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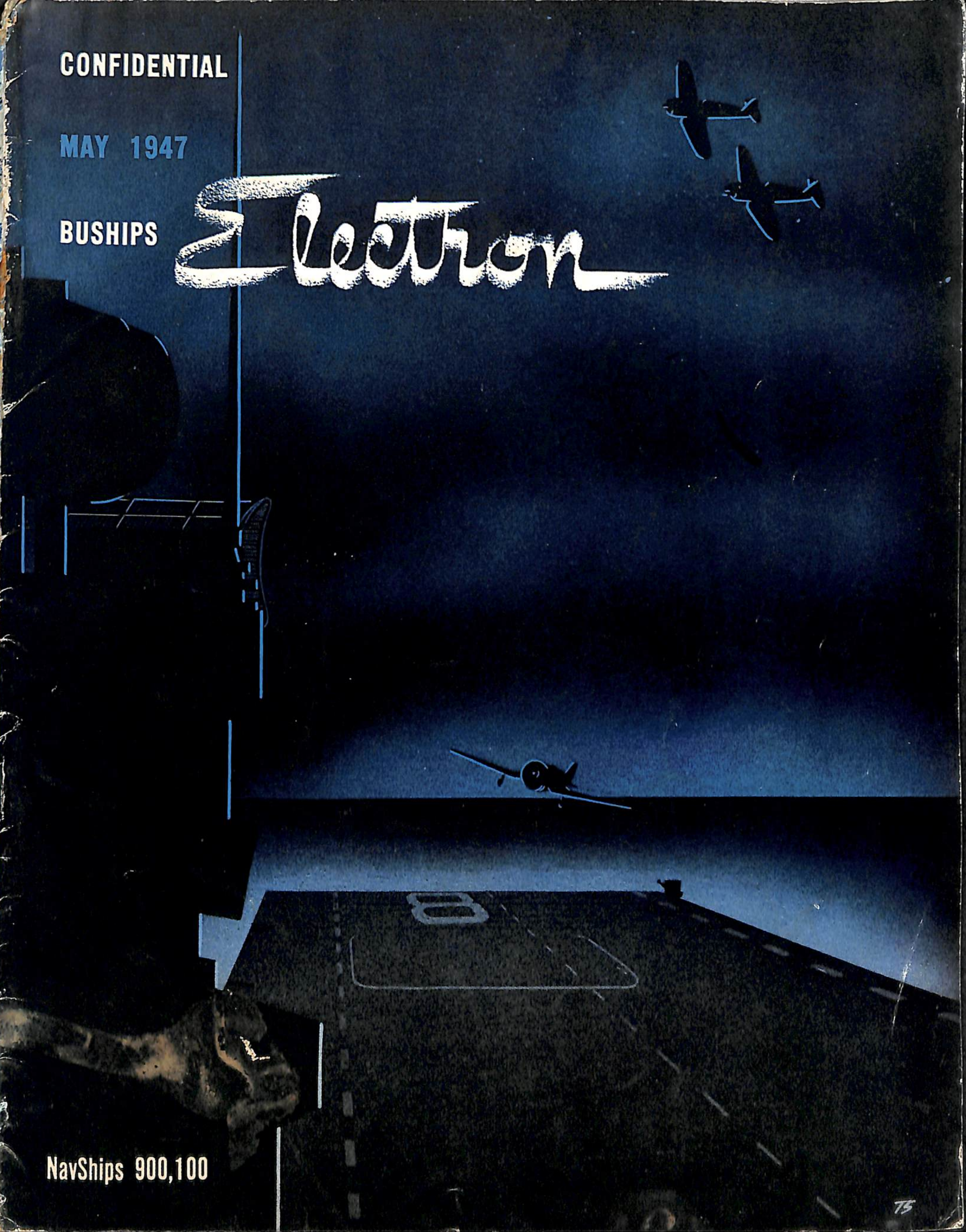

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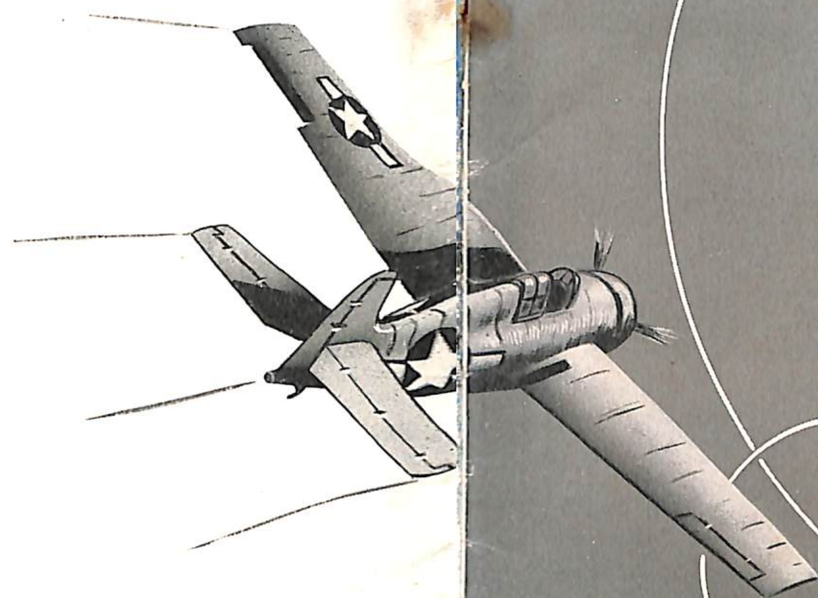

BUSHIPS Electron

A MONTHLY MAGAZINE FOR RADIO TECHNICIANS

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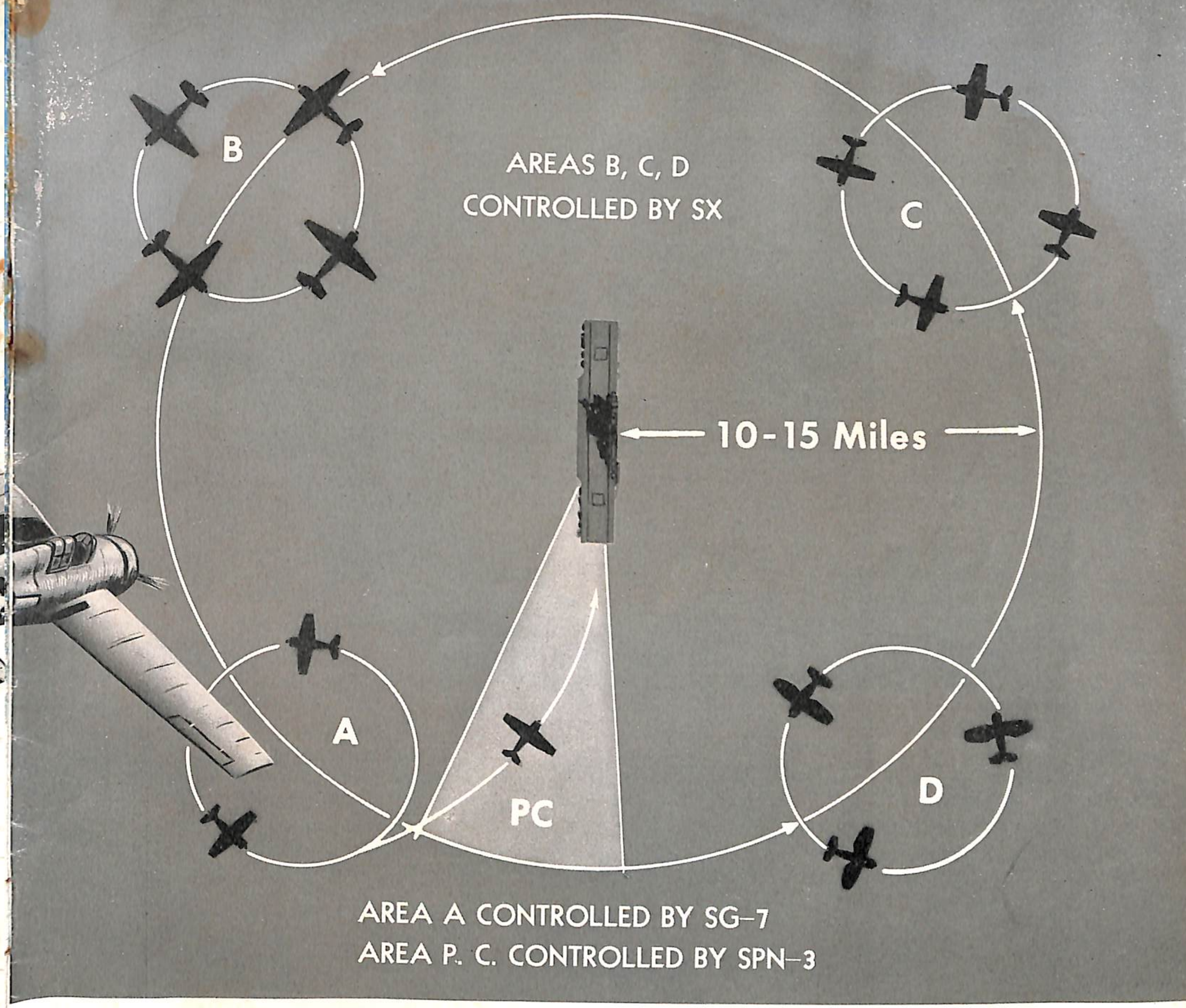


FIGURE 1—*Proposed landing pattern to be followed by planes returning to the carrier. Three orbiting areas, the peel-off area, and the precision-control sector are shown.*

Carrier-Controlled Approach—1947 Version

By R. E. WHITE, *Naval Research Laboratory*

In 1942, shortly after the start of the war, the extreme urgency for a solution to the problem of landing aircraft during periods of low visibility led scientists of the Radiation Laboratory at MIT to suggest that the information available from that new device—RADAR—should be sufficient to guide planes to safe landings during any kind of visibility. The outcome of this suggestion is the GCA (Ground Controlled Approach) system now coming into public use.

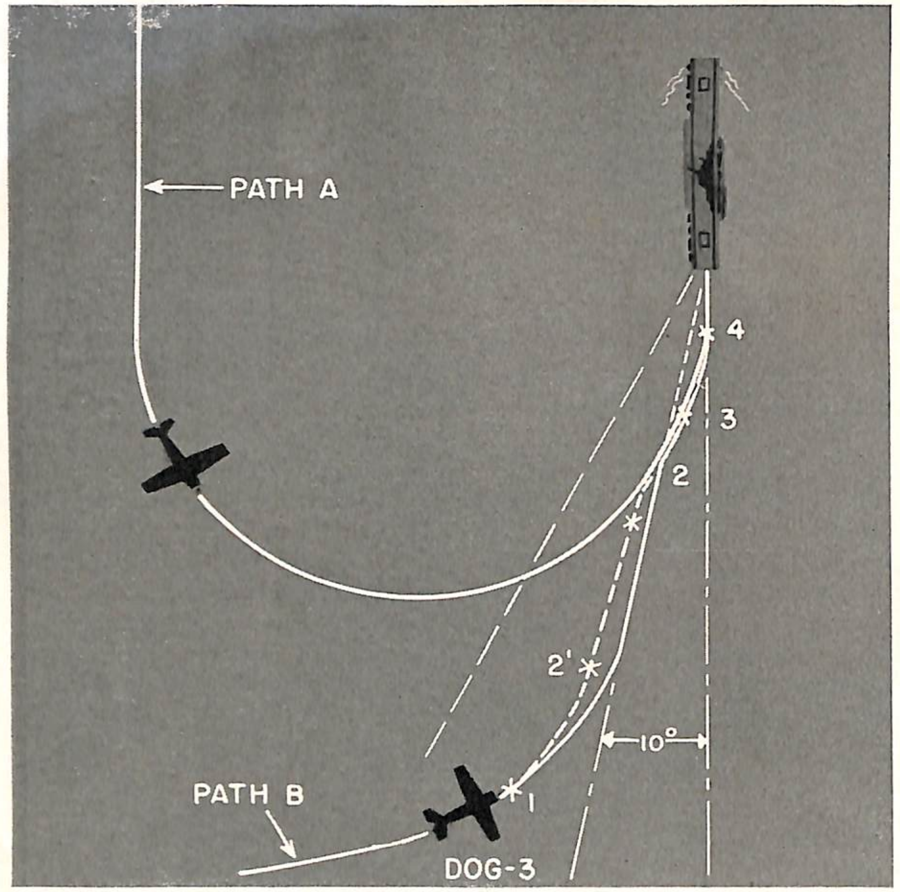


FIGURE 2—*Path A, type of approach flown under contact conditions at night. Path B, typical CCA approach path with radio transmissions shown.*

Early in the program the problem of landing planes aboard carriers was discussed, but it was not until late in 1944 that sufficient progress had been made on GCA to lend any hope of success when the short, narrow, unstable flight decks of carriers were substituted for the long, wide, stable landing runways of large airports ashore. At this time the Bureau of Ships, with technical help from the Naval Research Laboratory, conducted some operational tests to investigate the practicability of a radar-guided approach system. To the surprise of everyone concerned, the system was successful—even with the experimental equipment that had to be used for the investigation. Carrier planes were landed repeatedly on a CVE-type carrier under somewhat severe conditions. This investigation was reported in ELECTRON for October 1945.

