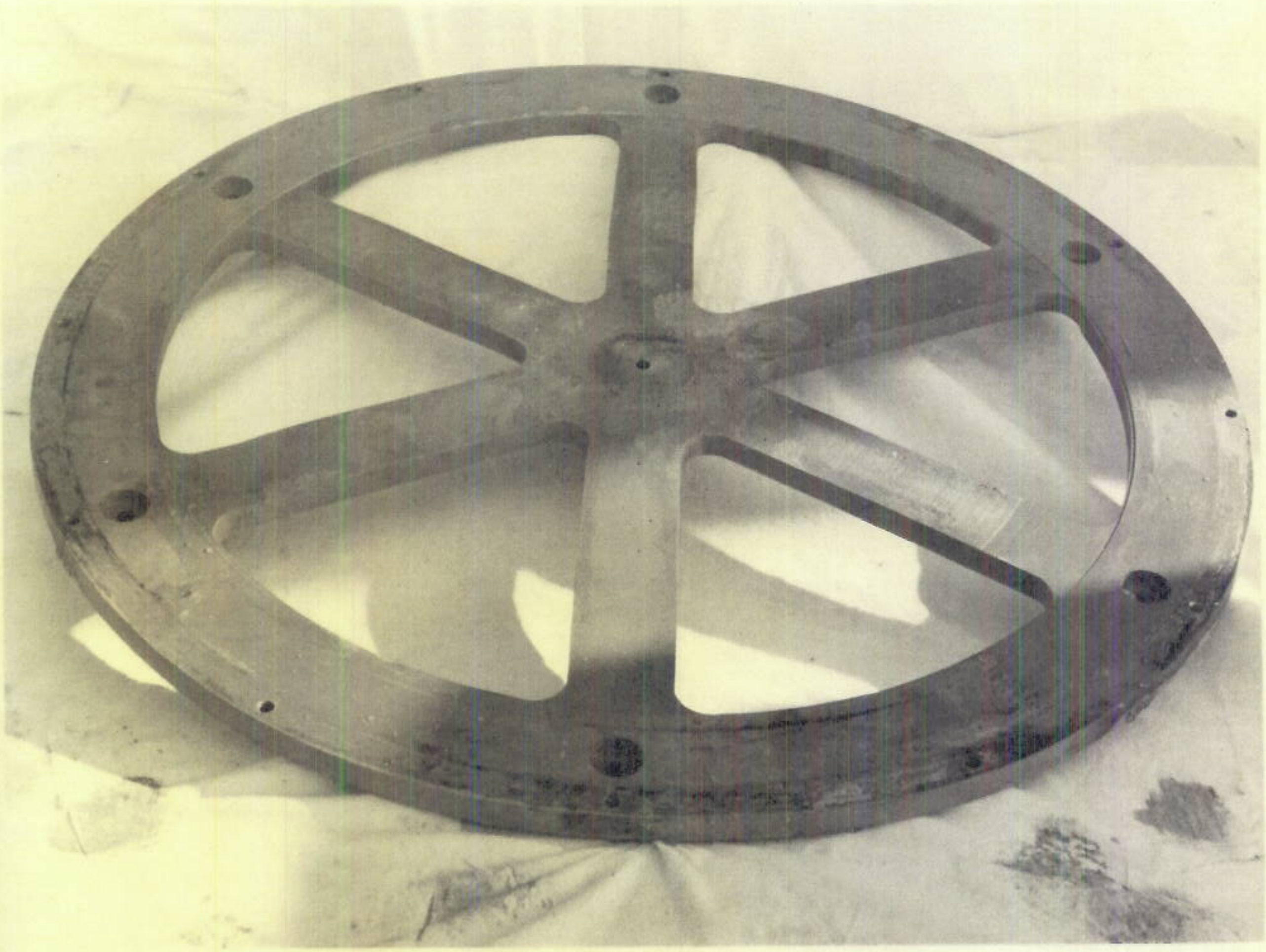
PLATE 12



ROTARY BASE - ASSEMBLED

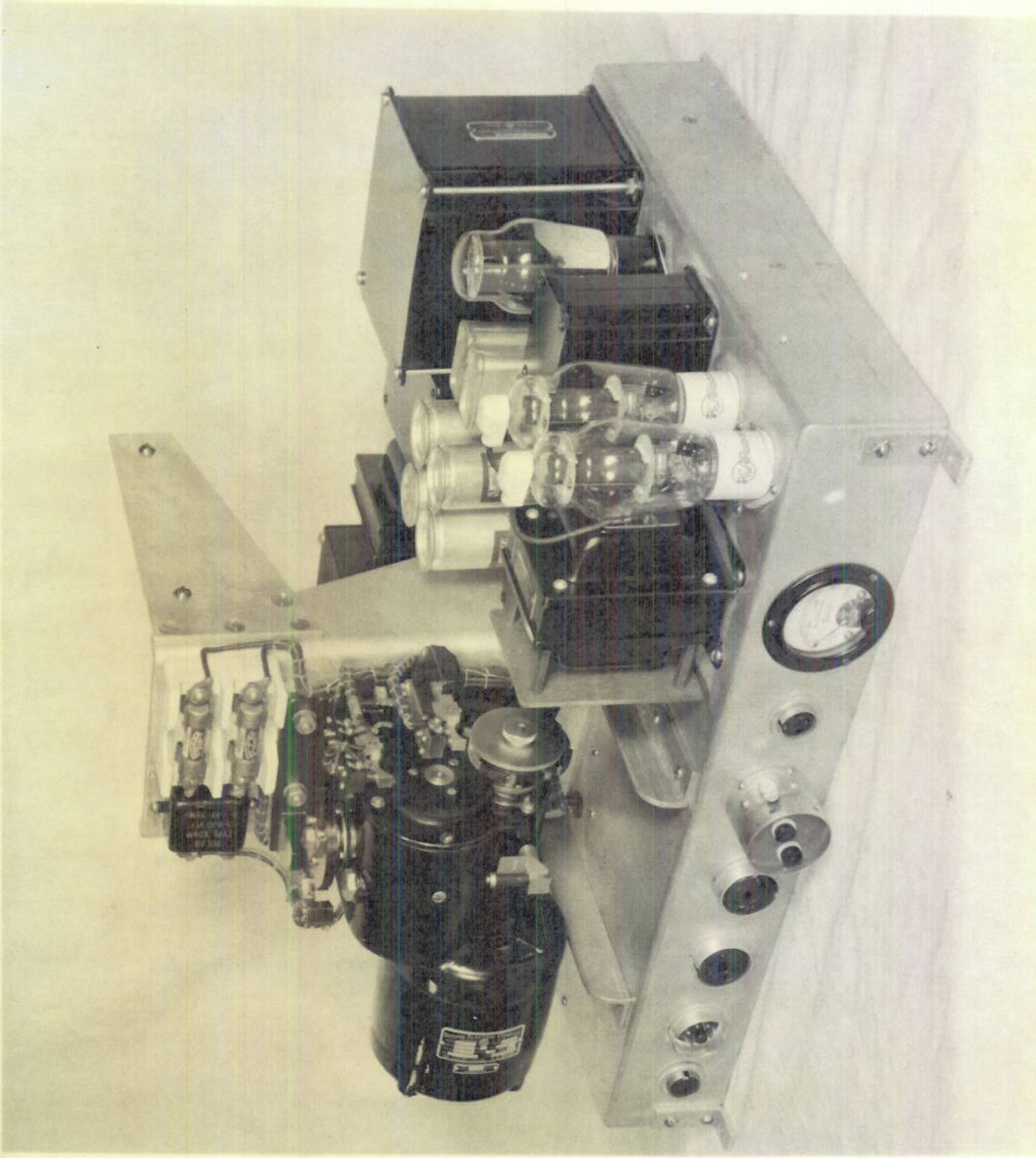
[redacted]

