TWELFTH WEEK.
RADIO-COMPASS

QUESTION #1. Compare directional antennae with non-directional antennae in regards to construction.

ANSWER #1. Nondirectional antennae. The antenna of moderate horizontal dimensions is nondirectional. This can be proved by moving the radio transmitter so as to make a complete circle about the receiving antenna and plotting the emf induced in the antenna against the angular position of the transmitter. The resulting polar diagram will be a circle, showing that the emf induced in the antenna is the same for reception from all directions. Therefore the signal will not very in intensity, and the direction of the transmitter can not be determined.

Directional antennae. If a loop consisting of several turns of wire wound on a fairly large form is arranged for receiving, so that it can be rotated on a vertical axis, the loop will make a verying angle with the direction of the source of electromagnetic waves produced by a fixed radio transmitter. If the emf induced in the loop is plotted in a polar diagram against the angular position of the loop, the resulting curve will be like a figure 8, the bilateral characteristic curve of the loop.

QUESTION #2. What is meant by maxima minima? Where are maximum and minimum signals received in regards to the plane of the loop with the transmitting station?

ANSWER #2. By maxima is meant the two places on the loop where a maximum signal will be received from the transmitting station. By minima is meant the two places on the loop where a minimum signal will be received from the transmitting station. The maximum signal will be received when the plane of the loop coincides with the line of bearing of the transmitting. The minimum signal will be received when the plane of the loop is at right angles to the line of bearing of the transmitting station.

QUESTION #3. What is the purpose of the compensating condenser and how is it connected in the circuit?

ANSWER #3. The purpose of the compensating condenser is to eliminate the antenna effect by balancing the capacity from filament to ground, by placing a condenser from the grid to ground. Antenna effect is the most common cause for the destruction of the null point in the practical radio compass. This effect is due to the electrical dissymmetry of the radio-compass circuit. In a standard radio-compass installation the terminal from the vertical side of the coil is connected to the filament of the vacuum tube of the receiving apparatus while the side opposite is connected to the grid. An electrical dissymmetry exists on account of the unequal capacities to ground of the filament-to-ground and the grid-to-ground caused mainly by the proximity of the filament battery to ground. The compensating condenser consists of a small continuously variable air-dielectric condenser.

QUESTION #4. Name three causes and state their remedies when considerable change in the quality of the minima develops.

ANSWER #4. Three causes for considerable change in the quality of the minima are: The capacity of the compensating condenser may not be sufficient. To remedy this replace with another condenser of higher capacity. The most common defects are caused by improper installation, these are (1) mechanical slip in the coil system. (2) Undrained communication lines. (3) Grounded antenna nearby. Their remedies are as follows: (1) Test coil system alignment. (2) All communication lines should be adequately drained of RF current. (3) Test antenna system for ground.

QUESTION #5. Explain fully how bearings are taken and what precautions must be observed.

ANSWER #5. Bearings should invariably be taken in accordance with the following procedure:

(a) Take bearing preferably with a clear tone signal, or else full operating condition. With receiver oscillating, the minima are more sharply defined. However interference will obscure an otherwise good, becuase tone selectivity is lost.

(b) Tune signal carefully, with coil system at, or near, the maximum.

(c) Rotate coil system thru the NULL point of the signal oscillating to and fro, finally bringing it to rest at the estimated center of the minimum.

(d) Adjust compensator carefully, in the same manner as the coil is rotated, seeking the exact center of the minima.

(e) Retune carefully.

(f) After retuning, rotate coil system thru the Null point again as in (c).

(g) Adjust compensator again as the coil is rotated.

The final adjustment of the compensator and coil should give a point of silence on some particular bearing. It is well to note, however, that some compass stations cannot obtain an absolute silent minima. Although these minima are exceedingly sharp and the station operation is excellent. The width of the zone of silence depends on the power of the transmitter, the distance of the transmitter and the sensitivity of the receiver.

