BUSHIPS APRIL 1952

ELECTRON

NavShips 900,100

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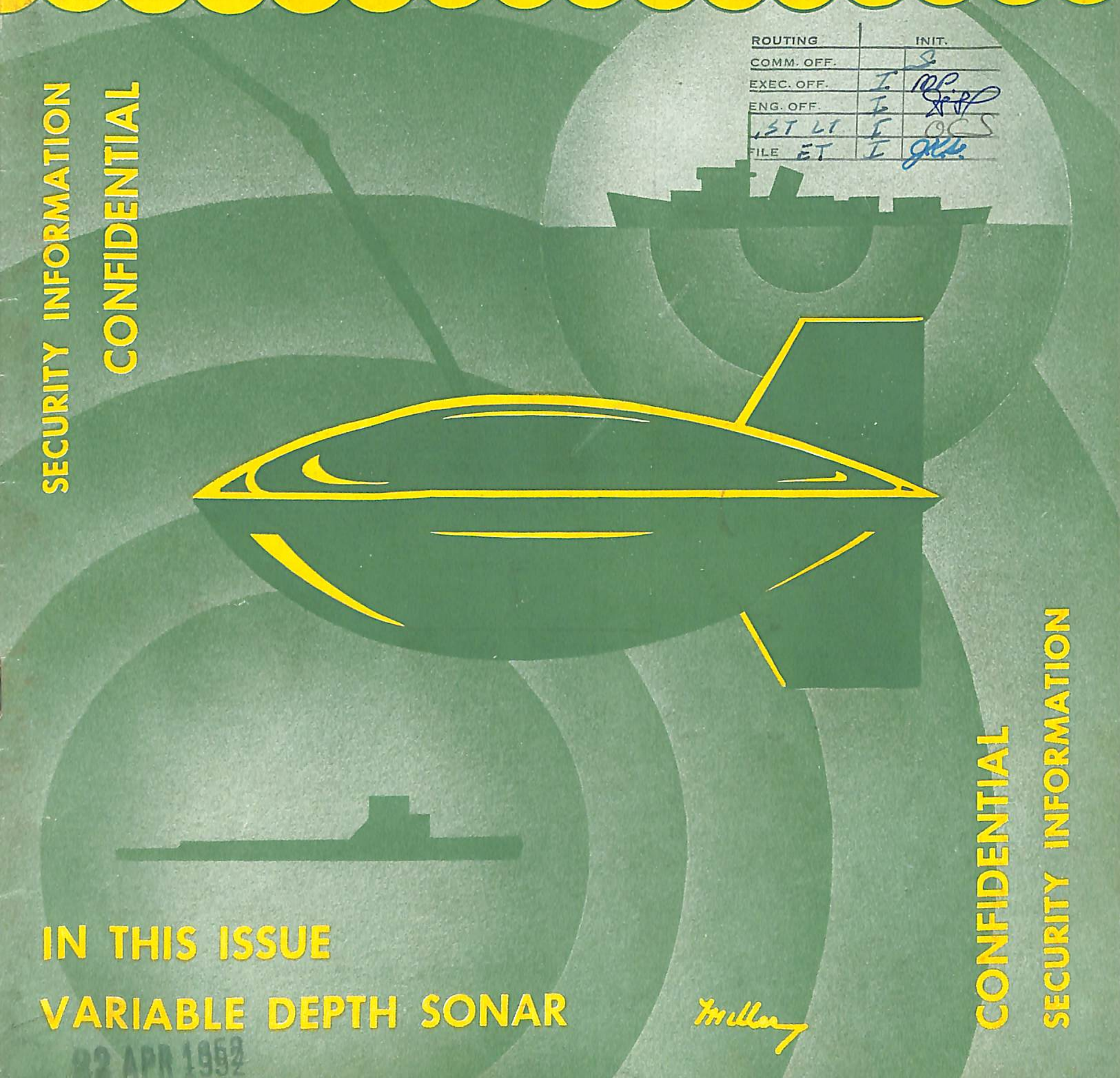

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IN THIS ISSUE

VARIABLE DEPTH SONAR

22 APR 1952

BUSHIPS
ELECTRON
VOLUME 7
NUMBER 4

April
1952

A
MONTHLY
MAGAZINE
FOR
ELECTRONICS
TECHNICIANS

THIS ISSUE

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THE PRINTING OF THIS PUBLICATION HAS BEEN APPROVED BY THE DIRECTOR
OF THE BUREAU OF THE BUDGET 13 JANUARY 1950

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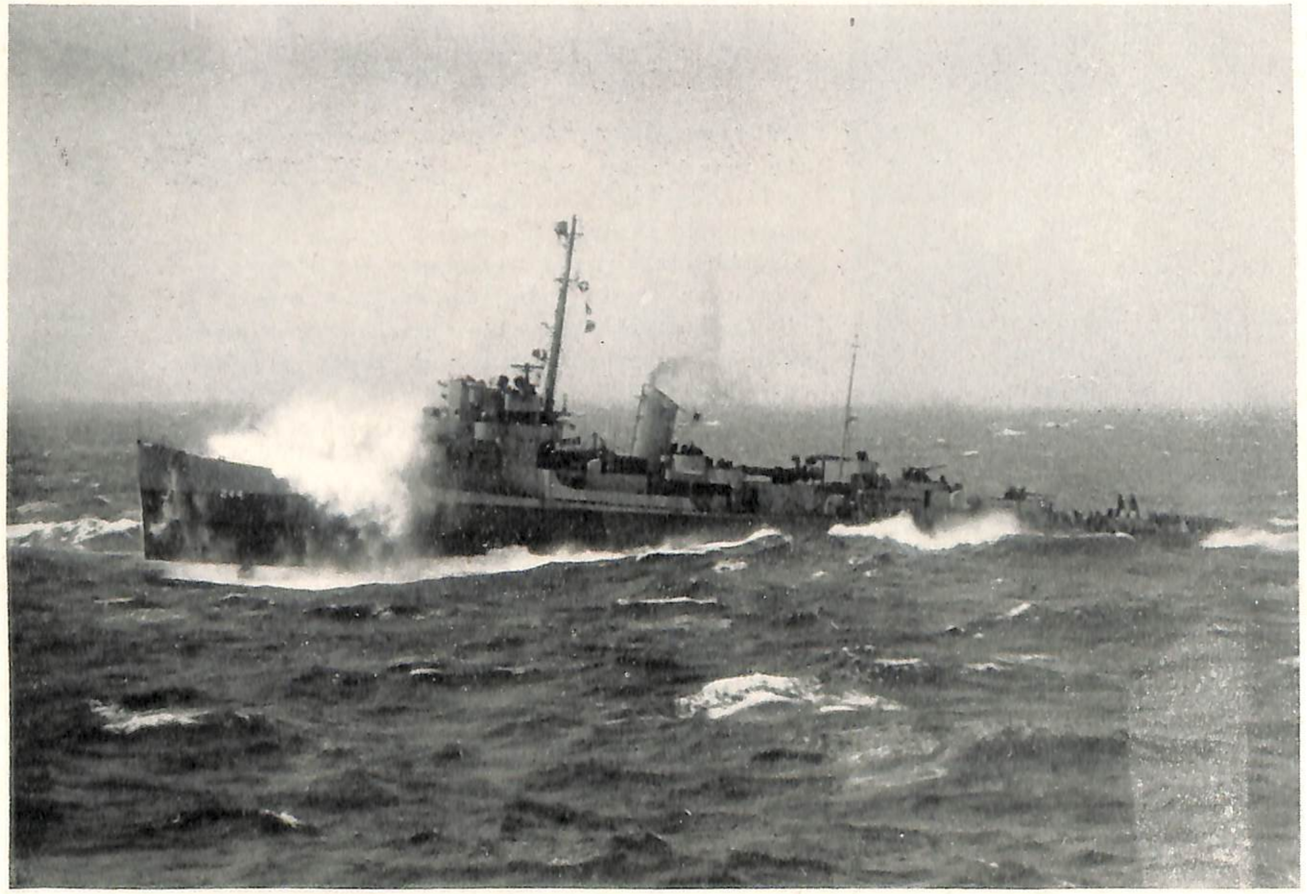
VARIABLE DEPTH SONAR

by
F. S. Andress
Electronics Design Division,
Bureau of Ships

The concept of towing a sonar transducer through the water is not new; as early as World War I, hydrophones were attached to the end of a cable and pulled through the water. It has long been thought that variable depth operation of the sonar transducer would reduce noise from own ship, eliminate quenching of the sonar energy in rough weather, reduce the crippling effects of certain thermal gradients, and provide a more stable transducer platform. Many difficulties were encountered by the early experimenters. Simple assemblies just wouldn't stay down in the water; they were noisy, and for various reasons the early experiments were doomed to be unsuccessful. At the present time three full scale variable depth sonar installations are installed aboard ships of the Navy. Much of the success of these results can be attributed to the efforts and enthusiasm of a single individual.

In 1943, Lieutenant R. L. Rather, USNR, was ASW officer on the staff of a Hunter Killer Group, composed of an escort carrier and four destroyer escorts. This force is credited with writing off many Axis submarines; Lt. Rather served as a key member of the attack team of the USS FRANCIS M. ROBINSON (DE–220), when this vessel sunk a Nazi U-Boat. During this tour of duty, Lt. Rather had occasion to observe sonar performance at its worst. In the mountainous seas of the north Atlantic, the sonar transducer often was lifted completely out of the water. When it was in the water it was shrouded by a cloud of bubbles from the breaking bow wave so that the outgoing ping was quenched and completely ineffective a large portion of the time. The terrific pounding which the sonar dome was subjected to in high seas caused failures and required drydocking of the vessel at very frequent intervals. In more southerly waters when the sea was calm and the sun beat on the surface of the water, causing a warm layer at the surface, the sonar detection range was reduced to 600 yards or less by downward refraction of the sound beam. When Lt. Rather was transferred to the Naval Research Laboratory, it is not surprising that he received the dormant towed sonar program. His first sonar fish was constructed around the barrel of a 3″-50 naval rifle. It swam stably; the great weight prevented it from rising toward the surface appreciably. Lt. Rather reverted to civilian life at the end of hostilities before any great progress was made except the renewal of interest. Work was continued at the Naval Research Laboratory at relatively low priority until about 1946, at which time the Bureau of Ships and the Bureau of Aeronautics put new life into the program with the development of the Air Towed Echo Ranging Equipment (ATERE) and the Surface Towed Listening Equipment (SURTLE). The ATERE fish was 19 inches in diameter, weighed 1300 pounds, and contained two model QBG Rochelle Salt transducers, one facing port and the other starboard. The SURTLE was smaller and contained two model JP line hydrophones, also alert to either side of the towed vehicle. These towed fish were manufactured by the EDO Corporation, College Point, Long Island under Bureau of Ships contracts. They were successfully towed from airships at speeds up to 50 knots, and valuable handling experience was obtained through many flights. They were also towed from surface vessels to a limited extent. The tow cable used was 3/10th of an inch in diameter; it was a stranded steel cable having from three to six electrical conductors. A rubber fairing was necessary to prevent vibration of the cable. The Bureau of Aeronautics has continued development of towed sonar fish and equipments for aircraft use. This program is beyond the scope of this article.



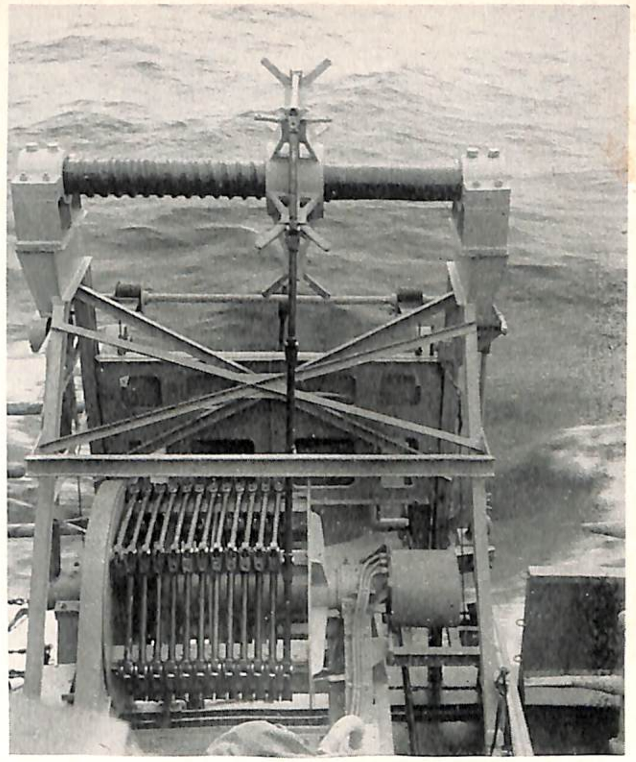
One good reason for variable depth sonar. The sonar dome is completely out of the water.

In 1947, Mr. Rather became an employee of the Woods Hole Oceanographic Institution and worked on general oceanographic problems under a Bureau of Ships contract. In 1948 he requested authorization to work on variable depth sonar. A separate contract was placed with the institution to allow development of such apparatus. The basic specifications established by the Bureau for the gear were general, but difficult. The sonar should have equal performance to that of normal shipboard equipment. This meant that a full size 19 inch diameter transducer must be used rather than the small 6-inch diameter transducers which had been employed in earlier variable depth sets, also that the transducer must be trainable remotely with ease and accuracy. The handling apparatus must be such that no particular skill would be required for its operation; it should be operable in rough seas.