DECLASSIFIED



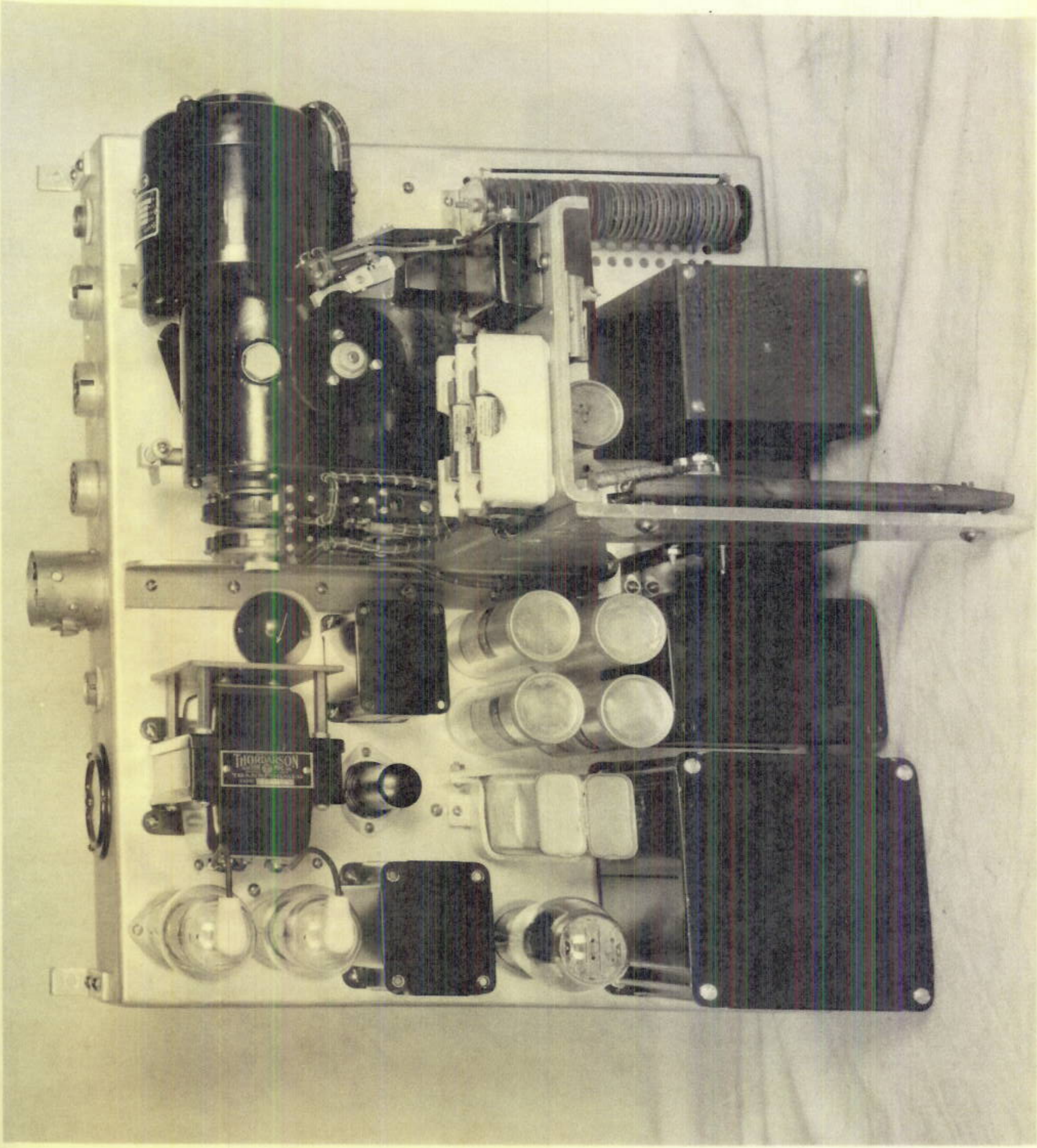
BASE PLATE

[redacted]



KEYER – MODULATOR UNIT – FRONT OBLIQUE VIEW

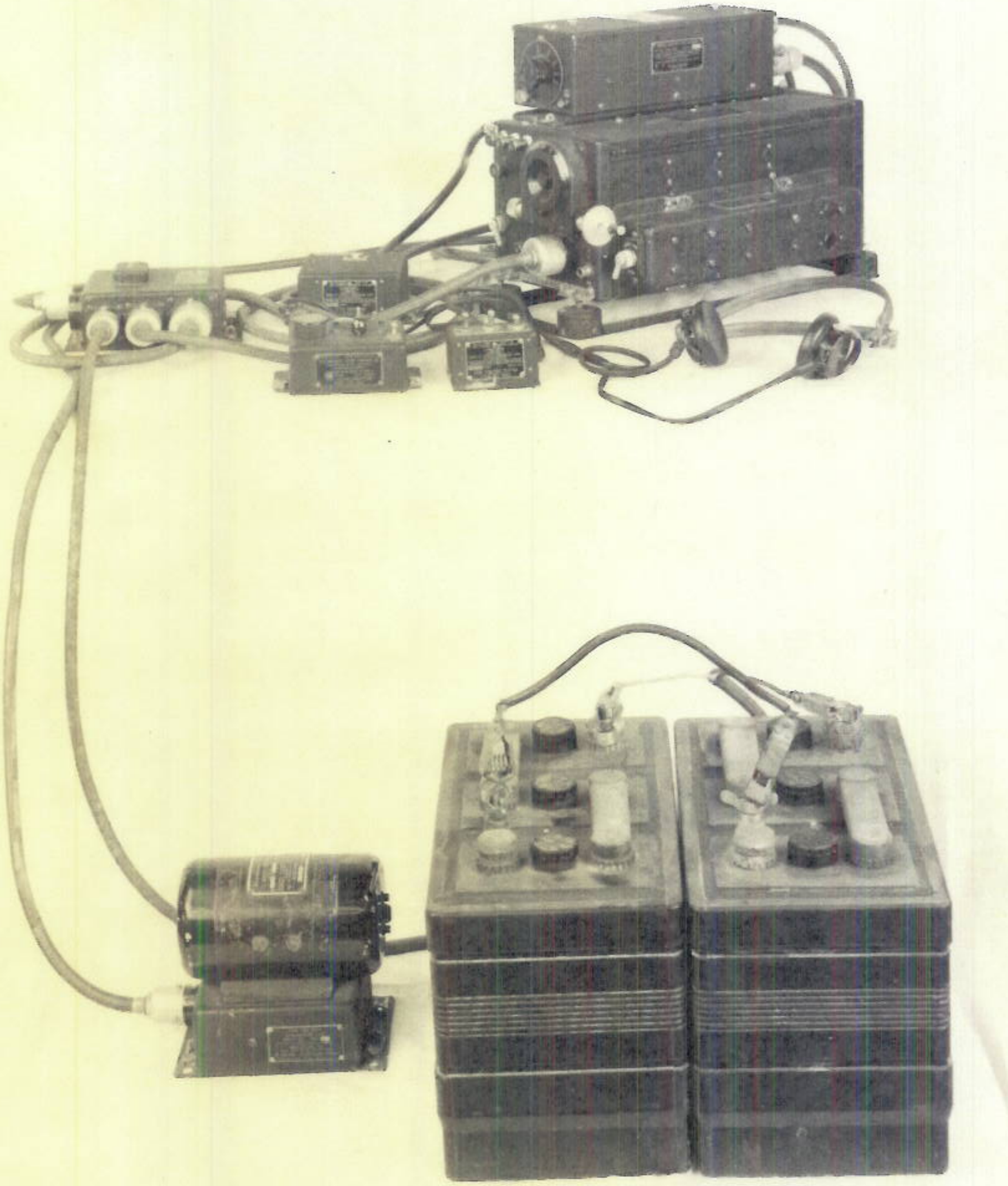
[redacted]



KEYER - MODULATOR UNIT - PLAN VIEW

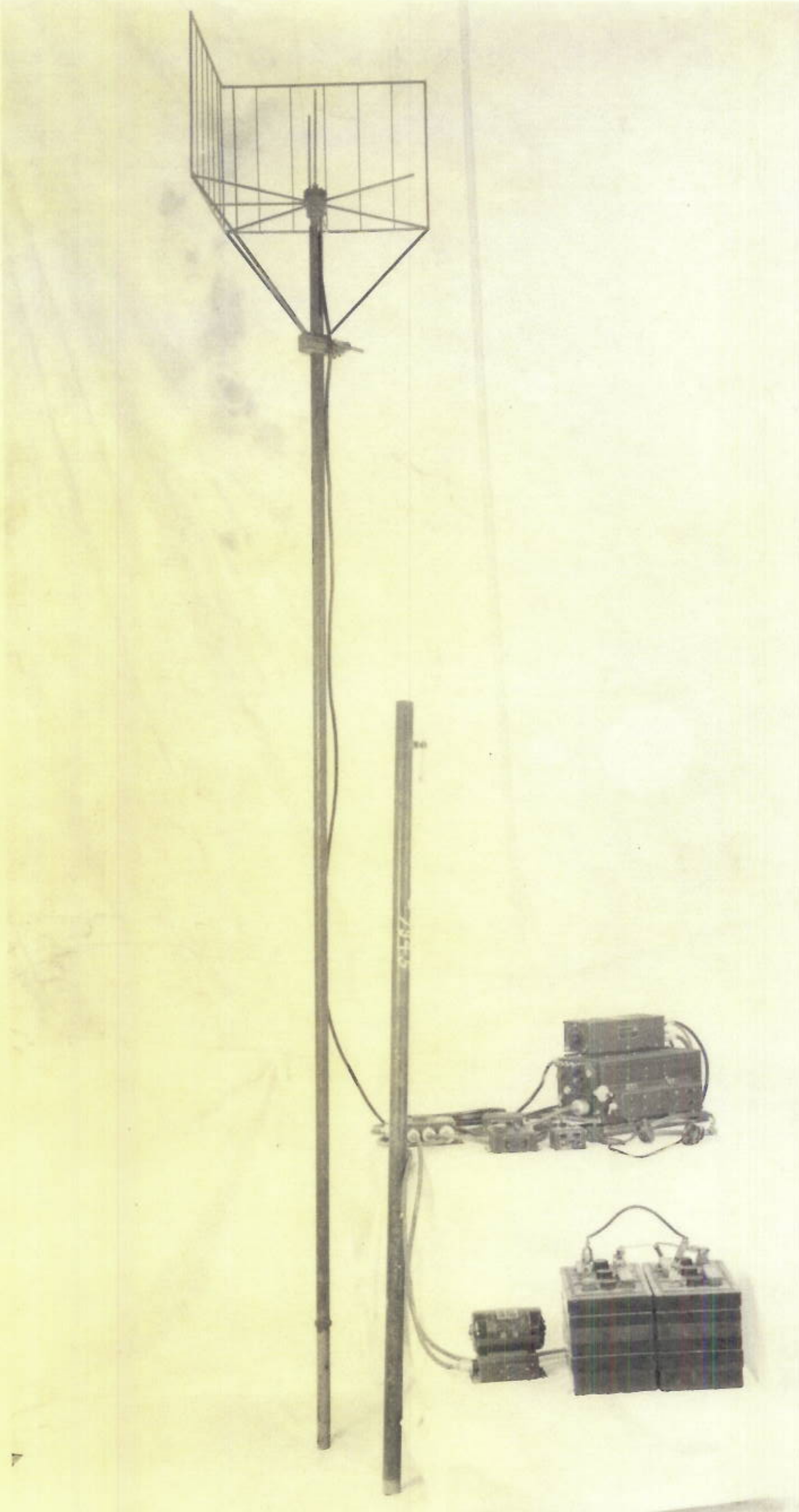
[redacted]