The following precautions should be observed: Never attempt to obtain bearing with receiver regenerating or barely oscillating as in this condition the circuit is very sensitive to any change in its decrement which will result from the adjustment of either tuning condensers or compensating condenser. Due to these variations in signal intensity resulting from these changes, proper operation will be difficult. If the signal intensity is

ANSWER #5. Continued.

low, regeneration should be used after all adjustments of tuning and compensation have been made.

Adjust tuning condensers for maximum signal intensity. All tuning must be done with the coil off the minimum. Incorrectly tuned circuits will result in erroneous bearings.

Do not swing the coil thru a large arc. Ten degrees on either side of the null point is sufficient at start; after retuning and re-compensating the swinging of the coil should be restricted to about one to three degrees on either side of the null point, depending upon the sharpness of the minimum.

At stations where the compensator values change greatly thruout the azimuth the detuning may be considerable. Therefore, the necessity for retuning is important.

When the coil system and compensator have been successfully adjusted to give a silent point, the entire attention may be devoted to the coil system. The coil system should be slowly rotated within the restricted arc, careful attention being given to estimate the true center of the minimum.

QUESTION #6. What is the purpose of shore radio stations and where are they located.

ANSWER #6. The purpose of radio compass stations ashore is to furnish some means by which ships may navigate with safety during thick, foggy weather as well as clear weather. For tracking and obtaining the positions of ememy vessels in time of war. These stations are located where the most favorable operating conditions are found but usually on, or near, a dangerous navigational sector.

QUESTION #7. Why are shore stations grouped and explain procedure of how observed bearings are plotted from each station in a group and transmitted to the ship concerned.

ANSWER #7. Shore stations are usually grouped about a harbor entrance or navigational hazard so that several bearings of a ship may be taken simultaneously. These bearings are plotted on the chart so that the lines cross each other. Where the lines form an intersection is the position of the ship. The various stations in the group are interconnected by some method of communication to a master station having control of a radiotelegraph transmitter. The stations in the groups take observations simultaneously upon the vessel requesting radio-compass service. These observed bearings are transmitted to the vessel to be plotted by the navigator. The intersection of the bearings indicates the position of the vessel at the same time that the observations were made. If there are more than two stations involved, the accuracy of the work will be indicated by the precision with which any bearings crosses the intersection of the other two.

QUESTION #8. Explain briefly the procedure used for calibrating a shore station.

ANSWER #8. The procedure is to rotate a radio transmitter about the radio compass to be calibrated, taking simultaneous readings of both true and radio-compass bearings. In the case of radio-compass stations on shore, all land lines must be completely installed and in operating condition previous to calibration. All radio antennae should be erected and proper precautions taken to insure that the antennae are disconnected at all times by means of an anchor gap and that the transmitting apparatus is in working order. The calibrating vessel should be maneuvered to a position approximately at right angles to the shore line. If the vessel is head-on to the radio compass house in this position there will be normally very little deviation of the wave front, and the true bearing as observed by the transit may be used as the setting for the radio-compass dial. In certain cases, a fixed radio transmitting station, preferably one from which the signals travel entirely over water, may also be conveniently used for this purpose, provided that the signal intensity is sufficient to give a good minimum. Previous to starting the run, tests are made for tuning, wave lenth, clarity of note, and requisite power followed by tests for the setting of the dial at the radio compass station. The vessel should send continous dashes of ten seconds duration with five second intervals for five minutes, followed by a one minute period of listening for communications from the radio compass station. The transmitter on the calibrating vessel should be capable of withstanding abnormally heavy duty. The apparatus should preferably be a 500 cycle quenched spark transmitter power rating not less than 2 kilowatts and be able to maintain a clear note under continuous operating conditions. The apparatus must be carefully tuned to the calibrating wave length. The radio compass operating wave length for shore stations established for the United States is 800 meters (375 Kcs). The following features are important: (a) The vessel must be visible from the compass station, or in case there is an obscured sector from the triangulation points. (b) The optimum radius of the circle is approximately five miles. (c) As viewed from the compass station, the vessel should move with an angular advance of not greater than 2° in a minute of time. (d) During the continuous calibration at the end of the course the vessel reverses her direction repeating the run to balance out any errors due to time lag between compass-transit readings as well as those caused by the center of radiation of the vessels antenna not being at the lead-in. Should a sudden change of deviation value be observed, the procedure in seeking the cause of this trouble is as follows: (a) Recheck transit set-up on landmarks. (b) Test peep sight alignment of coil system. (c) Note any possibility of grounds or open circuits in the wiring of the apparatus. (d) Investigate any possible change in communication lines, also in the antenna system at the station if there be one. During the calibration the divergence of the radio-compass bearing from the true bearing should be plotted in the form of a deviation curve.