As a result of the experience gained during this investigation a basic operational technique was evolved and a system of equipments developed. This material is at present awaiting installation aboard two CV-class carriers.

The overall system to be used on these carriers consists of three major equipments: 1—a long-range radar used for the direction of aircraft on missions and in returning to the vicinity of the ship after missions, 2—a comparatively short-range, high-scanning-speed radar for the control of air traffic in the vicinity of the ship, and 3—a high-resolution precision radar used for the direction of the final approach to the flight deck. Control information to the pilots is to be via radio communication equipment currently installed aboard carrier aircraft.

While the details of the overall traffic-control problem will be modified as required for each individual installation, the basic pattern will be somewhat as follows: Planes returning to the vicinity of the ship will be vectored to orbiting zones by the long-range radar, as shown in figure 1, the number and location of these zones being determined by the number of aircraft to be handled. Because of operational gunnery requirements these orbiting areas will be 10 to 15 miles from the ship. One of these orbiting areas will be located close to the PC (*Precision-Control*) sector as shown by circle A in figure 1. The traffic-control radar will keep the planes in area A under constant surveillance and will direct the flow of planes from this holding area into the PC sector. The precision-control radar will then direct the planes in this PC sector until the LSO (*landing signal officer*) aboard the carrier is able to assume

visual control of the landing. Present procedures require about 100 yards of visibility.

As the stack of planes in area A becomes depleted, planes from the other holding areas will be fed into area A until all planes have been landed.

The operational tests aboard the *Solomons* furnished sufficient data to set up a rather detailed operational procedure to be followed in the precision-control sector. Many of the considerations which apply to the landing path during contact operations apply to the determination of the optimum landing path under low visibility conditions. The present design of carriers places the ship's stacks and the island on the starboard side. These structures create disturbances in the air (known as *stack wash*) immediately aft of the starboard side of the carrier which are dangerous to landing aircraft and must be avoided. This indicates the desirability of confining the approach path to the port quarter as in the contact procedure. Since the success of all LSO-guided landings is directly dependent upon an unobstructed view from pilot to LSO, it becomes evident that the position, heading, and attitude of the plane at the moment when the LSO assumes control must be such as to provide and maintain this unobstructed view until the landing has been accomplished.

Consideration of all factors leads to the division of approach paths into three possible categories: 1—approaches from dead astern (180° to 185°), 2—approaches from small angles to port (185° to 195°), and 3—approaches from large angles to port (greater than 195°). A plane flying at low speed in landing attitude will unavoidably make small deviations in heading. In the approaches from dead astern these deviations may completely obscure the pilot's view of the LSO. The approaches from large angles to port lead to violent maneuvers close astern of the carrier. These are highly undesirable, especially under conditions of limited visibility. The approaches from small angles to port avoid both of the above difficulties and are therefore considered most desirable.

The requirement for an unobstructed view demands that at the instant of transfer of control from radar to LSO the plane's heading must be slightly to starboard of the LSO and its left wing be low. This requirement is met under contact procedure by having the plane approach the deck on a curved path as shown by path A in figure 2. During a radar approach, the requirement is met by placing the plane in a slight turn just prior to the shifting of control from radar to LSO. A typical radar approach path is shown by path B in figure 2.

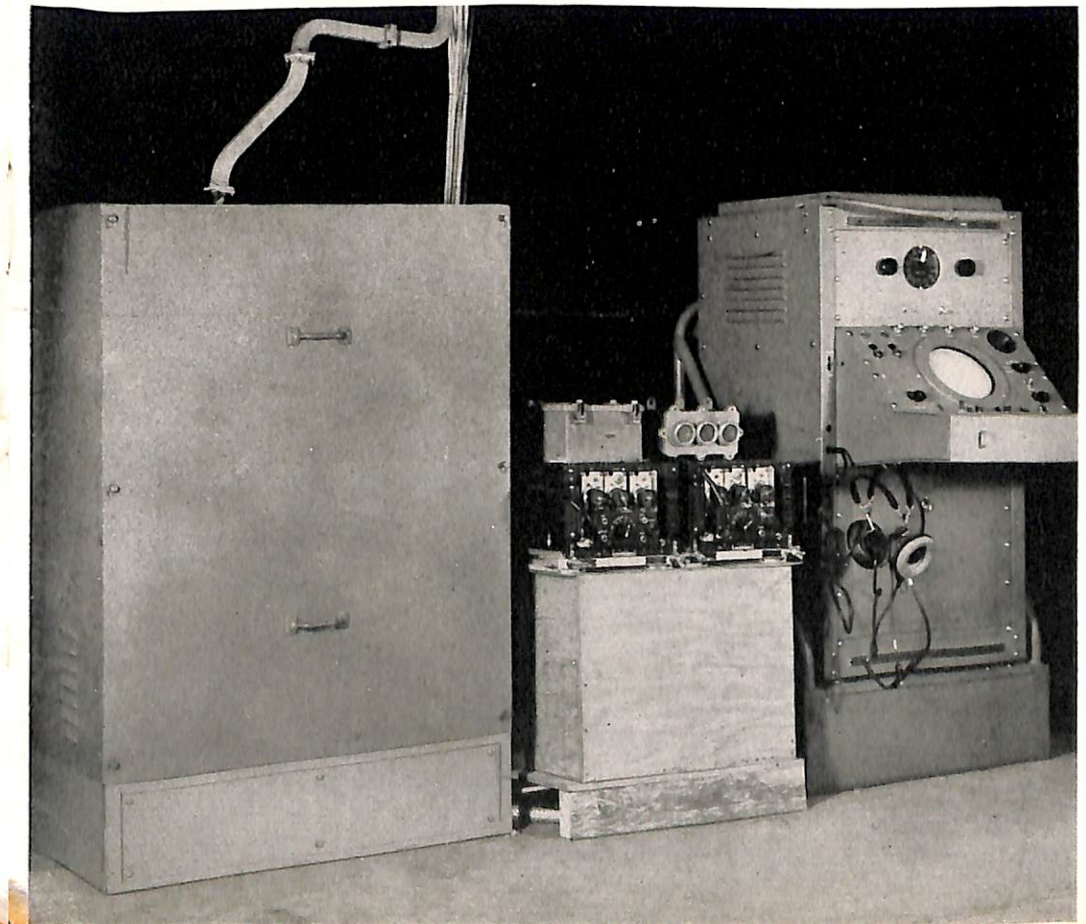


FIGURE 3—*A test installation of the precision-control equipment showing console, main frame housing r-f component, and communication equipment.*

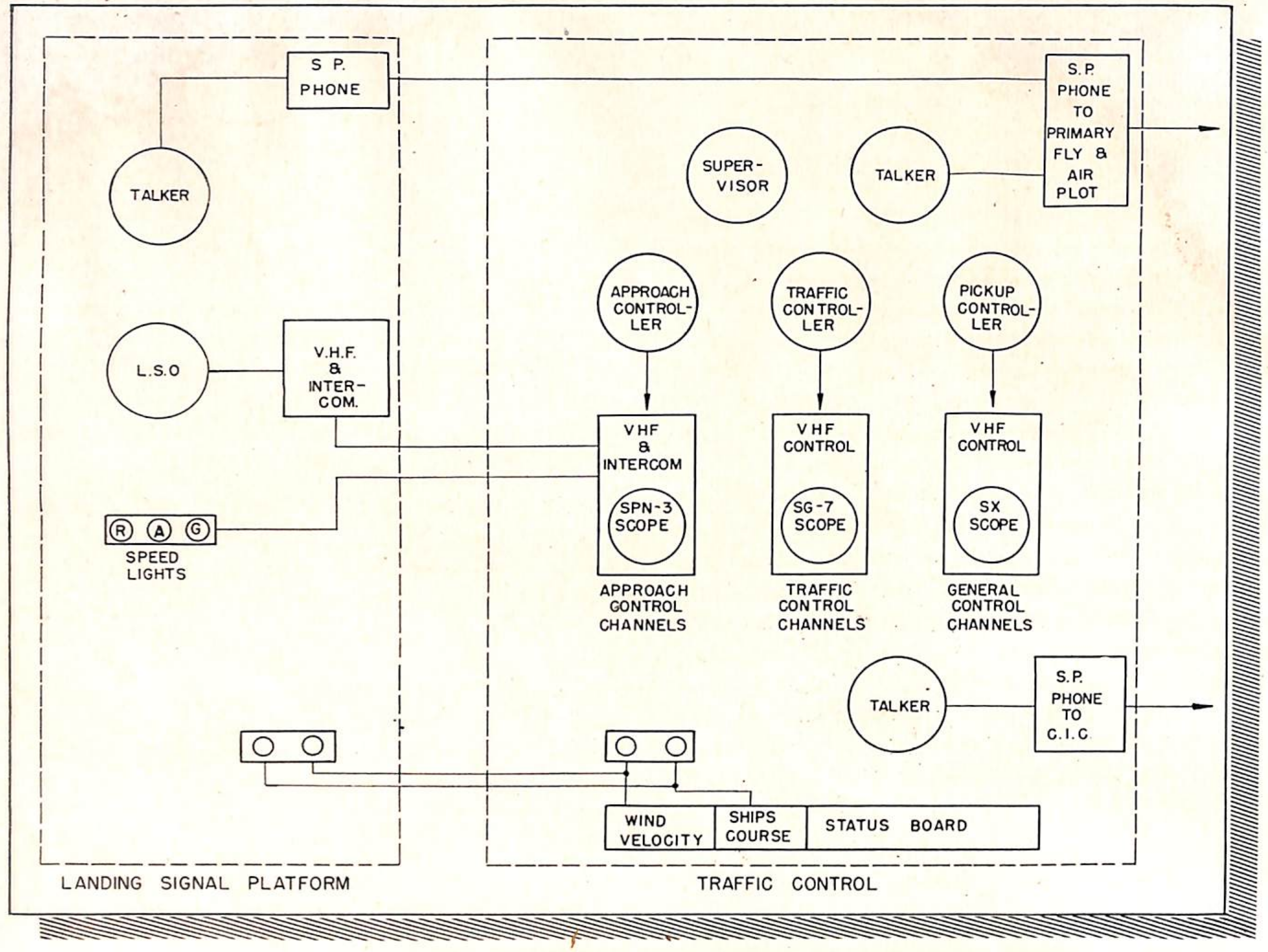


FIGURE 4—*Plan of the traffic control center as proposed for current installation on CV-type carriers.*

A first impression obtained from these paths by one unfamiliar with the system is that the desired course is one difficult to direct by radar. On the contrary, the B-type scope (which plots intersection courses as parallel straight lines) is adequately suited to the presentation of the desired information, and in the final correction of the deliberately inserted 10° course error, any small deviations are automatically removed.

The deliberate choice of an approach course off ship's heading constitutes one of the basic differences between CGA and GCA theories. The GCA procedures are based upon the theory that there exists only one perfect approach path and the aim of the controller is to direct the plane on to this and no other path. The CCA system admits of the existence of an infinite number of approach paths each leading to safe landings. The GCA assumption leads to many corrections in azimuth and when coupled with the difficulties of directing in altitude on a glide path, it becomes evident that only a long approach with many corrections will suffice. On the other hand, CCA does not have the problem of directing in altitude and the technique of directing a plane always to the nearest suitable path further reduces the need for course corrections. This allows the use of a short approach path and a minimum of corrections. The voice transmissions used during a typical approach are shown in the caption for figure 2. Normally, four transmissions are required, with a fifth correction (such as 2′) sometimes being given.