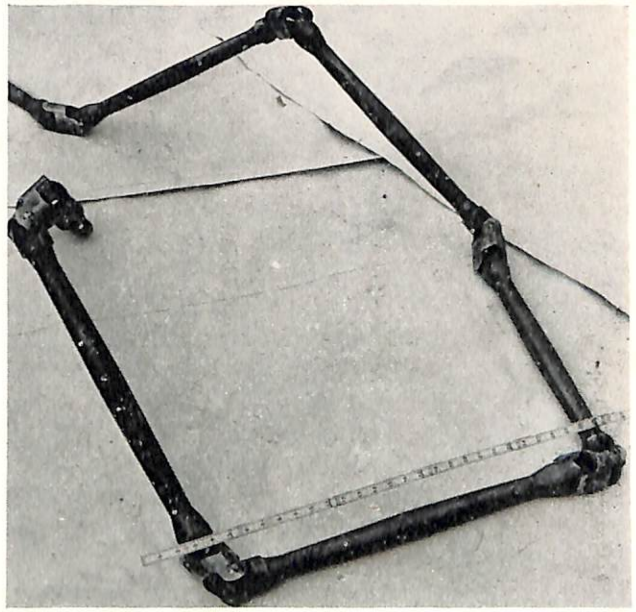
In April 1950 the Woods Hole Oceanographic Institution was authorized to construct an over-the-side hoist and complete variable depth sonar system for installation in the USS MALOY (DE791). The complete design, fabrication, and installation was completed in four months and the first full scale variable depth sonar system was tested at sea in August 1950.

This equipment weighed 15 tons and was installed on the port side of the main deck, amidships. It was located at the deck edge and means were provided for tilting the apparatus inboard to reduce the danger of damage when berthing alongside another vessel.

One of the most unique features of this apparatus is the use of an articulated strut line for towing the sonar fish. This tow line consists of 2 ft. sections of stainless steel rod; each section is joined to the next by means of a universal joint. A ⅞ inch diameter hole is provided, which can pass as many as 50 electrical conductors. The advantage of this type of tow line is that it does not vibrate appreciably when being towed through the water. An ordinary steel cable on the other hand vibrates through its entire length at considerable amplitude when passing through the water unless it is enclosed in a streamlined fairing. This not only produces sound energy which is detrimental to the sonar performance but results in fatigue to the cable making its life very short. Fairings for variable depth sonar cable have been developed.



Over the side variable depth sonar hoist installation on the USS Maloy (DE 791).



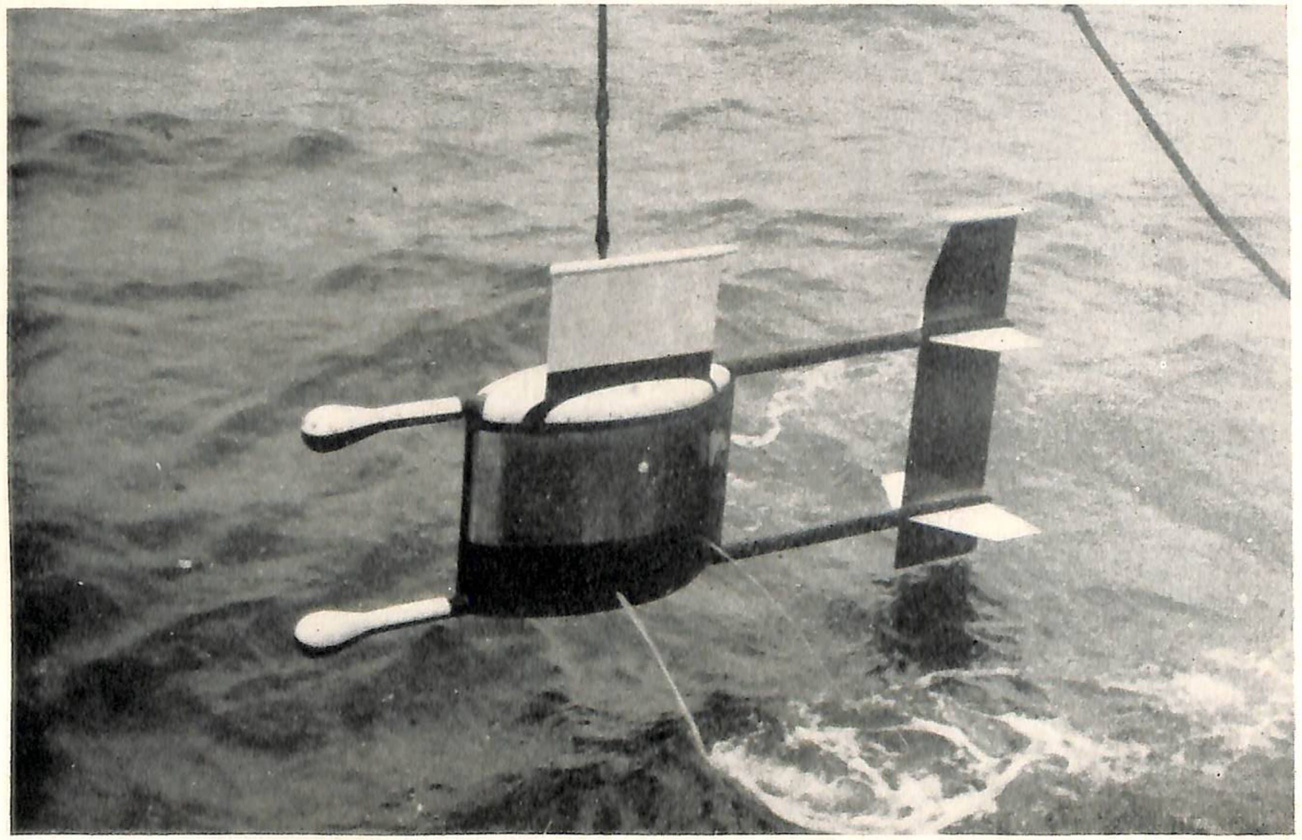
Articulated strut tow line.

However, the problem of reeling and handling the cable fairing has not been satisfactorily solved. The articulated strut line is spooled on a six sided reel. An idler sheave is caused to transverse fore and aft as the cable pays out to insure level wind on the storage drum.

The towed fish associated with this system is made of a 57-inch steel sonar dome. The bottom of the dome is filled with lead so that the complete towed body weighs approximately 6,000 pounds. An oil filled stainless steel can is included within the fish, which contains a model QJB searchlight sonar transducer. A size 7F synchro motor is included in the can for positioning the transducer in azimuth. This stainless steel capsule is secured to the end of the articulated strut tow line. Since this tow line is rigid and cannot be twisted, the forward portion of the can always maintains the same heading as the ship. The fish housing is free to swivel, riding on the top of the transducer can, and may turn completely around the transducer should the ship back down repeatedly.

The hoist is provided with handling apparatus which grasps the towed fish securely at all times during the transition between the secured point above deck to the towing position beneath the ship. This is accomplished by a retrieving plate which has fingers that engage the pipe extremities of the fish. This plate slides up and down in tracks which are welded to the ship's side, extending below the waterline. A second plate, called the towing plate, moves up and down in parallel tracks, and contains a towing eye through which the tow line passes. When the fish is lowered, the towing plate and retrieving plate follow it down, holding it securely. The plates rest on stops at the bottom of the tracks. The fish may then be lowered as much as 120 feet beneath the surface. The retrieving plate is returned to the main deck level until it is desired to retrieve the fish. This procedure prevents the fish from being damaged by striking the ship's side as a result of heavy seas. It is necessary for the ship to slow to approximately five knots when the fish is hoisted or lowered.

One of the principal advantages of this over-the-side hoist for variable depth sonar lies in the ease with which it may be installed on a ship. It is unnecessary to drydock the vessel for the major part of the installation, although the present systems have required some welding below the waterline to secure the tracks to the vessel's hull. The principal advantage, however, is in the ease with which the fish may be serviced. The top of the fish can be easily unbolted and the hoist itself will lift the transducer assembly from the fish, making drydocking for servicing completely unnecessary.



The towed fish used with the USS Maloy installation was constructed from a 57 inch steel sonar dome.

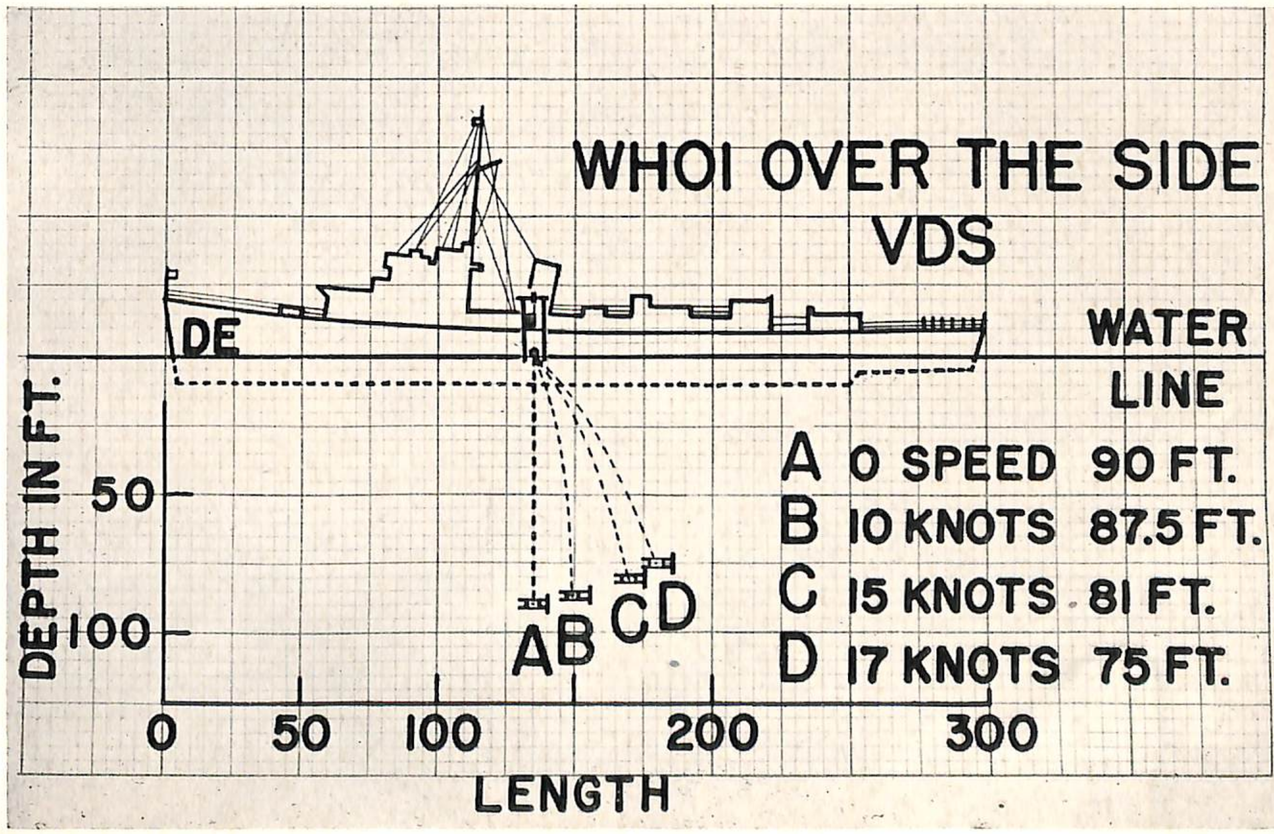
The results of the first several months of sea tests were so impressive that the Chief of Naval Operations directed that two similar variable depth sonar equipments be constructed at high priority for installation in destroyer escorts so that the equipment could be evaluated by the Commander Operational Development Force, to determine the suitability of such gear for fleet service. In November 1950 the Norfolk Naval Shipyard was requested to construct at high priority two variable depth sonar sets for installation in the USS DOUGLAS J. BLACKWOOD (DE–219) and the USS FRANCIS M. ROBINSON (EDE–220). The basic features of the Woods Hole Oceanographic Institution apparatus were used in the BLACKOOD and ROBINSON installations although certain improvements were made. Both ships were equipped with Model QGB sonar, employing a trainable transducer operating at a frequency of about 20 kc. The same sonar transmitter, receiver and indicator could be associated with either the hull-mounted or towed transducer by a single switch near the sonar operator's console. These installations were completed in August 1951 and have since been undergoing sea tests under the operational control of the Surface Antisubmarine Development Detachment. Because of the very short development time which has gone into these variable depth equipments, many crudities still exist and the life of the equipment is uncertain. The apparatus is large and heavy and considerable additional development is necessary before it will be suitable for installation in all vessels. A preliminary letter report from the Commander Operational Development Force listed the following conclusions as a result of sea tests conducted over a three month period:

a. The Variable Depth Sonar has a *detection range advantage* over hull-mounted sonar when certain conditions exist, as follows:

(1) With the target located within a strong or medium sound channel, a range increase of about 400 to 500 percent when the Variable Depth Sonar transducer is placed within the channel.