QUESTION #9. Are true or relative bearings transmitted from a shore compass station?

ANSWER #9. The observations made at radio-compass shore stations are read directly from true north, and are sent out as true bearings.

QUESTION #10. What is the purpose of radio compasses aboard ship? Where is the radio installation located on Destroyers, Cruisers, Battleships?

ANSWER #10. The radio compass is installed on naval vessels for the purpose of enabling commanding officers to determine the true bearing from the vessel to another vessel or to a radio station on shore. The radio compass installation on destroyers is situated in the after deck house. The receiver and apparatus is located in a little shack forward on the starboard side of the deck house, while the loop is directly overhead, encased in a canvas housing. The radio compass installation on cruisers of the Omaha type is located directly amidships. Entrance to the compass shack is gained by way of the Executive Officer's office. The compass loop is directly overhead encased in a canvas housing. Aboard Battleships the radio compass installation is located on the boat deck amidships.

QUESTION #11. What are the most important installation difficulties? Most common installation defects? Name remedies.

ANSWER #11. Aboard the average ship the most desirable locations are either not available or there are various metallic structures in the vicinity of the loop that produce deviations of varying magnitude unless certain precautions are taken. The stays to the mast and stack must be broken near their upper ends with strain insulators and securely grounded to the hull of the vessel at their lower ends by means of flexible copper jumpers. The railins placed around the edge of deck houses must not extend around the compass coil. These railings shud end at points several feet from the coil house and it is advisable to insert nonmetallic rope horizontal members in place of metallic rail adjacent to the compass coil. If the space surrounding the loop is occupied by movable metallic lockers, or structures of a similar nature, satisfactory performance cannot be expected. Closed metallic loops and metal structural details in close proximity to the compass coil cause excessive deviation. All radio compass bearings are taken as angles turned from the center line of the ship and the bow as zero degrees. In order that this may be accomplished the dial must have the correct relative positio with respect to the loop. The pointer should be placed so that the dial reading may be easily observed by the operator. The loop should then be turned so that the plane of the turns is at right angles to the center line of the vessel and the dial made to register 0° or 180° and then clamped securely to the shaft.

ANSWER #11. Continued.

The most common cases of installation defects, their effects and remedies, follow: The battery leads to the receiver are frequently run in lead-covered wire, which covering is generally grounded. This results in greatly increasing the capacity to ground of these circuits. It is imperative that the entire radio-compass circuit, inside the receiving cabinet, as well as the connections between the various pieces of apparatus comprising the unit, including also the batteries, be kept as far from the metallic hull of the vessel as is practicable. For this reason, the connecting wires must not be encased in a metallic sheath. The batteries must be raised from the deck and set out from the bulkhead and the receiver must be kept at lead 3 inches from bulkheads. The leads from the compass coil should be carried on column insulators down to the receiver. The most common defects in apparatus are: (a) Defective receivers and amplifiers, (b) Commutation (dc) noises. (c) Dirty collector rings. Very thorough tests should be made of the receiving apparatus previous to calibrating noting the control of the oscillations or prescence of excessive noises in the telephones particularly with receiver oscillating.

QUESTION #12. How should antennae be at all times while used radio-compass? Why?

ANSWER #12. In taking a bearing, whether during calibration or in subsequent operation, all antennae must be open - not grounded. A grounded antenna causes a capacity effect on the radio compass and will cause great deviation in the compass reading. Even if the antenna is connected to a receiver, tuning the receiver will change the reading on the radio compass loop.

QUESTION #13. Explain briefly a radio beacon.