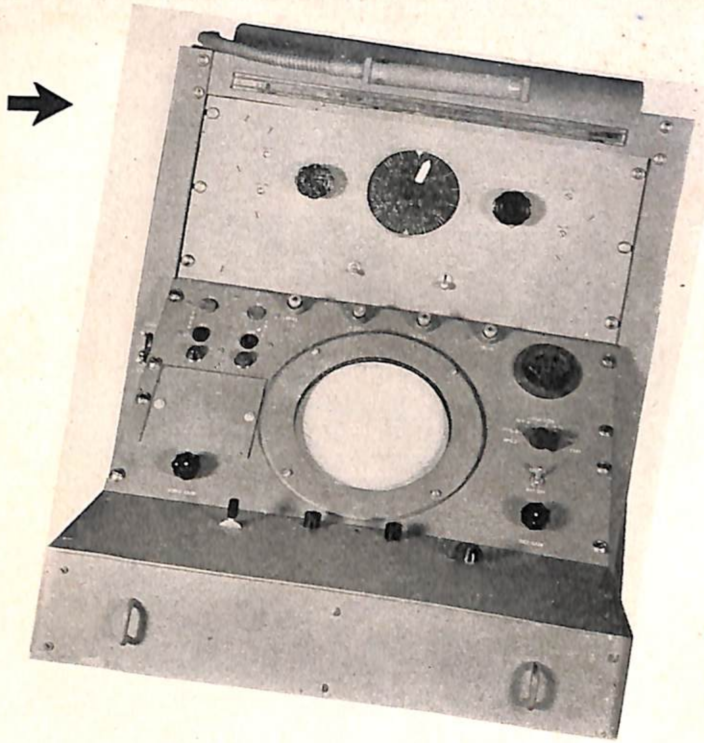
The equipment now awaiting installation consists of an SX radar for the long-range function, a new model of the SG radar (known as the XSG-7) with a high-speed scan for the traffic-control radar, the precision-control radar designated as the AN/SPN-3, and a c-w doppler radar, the AN/SPN-2, which is used to measure the approach speed of the landing plane. The latter two equipments are shown in figure 3. The c-w doppler radar is essentially an APG-17 radar which has been modified to indicate the closing speed of an approaching target. The SPN-3 equipment consists basically of the same type of components as used on the USS *Solomons,* namely a high-resolution X-band antenna and short-pulse r-f components. The major improvement in this system has been in the redesign of the indicator and the combination of the precision-control, approach-speed, and communication functions into an integrated system. All the information and all communication facilities required by the precision controller are available at the console, shown at the right in figure 3. The indicator for the approach radar may be seen on the sloping panel of the console, while the approach-speed indicator is located at eye level on the upper panel. Controls for the communication facilities are located on the horizontal shelf convenient to the controller's hands, while the earphones and boom mike which serve for both intercommunication to the LSO and radio facilities to the pilots plug into a jack on the console. The approach-speed indicator has facilities for the setting in of "wind-over-the-deck" information and thus may be made to read true airspeed. By a single knob setting, the controller may insert the correct landing speed for any type of aircraft, and the information as to whether the approaching plane is above, below, or in the safe-airspeed range then appears, both to the controller and to the LSO by the flashing of amber, red, or green lights respectively.

Since the communication link is so vital a part of the final approach, many precautions have been taken, including: 1—two AN/ARC-1 transmitter-receiver units are installed and either may be selected by the controller, 2—to assure the pilot that the communication link is operative and at the same time avoid disturbing him with unnecessary communications, a keyed-tone modulation is transmitted in the absence of voice modulation, and 3—override provisions are included to allow the pilot to interrupt the controller at any time and also to allow the LSO to interrupt and take control at any time.

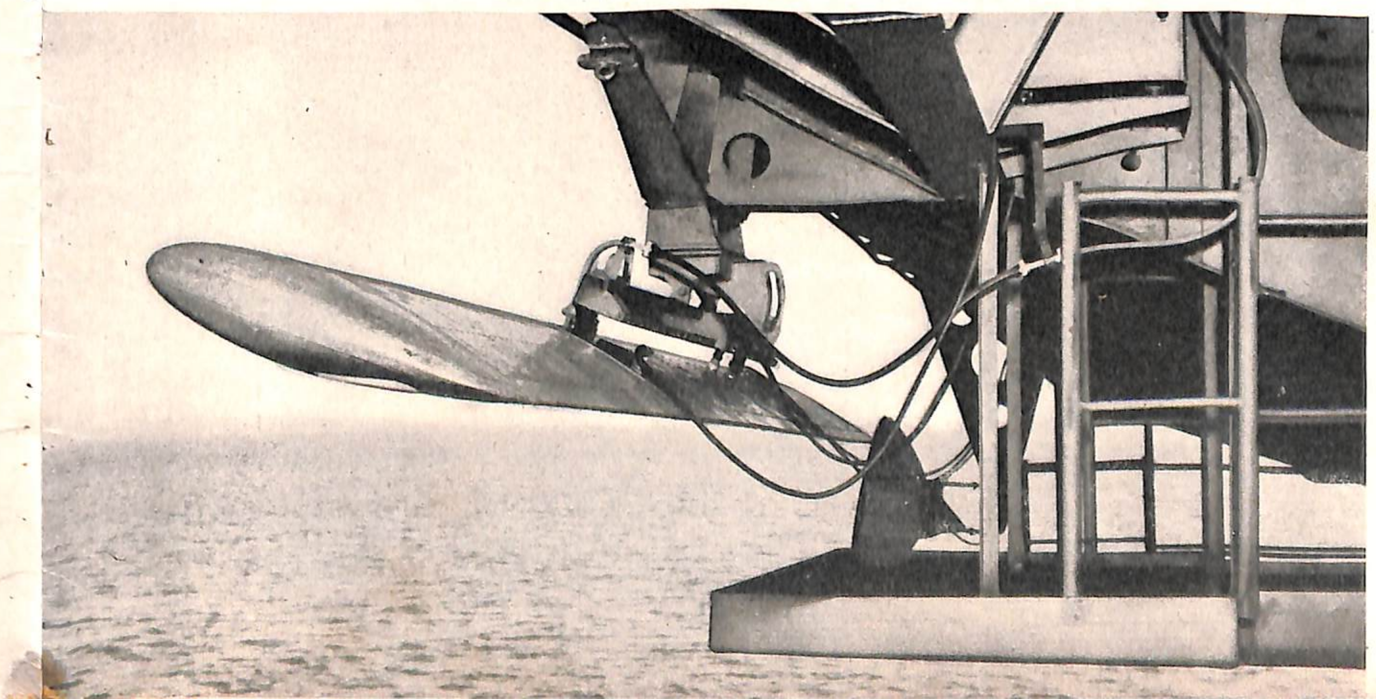
A proposed layout of the traffic control center is shown in figure 4. It is planned to locate the three radar controllers side by side to facilitate exchange of information and to assist in the integration of the three functions into an overall system.

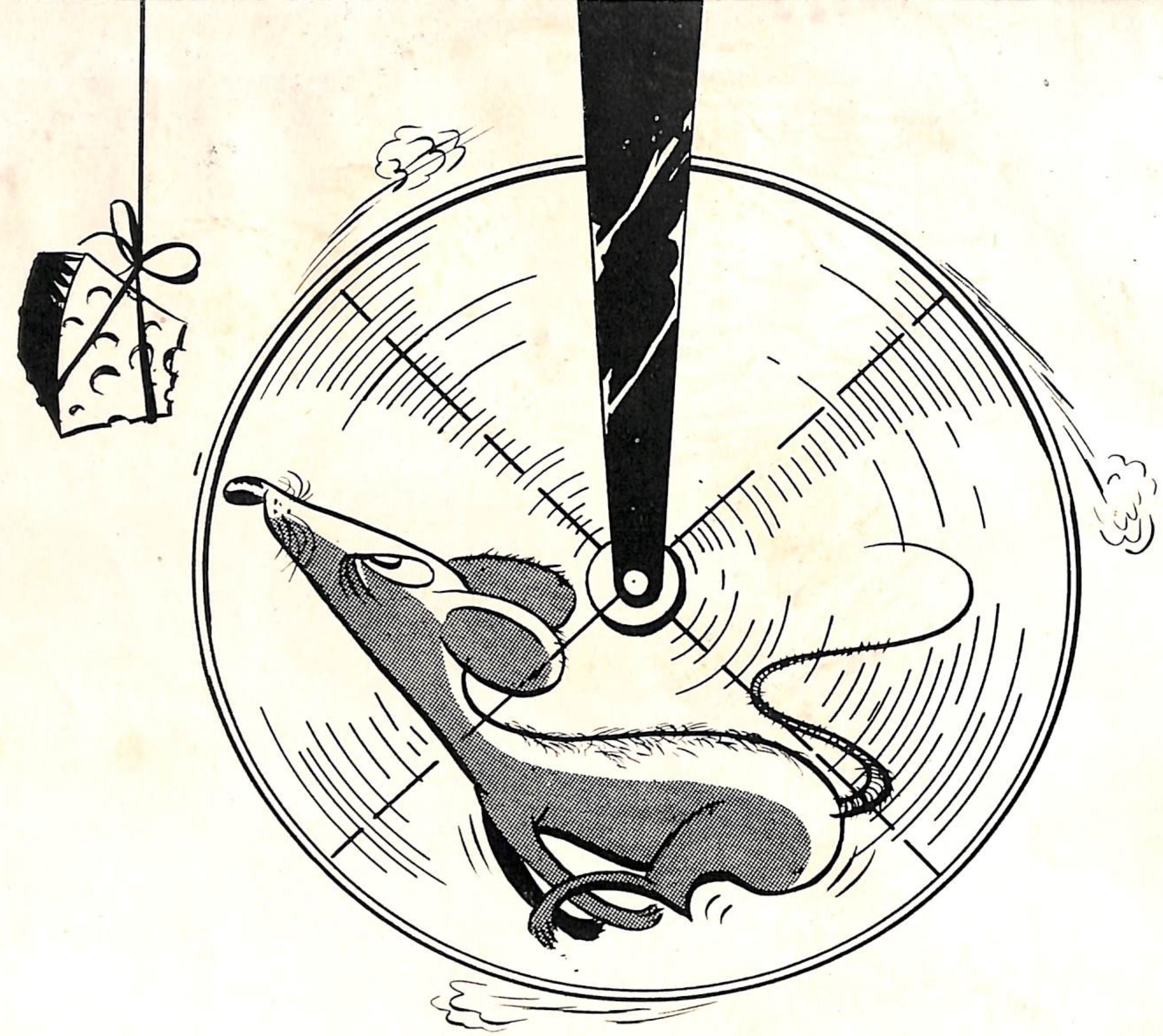
Although this system is considered an interim arrangement, the success of the operational tests so far conducted indicates that it should prove of major assistance to carriers faced with all-weather operations.

Closeup of precision-control console panels showing air speed indicator, control scope, and communication controls. →



The precision-control antenna mounted under the after end of the flight deck of the Solomons.





The Rat-Race Duplexer

■ The development of the rectangular magic tee (see page 16, last month's ELECTRON) and its application to the so-called magic-tee duplexer suggested the possibility of a duplexing system in which only *E*-plane junctions would be necessary. After considerable research and many experiments, such a duplexing system was developed and tested by the Radiation Laboratory at M.I.T. For want of a better name, and because of its physical appearance, the unit was called the *rat-race duplexer*. This duplexer consists of a circular ring of waveguide 1.5 guide-wavelengths in circumference at the center of the narrow dimension, with four rectangular waveguide branches brought out so that the spacing between them is ¼, ¼, ¼ and ¾ wavelengths, or 60°, 60°, 60°, and 180° in circular spacing. Figure 1 is a cross-sectional view of the completed rat race, dimension *a*, the narrow side of the guide, being 0.40″ for the X band. The narrow dimension of the ring is made

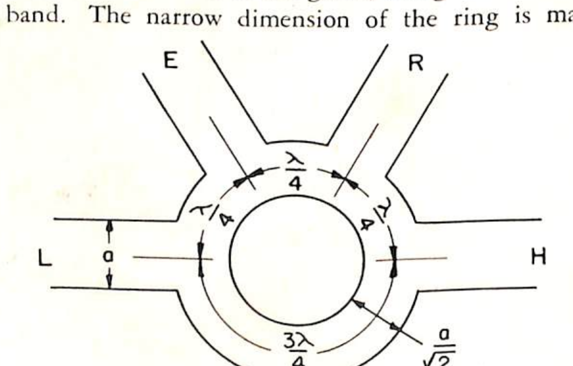


FIGURE 1 — *Waveguide-constructed rat-race duplexer illustrating wavelength spacing between individual branches. Dimension* a *is the narrow dimension of the waveguide.*

equal to $a/\sqrt{2}$ or 0.281″. The wide dimension *b* of all four branches, as well as the ring section, is 0.9″.

From information concerning *E*- and *H*-plane functions we know that power sent in the *E* arm will divide between the two adjacent arms, but the electric field or *E* lines will be opposite or out of phase with respect to the junction at points equidistant from the junction. Figure 2 illustrates the action of the duplexer when power is sent into the *E* arm. The arrows represent the direction of the electric field, neglecting the variation of the field with time and distance and showing only its variation in one arm with respect to the corresponding point in the other. It is pointed out that the direction of the arrows or *E* lines is opposite at the entrances to the *L* and *R* arms, indicating out-of-phase waves at the junctions of these arms with the ring. This is the desired condition because both are *E*-plane junctions and, to be excited, it is necessary that the approaching waves be out of phase. Not only are the waves approaching either the *L* or *R* arms out of phase with each other, but the waves which progress outward along these two branches are also out of phase with respect to each other.

Any power which leaks by the *L* and *R* arms will be equal in amplitude but opposite in phase when they leave these respective arms. Since the distance from *R* to *H* is a half wavelength less than from *L* to *H,* the wave from *L* to *H* will travel a half wavelength further, which will make the two waves in phase upon arrival at the *H* arm. An *E*-plane junction can not be excited by an in-phase field; therefore no power will go out the *H* arm.