(2) With the target in the negative gradient between a surface isothermal layer and a sound channel, a range increase of about 25%, when the Variable Depth Sonar transducer is placed in the lower half of the surface isothermal layer.

(3) With the target below a sharp negative gradient, a range increase of about 50% when the



Position of towed fish at several ship speeds.

Variable Depth Sonar transducer is also placed under this sharp negative gradient.

(4) With the target below a moderate positive gradient, a range increase of about 25% when the Variable Depth Sonar transducer is also placed under this positive layer.

b. The Variable Depth Sonar has a *detection range decrease* of about 30% as compared to hull-mounted sonar when the target is above any sharp negative gradient and the Variable Depth Sonar transducer is below this gradient.

c. *Under any thermal conditions* a depth for the Variable Depth Sonar transducer can be selected at which its performance will be *better than or comparable* to hull-mounted sonar.

Other conclusions were drawn from Variable Depth Sonar operations: These were:

a. When the Variable Depth Sonar is streamed at sea ship maneuverability is not affected, and when the rig is in the secured position, no special berthing arrangements are necessary.

b. The Variable Depth Sonar is easily operated and does not require additional personnel.

c. Drydocking is not required to repair or replace the Variable Depth Sonar transducer.

d. A considerable portion of the advantage gained through ability to position the Variable Depth Sonar transducer at a favorable depth is frequently sacrificed because a higher noise level is encountered at the Variable Depth Sonar transducer compared to that at the hull-mounted transducer. This noise originates in the ship's screws and machinery.

e. The characteristics of Variable Depth Sonar permitting successful operation under surface ships' wakes, together with the absence of the usual baffled stern sector, offer certain tactical advantages.

It was recommended that:

a. The Variable Depth Sonar be developed into a service equipment.

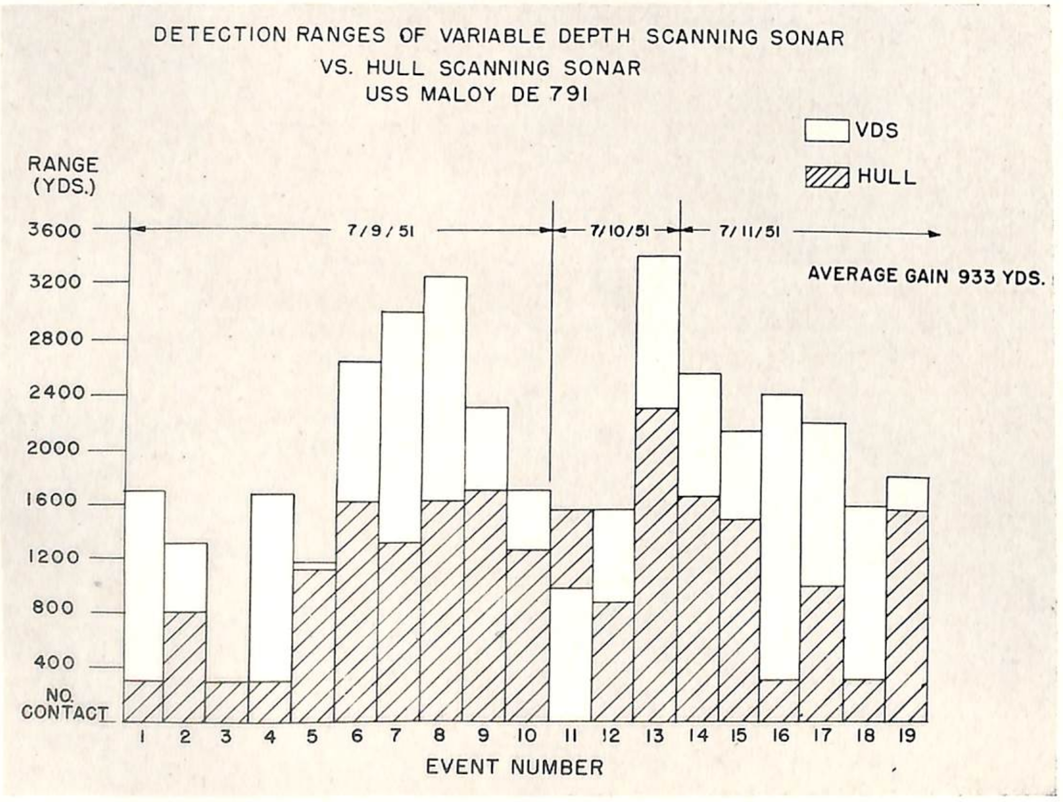
b. The over-the-side rig be reduced in weight as much as possible.

c. Maximum effort be directed to reduce the effect of own ship's noise on the Variable Depth Sonar transducer.

d. The fish towing assembly be re-designed to permit depth changes at ship's speeds up to 15 knots.

e. A Variable Depth Sonar installation incorporating scanning type sonar be considered for evaluation.

Concurrent with the construction and evaluation of the two installations in the BLACKWOOD and ROBINSON, development continued on the MALOY installation. This was carried on by the U. S. Navy Underwater Sound Laboratory, New London, Connecticut. In addition to certain mechanical improvements, the apparatus was modified for association with Model QHB scanning sonar equipment. The transducer installation is much simplified since no moving parts are necessary within the towed fish. Many sea tests have been conducted using this apparatus and results have been very promising. The chart shows a comparison of detection ranges obtained using the hull mounted transducer and the QHB transducer installed in the fish.



Variable depth sonar has a detection range increase of about 30% over hull mounted sonar.

In spite of the encouraging progress made to date in the variable depth sonar program, many unsolved problems exist. It is probable that large scale production of variable depth sonar sets for installation in all naval vessels will not be achieved until approximately 1950. In order to employ variable depth sonar apparatus effectively, a great deal of new research information must be obtained. Extensive studies must be conducted of the thermal and salinity structures of the ocean, throughout the world, at different seasons of the year, to enable the ASW ship of the future to place her transducer where it will do the most good.

Only the name of the most colorful figure in the Variable Depth Sonar program has been mentioned. It must be emphasized that equal credit is due a large number of persons throughout the Naval establishment for equally important contributions to this program. In addition to the scientists, engineers, and officers who have figured prominently in the design and fabrication of the several systems; the officers and men of the USS MALOY, USS ROBINSON and USS BLACKWOOD; the Surface Anti-submarine Development Detachment, and the Operational Development Force, have assured a promising future for Variable Depth Sonar as a result of their successful sea tests. These tests have been conducted under the most difficult conditions attendant with development apparatus and required hard work, patience, and enthusiasm of a high order.

NEW ATTACK SONAR SYSTEMS

AN/SQG–5

The AN/SQG–5 is a high resolution, light weight, comparatively short range (1500 yds) system. It utilizes a parabolic reflector and scans electronically, a horizontal row of piezo electric elements (barium titanate) producing a two-and-one-half degree beam pattern sweeping through a 20 degree sector on any chosen azimuth center bearing.

Proportional off center bearing information is developed in the vertical plane by lobe comparison techniques. The equipment is capable of following a target directly below own ship thereby affording a minimum of lost target time.

Two axis stabilization of the shipboard unit is employed. This will be the first test of such a stabilization system for sonar in the U. S. Navy.

Two operator consoles are employed one in depth and for azimuth. A total of two equipments is being procured for service test, the first to be delivered in March of 1952. Production quantities will be procured if the tests are successful.

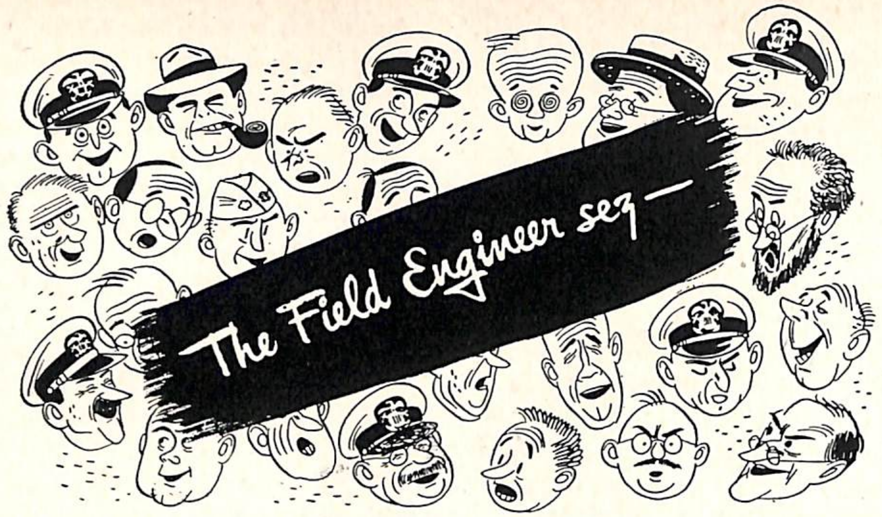
AN/SQG–3

The AN/SQG–3 is a continuous transmission echo ranging attack system reinforced by a "ping" range feature for removing doppler range ambiguity. It will use a parabolic reflector and a mechanically nutated piezo-electric element at the focal point to develop up-down—right-left bearing error information. Bearing error information is converted to control voltages to position the transducer automatically when sonar conditions are normal. Two axis stabilization is used to assist in the maintenance of transducer position.

One control console is provided. Control of depth and azimuth train of the transducer is accomplished by a monitoring operator with a "joy stick' control. Azimuth and depth center bearings are displayed on a single CRT. Continuous transmission range and "ping" range are displayed on an "A" scan scope and bearing on mechanical repeaters.

Continuous outputs of range rate, bearing rates and target aspect are available for integration into the associated fire control system. It is expected that the equipment will function automatically with only monitoring attention from the operator after target designation by the search system.

Two equipments are on order. The first is to be delivered for sea trials in February 1953. Production quantities will be determined upon successful completion of the trials.



VF

USS Wedderburn (DD687)

The range clutch plate was dragging slightly on the surface of the range clutch assembly, preventing the range correction potentiometer from operating properly. This resulted in the range spot on the "B" scope not returning to center after each sweep. Also, the range correction potentiometer had an intermittent open near one end.

The magnetic clutch mechanism was removed and thoroughly cleaned. The clutch plate was adjusted so that its surface was again parallel with the surface of the magnetic clutch. The range correction potentiometer was replaced. The "B" range microswitches were readjusted; then the assembly was replaced and readjusted. Equipment operated satisfactorily upon completion of work.

Ray E. Jacobs
Byron Frankenberger

MK. 10/IFF

USS Essex (CV9)

During installation and wiring of equipment units, Shop 51 found, that added to the inconvenience of the limited space for wiring in the video distributor unit, the color of the terminal numbers blended into the color of the insulating material on which they were stamped. This made reading of terminal numbers very difficult.

Terminals 02 and 03 in the Video Dist. Unit were piled with wire terminals according to the number of feeders to various video amplifiers. This pile-up will no doubt perform its function but it is not believed to be a satisfactory way of making the connections.

In future installations of this kind, it is recommended that a connection box be installed somewhere near the Video Distribution Unit to facilitate the wiring along with supplying adequate terminal space which will reduce the possibility of wiring errors. It is also believed advisable to run the regular size coax to the connection box with the RG–59/U type co-ax feeding video to the SA–220/UPX video distribution unit, from the connection box.

E. Doherr
D. O'Brien
C. McGehee
F. Reineking

USS Essex (CV9)

Operation of the Ship's UPX–1, recognition set using airborne identification set, proved very satisfactory. It was also noted that the display presentation was very sharp with good discrimination. Also, the UPX–1 target presentation shows considerable improvement over MK. 5 systems. During the operational tests weather conditions were such that it was necessary for the plane to fly on instruments a great deal of the time. Throughout the overall test period it was possible for the ship's CIC Officer to control the plane using UPX–1 signals. Due to the weather and the geographical location it was not believed advisable to send the plane more than 50 miles from the ship. It was quite easy to keep contact with the plane over land masses by switching Radar and IFF presentations at the control boxes.

F. F. Reineking, Jr.

WCA SONAR

USS Angler (SS240)

When the system was tracking properly, it was noticed that a low frequency parasitic oscillation was modulating the output. This spurious oscillation was eliminated from the driver by shunting a 3 megohm resistor across choke coil, L–1409. This change has been necessary on several installations and in every case does not otherwise effect the normal operation of the driver. After the alteration, the output frequency was clear of any raspy modulation. The modulator circuit was found to be defective as reported on the electronic inspection check-off lists. This trouble was traced to a wiring error. Charging capacitor, C–1401 was connected between the positive side of R–1402 as it should be and the operation of the modulator was made normal. While working on the QB Driver a short circuit developed across the bias supply. Damage was done to both type 807 tubes and a 5U4G in the bias rectifier supply. This short was found to be in the service cable from the Driver Rectifier Power Supply and the Driver Unit. The short was caused by grounded shielding over some of the leads of this cable contacting exposed terminals in the power supply. The entire length of this service cable was wound with vinyl tape to prevent future trouble of this nature. Upon completion of these repairs, the QB system gave very satisfactory results.