ANSWER #13. In certain important localities, stations are equipped to send out distinctive radio signals, broadcasting them at certain intervals. Ships equipped with radio-compasses or direction finders pick up these signals and get the bearing of the sending station by such compasses. They are then able to steam toward the station to make a landfall. These radio signals are usually sent out only in fogs or thick weather. If the beacons operate on schedule time and shut down immediately the weather in their vicinity may be considered clear. If, however, the beacons operate continuously the weather may be considered to have become thick. This "wrinkle" in navigation will prove of great value in determining if thick weather exists in certain localities when such information is not contained in radio weather reports.

QUESTION #14. What are the most important causes of radio compass deviation?

ANSWER #14. See next sheet.

ANSWER #14. Continued.

At shore radio-compass stations, a certain amplitude of deviation is normal to the station, depending on the characteristics of the site. Thus, it has been found that a compass station situated very close to the surf on a flat, sandy beach will exhibit a deviation amplitude (maximum) of about three-fourths of a degree, increasing to about 2° for a station located 300 yards inland and 25 feet above sea level. At compass stations such as these, the compensation values throughout the azimuth will vary from 100 to 200 mmf. Should a compass station in a similar location exhibit a deviation curve whose amplitude greatly exceeds these values, the condition of all antennae and nearby metallic circuits, should be investigated for the purpose of reducing this deviation to normal. In cases where compass stations are situated on or near high rocky ground, it is impossible to estimate the deviation that will be normal. Such locations should be avoided as much as possible and, if circumstances necessitate a compass station in such a locality, the site should first be tested by a trial calibration. In general, it has been found that the operation of compass station exhibiting a deviation curve of low amplitude is more consistently accurate. In the case of radio-compass installations on board ships, the same general conditions apply, although not so closely, as the factors which determine the amplitude of deviation are more constant. Neglecting the effect of local metal bodies on shipboard, it has been found that deviation is nearly proportional to the length and height of vessel. When extraneous effects are removed, the average for destroyers should not exceed 6°. For battleships and larger vessels it will be from 20° to 25°. It has been very evident from work on destroyer compasses that any metal body in the vicinity of the coil house which forms a closed electrical loop will cause excessive deviation. Brass rails or wire rope, awning supports and, particularly, mainmast stays forming loops will cause deviations as high as 45° on destroyers. When these influences are removed, the calibration curve passes through zero deviation very close to 0°,90°, 270° and 360°, which is normal. While battleships generally show a maximum of 20° to 25° and are approximately 600 feet in length, one vessel 700 feet in length had a maximum of 15°. The latter installation was located much higher than is ordinarily the case.

QUESTION #15. Give a general description of a DB compass installation a list of all parts and their uses.

ANSWER #15. The Model DB radio compass is designed for the determination of the bearing of transmitting station using short, intermediate, and long wave lengths using either damped or undamped methods of transmission. A RF driver is furnished for heterodyning the incoming undamped signals with a wave length range of from 125 to 30,000 meters.

ANSWER #15. Continued.

The list of all parts of a DB radio-compass and their uses follow:

1 Type SE 1829 coil system (6 feet by 4¼ feet).
1 Type A radio compass house (C & R drawing 100593)
1 Type SE 1830 tuning condenser.
1 Type 1387 radio frequency driver.
1 Type 1834 or SE 1833 R-A-F amplifier.
1 Type SE 1832 compedsator load condenser.
1 Type SE 1762 compensator condenser.
2 Type CW 834 head sets.

The coil system makes up the loop, or directional, antenna which is used to locate the direction of the incoming signals.

The compass house is used to house the equipment.

The tuning condenser has a .004 mfd variable air plate condenser and a two step fixed condenser which is controlled by a switch on the upper right hand side of the panel. The switch markings are: "short wave" (which employs the variable condenser only) "intermediate wave" (employing both the variable condenser and a .002 fixed capacitance) "long wave" (employing the variable condenser and a fixed .006 capacitance.