PLATE 16



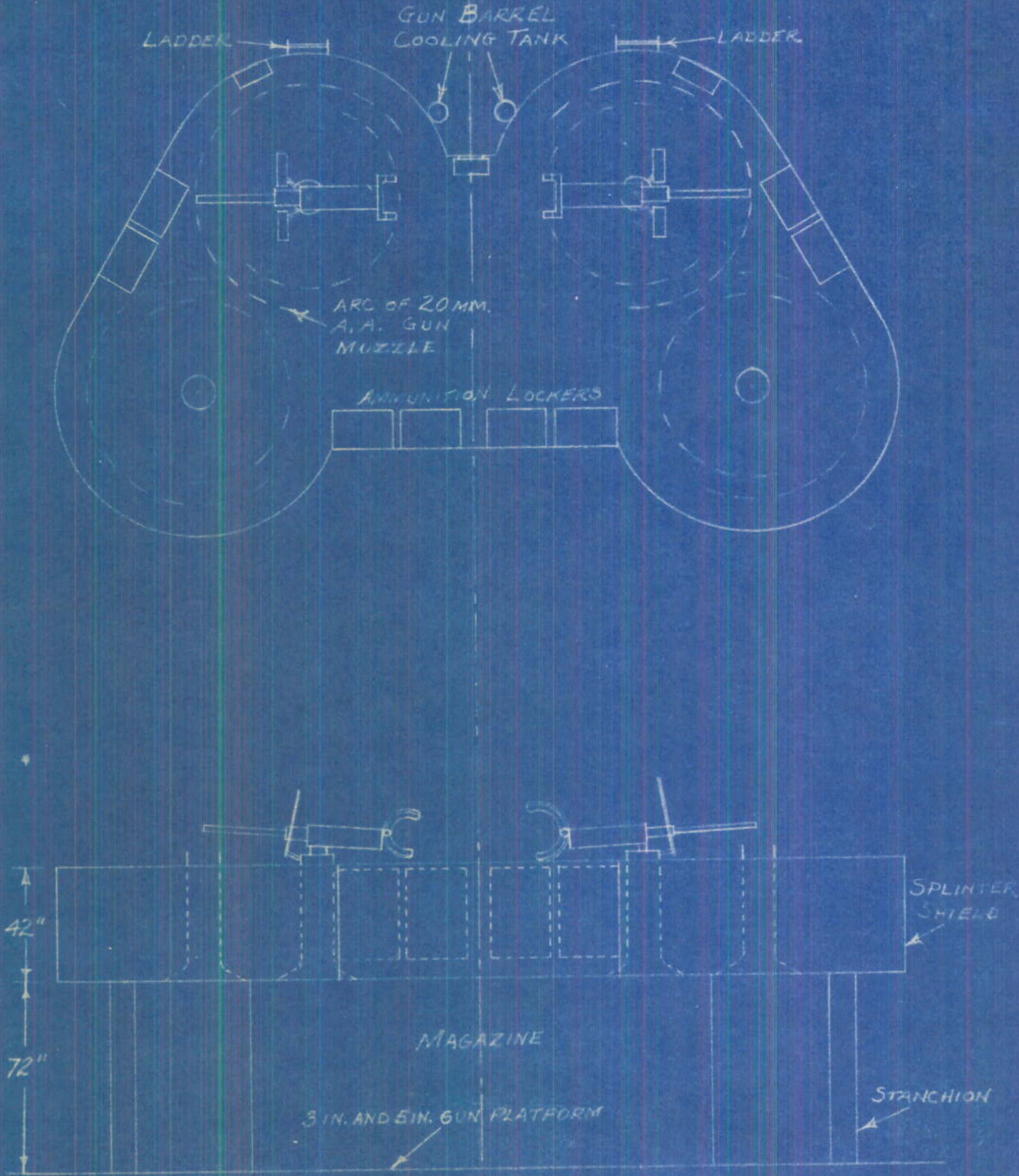
MODEL RU-ZB RECEIVING EQUIPMENT

[redacted]



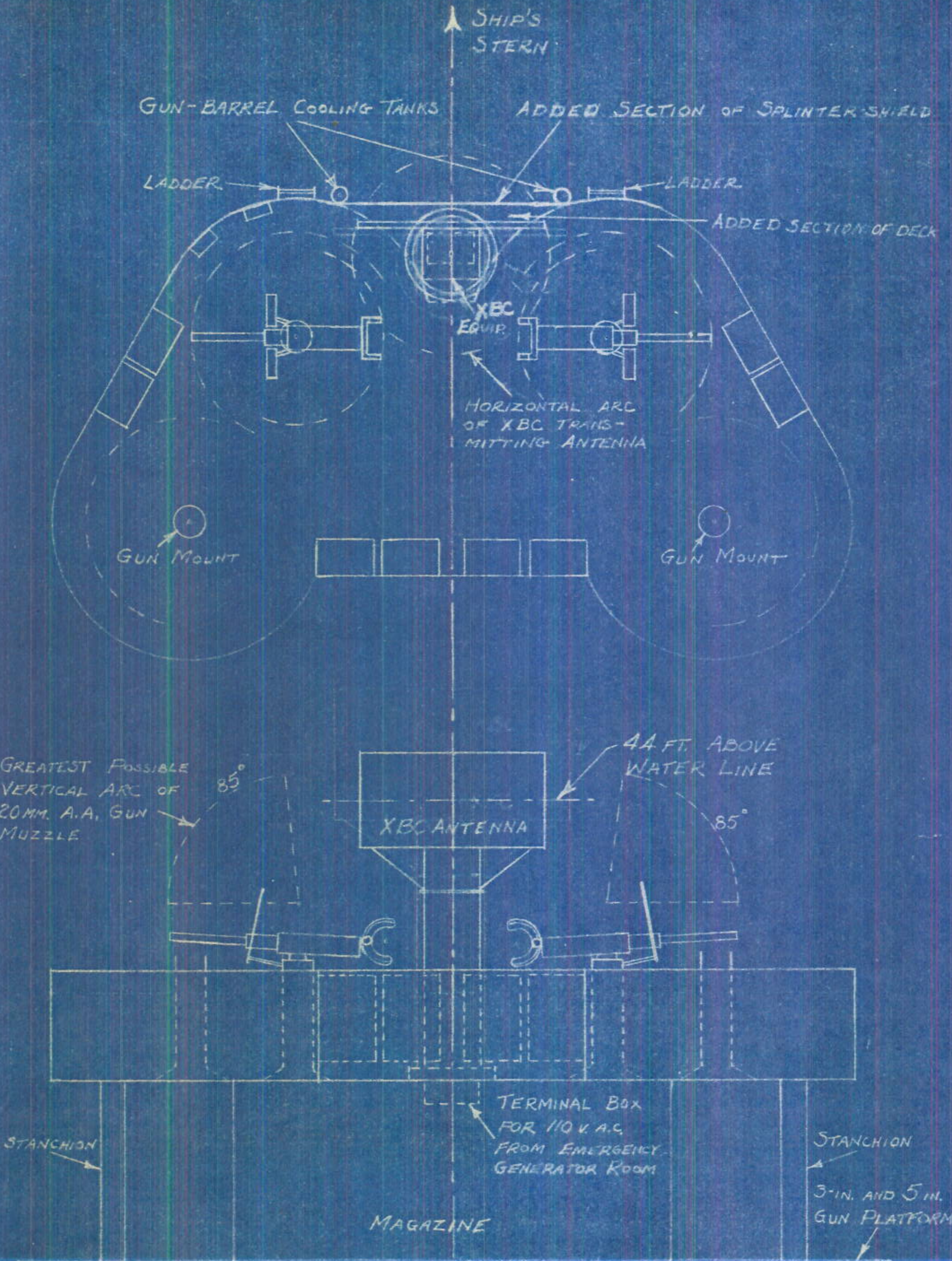
[redacted]