If power is sent into the *H* arm, as shown in figure 3, the two waves start from the junction out of phase, but one wave travels an extra half wavelength before reaching the *E* arm; therefore upon arrival at the *E* arm they will be in phase and this arm will not be excited. However, arms *L* and *R* will be excited because the two waves which approach these two junctions will be out of phase, but the waves proceeding out arms *L* and *R* will be in phase with respect to each other. Thus we have developed a device which divides power equally but out of phase between arms *L* and *R* with no power out arm *H* when power is introduced into arm *E* and, conversely, it will divide power equally but in phase between arms *L* and *R* with no power out arm *E* when power is introduced into arm *H*.

In order that this device be a magic tee, there must be a match looking into arms *E* or *H* when matched loads are connected to arms *L* and *R*. All the junctions are *E*-plane series junctions and, according to theory, impedances add at *E*-plane junctions. Consider the case where, with matched loads on *L* and *R,* power is sent into arm *E*. At the junction of *H* and the ring there

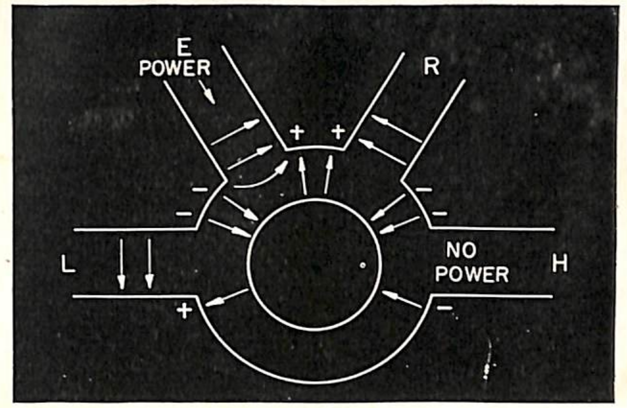


FIGURE 2—*Rat-race duplexer showing power sent into arm E dividing between arms L and R with no power going out arm H due to energy arriving at that arm in phase.*

are two in-phase waves of equal amplitude traveling in opposite directions in the ring so that the voltage distribution at arm *H* is symmetrical and *H* is not excited. The impedance at this point corresponds to an open circuit where the voltage is a maximum. Since the impedance at the entrance to the *H* arm is infinite, at a point ¼ or ¾ wavelength away, where the *L* and *R* arms join the ring, the impedance due to the *H* arm is zero. In general, the impedance of a waveguide is directly proportional to the narrow dimension *a* when the *b* dimension and frequency are held constant.

If it is considered that the characteristic impedance of all the four standard waveguides (branches) is unity (or 1), then the impedance at the junction of *R* and the ring is unity with respect to the *R* arm (looking into the *R* arm from the ring). Since the impedance is directly proportional to the narrow dimension of the waveguide (assuming *b* and frequency held constant) we can substitute 1 for *a* in the relationship between the narrow dimensions of the standard waveguide and the ring respectively. Thus the characteristic impedance of the standard guide will be assumed as 1 and the impedance of the ring will accordingly be $1/\sqrt{2}$.

At the junction of *E* and the ring, the impedance will be ½ looking into the *E* arm. This impedance can be shown by assuming the ring as a quarter-wave matching section between the *E* and *R* arms and applying the conventional impedance-matching formula. Let Z_e, Z_o, and Z_r, represent the impedances of the *E* arm, the quarter-wave ring between the *E* and *R*, and the *R* arm respectively. Then we can write the equation $Z_o = Z_e \times Z_r$, or $Z_e Z_r = (Z_o)^2$. Substituting the values of impedance assumed for these components, we have $Z_e \times 1 = \left(\frac{1}{\sqrt{2}}\right)^2$ or $Z_e = \frac{1}{2}$. This is the impedance at the junction of the *E* arm due to the action of the *R* arm. Likewise, the impedance at the junction of the *E* arm will be ½ due to the action of the *L arm*. Since these are *E*-plane junctions in which impedances add, the total impedance seen looking in arm *E* will be the sum of that from the two adjacent arms (*L* and *R*) transferred to the center ring. Therefore the device is matched looking into arm *E*. In a similar manner it can be shown that it is matched looking into arm *H* with matched loads on arm *L* and *R*.

For use in a duplexer, this type of magic tee is more practical than a rectangular magic tee. The only high fields are those in the *E*-plane series junction caused by the sharp corners, but these can be rounded. No irises need be used, the only matching device being the change of impedance of the center section. The TR tubes can be put quite far away from the junction and the magnetron standing-wave ratio can at the same time be made low over a wide band. (By magnetron standing-wave ratio is meant the standing-wave ratio seen by the magnetron when the TR tubes are fired and a matched load is placed on the antenna arm). This is not possible with the rectangular type of magic tee.

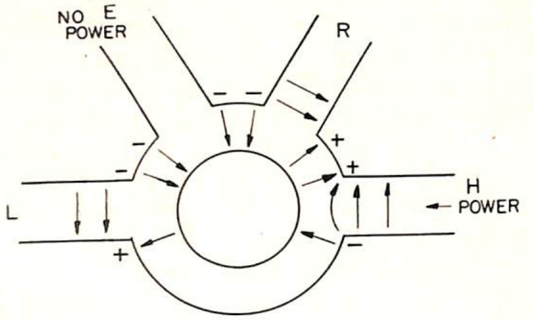


FIGURE 3—*Division of power between L and R arms with input through arm H. Wavelength spacing prevents any power being sent out arm E. Note that this situation is the reverse of that shown in figure 5.*

In some applications it is advisable to have all the plumbing in one plane. This can be conveniently done by using the rat race, but not with the rectangular magic tee. Since the cancellation of power coming out arm *H* when power is sent into arm *E* with matched loads on the *L* and *R* arms is dependent upon a path difference of a half wavelength and, since this cannot be a half wavelength at all frequencies, the cross attenuation is frequency dependent. However, it is greater than 20 db over a 12-percent band, and is therefore suitable for use as a duplexer.

Voltage standing-wave ratio as a function of wavelength looking into the *E* arm and the *H* arm with matched loads on the *L* and *R* arms is shown in figure 4. It is to be noted from the symmetry of the device that we might match the loads from the *L* and *R* arms to the *E* and *H* arms and get the same results looking

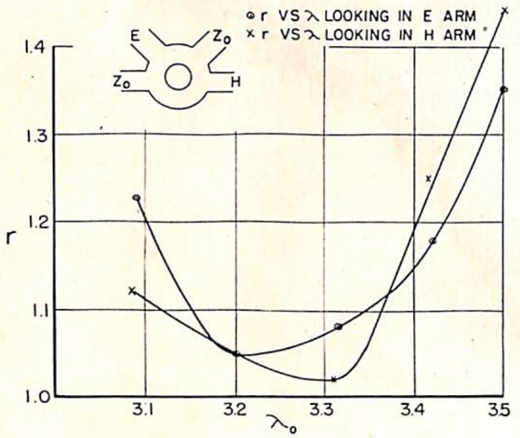


FIGURE 4—*Standing-wave ratio versus wavelength for X-band rat race with matched loads on adjacent arms.*

in *R* and *L* as we now get looking in *E* and *H*. This type of symmetry is not met in the rectangular type of magic tee. Figure 5 shows the cross attenuation as a function of wavelength. This we define as the ratio of power which comes out arm *H* to the power fed into the *E* arm with matched loads put on the *L* and *R* arms. The same symmetry conditions hold here as for the standing-wave-ratio case. In the rectangular magic tee, with perfect symmetry and identical loads, the curve would show infinite cross attenuation for all values of wavelength between the *E* and *H* arms with matched loads on *L* and *R*.

Another question which presented itself was the achievement of a low magnetron standing-wave ratio over a broad band. Assume we have a magic tee that is perfect over the 12-percent X band (3.13 to 3.53 centimeters); that is, the cross attenuation is infinite over the whole band and the match looking in both the *E* and *H* arms is $r = 1.00$ over the same band when matched loads are put on the *L* and *R* arms. Then if we put the TR tubes in arms *L* and *R* spaced a quarter wavelength (at 3.33 cm) from the junction, the magnetron match will be perfect at 3.33 cm, but will rise to a voltage standing-wave ratio of 1.5 at the edges of the band due to the fact that the spacing between the

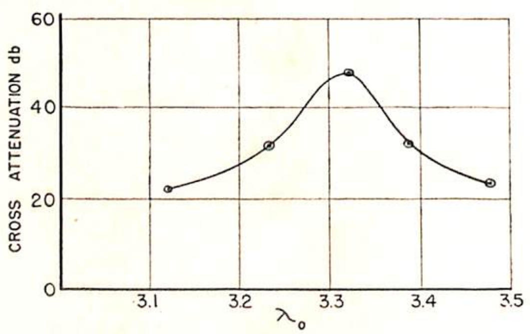


FIGURE 5—*Ratio of power in H arm to power out E arm with matched loads on L and R arms.*

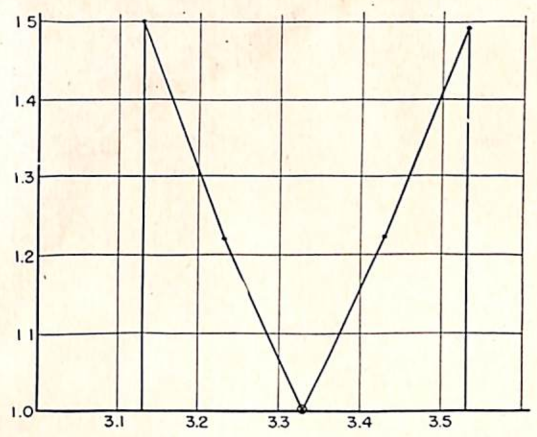


FIGURE 6—*Theoretical magnetron standing-wave ratio for "perfect" magic tee with TR spacing of one quarter wavelength at 3.33 centimeters.*

two TR boxes is no longer a quarter wavelength at these border frequencies.

As can be seen from the performance curves in figures 4 and 5, the rat race is practically a perfect tee at the center of the band. For the rat-race type of waveguide magic tee, it turns out that if the TR tubes are placed a quarter wavelength apart for the center of the band, then the reflection at the middle of the band will be low. At the edges of the band, the reflection caused by the spacing not being a quarter wavelength can be cancelled with the combination of the reflection caused by the mismatch of the tee when looking into matched loads and that due to the imperfect cross attenuation found at the edges of the band. This mismatch caused by moving one of the TR's away from the quarter-wave position can be calculated, but the process is beyond the scope of this discussion. If the nominal guide wavelength is 2.00″, these calculations disclose that if one of the TR's is moved by 0.015″ the magnetron standing-wave ratio will be changed by 0.10; for example, from $r = 1.00$ to $r = 1.10$. The magnetron standing wave is a function of four effects: the match of the *H* arm to the *L* and *R* arms, the spacing of the TR tubes from the junction, the match between the *E* arm and the *L* and *R* arms, and the cross attenuation between the *E* and *H* arms. Since the rat-race tee is practically perfect at the center of the band, then any spacing of the TR tubes a quarter wavelength apart for the band center will give a nearly perfect match for the magnetron standing-wave ratio. The positioning of the TR tubes can then be adjusted so that match is achieved at the band center and so that the four effects add to give good match at the band edges.

As mentioned above, the inside corners of the *E*-plane waveguide junctions must be rounded in order to withstand high power. Great care has been exercised in this rounding process, which includes milling the waveguide slots with a 0.4″ milling cutter to make a junction with the inside section and then running a 0.5″ cutter partway down the same slots as shown in figure 7. The waveguide which fits into this slot is then specially machined for an accurate fit. The method of double milling offers the advantage that the inside corners can be rounded before the waveguides are soldered into place, thus offering the possibility of a better finish for high power. This may seem like a lot of extra work, but tests have proven that duplexers with high-power rat races of the type discussed have handled up to 420 kw peak power, while those with no corners rounded withstand only about 80 kw of peak power.

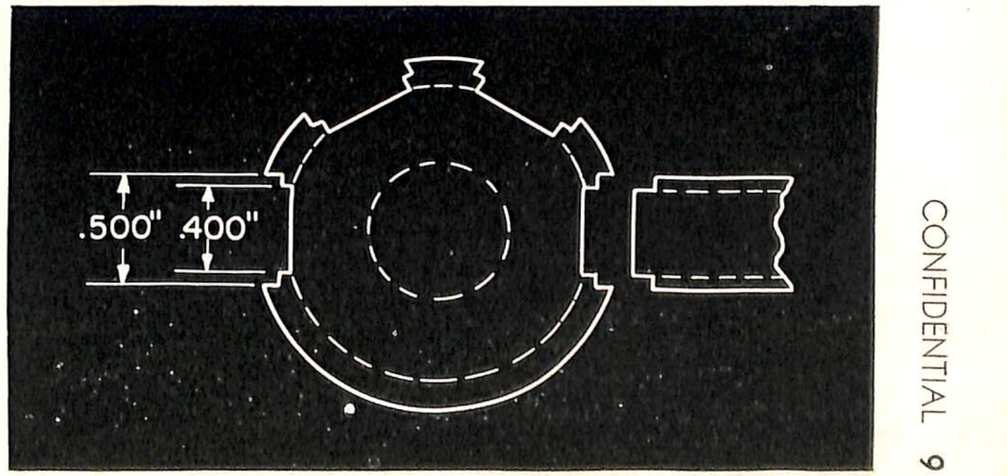


FIGURE 7—*Cross-sectional sketch of the center ring of the rat-race duplexer showing the dimensions of the waveguide junctions with the ring as well as the smooth contour at these junctions.*

QDA TROUBLE

All units of the Model QDA Depth Determining Equipment aboard a DE were inspected and found functioning normally except the receiver, which performed as follows:

- Test bias: normal
- Sum channel: normal
- Dif channel: low
- Withholding loss: high
- Preliminary phasing: could not be made
- Up-down deflection: unsatisfactory
- 50-db pad and 60-db attenuator: low
- Final phasing: could not be made
- Overall sensitivity: low
- Output meter: periodically swinging to a very high reading.