By means of a switch on the upper left hand side of the tuning condenser the compensator units may be employed either on the grid or the filament side of the coil. The tuning condenser has also been supplied with a compensating resistance located behind the nameplate on the front of the panel access to which may be had be had removing the name plate.

The RF driver is a generator of radio frequency currents which are used to heterodyne undamped incoming signals by means of a coupling coil.

The Type SE 1834 amplifier employs six Type SE 1344 vacuum tubes providing three steps of RF amplification a detector and two stages of AF amplification and covers a range of from 125 to 30,000 meters.

The compensating condenser is used to compensate for the difference in capacity between the grid-to-ground and filament-to-ground caused by the filament battery being closer to the ground.

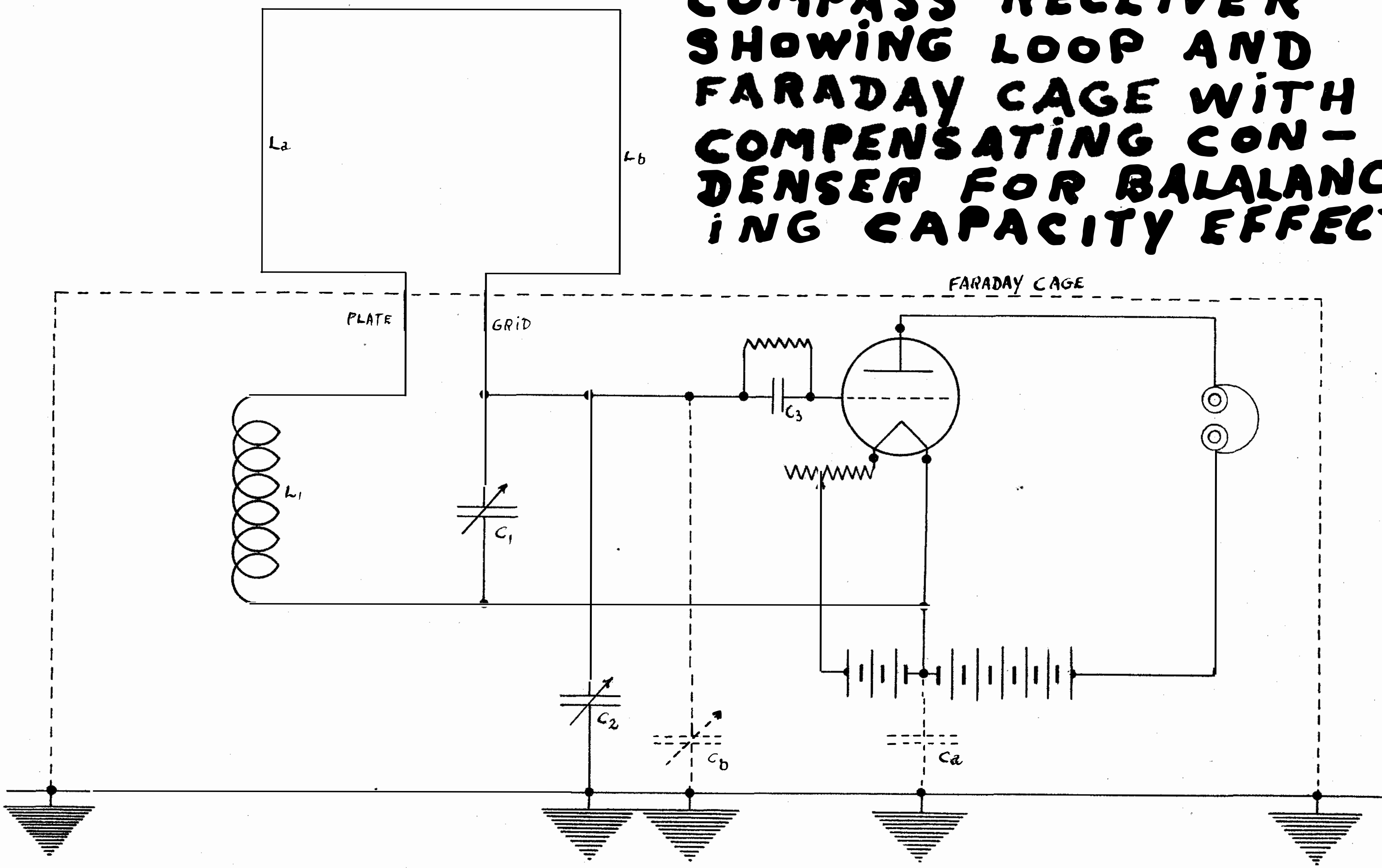
QUESTION #16. Draw a diagram of a loop; Faraday's cage and receiver as shown on Page 632, Robison's Manual, 1925.