MODEL RU-ZB RECEIVING EQUIPMENT WITH 130 DEGREE BEAM RECEIVING ANTENNA



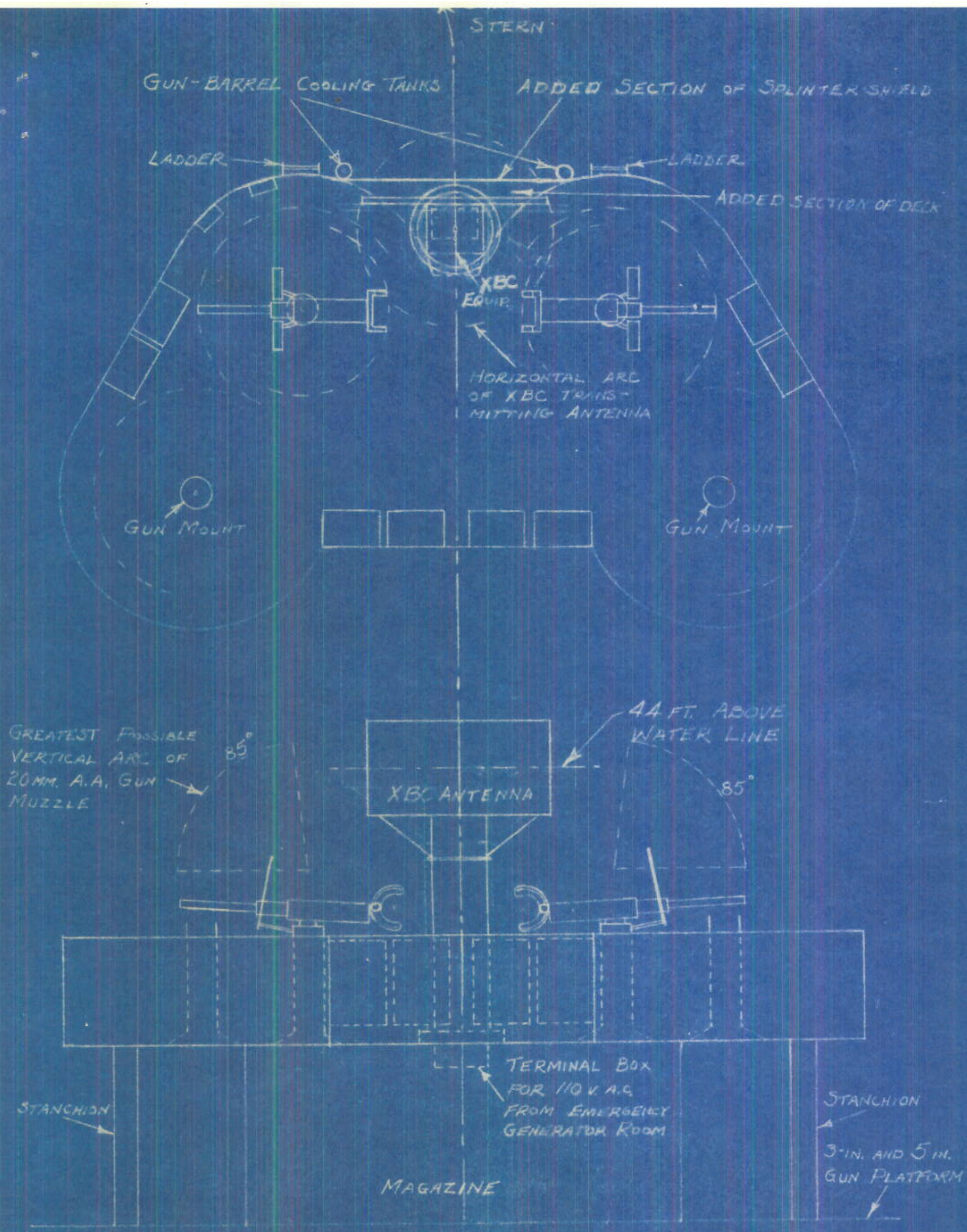
ORIGINAL 20MM. A.A. GUN PLATFORM ON [redacted]
AFTER DECK OF U.S.S. HARRY LEE