At a sea trial it was found that the JK/QC Receiver-Amplifier was dead. Trouble was traced to the input circuits. Both the JK and the QC transducers were tested and found normal. An open circuit was found in the JK circuit due to leads broken away from the JK plug. The 325K cable to the plug had not been secured by the clamp on the plug, and had been pulled loose. While testing the QC transducer, it was found that the QC cable between the training shaft and the plug was open. A cut in the cable about 3 feet from the shaft disclosed the open lead. In tracing more of the QC transducer circuit back into the QC Driver, a bad condition was found. Normally the output of the QC Driver is balanced to ground and each hot lead is capacity coupled to the transducer. On this installation having an OL Field Change, one side of the QC Driver is grounded and the shield in the 325K cable is used as a signal conductor and common ground. The series capacitors in the Filter Junction Box therefore placed the shield of the JK/QC cable above ground. This capacitor was removed from the ground side of the QC transducer circuit and was wired in series with the second capacitor in the hot side of the transducer circuit. There was a discontinuity in the transducer circuit through relay, K–402. All the spring contacts on this relay were bent and in very poor condition. This relay will have to be replaced. The grasshopper fuse was found defective due to an extra long machine screw shorting out the load contact. A list of items were left with ship's personnel for necessary attention.

Charles W. Wilkinson

SG–1

USS Preston (DD795)

A poor receiver sensitivity was observed, especially at close range. The Crystal Marker (Y301) was found with a 2:1 front-back ratio. The parts were replaced from ship spares.

All the contacting surfaces for duplexer tubes in both cavities were badly oxidized. The cavity clamping rings were loose, and the duplexer tubes were badly burned. The range potentiometer was not linear. To correct these conditions, RF106 was removed and all the contacting surfaces in both duplexer assemblies were burnished. The tubes were replaced from the ship spares. RF106 was then properly reassembled and replaced, and the TR Cavities were resonated. The range potentiometer error was corrected by calibrating against range markers. Normal performance of the equipment was observed upon completion of the above actions.

Carl Boltz
Byron Frankenberger

MK 25/2

USS Essex (CV9)

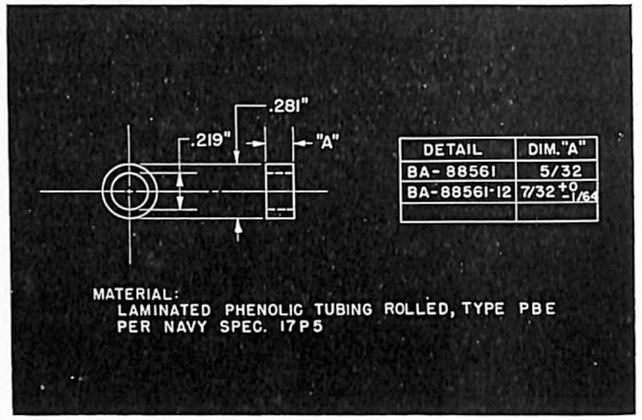
Ten or twelve capacitors in the regulating transformer circuit were reported to have failed during the past two or three months. This is a fairly common trouble as the condensers are operated at near their rated value when the system is on "filament" or when the regulating transformer is "on" but the MK 25 "off". This procedure creates a "no load" condition. The best solution for the problem at present is to avoid a "no load" condition for the transformer and to install a "normal-standby" switch to by-pass the transformer in standby. The Navy stock number of a switch meeting the required specifications is 17–F–255–47–400. This alteration is covered in Ship Alt. #778 for Destroyers and Nav Alt. 13E.

O. R. Beach

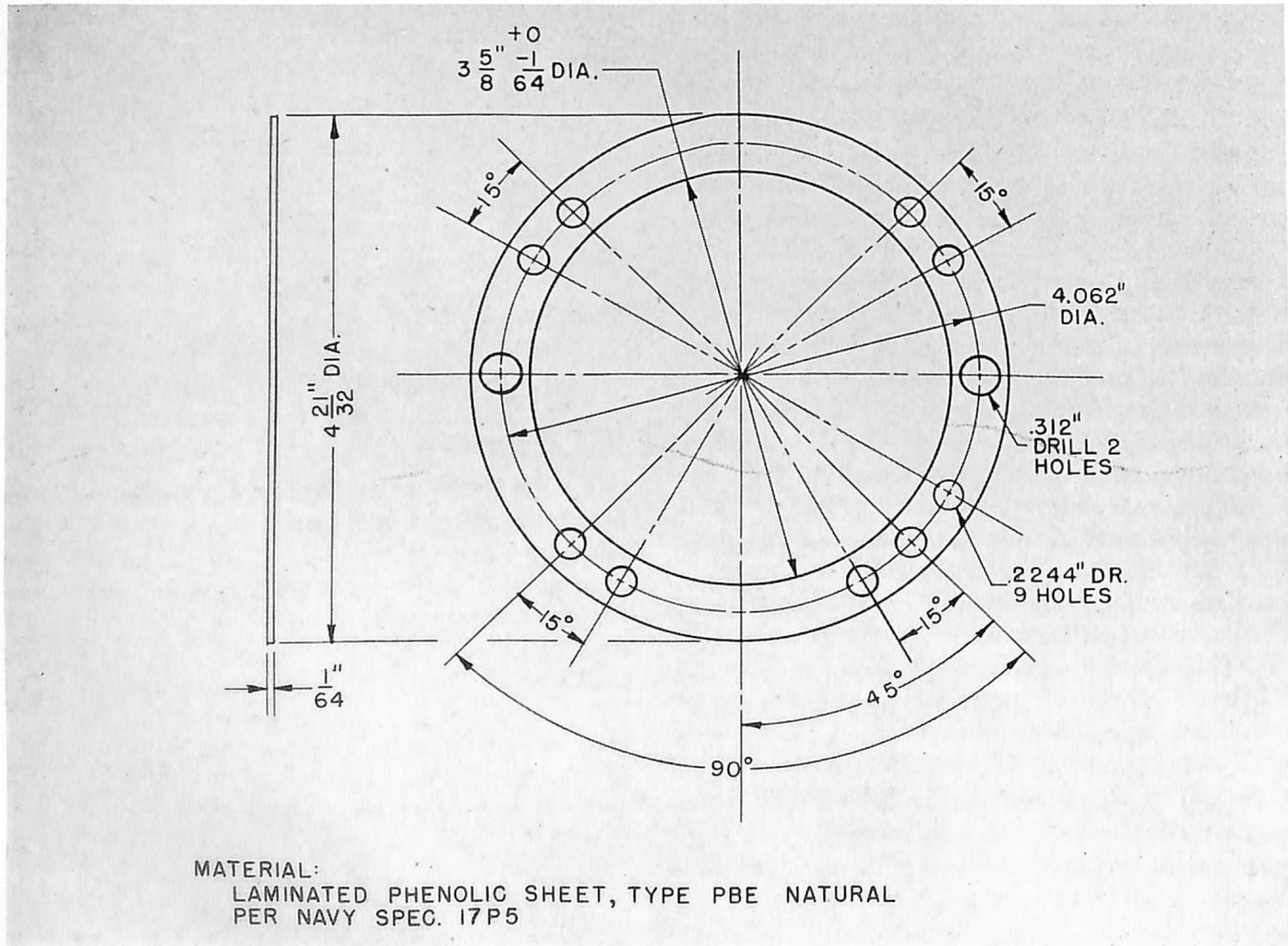
MODEL SV AND SV-3 MAGNETRON RINGS

In the Models SV and SV–3 radars the magnetron is insulated from ground by phenolic insulating rings and insulating bushings. This is necessary in order to obtain magnetron current readings on the test meter. When these bushings become damaged or the rings broken the magnetron frame becomes grounded and current readings are unobtainable. Furthermore, these bushings and rings are not in spare parts and replacement becomes very difficult.

To enable maintenance personnel to fabricate these rings and bushings locally the following manufacturing data is supplied. Two magnetron insulators, two insulating bushings 7/32″ high and eight insulating bushings 5/32″ high are required.



Insulating bushing.



Magnetron insulator.

HIGH VOLTAGE BREAK DOWN PRECAUTIONS FOR PULSE ANALYZER AN/SLA-1

Heater-cathode failures of type K1052P2 cathode-ray-tubes, used in the Pulse Analyzer AN/SLA–1, occurred recently in the AN/SLA–1 equipment located at the U. S. Naval Radio Station, Cheltenham, Maryland. Investigation of the tubes disclosed high-voltage breakdowns of the heater of one gun in each tube. The normal potential difference between the heater and the cathode is —125 volts and an investigation of the effects of line voltage surges on this heater-cathode potential showed that transient voltage increases are of insufficient magnitude to cause such breakdowns.

Experiments were made to show the effect upon heaters as a result of the application of voltages above 2000 volts between the heater and cathode. The results appeared to be the same as those in the failed K1052P2 tubes.

Experiments were then made applying voltages above 2000 volts within the AN/SLA–1 equipment. Voltage breakdowns occurred from the shield of V–249 (6AL5) to the shield of V–229. It was noted that simultaneously with these voltage breakdowns, breakdowns also occurred withing the cathode-ray tube from the heater to the cathode. Investigation showed that the tube shield of V–249 was a 1¾″ long shield which is a standard shield. This is NOT the correct size shield for this tube as supplied with the AN/SLA–1. V–249 employs a small 1⅜″ tube shield. The longer tube shield fits loosely and lies near the shield of V–229. The shield of V–249 is not grounded whereas the shield of V–229 is grounded. Because of the presence of —2000 volts at V–249 during normal equipment operation, should the shield of V–249 be grounded or nearly so by its proximity to the shield of V–229, the voltage gradient between pins 3, 4 and 9 of V–249 and the shield saddle is increased beyond a safe value and breakdown is likely to occur. The voltage breakdown at the shield of V–249 places the heater of the cathode-ray tube at a voltage gradient of about —2000 volts with respect to cathode causing the failure of the heater.

Replacement of the incorrect 1¾″ tube shield with the proper 1⅜″ shield on V–249 removes the possibility of the trouble occurring. Voltages of 4500 to 5000 volts can be applied to V–249 before breakdown occurs.

It is therefore important that ONLY a 1⅜″ TUBE SHIELD be used with V–249. Since it is easy to pick up a 1¾″ tube shield by mistake from a group of tube shields of more than one size when servicing the AN/SLA–1, it is strongly recommended that the correct 1⅜″ tube shield of V–249 be painted RED on the outside to permit easy and certain identification. When the correct tube shield, 1⅜″ long is employed for covering V–249, voltage breakdowns will not occur and damage to the heaters of the cathode-ray tube K1052P2 will be avoided.

Because of the presence of —2000 volts in V–249 and its circuits and the likelihood of voltage breakdown occurring if the shield of V–249 is grounded or nearly grounded; EXTREME CARE MUST BE USED WHEN SERVICING THIS EQUIPMENT TO AVOID SUCH A BREAKDOWN TAKING PLACE AND PASSING THROUGH THE BODY OF THE SERVICING PERSON. Severe injury or death may result from carelessness in this regard. This warning concerning the possibility of severe shock from V–249 is made and strongly emphasized because servicing personnel are not aware of the imminence of voltage breakdown at the tube shield of V–249 and the potential danger to personnel that such a breakdown represents.

The Bureau of Ships is investigating this matter to determine whether a field change is possible that would preclude such danger of injury to personnel. A field change is also contemplated to protect the heaters of the cathode-ray tube K1052P2 from high voltage breakdown in the event of the shorting of the —2000 volts to ground in V–249.

Since V–248 (6AL5) also has —2000 volts present at its tube base, it is suggested that the V–248 tube shield, 1⅜″ long, also be painted RED as a safety precaution and that extreme caution be taken when working in its vicinity.

SHIPBOARD ELECTRONIC INTERFERENCE

by
R. L. Haskins *and* A. S. Zamanakos
*Electronics Ship and Amphibious Division,
Bureau of Ships*

This article is concerned specifically with shipboard electronic interference. It will present the problems posed by such interference aboard ship. To begin with, let us define electronic interference as any electrical disturbance which causes undesirable response or malfunctioning of electronic equipment.

Preliminary investigations of shipboard interference during the last war revealed that shipboard radio operators were experiencing levels of interference that were far beyond the conception of Bureau engineers prior to such investigations. Single vessels were first selected as sample vessels in the attempted reduction of interference to acceptable levels.

In 1943 the Commander Service Forces, Atlantic Fleet reported interference on APc class and PYc class vessels. Such interference was traced to a certain motor generator, part of a radio transmitting and receiving equipment. Immediately the Bureau initiated action to:

(a) determine whether interference from this motor generator set was a common occurrence and;

(b) have steps taken by repair ships and Navy yards to eliminate this interference in this and other types of vessels;

(c) ascertain the degree of success attained by the application of interference reduction methods;

(d) obtain any additional information on the interference problem in general on naval vessels.

From that time to the present date interference investigations have continued. They have been prosecuted by the Electronics Installation and Maintenance activities, Bureau of Ships. As a result, the level of interference aboard such naval vessels has been gradually reduced to conditions that were described by one radio operator as "quiet as a church". After the reduction of interference on one vessel of a class has been attained, it has been found that information concerning its accomplishment spreads rapidly throughout the fleet. This is attributed to the fact that radio operators of similar class vessels, while visiting together in port, are very anxious to relate their recent achievements, reduction of interference being included. As a result the Bureau of Ships has received urgent letters from the various type commanders for similar remedial actions to be taken on the vessels under their command. Such a plan of action was the start of shipboard interference reduction work of the Bureau. These accomplishments serve to intensify the need for the reduction of interference on board all classes of vessels.