ANSWER #16. See next sheet for diagram.

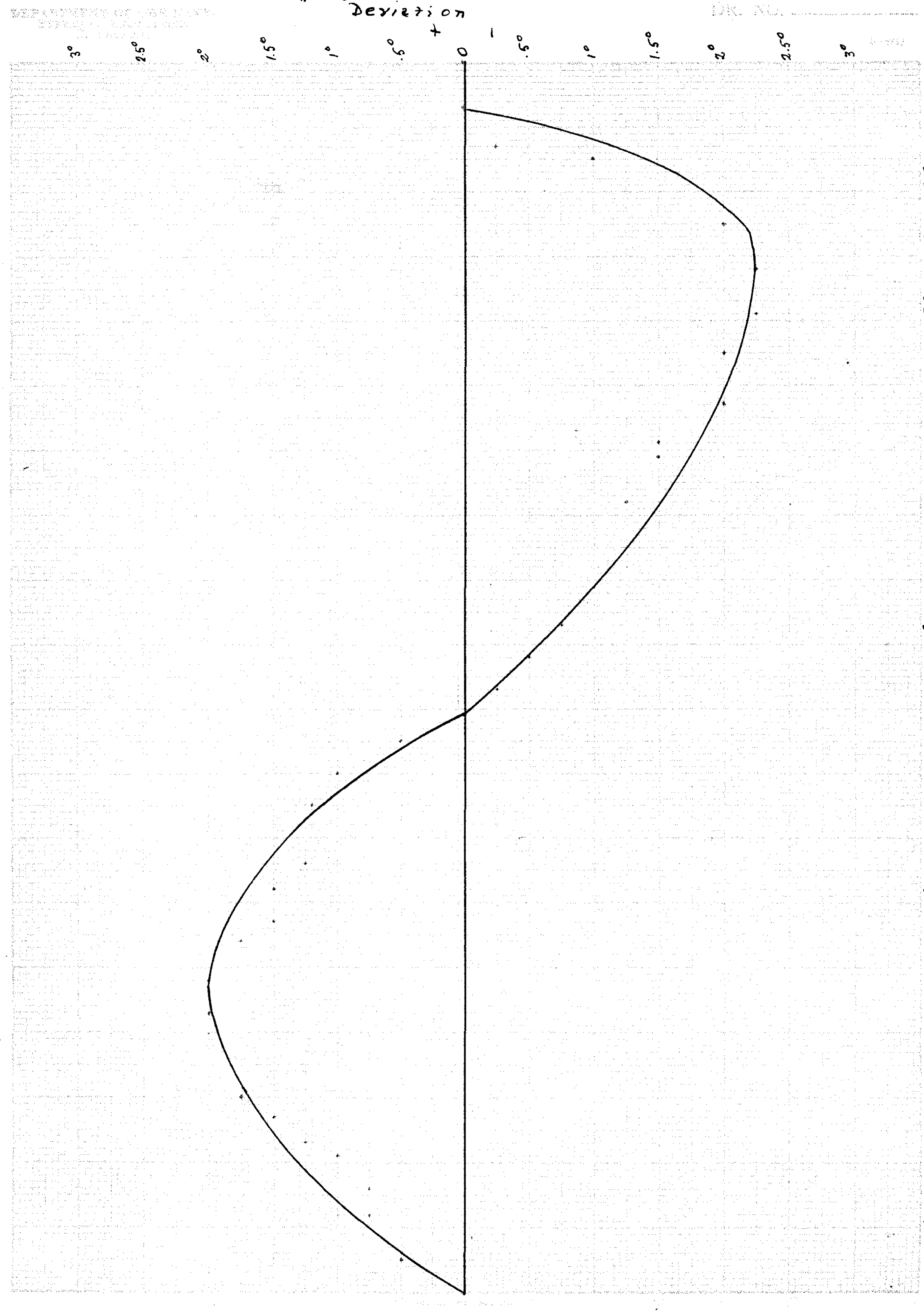
QUESTION #17. Make up a typical curve with graph paper and bearings furnished.