PLATE 19



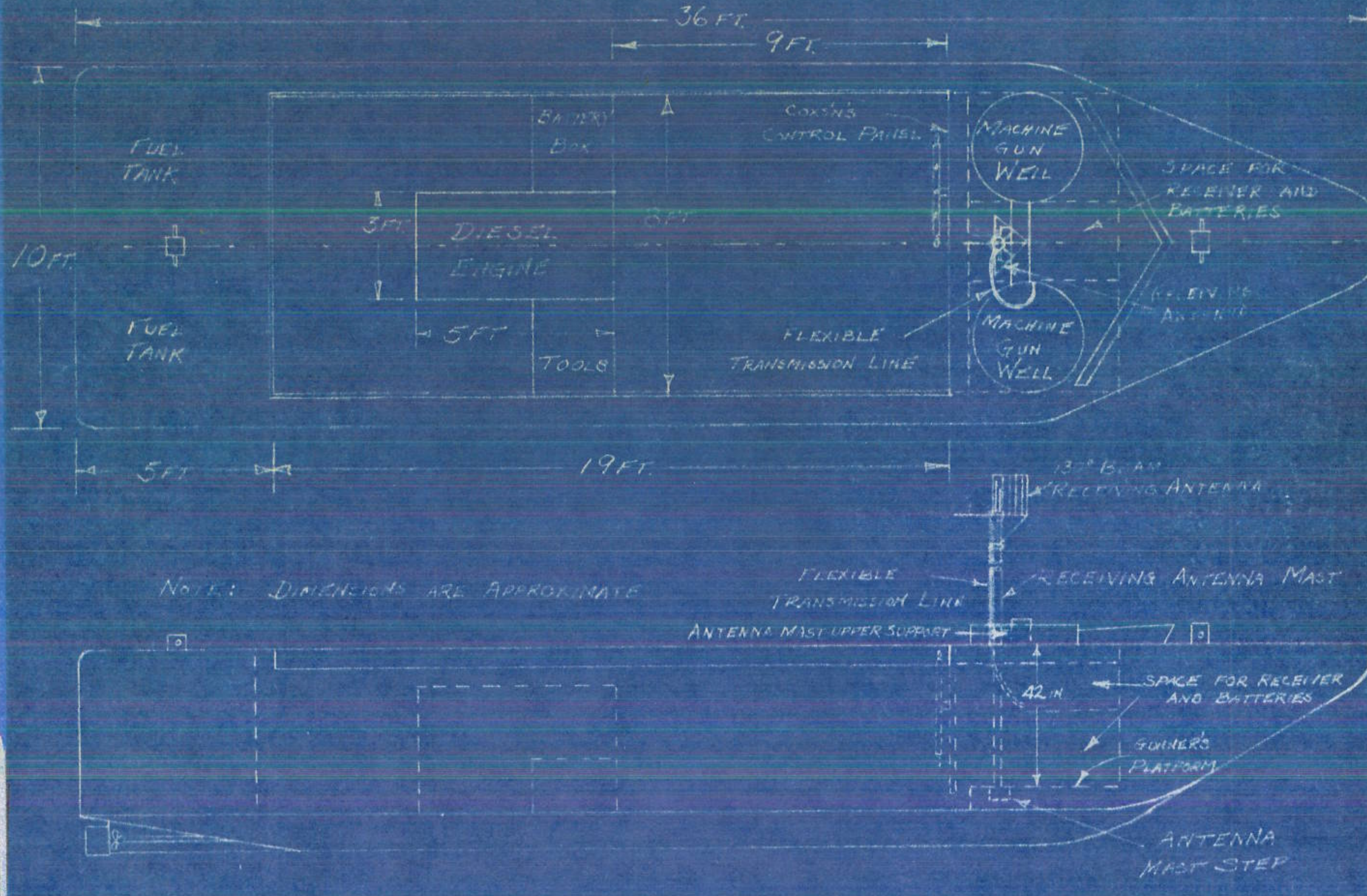
MODIFIED 20 MM. A.A. GUN PLATFORM ON AFTER DECK OF U.S.S. HARRY LEE

PLATE 20



MODIFIED 20 MM. A.A. GUN PLATFORM ON AFTER DECK OF U.S.S. HARRY LEE

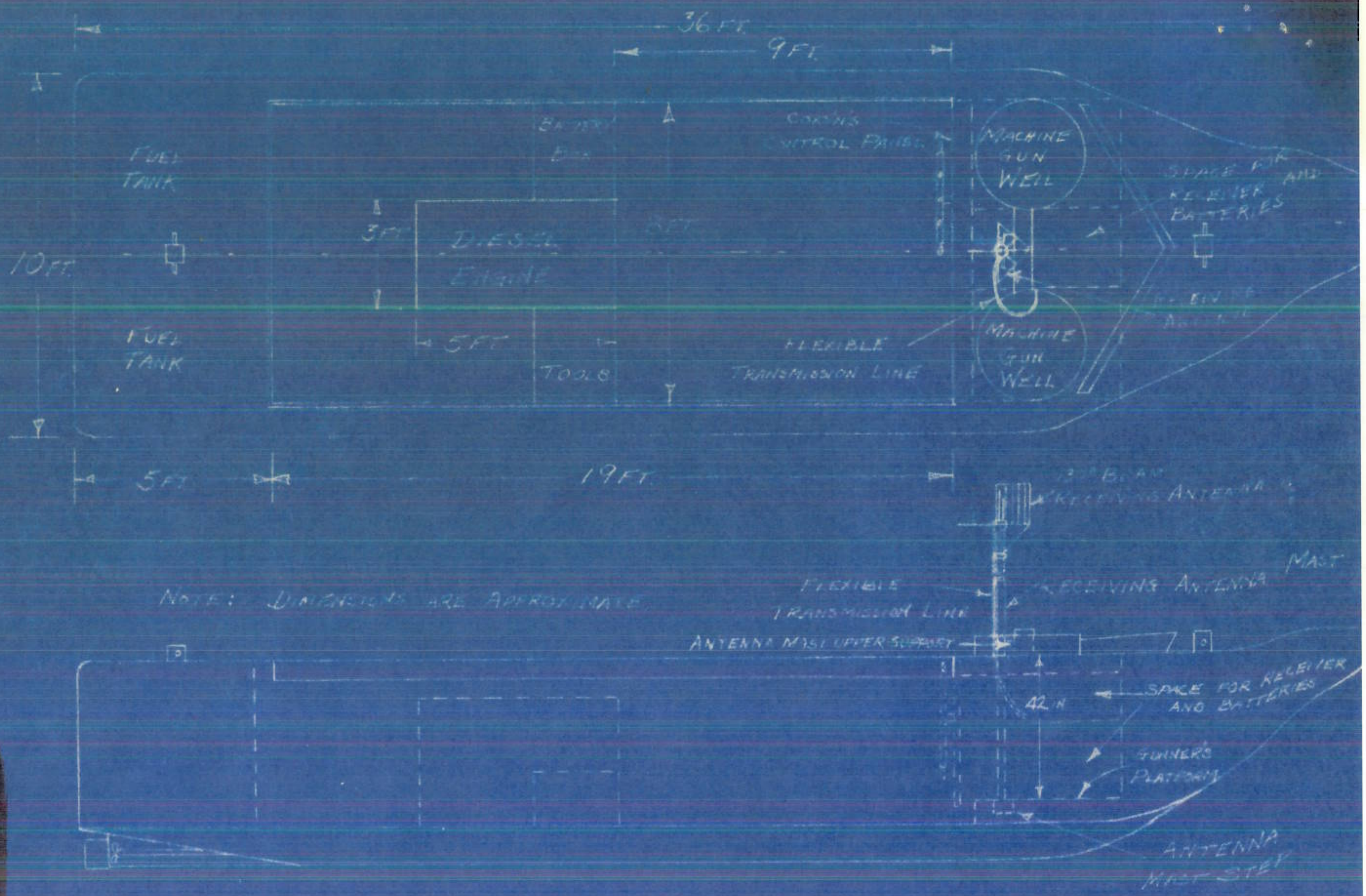
PLATE 20



NOTE: DIMENSIONS ARE APPROXIMATE

36-FT "EUREKA" PERSONNEL BOAT (LCP(L))

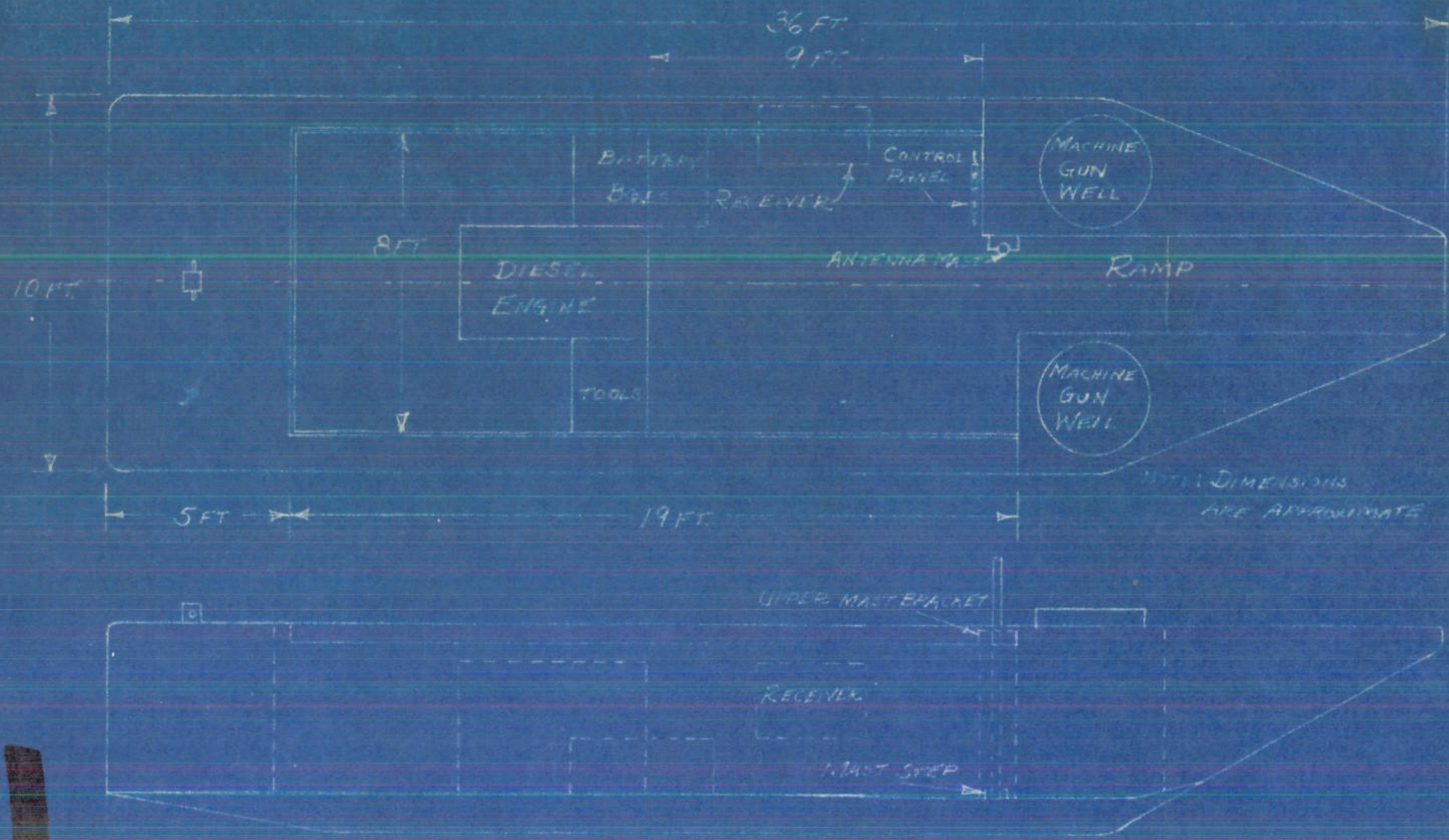
[redacted]



36-FT. "EUREKA" PERSONNEL BOAT (LCP(L))

[redacted]

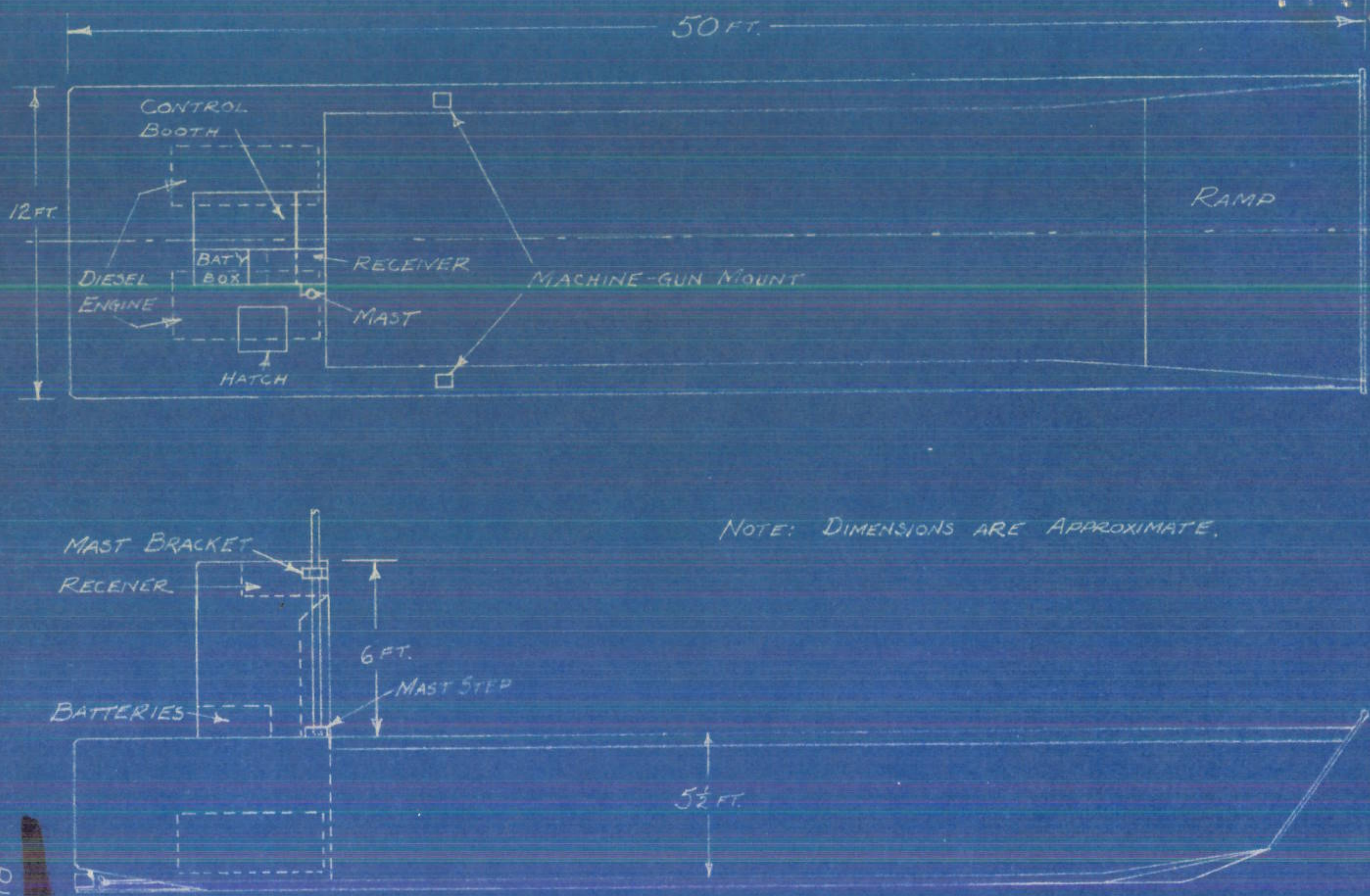
PLATE 21



36-FT. PERSONNEL-RAMP BOAT (LCP(R))