The periodic swinging of the output meter indicated a loose connection in the system, causing an electrical disturbance. A check of the main terminal board of the transceiver power cabinet showed that the plate power lead, terminal #39, had not been soldered when the equipment was installed. This connection was soldered and the receiver rechecked. This corrected the periodic swinging of the output meter.

A check of the bias voltage supplied by threshold potentiometer R-718 to audio detector V-706 disclosed that when the receiver was driven during keying, the bias increased. V-706 was found to have a shorted grid. Further inspection disclosed that V-708 drew grid current, and under prolonged excitation, the grid became incandescent.

The receiver in the equipment was replaced with a new one from the Fleet Sonar School. Since it acted the same under test as the original receiver, the external circuits to the receiver were suspected. The test circuits in the cabinet aboard the ship were inspected, and the UP-DEFLECTION switch was found to be making bad contact. This was corrected. Further inspection of the test circuits did not disclose any other discrepancies. The receiver was then re-checked and found to be operating normally. It is suspected that the trouble is either intermittent or was accidentally cleared during the investigation of the test circuits.

The QDA stylus of the depth recorder was not returning to zero position. Investigation showed that the drive shaft to the clutch was bent so as to require machine truing, and that the cord pulley disk had worn, thus reducing the reluctance gap and allowing the disk to be held in by residual magnetism during the flyback period. These conditions were corrected and flyback was then normal.

The shear pin of the hoist-tilt unit failed. This pin was smaller than standard size. Prior to its failing, the hoist-tilt unit was hunting continually. This was traced to a poor contact feeding the 36x order of Eq through the type JBR switch to the computer.

—*E.F.S.G.*

MARK 23 MOD 0 COMPUTER

The Mark 23 Mod 0 Computer installed aboard a DE failed in operation due to the burning out of the resolver that takes the relative sound bearing. There were no spare booster or motor amplifiers available and, due to the compactness of these amplifiers and the lack of schematic diagrams, it is not possible to effectively repair them in the field.

After much search, a new Mark 23 Mod 2 Computer was located. Inspection showed that parts from the two computers are not interchangeable. In view of this, it was decided to install the new computer. In this connection it should be pointed out that a considerable amount of the time spent in placing this equipment into operating condition could have been saved if correct schematic diagrams, ship inter-wiring prints and correct instruction books had been available.

—*E.F.S.G.*

Electronic Spare-Parts Program

■ With the gradual increase in the size and complexity of shipboard electronics installations, it has become apparent that the system of providing boxes of spare parts for each equipment (regardless of the number of similar equipments installed) is wasteful, space and weight consuming, expensive, and generally unsatisfactory. For example, a TDZ installation involves not only a consideration of the transmitter itself but the 9 boxes of spares that go with it. However, if we are to install 26 TDZ transmitters we are confronted with the possibility of having to stow 234 spare-parts boxes for the TDZ only!

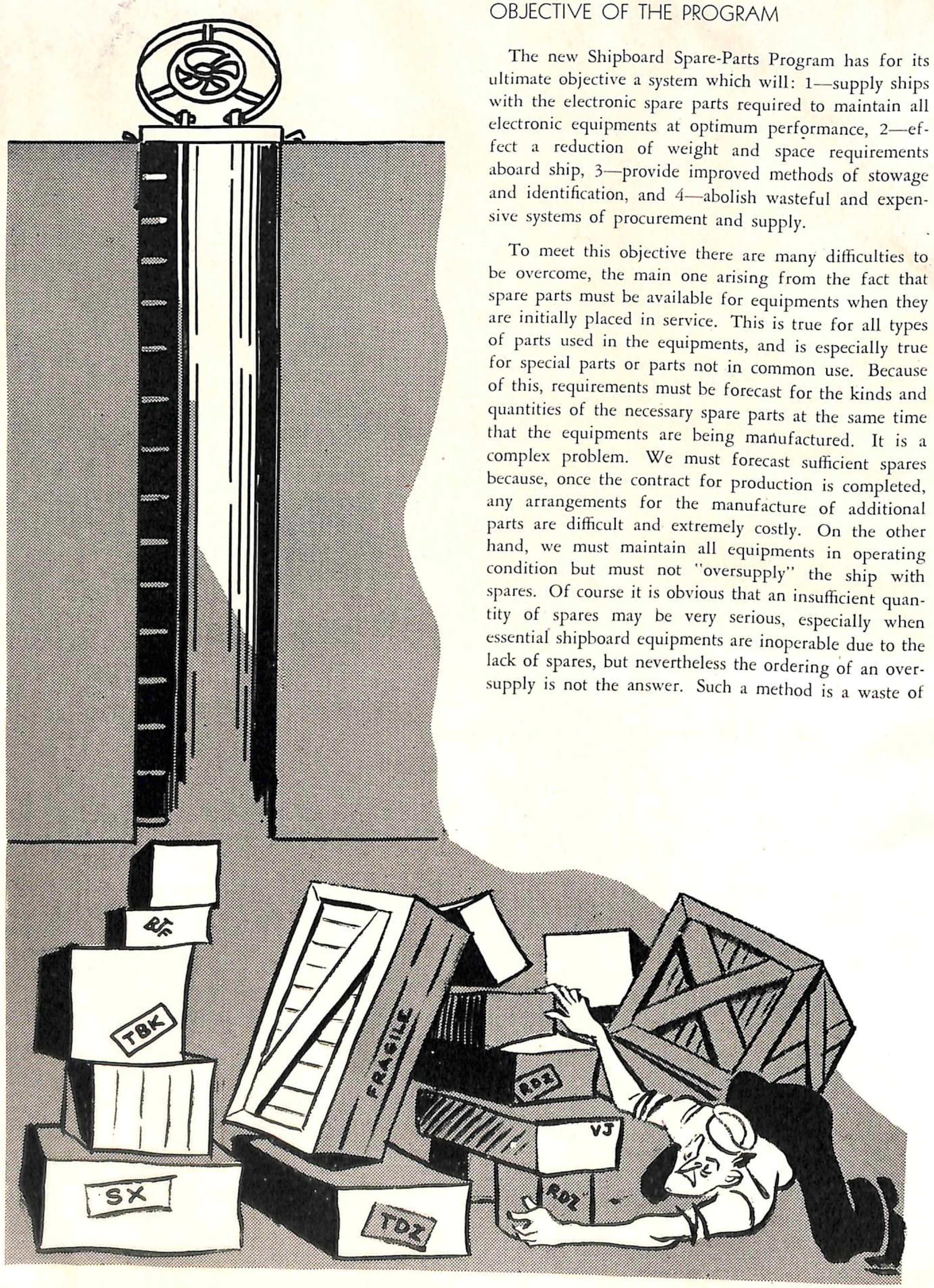
In October 1945 CNO convened a conference of representatives from various bureaus and other agencies to discuss the spare-parts situation. It was found that for every 100 persons there were at least 150 ideas on what a spare-parts system should be. The conference ended in a "we don't know what we want, but we want it" spirit, with BuShips commissioned to study the problem and, if possible, to do something about it.

There followed a series of letters in the Navy Department Semi-monthly Bulletin, R. I. B., etc., asking for opinions from the fleet. The response was more than generous, despite rapid demobilization, the famous *Magic Carpet* operation, inactivation of ships, *Crossroads,* and general all-around confusion.

The number of replies and the comprehensive thought used in framing those replies enabled the Bureau to work out a proposed system which should be a tremendous improvement over the present one.

The Bureau of Ships, as well as the fleet, had its demobilization and manpower problems, and found itself in the position of wanting to do something, knowing what it wanted to do without having the means to do it.

After a discouragingly long period, a start was made. Slow, to be sure, but it was a start. And while the infant organization is not yet able to carry on a man's job, it is well beyond the toddling stage. The schedule of its progress is laid out; it is trying to achieve a goal, and to repay the fleet for its cooperation and interest.



OBJECTIVE OF THE PROGRAM

The new Shipboard Spare-Parts Program has for its ultimate objective a system which will: 1—supply ships with the electronic spare parts required to maintain all electronic equipments at optimum performance, 2—effect a reduction of weight and space requirements aboard ship, 3—provide improved methods of stowage and identification, and 4—abolish wasteful and expensive systems of procurement and supply.

To meet this objective there are many difficulties to be overcome, the main one arising from the fact that spare parts must be available for equipments when they are initially placed in service. This is true for all types of parts used in the equipments, and is especially true for special parts or parts not in common use. Because of this, requirements must be forecast for the kinds and quantities of the necessary spare parts at the same time that the equipments are being manufactured. It is a complex problem. We must forecast sufficient spares because, once the contract for production is completed, any arrangements for the manufacture of additional parts are difficult and extremely costly. On the other hand, we must maintain all equipments in operating condition but must not "oversupply" the ship with spares. Of course it is obvious that an insufficient quantity of spares may be very serious, especially when essential shipboard equipments are inoperable due to the lack of spares, but nevertheless the ordering of an oversupply is not the answer. Such a method is a waste of materials, is costly, and on board ship requires additional space and cuts into the critical weight allowance. To sum this all up we can say that an accurate forecast is an absolute necessity if we are to reach the necessary happy medium.

Now to make an accurate forecast of the common spare parts requirements for a ship it is necessary to determine the type and quantity of all electronic equipment aboard that particular ship, the type and number of all in-use parts used in each equipment, and the expected life of each part and tube in use. This is accomplished by the bureau with the assistance of a mechanical tabulating machine system, the first step being the Ship's Electronic Inventory Report which was explained in the November 1946 issue of the ELECTRON. The next step in this project is to compile the number and type of all parts used in each of the equipments. This is also set up on a mechanical tabulating machine system in which a card is punched for each component part and tube in every type of electronic equipment. Each card will contain the type number of the part or tube and the model of the equipment in which it is used. When these cards are run through the tabulating machine, the quantity of every part and tube in use for any equipment or group of equipments is tabulated. With this information and that from the Inventory Report, it is possible to obtain mechanically the number of in-use parts and tubes aboard a particular ship.

We must now ascertain the expected life of each of these parts and tubes. It is at this point that the NBS-383 Failure Report Form is all important because, in addition to providing design and contractual adjustment information, it is also set up in the mechanical tabulating system for further spare-parts analysis. The cards are punched to contain the information taken from the failure-report forms; namely, Date of Failure, Equipment Model, Type Number, Manufacturer, Circuit Symbol, Type of Failure, Hours of Operation, and where failure occurred (Installation, Operation, etc.). These cards are then tabulated in various forms as required. Information is now in the proper form to be fully available to forecast accurately the spare parts required for any particular shipboard installation.

SPACE AND WEIGHT

In order to provide adequate spares to meet the maintenance requirements and at the same time reduce the weight and space of the present spare parts allowance we must, first, group-stock all components, parts, and tubes which are considered common items; second, provide parts and tubes to cover an operating period of, say, three months, and keep large-quantity items at the minimum-stock level; third, standardize electronic parts and tubes; and, last, remove all obsolete and non-failing items from the allowance.