ANSWER #17. See second next sheet for curve.

COMPASS RECEIVER SHOWING LOOP AND FARADAY CAGE WITH COMPENSATING CON-DENSER FOR BALALANC-ING CAPACITY EFFECT.



ANSWER #17. Typical Deviation Curve.



QUESTION #18. Explain in full the procedure for taking a bearing and ready for the navigator.

ANSWER #18. This was fully explained under the answer to question number five. In addition, before the bearing can be sent to the navigator, the proper correction must be applied. Due to a certain deviation on each particular heading, deviation curves are plotted which give very closely the deviation for any bearing. This must be applied to the received bearing before sending to the navigator. In some cases the bearing may be doubtful; that is, it may have an error of 180°. In this case it is best to take another bearing after the ship has traveled along her course a few miles. This will give a fix so that the proper direction can be determined.

QUESTION #19. Explain in detail the method used in calibrating a radio compass installation. How long should it take to calibrate and what are the duties of the senior radioman?

ANSWER #19. There are two ways in which a ship's radiocompass may be calibrated: (a) The vessel equipped with the radiocompass may heave to or anchor while the transmitting vessel circles entirely around it, (b) the transmitting vessel may heave to or anchor while the vessel equipped with the radiocompass swings ship.

When there is only one vessel to be calibrated, method (a) will give more accurate results, as it is then possible to hold the angular speed of the transmitting vessel to two degrees per minute. Method (b) will probably be the one most often employed as this method makes it possible for a number of vessels equipped with radiocompasses to calibrate at the same time. Each vessel can swing ship at whatever rate is desired. Using method (b) it is impracticable to swing ship so slowly that the relative bearing of the transmitting ship changes at only 2 degrees per minute. This means that it is not possible to get enough observations for a reliable calibration in a single swing and it will be necessary to swing ship several times unless a sufficient number of observations are obtained in all sectors. Five or six swings are usually sufficient but in all cases the plotter must judge from his data when enough observations have been obtained. Method (b) also has the advantage of making it possible to repeat observations in any sector without extensive maneuvering and without sending instructions to the transmitting vessels.

The personnel necessary to conduct a radiocompass calibration includes a plotter, a radiocompass observer, a pelorus observer, a data recorder, and voice tube men messengers, etc. The senior radioman should be the radiocompass observer, and he should see that all equipment is in good working order before the calibration commences. The half scale method of calibration should be used; that is, all radio bearings are to be taken

ANSWER #19. Continued.

between 0° and 190° on the compass scale, regardless of the position of the transmitting vessel. The other pert of the scale is not to be used. The visual bearings are taken by means of a pelorus. At the instant the radiocompass observer takes a bearing, he gives the mark signal by ringing the voice-tube call bell or by other prearranged signal. He then sends the bearing and compensator settings to the bridge by means of the voice tube. He should observe the bearing to the nearest quarter degree. Thevisual observer notes the bearing by the pelorus at the instant he hears the mark signal and reports it to the data recorder. The plotter immediately computes the deviation and plots the observation on the proper curve. It is absolutely essential that the data be accurate. The plotter should plot the observations as they are obtained. In this way he can make sure that the proper results are being obtained. He can also arrange to repeat the calibration of any sectors in which doubtful results are obtained. As the half scale method of calibration is used, two deviation curves, A and B, are required. After the calibration has been completed and satisfactory A and B curves obtained, smooth copies of the curves should be plotted and the curves drawn in and inked. The table of corrected bearings is then prepared from the inked curves.