Today the shipboard electronic interference problem is somewhat different than it was ten years ago. We now not only have a greater number of electronic equipment aboard but they are more sensitive and scan a wider range of frequencies. Any "old Salt" will be able to provide information about this progressive increase in complexity and number of electronic equipments. It is not unreasonable to say that we can receive signals or interference in the order of a few microvolts from low audio to frequencies greater than one thousand megacycles. Military requirements are such, moreover, that maximum sensitivity is required over most of this wide frequency range.

Another important requirement is that all of these equipments plus all electrical and interior communication equipment aboard ship must be capable of simultaneous operation without mutual interaction and mutual interference. This is a major problem when considered on the basis of a community or a shore station receiving area, but when applied to a mobile craft such as a ship, the problem is greatly amplified. The need for operating large numbers of equipments in small areas at the same time without mutual interference imposed a problem not fully appreciated by those who are concerned only with the operation of a single equipment.

Field engineering experience aboard ship shows that poorly maintained and poorly operating equipment contribute appreciably to the electronic interference problem. A recent complaint involved an SV radar and an RCM receiver and subsequent tests and corrective action clearly demonstrated the fact that poorly functioning equipment, both radar and receiver, were partly responsible for the interference complaint. Improper waveguide adjustments created excessively high radiation levels below deck, so much so, that a neon bulb could be lighted over most of the waveguide and over parts of the equipment frame. The receiver antenna leadin cable was poorly shielded and a partial short decreased the incoming signal considerably. Correction of these deficiencies materially improved the interference conditions.

It has become evident that there exists a need for an equipment checkout system. This checkout would provide the vessels with the assurance that the equipment is functioning properly. But, in order to be effective and efficient, the Yards must be able to assign a definite amount of time to accomplish this phase of its work.

Installation factors appreciably affect the interference problem. Placement of equipments and cables, grounding of frames and shields and the quality of workmanship are important items that tend to control shipboard electronic interference. Very often design deficiencies limit the installation engineer insofar as freedom in the location of equipment is concerned. Space and operational requirements indicating one solution and electronic interference reduction another are typical problems that confront the engineer. The SV radar installation aboard submarines is an example of this predicament. On a number of installations this transmitter is installed in the radio receiving room and invariably these installations cause serious radar interference. Actually this may be a good installation plan insofar as operation requirements are concerned, but it is a poor installation plan with regard to electronic interference reduction. Design deficiencies contribute to this situation since these equipments are not sufficiently filtered and shielded to give the safe margin of interference protection. The waveguide and phasing stub assembly requirements are quite critical in respect to the generation of standing waves along the outside of the waveguide. Faulty workmanship, such as leaving paint between mating flanges easily creates interference which affect nearby radios. This is the type of installation which causes interference but which could have been initially avoided by proper care in painting. Figure 1 shows a not unusual installation in which a YE transmitter and several RCK receivers are installed adjacent to each other. Tests show considerable interference between these equipments.

This type of *coupling* is responsible for much of the interference but can be reduced when the installation planning engineers make adequate provisions for electrical and physical separation of

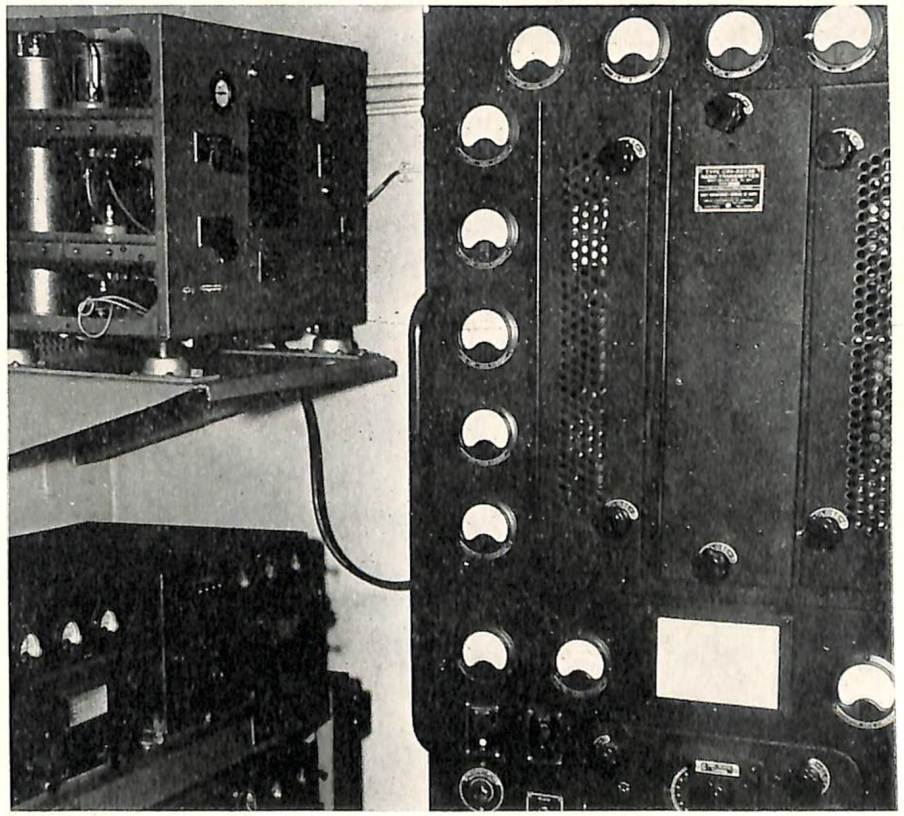


FIGURE 1—YE transmitter and RCK receivers in close proximity.

the equipments. Bulkhead separation should be a minimum requirement between transmitters and receivers.

Cable placement is another factor affecting shipboard electronic interference levels. Quite often pulse cables are placed close to low level receiving cables; in some cases even in the same cable runway with the result that interference is coupled from one circuit to another. Figure 2 shows a Loran receiving input cable (low level) placed very close to a TBL antenna transfer switch circuit (high level). Such close coupling between high and low level circuits provides further means of interference coupling. Therefore, it is more than a coincident that the ship with the above installation complained about TBL interference with the Loran receiver.

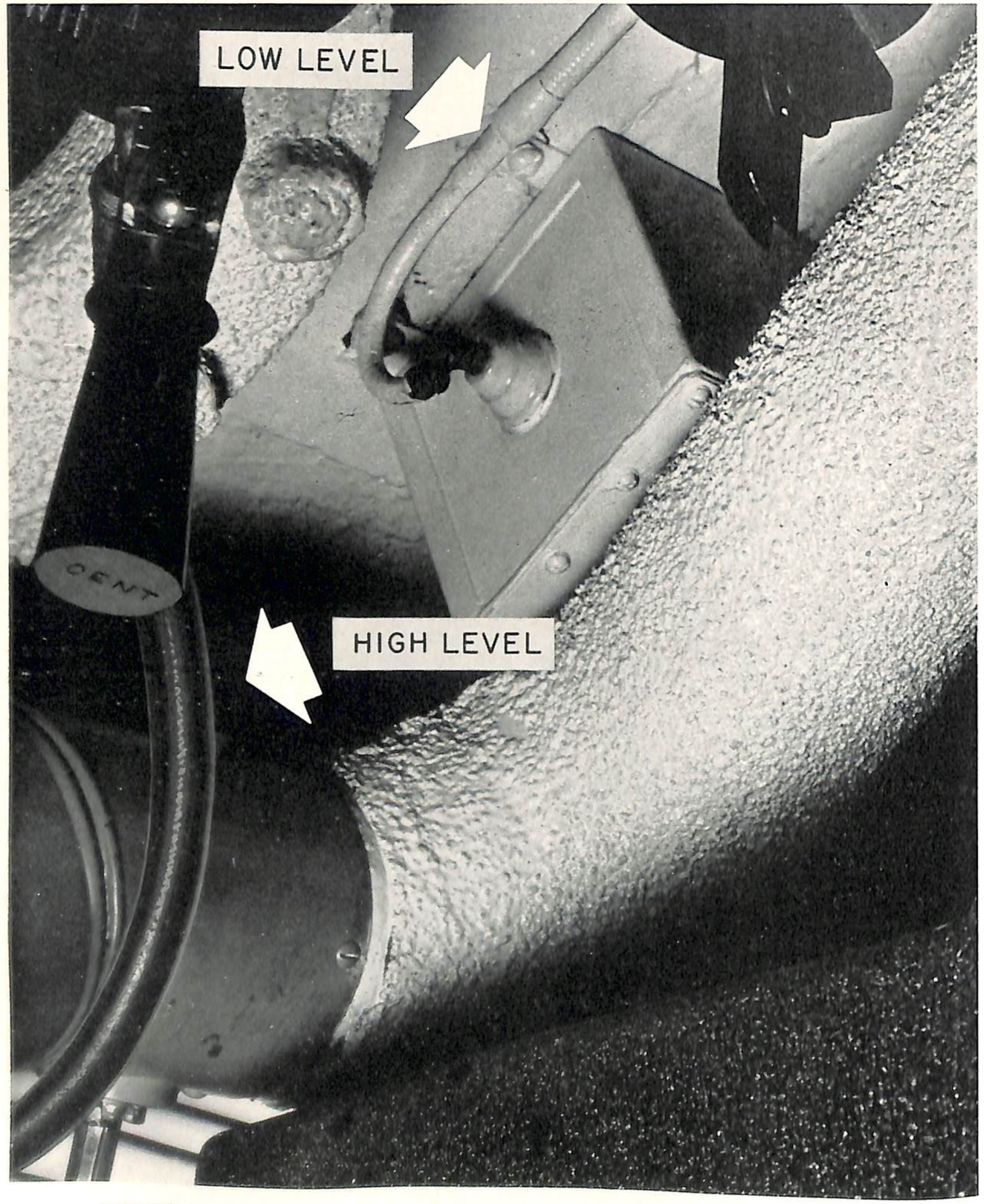
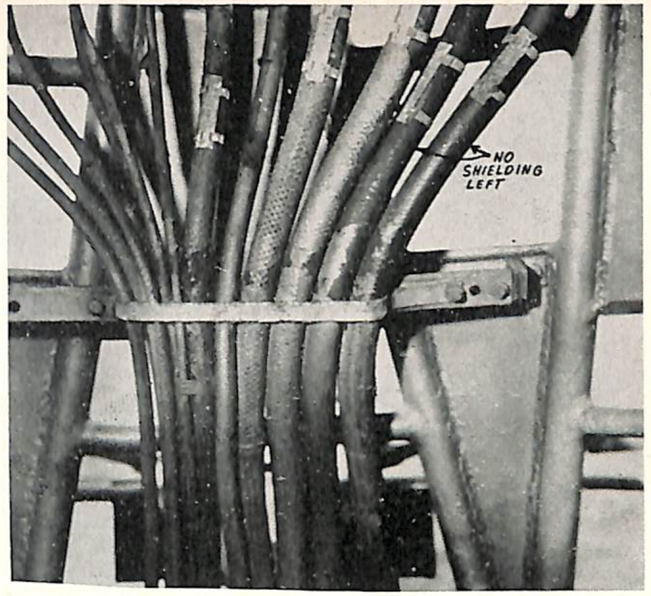


FIGURE 2—Interference coupling between Loran input cable (low level) and TBL antenna circuit cable (high level).

Good bonding and *grounding* techniques provide one of the most valuable tools in electronic interference correction work. It is very important that all equipment frames be correctly grounded to the ship's bulkhead. Antenna leadin cables are extremely critical to grounding requirements and very often serious interference complaints are corrected by proper grounding of these cables. Results of the Philadelphia Naval Shipyard in correcting electronic interference aboard the USS CUBERA indicates what can be done with this tool. They were able to reduce the radar interference to loran equipment by bonding and grounding, and to eliminate interference completely in RCM equipment by bonding and grounding cables in the vicinity of the receivers and by grounding the receiver cabinets.

Cable holders and clamps are not intended to provide good cable grounding and should not be used as such. Pulse and video cables should be well grounded at the equipment unit by either a grounding strap around each cable or by a suitable grounding unit between the cable armor and stuffing or terminal inner wall. Details on the proper techniques of either method will be published in both Electron and E.I.B.

The preceding material was based on the individual reports as they were submitted, but through the accumulation of these reports, it has been possible to analyze them to find exactly what methods, and to what extent, were used to eliminate interference. As the table illustrates, of the 108 vessels for which reports were available: 50.0% of the corrective work required installation changes; 19.5% involved an increase in the degree of maintenance and efficiency of operation of the equipment; 29.5% involved component construction changes; and 1.0% was due to frequency difficulties.



SX power and pulse cables located near the main exhaust stack, eaten away by gasses and moisture.