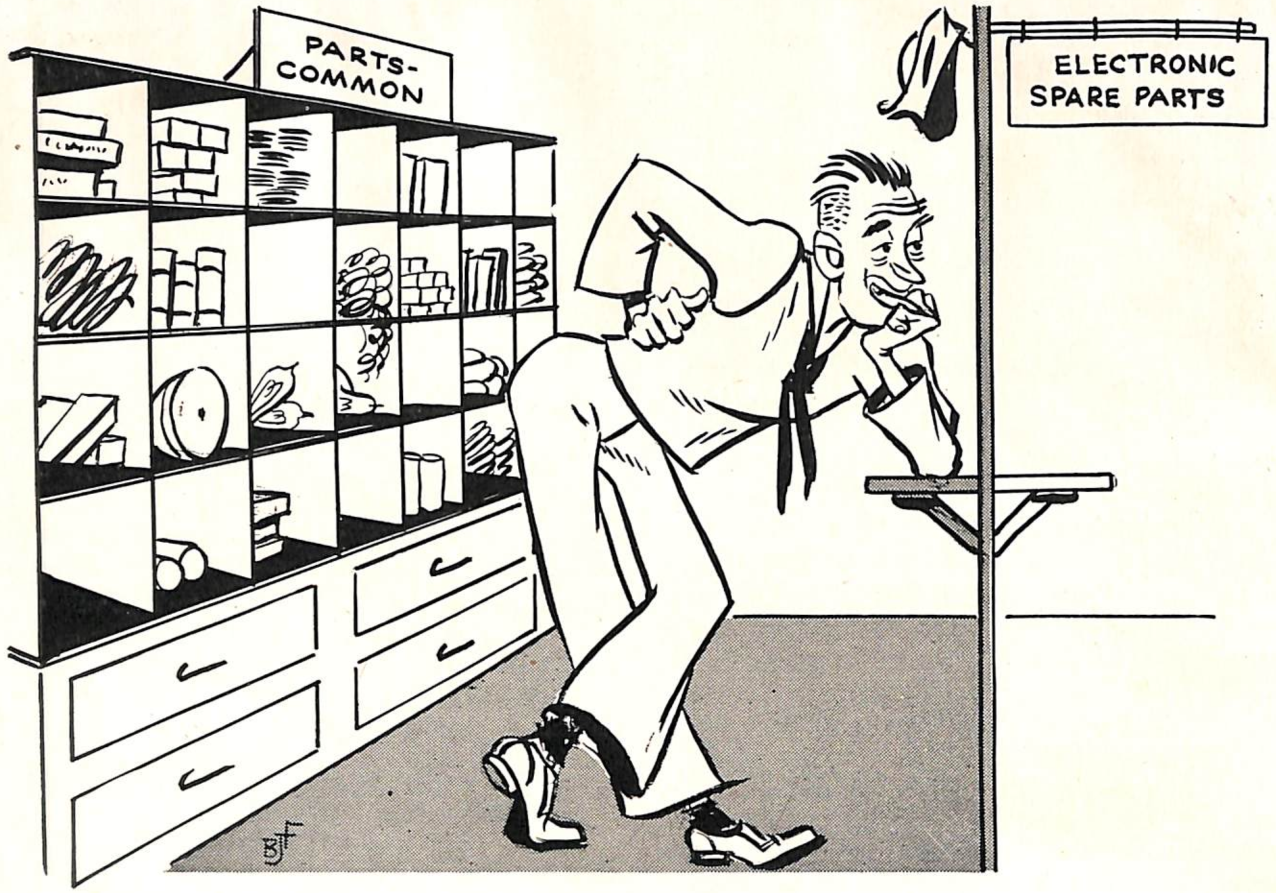
In the proposed spare-parts system the spare-parts allowances are separated into two distinct groups, namely, *parts-common* and *parts-peculiar*. A *part-common* is an item whose physical, electrical, and mechanical characteristics conform to federal, military, or approved commercial specifications and is suitable for use in two or more shipboard electronic equipments. It is distinguished by its high degree of interchangeability. A part-common may be either a standard-stock or BuShips-controlled item, and can usually be procured from several manufacturers. A *part-peculiar* is an item designed specifically for a particular piece of equipment. Although another part may conform with general material specifications, it will not conform to detail specifications covering that item alone due, for example, to physical size, shape, location of mounting holes, etc. An item in this category is distinguished by its uniqueness, but may eventually become a part-common through widespread usage. Parts-peculiar are usually procured from the manufacturer of the basic equipment of which it is a component part.

Parts-peculiar items will be the only ones furnished as equipment spares with the major equipments. The parts-common will be group-stocked aboard ship in suitable fashion, thereby eliminating most of the bulky and heavy spare-parts boxes now used to stow equipment spares.

If special operations require a longer period than, say, three months, the quantity can be increased in the proper proportions. When the items are group-stocked the quantities can also be lessened when large amounts are involved. For example, it may be considered necessary to supply two of a particular item to maintain one equipment, but when the item is used in ten other equipments an allowance of ten (or even six) may be adequate instead of twenty.

New equipment specifications require the use of approved navy-type component parts, and special effort is being made in the design of equipment to select parts which are interchangeable with other parts in the equipment, thereby reducing the number of different types. If a new part is required that has not been previously approved, the equipment manufacturer is required to justify the use of this new-type component. Before its use will be approved the Bureau investigates the component field for a possible substitute for this item.

The next attempt to reduce weight and space is the removal of obsolete and non-failing items from the allowance. Periodically, the allowances must be reviewed for accumulation of obsolete, non-moving and oversupplied items. Obsolete items may be due to a new field change which was made to the equipment and



thereby made the original spare for the replaced items to be in excess. Non-moving items may also be due to improvements in the manufacture of the part. Oversupply is usually the result of no failure data being available on the item, and estimates that are based entirely on judgment or information which did not apply to the particular application.

STOWAGE AND IDENTIFICATION

That part of Chapter 31, Bureau of Ships Manual, pertaining to the stowage of electronic spare parts is being revised. The revision is as follows:

"**Electronic Parts:** When selecting the stowage spaces a number of factors must be considered, such as proximity to the equipments to be serviced, the adequate availability of spares for repairs during battle conditions, together with ease of accessibility, ready identification, etc. As far as practicable, spare parts in the high-failure-rate category which are necessary for the rapid repair of equipments should be located in the same compartment as the equipments and in easily-accessible and plainly-marked stowages such as drawers, lockers, etc. This is especially applicable to spare *parts-common* such as fuses, condensers, brushes, etc., and spare electron tubes which by their nature lend themselves to rapid repairs which must be effected during battle conditions. Spare *parts-peculiar* which fall into the foregoing category should also be stored in the same manner. Additional parts-common and electron tubes for supplementing the parts located near the equipments, plus those parts-peculiar too bulky for stowage at equipment locations or too difficult for ready installation shall be stowed as follows:—In seagoing vessels, except submarines, the stock of spares not stowed near equipments will be stowed in storeroom stockbins as practicable. They will be divided into two or more equal stowage lots as widely separated in a forward and after distribution as is compatible with the ship's plan, in order to avoid total loss of spares if one section suffers severe damage. The Bureau has separated the spare parts allowances into two distinct groups, namely, 'parts-common' and 'parts-peculiar'.

"**Electronic Parts-Common:** The allowances of parts-common as specified by the Bureau shall be group-stocked aboard ship in suitable bins and lockers. The overall ship allowance of such parts-common will be determined from failure probability considerations of the total number of installed parts based on the types and quantities of equipments installed on board.

"**Electronic Parts-Peculiar:** The electronic equipment allowance of parts-peculiar shall be retained in the spare-parts containers in which they are received. These containers should be stowed as near as possible to the major units of the equipments in which they are used in order to facilitate rapid servicing. When the basic equipment is removed or installed in another location, the spare parts-peculiar to that equipment shall accompany it."

As for identification, there is considerable work now in process to provide a cross-reference catalog for all shipboard electronic equipments. A Navy contract has been given to the Remington Rand Company to compile data and provide the necessary detailed information. This catalog will give a complete description of the parts in accordance with the Joint Army-Navy Manual of standard descriptions (JANP 109) and will cross-reference Navy type numbers, manufacturers' numbers and all other stock numbers that have been assigned to the part. The problem of clarifying descriptions and cross-referencing all the component part numbers for over two thousand different types of shipboard electronic equipments is a major task. In fact, it took thirty-five Naval technical personnel almost two years to gather the data from the field, and fifty employees of the Remington Rand Company a year to compile this information in preparation for cataloging. However, it is expected that this cataloged information will be ready for distribution in October of this year.

TUBE ALLOWANCES

While work is underway for the establishment of new spare allowances for component parts there is also considerable work being expended in the establishment of new tube allowances for the same equipments. All steps covered in the above paragraphs are also applicable for tube allowances with the exception of the cataloging and cross-referencing which is already available. A tube allowance for a DE-class ship based on the new system has been completed and it was interesting to note that the old allowance based on the per-equipment basis called for 957 tubes, while the new allowance based on group-stocking and average-tube-life basis totaled only 532 tubes. This is a 44% decrease in quantities of tubes required aboard this ship. In the compilation of this new allowance at least 200% spares were allowed when long-life tubes were used in small quantities (more allowed on short-life tubes) while the old allowance only permitted a straight 100%. The new allowance doubled the tubes used in small quantities but, despite this, the overall allowance was reduced to approximately one-half by cutting down on the common-long-life tubes used aboard ship in large quantities. Tube complements for all equipments are being compiled for handling on mechanical tabulating machines and it is expected that within 60 days a steady flow of new tube allowances will be sent to ships. Allowances for tenders and electronics maintenance vessels will in time also be computed from this source of information.

COOPERATION NEEDED

The success of the entire Electronics Spare Parts Program is in direct proportion to the fleet's cooperation in properly setting up the new allowances when received, in the submission of the Electronic Equipment Failure Reports (NBS-383) and especially in the prompt and accurate submission of the Ship Electronic Inventory Reports when changes are required. The Bureau also utilizes the stock and issue data available at the Electronic Supply Offices. With this information the Bureau is in a good position to forecast the exact requirements of the fleet. In order that all hands may be well informed the Bureau will supplement this information as the program progresses and as new problems are encountered. This article was written to inform all hands of what has been done in the spare parts problem and to prevent activities from unknowingly duplicating the work in the field. Activities having recommendations, suggestions, comments, and criticisms that will assist this program are requested to forward them to the Bureau of Ships, attention Code 980.

No nameplate, no tag, no number. What the heck is it?

DATE MARKINGS ON ELECTRONIC EQUIPMENT

■ During the war the Joint Security Control directed that all forms of date markings, such as date of contract, date of manufacture, date of acceptance, etc., should be omitted from all electronic equipment for security reasons. This was later modified several times to permit coded dates, dates on components, dates on tubes, dates on commercial units, etc., to satisfy unforeseen conditions arising due to the application of the original directive.

The Joint Security Control has recently amended their policy on the date marking of electronic equipment and the following is quoted from their letter JSC/L21-3 dated 19 November 1946 and received via the Chief of Naval Operations:

a. No markings which indicate date of manufacture, either coded or uncoded, shall be permitted on any electronic systems, equipments, units or removable assemblies, except as provided in paragraphs b and c below.

b. Appropriate date markings shall be permitted on component parts of electronic equipment when necessary for quality control, production or maintenance purposes.

3. Service agencies shall be permitted to affix appropriate date markings on electronic equipment when required in connection with servicing, overhaul and preventive maintenance work.

NOTE: It is to be understood that the above policy does not prohibit the use of code designations for the fiscal year of purchase order on nameplates of equipment.

It should be noted that the above policy *permits* the application of uncoded dates in connection with servicing, overhaul and maintenance work on equipments. Such dates are very desirable, and sometimes essential, in the proper accomplishment of routine overhaul and preventive maintenance on certain types of electronic equipments. The Bureau encourages the application of such dates, along with the appropriate information, in all instances wherein the application of such information is presently specified in existing instructions and also in all other cases where the information might be of value to repair, overhaul and maintenance personnel. It is frequently necessary or desirable to know the date on which a Field Change (modification) was made on an equipment, when it was last overhauled, when last lubricated, when last inspected, etc., without referring to logs or records, which may or may not be available.

The form of information and the method of application will vary considerably to suit the specific equipments and units involved, therefore, a uniform procedure or method cannot be specified herein. However, the marking should be legible, prominent, and of sufficient permanence to insure existence during the expected period of usefulness.

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REPLACING TUBES IN THE MAR EQUIPMENT

Navy model MAR radio equipments make use of tubes with 6.3-volt heaters but, due to the fact that the primary heater voltage of this equipment is 13 volts, the tubes are connected in series-parallel to supply them with their rated voltage. However, in this arrangement the removal of any one of the tubes with power on causes excessive heater voltage to be applied to the other tubes in the circuit. This fact is particularly true in the case of the 2C39 tubes in which the removal of one causes the heater voltage of the other to rise to 8.5 volts, and overloads the filaments.

It is therefore recommended that all personnel assigned to the maintenance of the MAR equipment take the special precaution of turning the power off before removing any of the 6.3-volt tubes from their sockets, and leaving it off until the defective tube has been replaced.

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CRYSTAL OVENS FOR UHF EQUIPMENTS

Production of crystal ovens for models MAR, RDR, RDZ and TDZ radio equipments has been stopped because of trouble experienced with the associated thermostats. However, the manufacturers have been permitted to ship certain of the above equipments less the crystal ovens until such time as adequate supplies become available. The cognizant Inspectors of Naval Material have been advised to keep a record of such equipment in order that ovens may be shipped to proper destinations at a later date.

The following table indicates the equipment models, approximate quantity shipped to date without ovens, and the dates subsequent to which the contractors were permitted to ship equipments less ovens. The equipments and spares in this category are plainly marked "Crystal ovens required to complete the equipment".