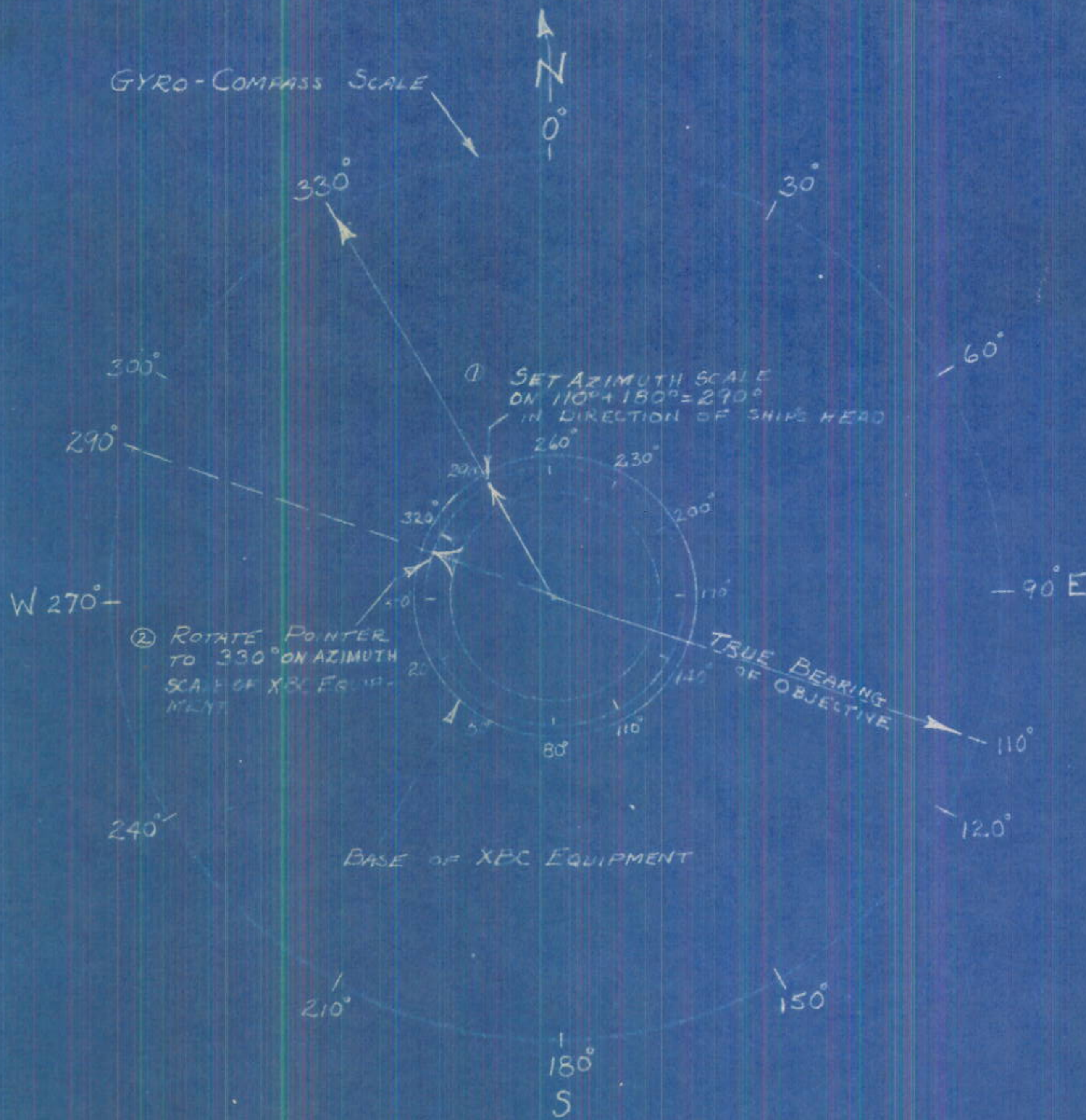
[redacted]

PLATE 22



50-FT. TANK LIGHTER (LCT)(3)

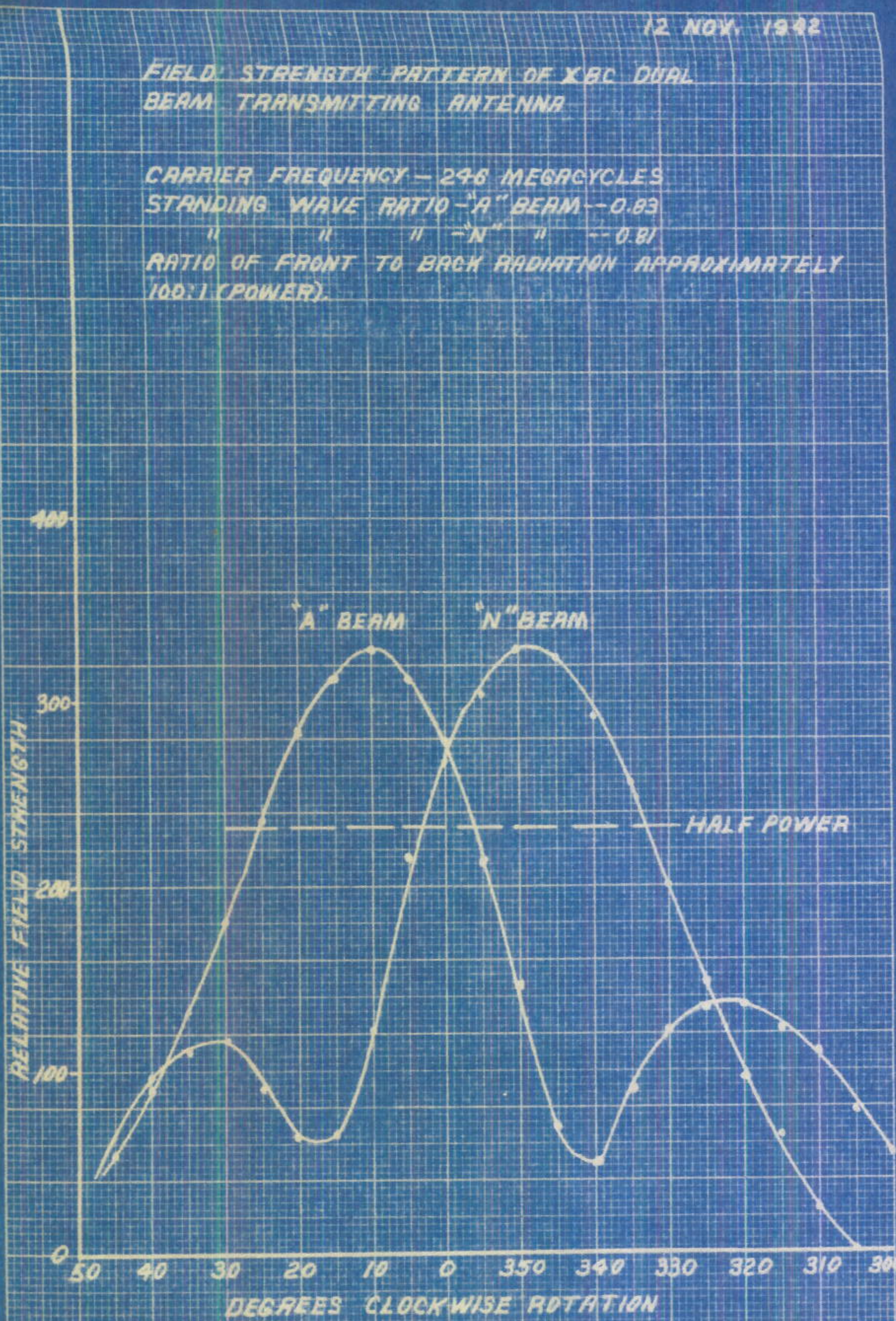
PLATE 23



EXAMPLE SHOWING METHOD OF SETTING XBC ON-COURSE BEAM ON OBJECTIVE

[redacted]

PLATE 24



[redacted]