INTERFERENCE REDUCTION METHOD OF ELIMINATION

Class	No.	Component Construction	Frequency Allocation	Installation	Maintenance and Operation
Auxiliaries	38	29		17	34
Carriers	6	2		7	2
Cruisers	2	4		4	1
Destroyers	16	9	2	30	3
Miscellaneous	6	3		10	
Submarines	40	37	1	73	14
Totals	108	84	3	141	54
Distribution		29.5%	1.0%	50.0%	19.7%

The only conclusion to which one can arrive states that many of the causes for interference can be initially avoided to a great extent by more careful practices in maintenance, operation, and installation. In fact, except for frequency difficulties and filtering which may be considered beyond the scope of the Yard or the ship to anticipate, approximately 70% of this corrective work may be reduced by proper initial maintenance operation and installation practices.

DEFINITIONS

Component Construction — Embraces filters, equipment and equipment design.

Frequency Allocation—Conflicting frequencies.

Installation—Wiring, wireways, grounds, shields, and quality of workmanship.

Maintenance and Operation—Factors that can be directly attributed to the degree of maintenance by ships personnel and the efficiency of operation of the ships equipment—all kinds.

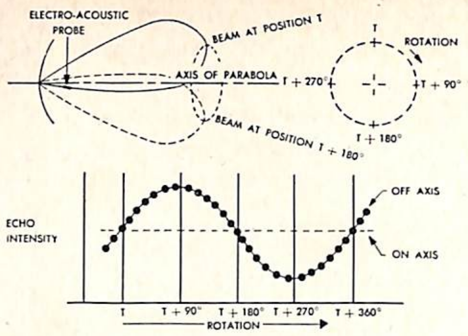


FIGURE 1—Lobing, and echo-intensity with lobing, of the Conical-Scan Tracking Hydrophone.

nel notes: conical-scan tracking hydrophone

Familiar radar tracking techniques have been applied for the first time to sonar with the development by the U. S. Navy Electronics Laboratory of a hydrophone that "locks on" and automatically tracks by echo-ranging a moving sonar target. The new "Conical-Scan Tracking Hydrophone" was designed for use with a Continuous Transmission Attack Sonar currently under development by the Laboratory.

The hydrophone incorporates radar techniques by providing a high-gain directional beam which scans conically at 30 rps (fig. 1). The conical scan is achieved by mounting an electro-acoustic sound sensitive element—barium titanate in the present unit—at the end of a probe which nutates (nods or "wobbles") around the axis of rotation of a 16-inch parabolic reflector (figs. 1 and 4). The probe, projecting through a center hole in the reflector, is held at its pivot point by a flexible rubber diaphragm which also seals the watertight housing containing the electric components of the unit. Inside the housing the probe is secured to an off-center point of a cam whose 30-rps rotation imparts the nutating motion. Nutation of the probe causes the axis of its main lobe to generate a cone whose apex lies on the parabola's axis of revolution (fig. 1). If the hydrophone "looks" at a target that lies exactly on the parabola's axis, a signal of constant level is received. Signals from a target at a position off the axis, however, will change in level as the beam is moved toward or away from the target. This null-tracking principle is similar to that used in the Mark 25 radar.

Input leads are brought from the sound element inside the probe and are taken off to the receiver by pigtails just behind the diaphragm. From the receiver the signals are passed to phase-sensitive detector circuits where they are compared with a 30-cps, 2-phase reference generator. The phase detectors in turn drive a pair of amplidyne-controlled dc motors which orient the parabola, bringing the axis of the reflector on target in accordance with the error signal voltage generated in the pulse sensitive circuits. Train-tilt assemblies (fig. 3) make it possible for the hydrophone to track continuously a target moving anywhere within the range of the associated sonar (approximately 2000 yards with the Continuous Transmission Attack Sonar).

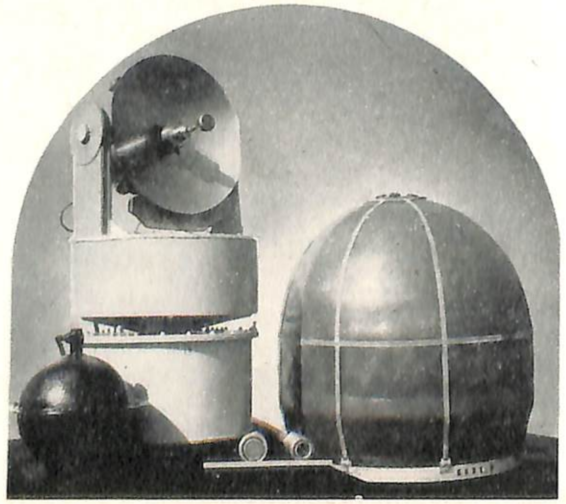


FIGURE 3—Early model of the hydrophone with train-tilt assembly and rubber dome.

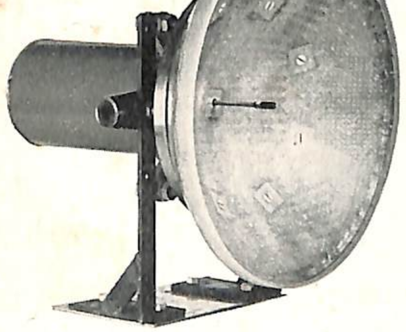


FIGURE 2 — Parabolic reflector and nutating sound probe.

In the present unit, the sound element is positioned $\frac{1}{4}$ inch off the parabola's axis, resulting in a $2\frac{1}{2}$ degree angular displacement of the beam. The half-power beam-width of the hydrophone is 5 degrees.

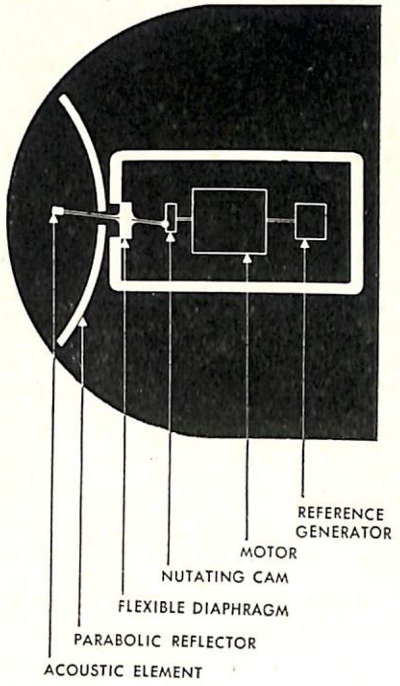
Although the sound element, because of the small area it presents to the signal, has low sensitivity, this apparent restriction is compensated for by the gain realized through the parabola's focussing effect (approximately 40 db in the present unit).

Effective as the conical-scan tracking system has proved in sea trials, a second "lock-on" system has been designed by NEL that promises even higher accuracy. The alternate design employs an arrangement of four crystals mounted in fixed positions off the axis of the parabola. Each crystal develops its own continuous lobe. The outputs of associated pairs of crystals are observed simultaneously through comparison circuits similar in operation to the Bearing Deviation Indicator. Equipment has been constructed and calibrated to conduct a preliminary study of this design.

In actual operation with its sonar equipment, the hydrophone will benefit from standard pitch-and-roll compensating devices. Since no such stable platform is available for laboratory tests, pitch and roll are eliminated during sea tests by mounting the unit on a submarine and submerging the boat to relatively quiet depths.

During tests conducted in March, the hydrophone echo-ranged on both triplane and surface-ship targets. The performance exceeded expectations. Even when the hydrophone was tilted upward against the surface ship, with resulting strong surface reflections, it responded to the target echo, continuing to track the target at times when the echo was neither audible nor visible on the PPI scope.

FIGURE 4—Block Diagram, Conical-Scan Tracking Hydrophone.



MARK 10 RADAR IDENTIFICATION SYSTEM

This is the first of a series of CONFIDENTIAL descriptive and technical discussions of the Mark 10 Radar Identification System prepared by Buships Staff members H. L. Coile and F. A. Russell in colaboration with factory engineers Donald Leiphart, RCA, Instructor of the Mark 10 System at the Norfolk Naval Shipyard; Frank Noll, General Electric Company, Technical Advisor for the Radar Identification Trainer; and Carlton Schoen, Western Electric Company, Technical Consultant for the Mark 10 Training Film Series.

With the present high speed of aircraft targets we are confronted with a more critical problem involving the detection, identification, tracking and evaluation of these targets. When enemy aircraft are in an area detection and identification must be made rapidly and at the greatest possible distance in order to provide ample time for the initiation of such offensive or defensive action as may be necessary. For operations involving our own planes it is not only important to know where they are but the identity of each plane. Another important factor affecting our problem is the small area of the reflecting surface on modern high speed aircraft which limits the amount of radar echo energy reflected back to the radar receiver thus reducing the range of detection.

The foregoing factors have led to improvements in radars and the development of an identification system capable of surmounting some of these difficulties. This article will deal with the MARK 10 RADAR IDENTIFICATION SYSTEM which is in use at the present time. It evolved from the Mark V IFF System which was not extensively used by the Fleet. The Mark 10 embodies improvements over its predecessors since it is capable of handling greater traffic loads, provides for speedier and more positive identification, higher security and greater flexibility which increases its operational potentialities.

Mark 10 does two basic jobs. (1) It identifies friendly craft from the enemy craft, and (2) It identifies one or more friendly craft from others in a group. In addition, for friendly aircraft, it also provides special identification signals for use in an emergency condition and an individual identification signal which is emitted only during voice radio communication.

To do these jobs, the Mark 10 System employs two major components: (1) The Recognition Component which emits the challenge signals and receives the identifying replies; and (2) The Identification Component which provides the identifying signal when challenged.

Before proceeding to a detailed discussion of the Mark 10 System Components let's examine the basic ideas of identification. The chain of events is in the following order: (1) the Challenge, (2) the Identification Reply and (3) Recognition.

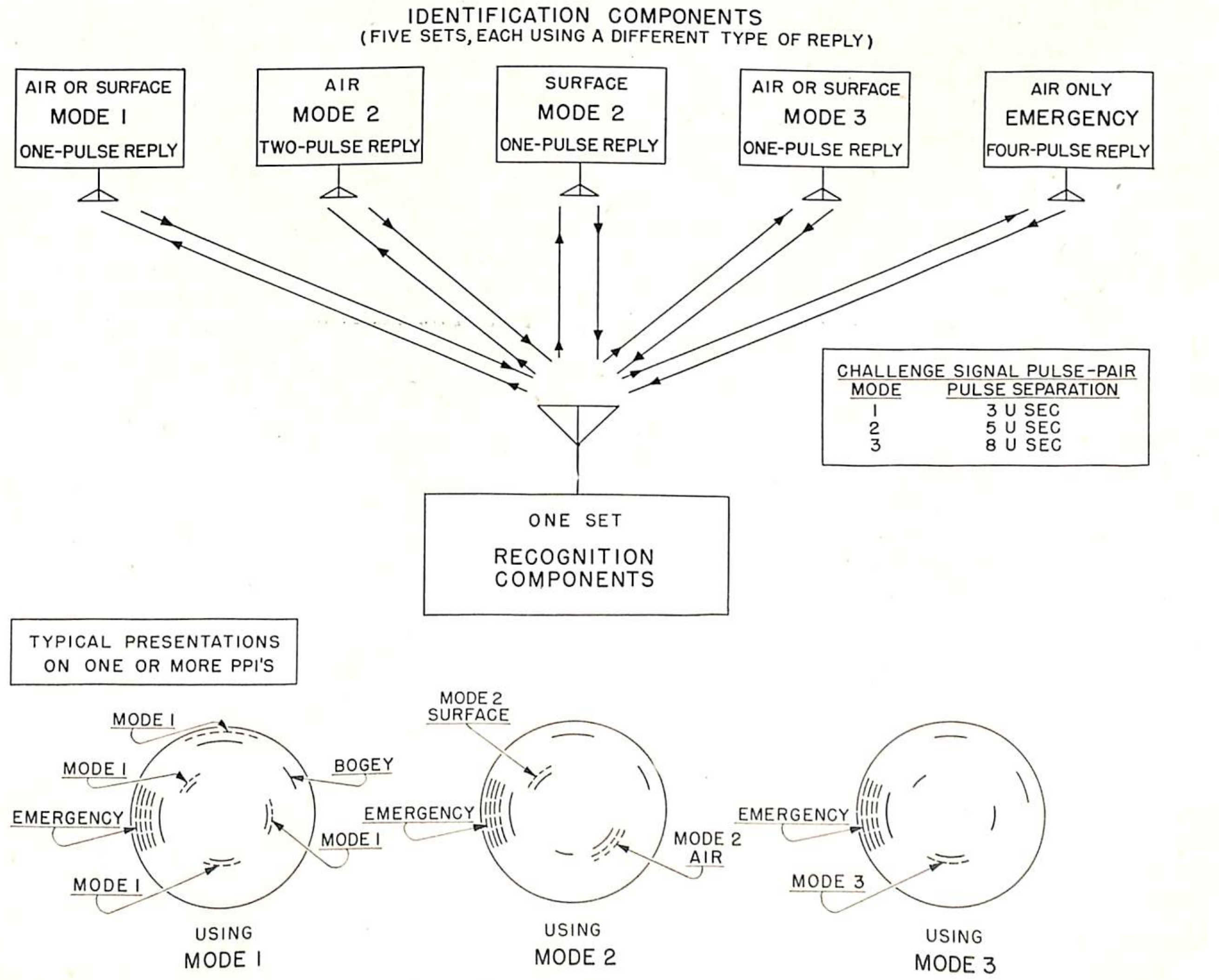
The challenge consists of paired UHF pulses near 1000 megacycles and are generated in the recognition component. Each challenge pair is emitted a few microseconds after the radar pulse. Three types of challenge signals are available and they are called MODE ONE, MODE TWO AND MODE THREE. The MODE ONE challenge consists of paired one microsecond pulses spaced three microseconds between leading edges. The MODE TWO challenge consists of paired one microsecond pulses spaced five microseconds between leading edges. The MODE THREE challenge consists of paired one microsecond pulses spaced eight microseconds between leading edges.