Equipment	Approximate Quantity	Date
RDZ	220	14 Jan. 1947
RDZ-1	1189	21 Nov. 1946
TDZ	496	31 Dec. 1946
MAR	817	22 Nov. 1946
RDR	485	22 Nov. 1946

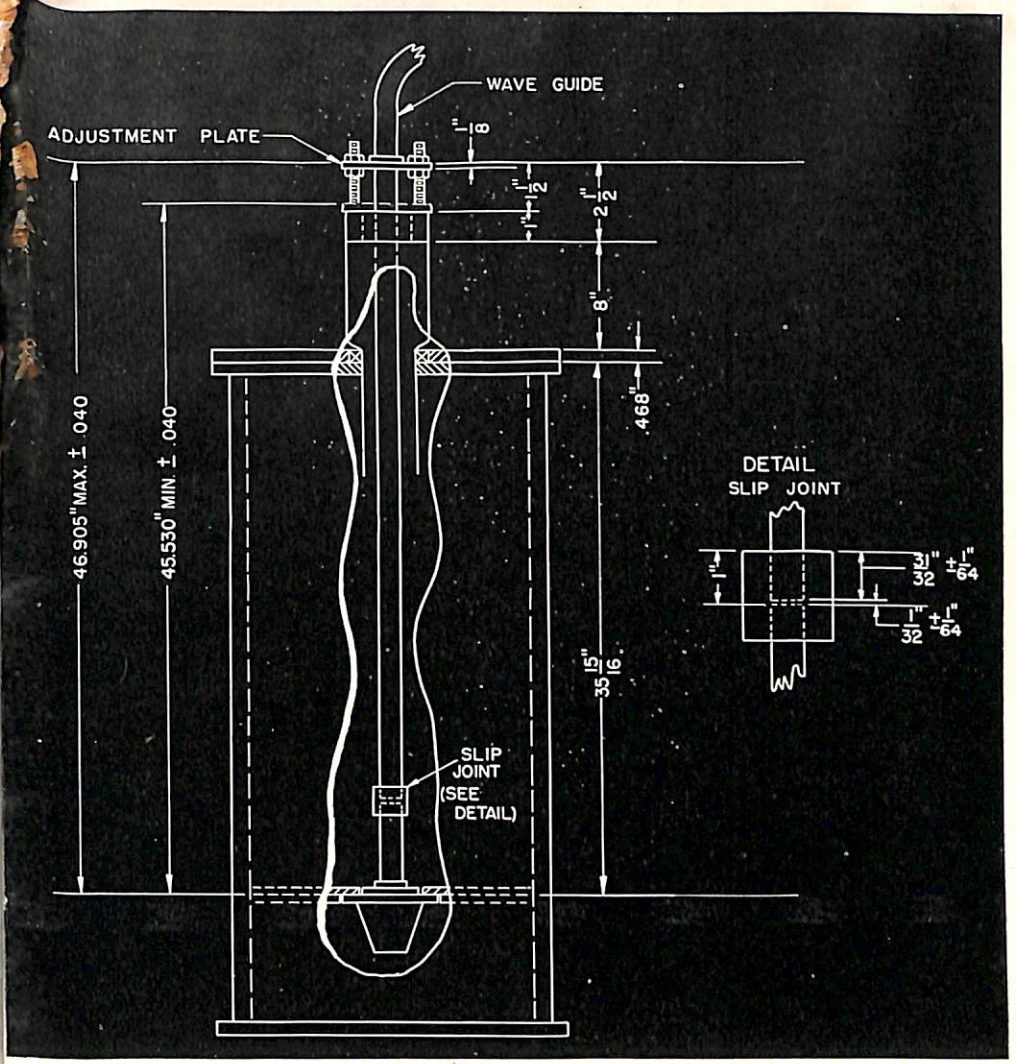


FIGURE 1—*Mark 57 Mod 2 Gun Director with details of slip joint.*

Waveguide Installation on Mark 34 Radar

■ Field service engineers and installation activities have reported that in some instances it has been impossible to assemble the waveguide correctly in the Gun Director Mark 57 Mods 2-5 for the installation of the Mark 34 Mods 3, 4, 7, 8, 9, 10 and 12 radars. Investigation has revealed that when the waveguide has been installed in accordance with the applicable drawing (BuOrd Dwg. No. 493060), the range of adjustment provided by the "adjustment plate" (see figure 1) at the top of the director pedestal is not sufficient to permit butting of the waveguide parts in the slip joint. In some cases the extreme position of adjustment has left a gap of ¾ inch instead of the specified $\frac{1}{32} \pm \frac{1}{64}$ inch (see detail "A" of figure 1). This results in a serious mismatch in the line and in some instances has very seriously reduced the ranging capabilities of the equipment when not discovered at the time of installation.

The build-up of dimensions as taken from director manufacturing drawings (see figure 1) indicates that factory fabricated waveguide parts should install properly without alteration. However, since this director is no longer in production and does not lend itself to field modification, it may be necessary that the parts be modified to provide the required clearance in the slip joint.

It is therefore requested that all installations of Gun Fire Control System Mark 57, of which a Radar Equipment Mark 34 Mod 3, 4, 7, 8, 9, 10 or 12 is a part, be inspected to determine that the waveguide parts in the gun director are correctly assembled in acordance with BuOrd Dwg. No. 493060. Special attention should be given to the slip-joint detail. When inspection reveals that the specified clearance in the slip joint cannot be achieved by means of the adjustment plate, the section of waveguide running from the adjustment plate to the slip joint (see BuOrd Dwg. No. 493069-3) should be replaced by a similar section 39¾ inches long.

It is further requested that all activities planning installations of this gun fire control system take the necessary steps to fabricate, at the time of installation, the replacement section for part No. 493069-3 if required.

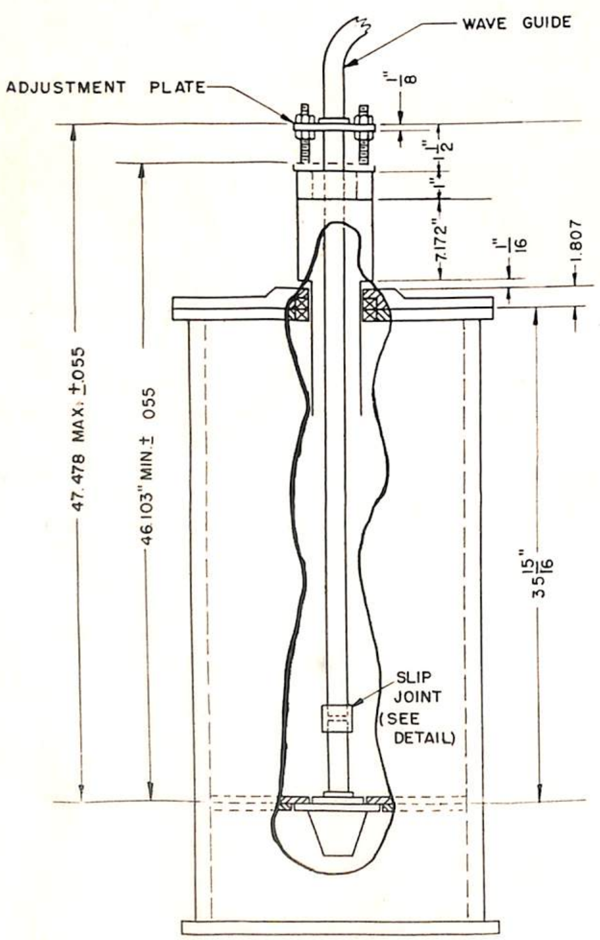
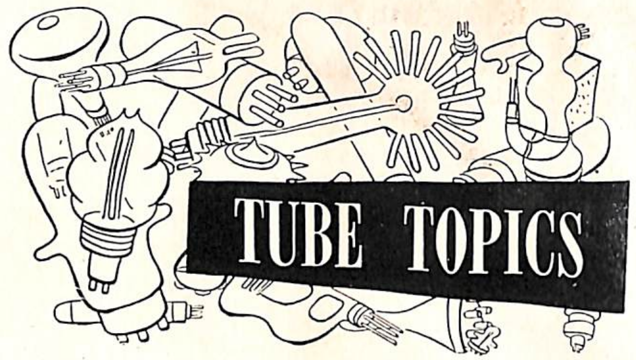


FIGURE 2—*Mark 57 Mods 3, 4, and 5 Gun Director showing adjustable waveguide section and slip joint.*



THERE WILL BE MUSIC

The Bureau authorized a modification to replace the 6X5-GT rectifier tubes which were causing considerable maintenance trouble in the RBO. The change, known as Field Change No. 2, provided a replacement power transformer which incorporates a 5 volt secondary winding. With this set-up 5Y3-GT/G rectifying tubes can now be used in place of the troublesome 6X5-GT and in that way provide more dependable operation. Instructions for accomplishing the change are included in the kit and it is considered that a technician should be able to make the change in approximately two hours.

This change was made available some time ago but there is always someone who comes out on the short end. For these unfortunate characters it may be interesting to know that an additional quantity of these kits were procured recently on contract NObsr-30032X. They were distributed to the Supply Officer in Command at Mechanicsburg, Penna., and the Supply Officer in Command at Clearfield, Utah. They are available from either of these activities on request.

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ZERO-SETTING RANGE UNIT ON MARK 13 MOD 0

Two sets of instructions are given in Ships 327 (Instruction Book for Radar Equipment Mark 13 Mod 0) for zero-setting the long-range unit of the Mark 13 Mod 0. When the method described in Section III Paragraph 8 is used it may result in the long-range unit giving errors of over 1000 yards at relatively short ranges. The method described in Section V Paragraph 9 results in a greater range accuracy, of the order of ±1% of measured range.

In order to assure the best range accuracy possible with the long-range unit, it is recommended that the zero-set adjustments for the long-range unit of the Mark 13 Mod 0 always be made in accordance with the instructions contained in Section V Paragraph 9 of Ships 327.

REVISED FCR BULLETIN

Bureau of Ships Bulletin 982-700 entitled "Requirements for the Preparation of Field Changes" has been issued and replaces the present bulletin of 1 September 1945, identified by the file number "Serial 982-700", and entitled "Instructions for Field Changes". Correspondence reaching the Bureau of Ships in the past three months indicates that a number of people concerned with the distribution of bulk field change instruction bulletins are not aware that the distribution list for these bulletins is contained in both the superseded and revised editions of Bulletin 982-700. Many Inspectors of Naval Material have been requesting the Bureau to provide distribution lists for each individual case where instruction bulletins become available for distribution. This time-consuming procedure is unnecessary as the distribution list in Section Four of FCR Bulletin 982-700 should be followed for all bulk-quantity bulletins, unless specifically advised otherwise by the Bureau.

The complete mailing or shipping addresses of the grouped activities on the list such as "all destroyer tenders", "all repair ships", "all Electronics Officers", etc., can be obtained from the "Standard Navy Distribution List—Part 1" and the "Distribution List for Electronics Activities—Special List 4". The latest revised issues of both these lists are furnished to all inspection activities and, therefore, the current lists should always be available at field inspection offices. If they are not already on file, copies should be requested. Copies of "Special List 4", however, are not available at the present time because the list is being revised.

REPORT THOSE UHF INSTALLATIONS

The Bureau of Ships again urges field activities to report all UHF installations. Page 18 of the October 1946 Electron carried an article requesting this information. The relatively few installations reported by installing activities during the past six months are listed below:

SHIP	EQUIPMENT
AF-28	1—MAR
AGC-5	2—MAR, 2—RDZ
AGC-7	2—MAR, 2—RDZ
AGC-11	2—RDZ, 1—TDZ
AGC-13	2—MAR, 2—RDZ
CL-66	2—RDZ, 1—TDZ
CL-91	6—RDZ, 1—TDZ
CL-104	2—RDZ, 1—TDZ
CV-36	2—RDZ, 1—RDZ
DD-748	2—RDZ, 1—TDZ
DD-807	2—RDZ, 1—TDZ
DMS-38	2—RDZ, 1—TDZ

The importance of reporting UHF installations cannot be overemphasized. Accurate up-to-date information as to the location, type, and serial number of these equipments is of extreme importance in the coordination of the UHF program with other vitally interested agencies such as the Army, CAA, Bureau of Aeronautics, and others.

Full cooperation in this important UHF conversion program is essential. It is requested that all installing activities report all completed installations that are not included in the above list, and that all future installations be reported promptly to Code 980, Bureau of Ships. This information should not be held up pending the report to the Bureau of the vessel's electronic inventory.

VJ USED AS MASTER INDICATOR

The model VJ radar repeater is shipped by the manufacturer as a master indicator for the model SG-6 radar and is included as part of the SG-6 contract. In the case of the SR-3 and SR-6 radars, no master indicator is shipped with the equipment but they are designed to use a model VJ (or its equivalent) as a master indicator. In view of the fact that no master indicator is furnished with these two equipments, a model VJ repeater (or equivalent) must be requisitioned prior to installation.

When model VJ radar repeaters are used as master indicators, they are to be considered part of the radar repeater allowance. They are to be reported separately when SG-6, SR-3, or SR-6 radar equipments are reported on ships inventory. Ships having SG-6, SR-3, or SR-6 radar equipment will have their radar repeater allowance increased to provide for the master indicator.