PLATE 25

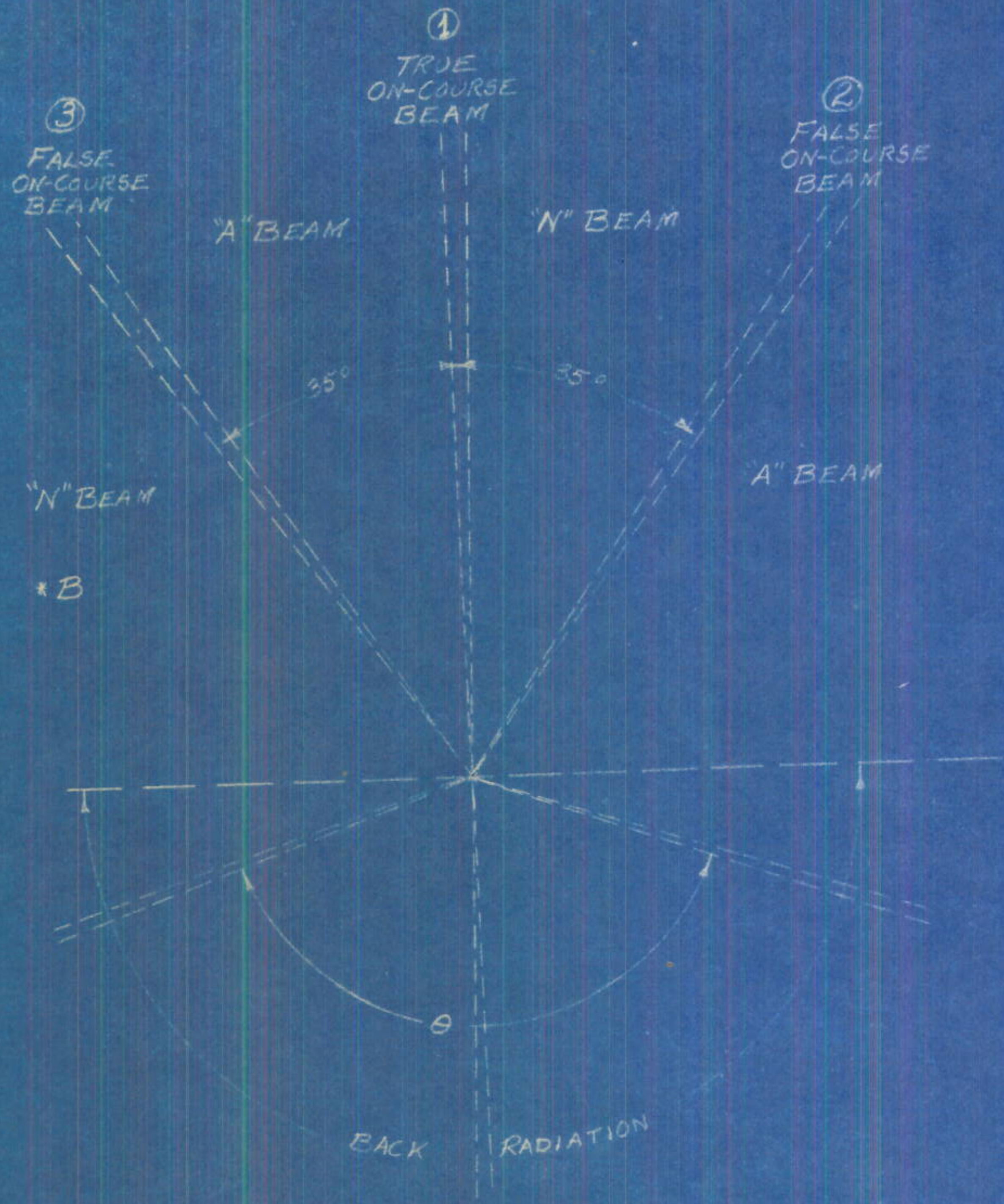
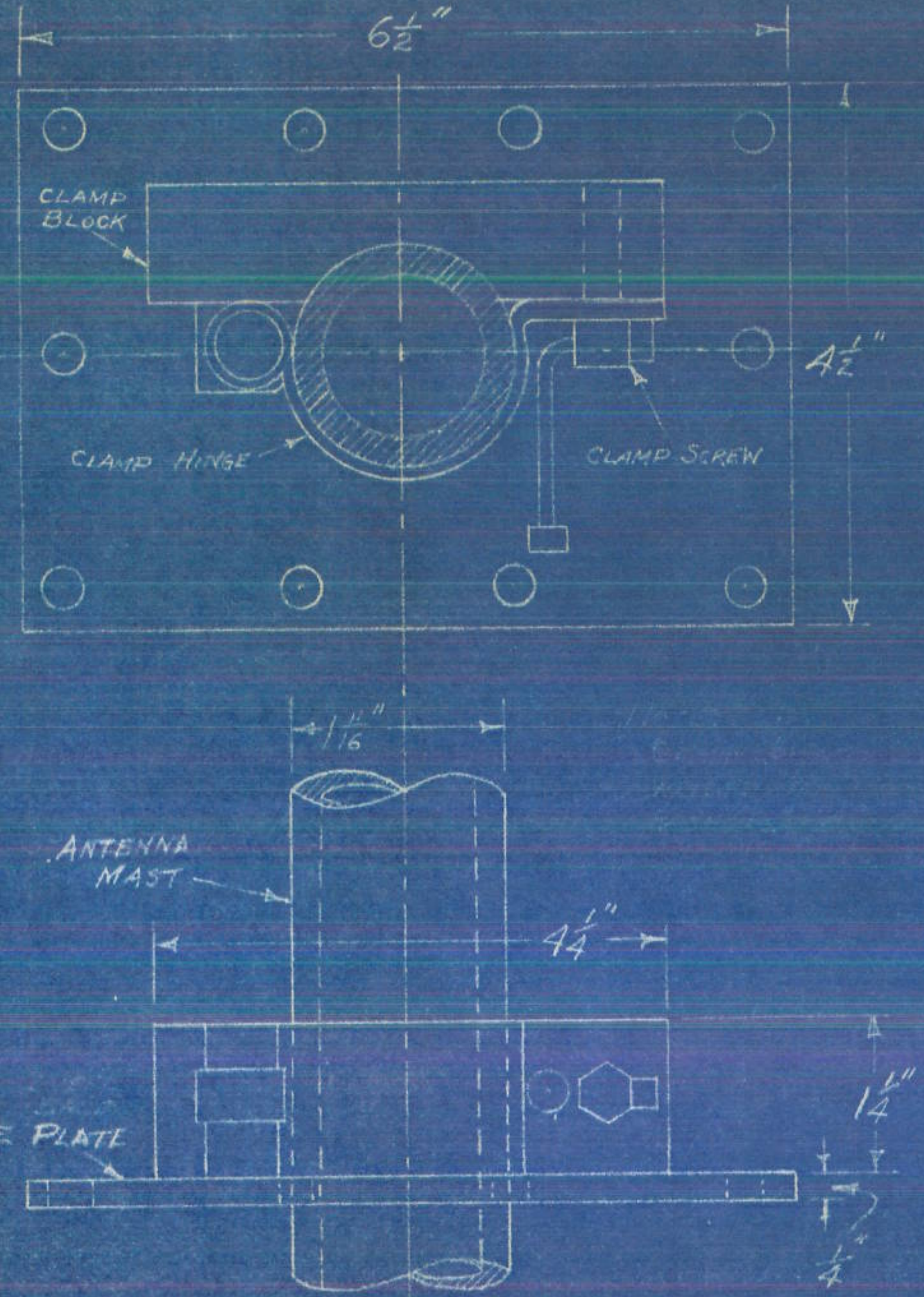
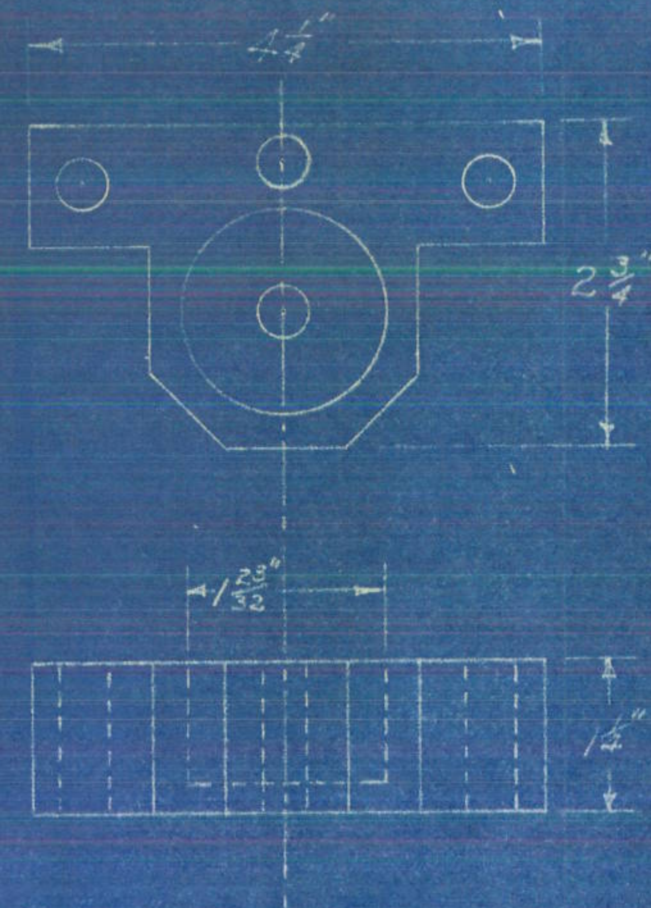