Challenge and selection of the mode of challenge are made at the radar display station and the challenge signals are synchronized with the particular radar to which the PPI display is switched.

Two types of operating systems are in use which affect the challenge. In the first type, selection of the mode of challenge is vested in a master PPI station control. In this case all remote PPI stations are restricted to challenges on the mode selected at the master station. This is known as SINGLE SYSTEM OPERATION. In the second type all stations, master and remote may challenge and select the mode of challenge independently. This is known as INTERLACED SYSTEM OPERATION. The principles of interlacing the three modes of challenge is a function of a coder circuit and will be discussed later.

The IDENTIFICATION REPLIES are UHF pulses also near 1000 megacycles at a somewhat higher frequency than that of challenge pulses. They are emitted from airborne or surface identification components when triggered by the UHF challenge pulses. Each identification reply lags the radar echo by a few microseconds. Considering only the airborne identification component for the moment, the response it gives to each *mode one* challenge pair is a *single* one microsecond pulse. The response to each *mode two* challenge pair is a *pair* of one microsecond pulses spaced sixteen microseconds between leading edges. The response to each *mode three* pair is a *single* one microsecond pulse. The identification component replies to mode one challenge at all times but must be switched to reply to challenges on mode two or mode three or both. Two additional reply conditions are available from airborne identification components. (1) It may be switched to emergency operation in which it will respond with an emergency reply when challenged on any mode. This is a four pulse reply consisting of one microsecond pulses spaced sixteen microseconds between leading edges and (2) it may be switched to a special mode two condition in which it will reply to mode two challenges only when the pilots microphone button is pressed for voice radio communication. This response is a pair of one microsecond pulses spaced sixteen microseconds between leading edges the same as normal mode two responses. The pilot controls the selection of replies for mode two, mode three, emergency and the special mode two as dictated by the operational procedures then in use.

Surface station identification components operate in a similar manner to airborne but reply with single one microsecond pulses on all three modes



MARK 10 IFF System Operation Diagram.

and do not have the emergency or special mode two condition. They also reply to mode one challenges at all times but must be switched to reply on modes two and mode three or both.

Replies from the identification component are received by the recognition component which converts them to video pulses for presentation on the PPI where final RECOGNITION is accomplished. They may be displayed separately or mixed with the radar presentation. In the interlaced system operation the replies from the three modes are separated and automatically channelled to the PPI station originating the challenge. For example, stations originating a mode one challenge will receive only the mode one responses to that challenge, likewise stations initiating the other modes of challenge receive only responses to their respective mode challenges. This sorting action is synchronized with the mode interlacing of challenge and will be discussed later.

Identification signals are displayed on the PPI as a narrow dashed line just beyond the radar target echo. The length of this dashed line will vary with the range or targets and type of antenna used with the recognition component. Discussion of antennas and their effect on operation of Radar Identification will be discussed in a later article. The mode one and mode three identification signals appear as a single dashed line just beyond the radar echo of the target carrying the identification component (either airborne or surface). The mode two response appears as a double dashed line from airborne identification components and as a single dashed line for surface identification components. These are also just beyond the target echo. The airborne emergency identification signal appears as four dashed lines beyond the target echo. The dashed effect is due to the mode interlacing action of the recognition component's coder. The blank spaces represent the time challenges on the two remaining modes are being emitted. The dashed presentation distinguishes the IFF presentation from that of the radar and has *NO* coded significance.

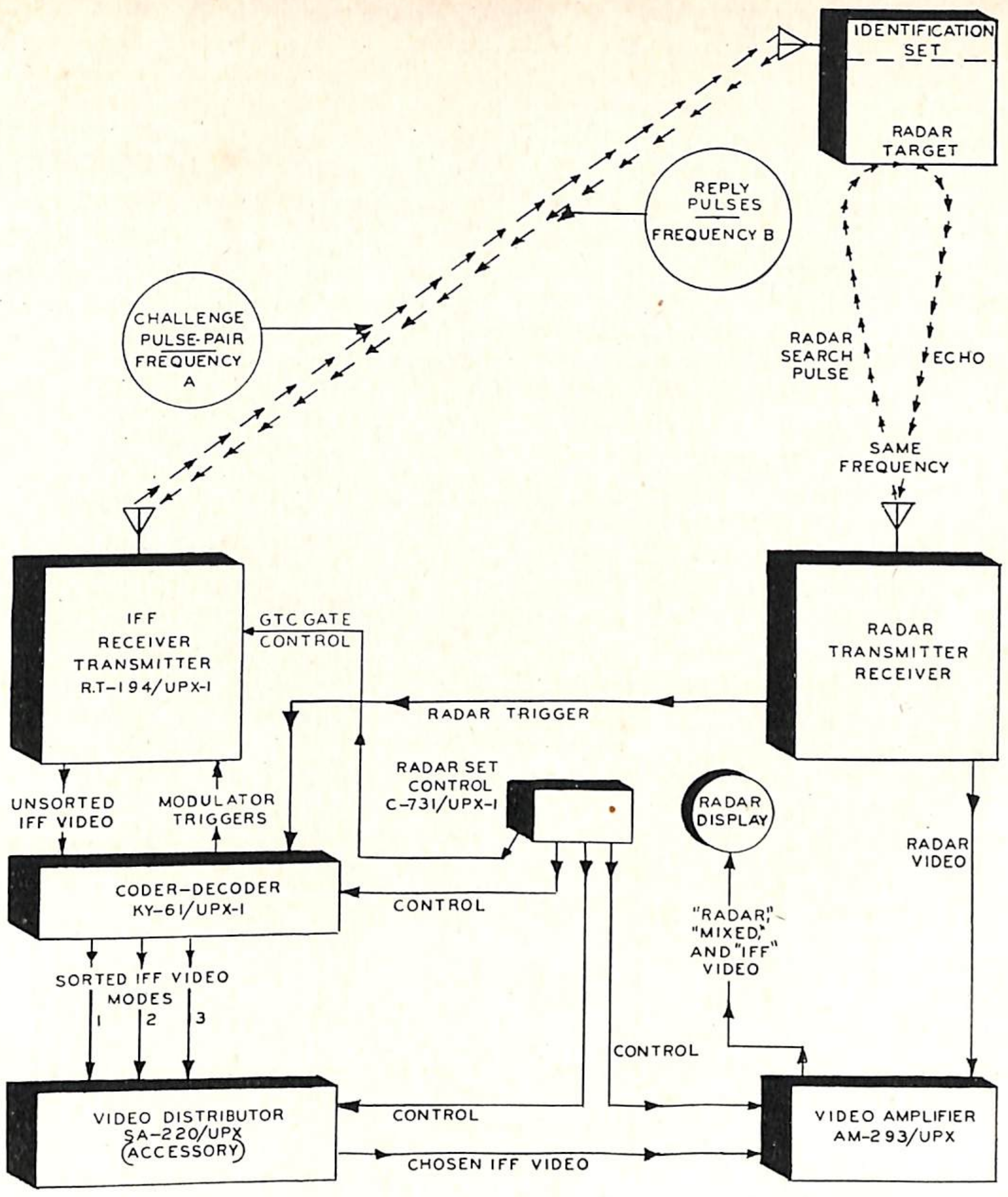
The recognition component which develops the challenge signals and receives and converts the identification reply signals to video for scope presentation consists of the following basic circuits: a coder, modulator-transmitter, receiver, decoder, video mixer-amplifier, control boxes and, for interlaced operation, a video distributor.

The coder is triggered by the radar with which this recognition component is associated. For each radar trigger pulse accepted it produces paired one microsecond IFF trigger pulses spaced 8, 5, and/or 3 microseconds between leading edges (for modes three, two and one), depending on mode selection and challenge operation at the PPI control stations. The coder is capable of producing these pairs in a cycling sequence. For example, two eight microsecond pairs for mode three, two five microsecond pairs for mode two, two three microsecond pairs for mode one and repeating in a continuous cycle. Of course, it will produce these pairs only when a challenge is made on the modes. It follows that if challenges are made on modes one and three, it will produce two eight microsecond pairs for mode three, rest for an equivalent time instead of producing mode two pairs and then it will produce two three microsecond pairs for mode one, repeating this condition until a change in challenge is made.

The paired IFF trigger pulses developed in the coder are amplified in the modulator circuit to high level pulses which fire the transmitter oscillator producing the one microsecond UHF pulse pairs of 8, 5 or 3 microsecond spacing as mode three, mode two and/or mode one challenges.

The returning identification replies from the identification component are converted to video replies in the receiver of the recognition set and pass to the decoder which separates the three modes of replies to three separate outputs. These separator circuits are gated in step with the cycling action of the coder during challenges allowing only one mode of reply signal to pass thru each output.

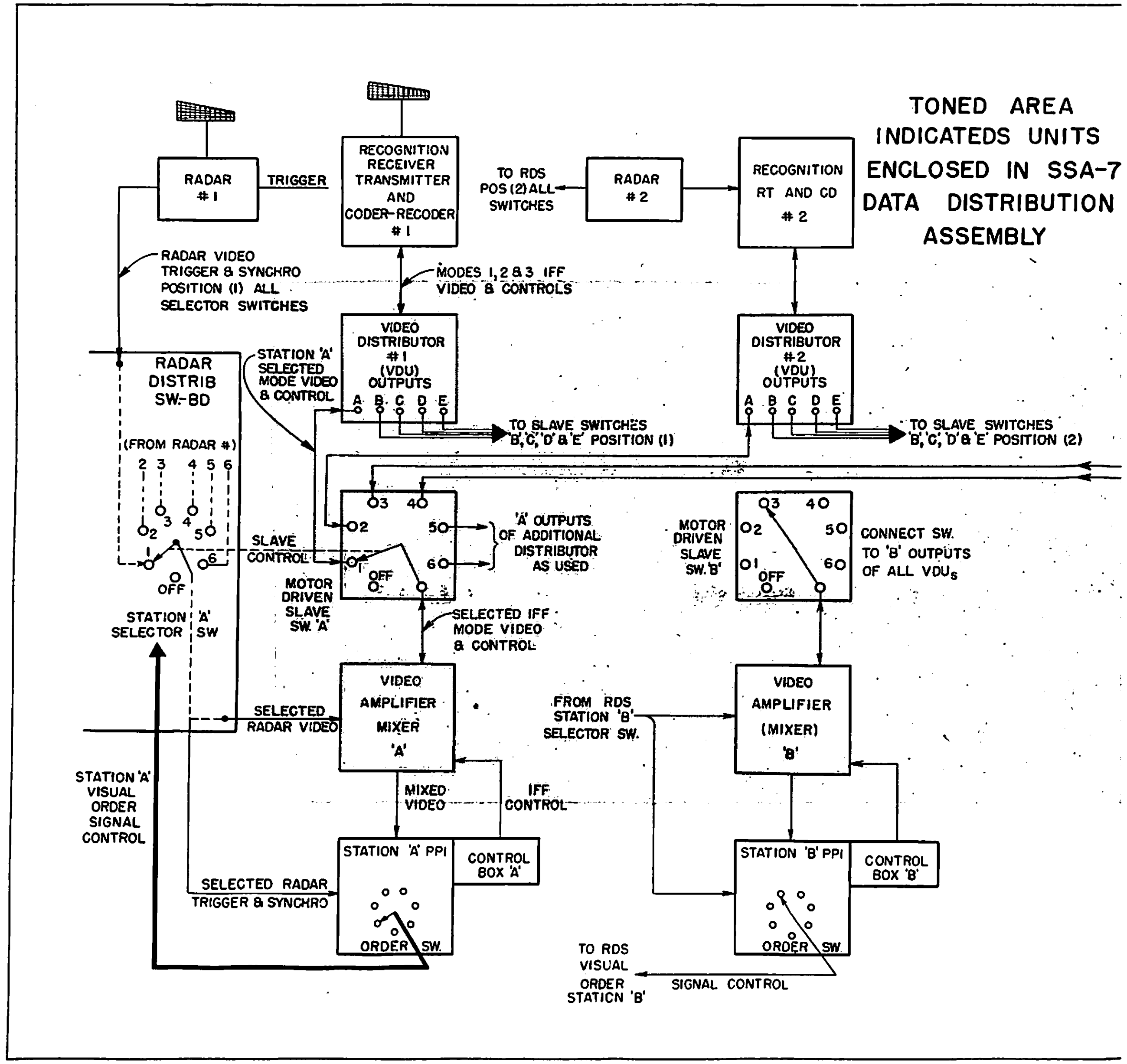
The three individual outputs from the decoder containing the separate modes of reply video are routed to a video distribution unit for distribution back to the station or stations originating the various challenges. This job is accomplished by the use of three relays in the viedo distributor for each station. When a station challenges it automatically closes the relay connecting that station to the video line of the mode it challenged on. This assures that only responses to its mode of challenge will be presented on its display. Each video distributor unit has provisions for five display stations. The video that has been chosen then goes to a mixer-amplifier where it may be mixed with the radar video. A video selector control on the operators control box permits the operator to select from this mixer-amplifier either IFF alone, radar alone or IFF and radar video mixed for presentation on his display scope. This path of events is used for triple interlaced system operation. When single system operation is desired the decoder portion of the recognition set and the video distributor are not needed and the video output of the receiver goes directly to the mixer-amplifier for mixing and selection of video.