PLIERS AND NUTS

The most expensive tool in the average ETM's tool kit are the combination slip-joint pliers. They are among the cheapest in original cost but, in the hands of an inexperienced or careless man, they damage more equipment by ruining the nuts than any other single item. Combination pliers, sometimes called "gas pliers", were intended to be used for gripping or holding crude and rugged objects which are not damaged by the nicks the pliers will cause. They should *never* be used to tighten or loosen nuts or bolt heads. Such use almost invariably results in damaged nuts or bolts which will become hard to remove even with a wrench, and may have to be chiseled off. Wrenches were designed for use with nuts. Nuts were designed to be turned by wrenches.

SP 8-FOOT ANTENNA

A supply of special tools for the assembly and maintenance of SP 8-foot antennas are now available. Radar personnel of SP-equipped vessels desiring a set of these tools should request them from the Electronics Officer at one of the following activities:

- Boston Naval Shipyard
- New York Naval Shipyard
- Philadelphia Naval Shipyard
- Norfolk Naval Shipyard
- Puget Sound Naval Shipyard
- Mare Island Naval Shipyard
- San Francisco Naval Shipyard
- Naval Supply Depot, Bayonne, N. J.
- Naval Supply Depot, Oakland, California

TELETYPE PAMPHLET

The Bureau of Ships now has in stock a considerable quantity of the pamphlet "Radio Teletype—Speech Plus Duplex". This pamphlet was referred to on page 21 of the July 1946 ELECTRON in an article entitled "Terminal Equipment Modified For UHF Teletype", and refers to the modification, operation and maintenance of the Models TH-1/TCC-1 telegraph terminal equipment. Copies of this pamphlet may now be obtained by requesting them from the Chief of the Bureau of Ships, attention Code 982b.

SIGNAL GENERATOR

Development of the type TS-331/UR Signal Generator has been cancelled and all references to it will be deleted from the Type Allowance Book as the pages are revised. The present allowance should be disregarded wherever it calls for this equipment, and no requests for it should be sent to the Bureau. The Model LX-1 VHF Signal Generator and the OCD Video Signal Generator will, in general, be supplied as replacements.

MAR INSTALLATIONS

The attention of all activities concerned with the installation of Model MAR transmitting-receiving equipments is invited to the fact that equipments bearing serial numbers 1 through 500 inclusive are not suitable for shipboard or Marine Corps installation. Accordingly, installation activities are cautioned not to issue these units to vessels of the fleet or to Marine Corps activities unless specially authorized to do so by the Bureau of Ships.

TEST EQUIPMENT

No requests for the type TS-34A/AP Oscilloscope or the type 60089 Vacuum Tube Megohmmeter should be sent the Bureau as these equipments are not available at this time. They are both on order and will be distributed to the E. O.'s when received from the manufacturer. It is possible that the early shipments may contain only limited supplies and priority should be given to activities which have none of this equipment over those having part of their full allowance.

KNOTS

The Navy and the Army Air Forces have agreed to the joint adoption of the *knot* as the standard aeronautical unit of speed and the *nautical mile* as the corresponding unit of distance. A nautical mile, approximately 6080 feet, is the distance covered by one minute of arc at the equator. The use of the knot (a speed equivalent to one nautical mile *per hour*) facilitates the plotting of plane's tracks on aeronautical charts. Use of the knot and nautical mile will be specified in all future procurement of air-speed indicators, charts, handbooks and related equipments.

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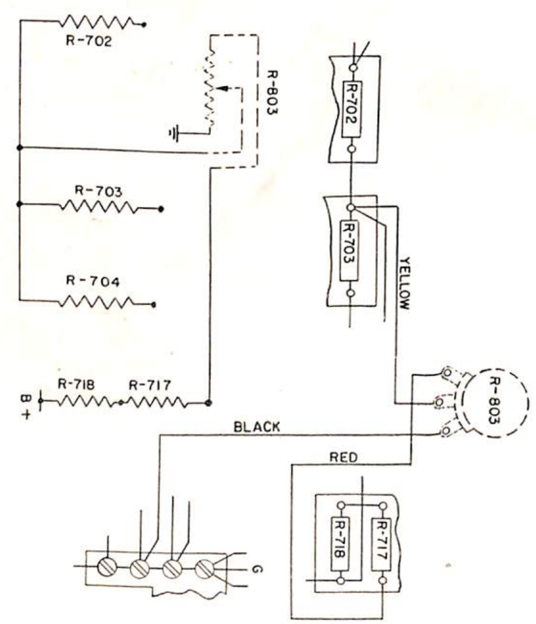
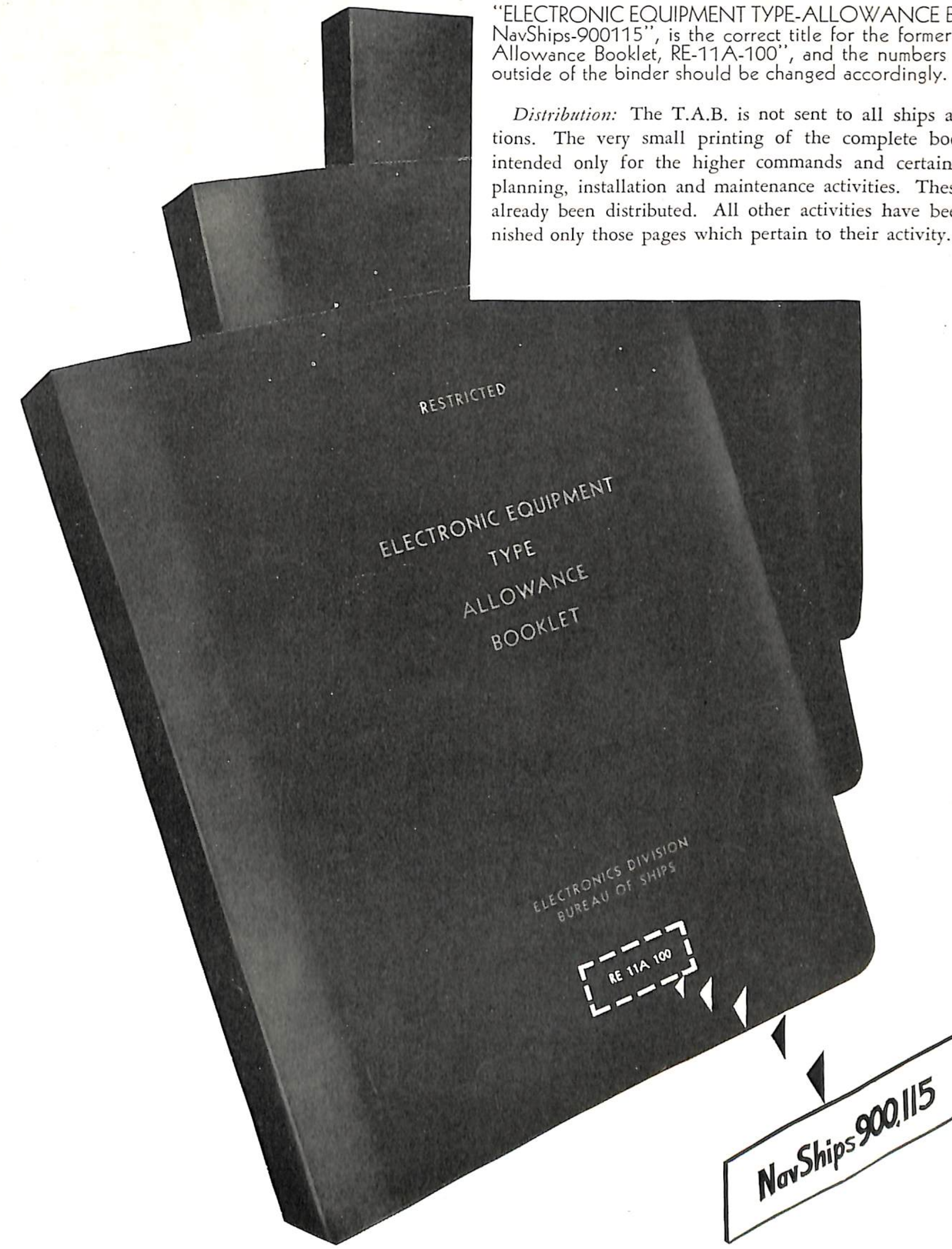
NJ-8 EQUIPMENT WIRING CHANGE

All vessels having Model NJ-8 sonar sounding equipment recorders, Navy type CIP-55127, or obtaining these units for future installation, are requested to check the wiring to volume control R-803. The correct wiring and circuit arrangement are shown in the accompanying illustration. A marked increase in amplifier sensitivity will occur when the wiring of the recorder is changed to agree with that shown in the illustration.

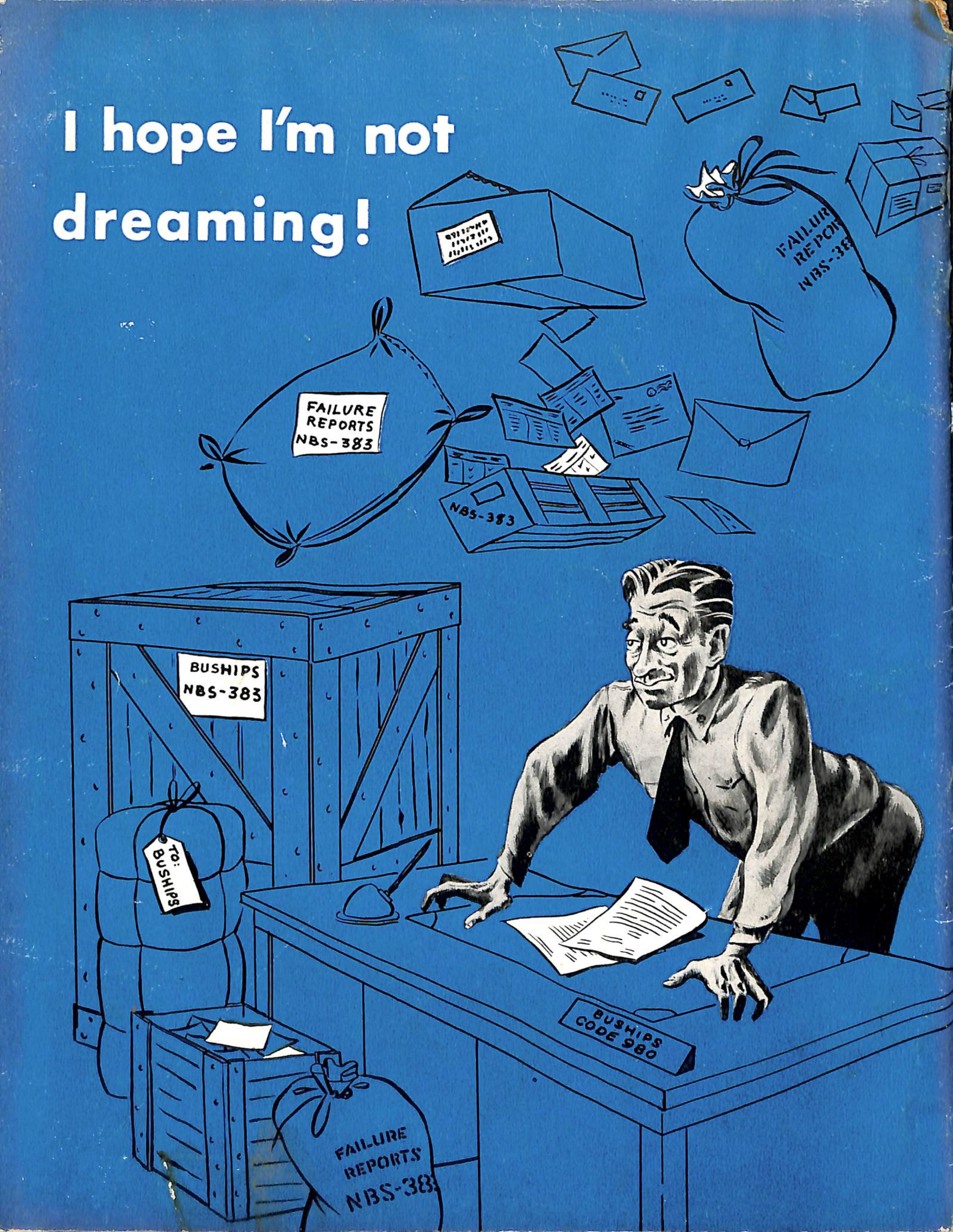
The NJ-8 recorders were apparently shipped from the factory with incorrect wiring in this circuit. The wiring and schematic diagrams in the NJ-8 instruction book are correct as shown, as are the voltage measurements given under "Circuit Tests". Due to the fact that no new parts are required and no major rewiring is called for, no field change kit will be issued and no field change number will be assigned to this wiring change.





"ELECTRONIC EQUIPMENT TYPE-ALLOWANCE BOOK, NavShips-900115", is the correct title for the former "Type Allowance Booklet, RE-11A-100", and the numbers on the outside of the binder should be changed accordingly.

Distribution: The T.A.B. is not sent to all ships and stations. The very small printing of the complete book was intended only for the higher commands and certain major planning, installation and maintenance activities. These have already been distributed. All other activities have been furnished only those pages which pertain to their activity.


I hope I'm not dreaming!
FAILURE REPORTS NBS-383
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