DIAGRAM OF TRUE AND FALSE ON-COURSE BEAMS

PLATE 26



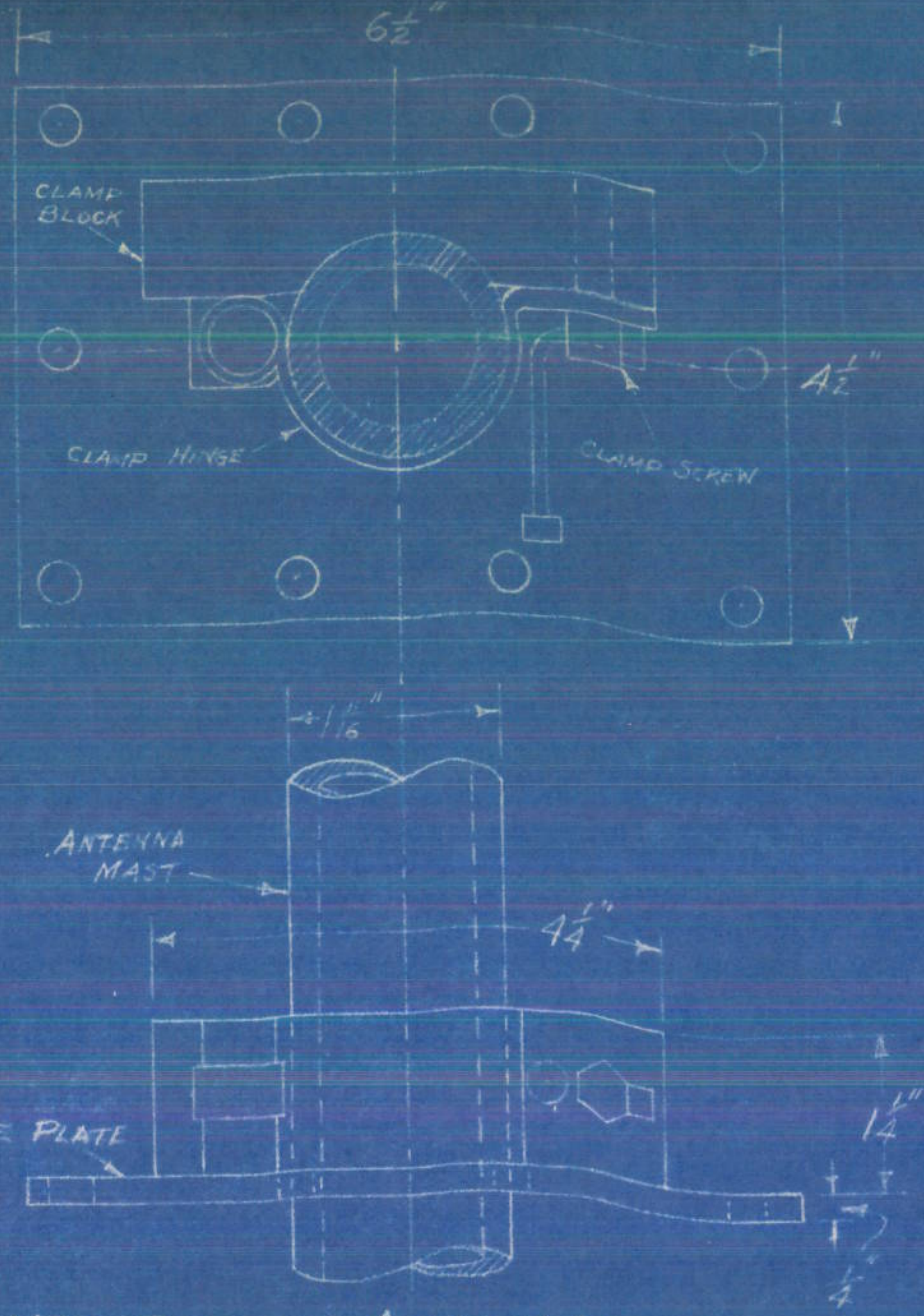
XBC RECEIVING ANTENNA MAST CLAMPING BRACKET.



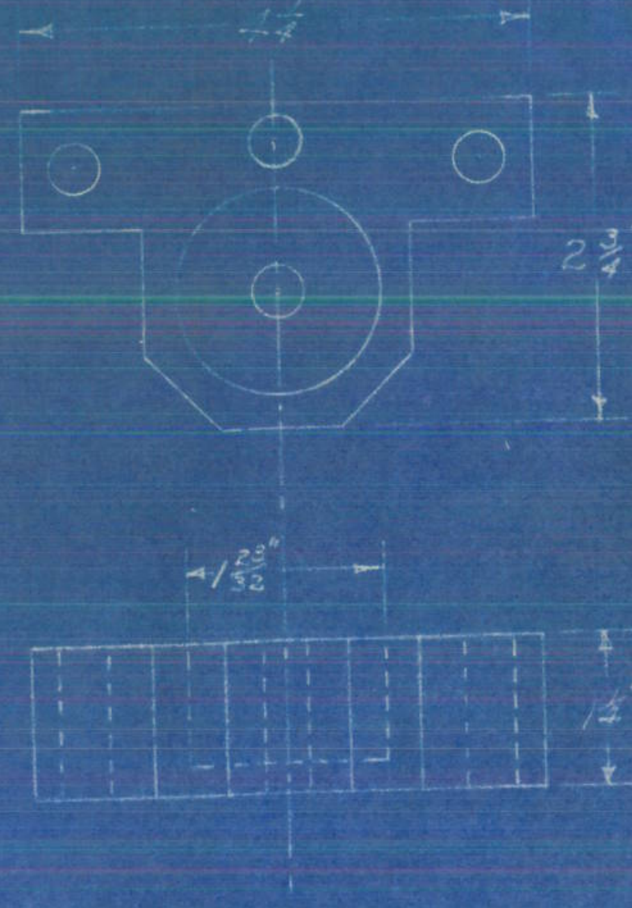
XBC RECEIVING ANTENNA MAST
BASE STEP

NOTE: MATERIAL:- STEEL.
FINISH:- CADMIUM PLATE.
CLAMP BLOCK WELDED TO BASE PLATE.

[redacted]



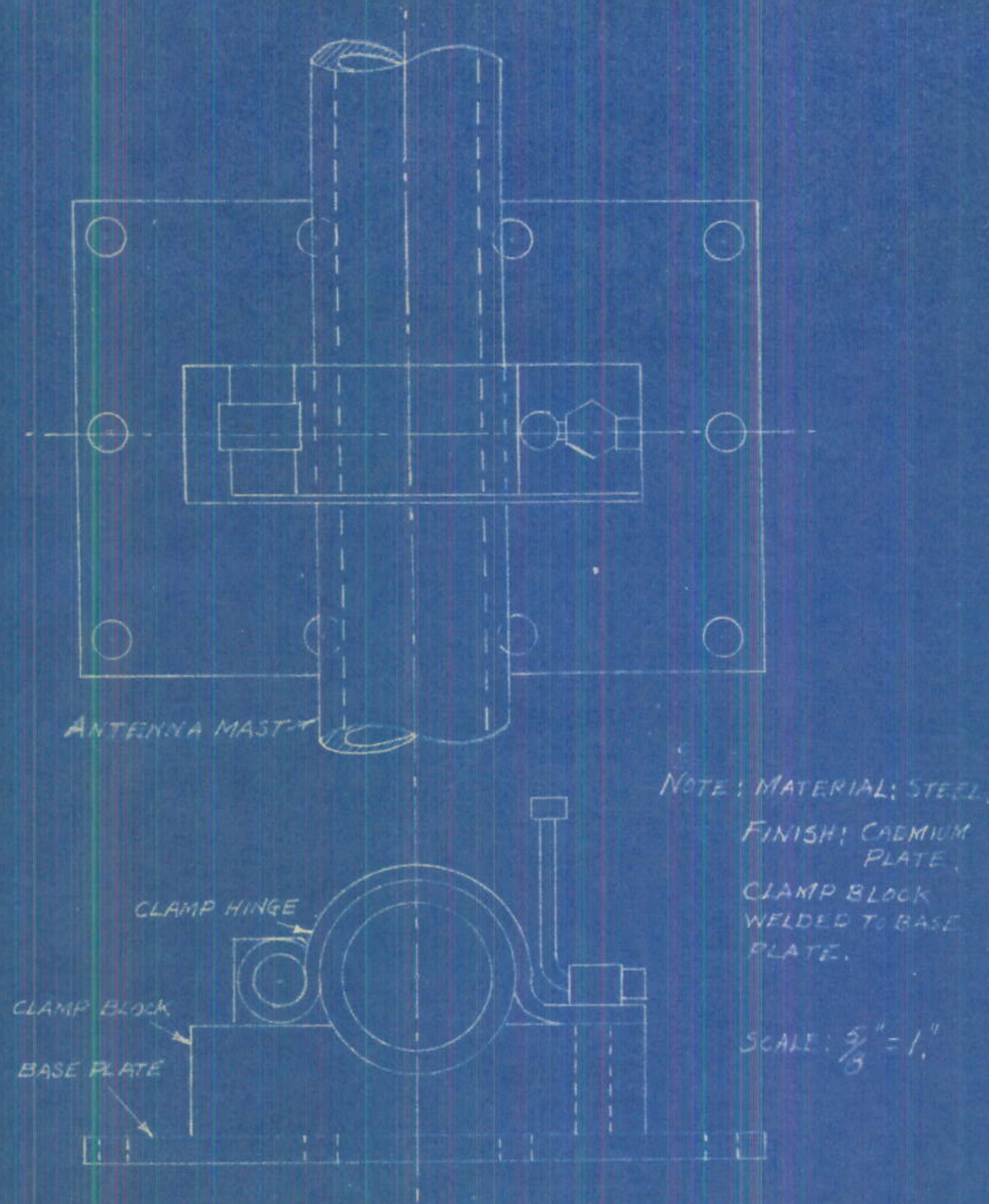
XBC RECEIVING ANTENNA MAST CLAMPING BRACKET.



XBC RECEIVING ANTENNA MAST
BASE STEP

NOTE: MATERIAL:- STEEL.
FINISH:- CADMIUM PLATE.
CLAMP BLOCK WELDED TO BASE PLATE.

[redacted]



XBC RECEIVING ANTENNA MAST CLAMPING BRACKET

[redacted]

PLATE 28