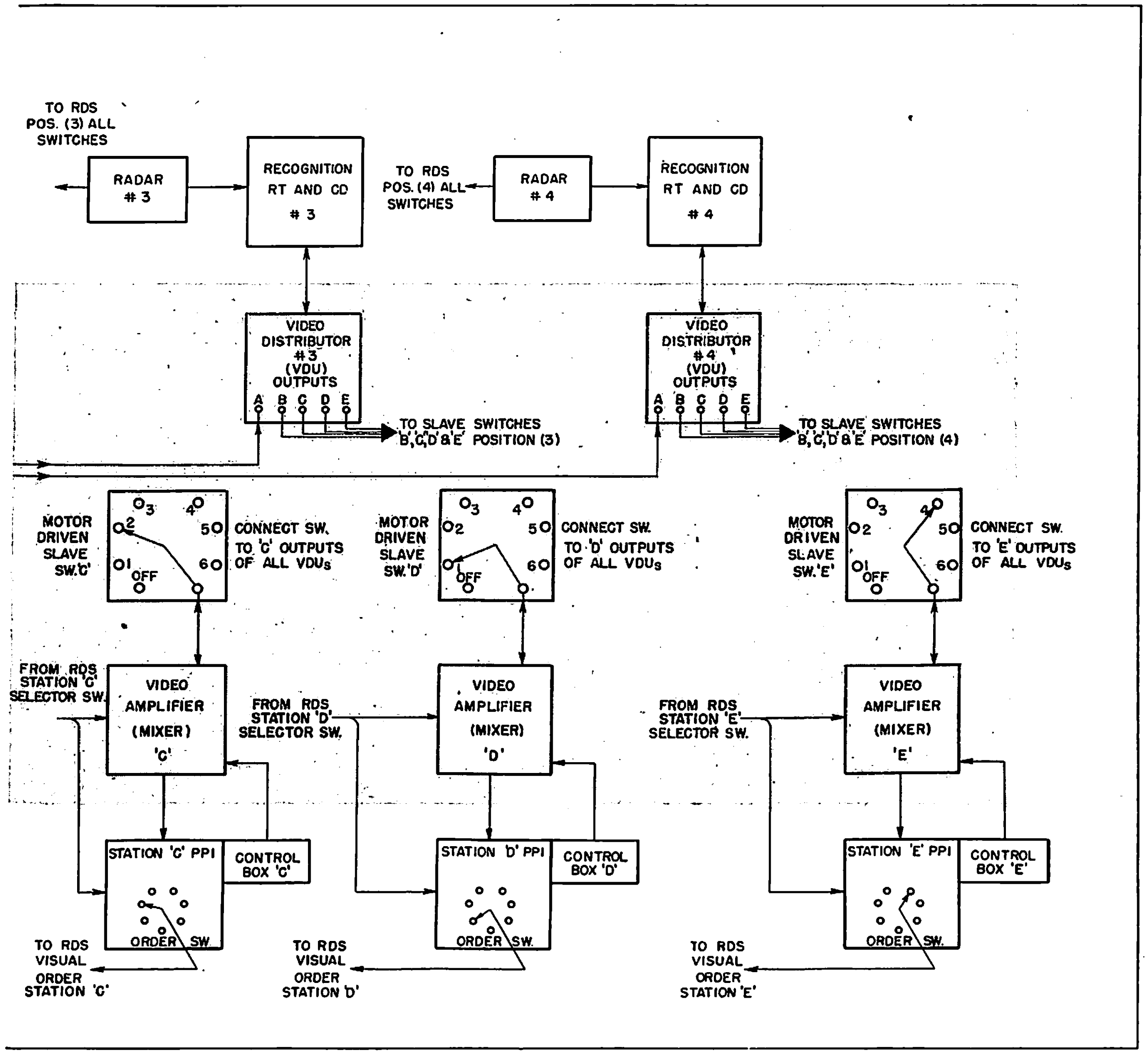
Radar Recognition Set AN/UPX–1 Operation Block Diagram.

System controls are located at the PPI display stations and the degree of control that the operator will have depends on whether it is a master or remote station and the type of system used (single or interlaced system operation). For either type of system the master control station will control gain, gate-GTC (to be explained in a later article), mode selection, challenge, video selection and power to the mixer-amplifier. In the single system operation the remote stations may control only challenge, video selection and mixer-amplifier power. In triple interlaced operation the remote station will have control of mode selection, as well as, challenge, video selection and power.

The problem of presenting IFF and Radar information to the various stations becomes complicated by the fact the stations may choose any one of many radars aboard ship. Since the identification system must always be associated with the radar selected a problem of switching and distribution arises particularly in the interlaced system operation. Suppose, for example, we have four radars each with its own recognition component and five PPI stations. Each station to be able to select any one of the four radars for display. Each



SSA–7 Data Distribution Assembly with four radars and five PPI stations.



SSA–7 Data Distribution Assembly, continued.

identification system will utilize one video distributor to handle the five stations. If we number the radars 1, 2, 3, and 4 and the stations A, B, C, D AND E let's examine our problem. If station A selects radar 1, the radar 1 video must go to the mixer-amplifier for station A. The IFF video for the recognition set associated with radar 1 must be selected from the A output of its video distributor. This requires the switching of station A video mixer-amplifier to the A output of this video distributor.

The radar distribution board takes care of the switching of the radar video to station A. However, to get its IFF Video, Station A must have a motor driven switch which is slaved in its operation to the switch at the radar distribution board and when the radar distribution board switch is turned to the position to select radar 1 the motor driven slave switch also operates to select the A output of the video distributor for the identification system associated with radar 1. This indicates that each station must have a motor driven switch for IFF which is slaved to the radar selector switch of the RDS board. With so many individual units and switches involved for the selection of IFF the most logical conclusion is that these switches and units be enclosed in a rack at a centralized location. This lead to the development of the data distribution assembly which houses the motor driven switches (five stations), the five video amplifiers, four video distributors (with provisions for mounting two additional to take care of two more radars it needed. One data distribution assembly then can handle four radars (or up to six if needed) and five display stations. Where more stations are used additional data distribution assemblies are added for each five stations and are connected in string to the first assembly. A representative example of such an assembly is the SSA–7. In addition to the units mentioned above this assembly also contains provisions for testing video and trigger at the inputs and outputs of all units.

The Identification component basically contains a receiver, decoder, coder and modulator-transmitter. The receiver converts the UHF challenge pulses into video replicas which are decoded and recoded into the various reply pulse groups. These are then transformed into UHF replicas in the modulator-transmitter. In addition to the basic circuits the identification component contains guard circuits to prevent operation by unauthentic signals such as wide pulses, spike pulses and echo signals of the authentic challenge pair reaching the identification set.

Later articles of this series will treat the recognition and identification components in more detail. Articles on antennas for use with the Mark 10 Radar Identification System and Data distribution will also appear in a subsequent issue.

ELECTRONICS IN THE NEW FLEET

by

LCDR Frank H. Cunnare, USN

Electronics Ship and Amphibious Division, Bureau of Ships

The Navy Department is now engaged in the task of designing a new prototype fleet of naval vessels. The magnitude of this assignment approximates that of World War II. There are some 64 different types of vessels being designed and approximately 750 to be constructed. Among them are many vessels having new and unusual military capabilities made possible by new electronic equipments and systems which will allow these vessels to accomplish new missions and tasks.

The guidance in designing each new vessel is provided by the Chief of Naval Operations through the Ship Characteristics Board. Various members of the Bureau of Ships participate in the meetings of this Board to help generate the military characteristics for each new vessel only to the extent to which new technological developments are available and that such developments will actually be incorporated in new or improved equipment.

New Fast Command Vessel

Modern warfare has necessitated many changes in the construction of naval vessels. Independent operation of single ships was common in the early days of the navy, but such tactics have been replaced, in most cases, by the task force or group organization of ships with each ship mutually dependent on each other. As warfare became more complex, it became apparent in World War II that a special type of ship was necessary in order to exercise command properly over the large number of ships which participate in an operation and to control the varied functions performed by such an amphibious force. The amphibious command ship, AGC, with its large complement of electronic equipment was the result.

The necessity for a similar type of control exists in the fast carrier task force. Due to the relatively slow speed of the AGC type vessel, it cannot perform the command function for a fast carrier task force, consequently a ship of seagoing characteristics similar, or identical to those possessed by the ships which compose a fast carrier task force was required. The heavy cruiser hull was chosen as suitable to fill this need. The first ship of this type is the USS NORTHAMPTON and is designated as CLC–1. The CLC–1 is being built at the Quincy, Massachusetts yard of the Bethlehem Steel Company, and the vessel is scheduled for delivery to the Navy during the later part of 1952. The superstructure of this vessel is completely different from the original cruiser configuration.

As a command ship, the primary requirements for the ship to perform its assigned task are sufficient communications circuits together with adequate information gathering and control facilities, such as radars and sonars. Fire power had to be sacrificed to the extent that the largest gun mounted is 5 inch.

The electronics installation includes well over one hundred radio receivers with approximately half as many radio transmitters, five radars for search and control plus gunfire control radar systems, airborne early warning radar, numerous teletypewriters, facsimile equipments and speech privacy systems. Sonar facilities include torpedo detection equipment and a bathythermograph in addition to the customary fathometer. Electronic countermeasures will be provided to cover practically all of the electromagnetic spectrum used in electronics.

A closer study of the ship reveals several interesting points, two of which follow. Although there are but thirty-one radio antennas, it will be possible to operate all of the nearly two hundred transmitters and receivers simultaneously from these antennas by using multi-couplers. Since there are fewer antennas than would otherwise be required, it is expected that the better antenna locations obtained with the resultant improvement in antenna radiation pattern will result in considerably more efficient performance of the communications equipment. The second interesting point is the AN/SPS–2 radar—the heaviest and largest radar ever installed aboard any ship. The antenna alone weighs about thirty-three thousand pounds and its overall dimensions are approximately 35 feet high by 40 feet wide with a swing circle diameter of 53 feet. Its range is expected to be 200 miles or more, depending upon the size of the target. The below deck units of this radar weighs about 27,000 pounds.

The weight of all this installed electronic equipment will be about 105 tons with a total power requirement of about 350 kilowatts.

Guided Missile Ship Conversion

A guided missile ship (CAG) converted from a heavy cruiser hull of the *Baltimore* class is being developed to augment the air defense of the fleet. It will control surface to air guided missiles and provides defense against air targets at ranges considerably in excess of those obtainable with conventional anti-aircraft guns.

The CAG–1 will have installed only about half as many radio transmitters and receivers as the CLC–1 but radar, sonar and electronic countermeasures facilities will be almost identical in the two ships. Although CAG's will not have the command function performed by the CLC's, they must be completely informed of the condition of the surrounding air and sea at all times, so that approaching targets can be intercepted by the missile at the earliest possible moment. At the same time the ship must be able to defend itself from close-in attack from either the air or sea.

Electronics installations on these two types of ships are taxing the ingenuity of the Navy by presenting such a concentration of weights and antennas that it is almost impossible to obtain sufficient space in acceptable locations on the superstructure for proper installation of the multitudinous electronic equipments aboard.

Minesweeper and Small Craft Conversion

The present expansion of the shipbuilding program is especially noticeable in the group consisting of the smaller craft such as minesweepers, patrol craft, landing craft, and aircraft rescue boats. Each of these types have their own peculiar problems and requirements. For example, in addition to the normal communications and navigational equipment installed on board a minesweeper, special underwater mine locating equipment is necessary. To be effective the very latest in this type of equipment must be installed. The AN/UQS–1 equipment answers these requirements and is being installed on the AMCU conversions. Preliminary tests of this equipment have shown it will be highly effective.

In the landing craft program an effort is being made to provide the latest in surface search radar, air search radar, (where required), navigation and sonar equipment. On LST's particular emphasis is placed on the installation of communication equipment in the 27–38.9 mc and the 225–400 mc ranges. The SCR-608 and SCR–610 will continue to be utilized for the lower ranges while TDZ/RDZ and TED/URR–13 will cover the 225–400 mc range. Newly developed portable equipment to cover this latter range will soon be provided.

Two classes of aircraft rescue boats are now under construction. The smaller boat having a length of 52′ and the larger 94′. Special allowances of electronic equipment provided include such items as aircraft homing beacons and lightweight communication equipment. Problems of vibration and lack of masts increase the difficulty in obtaining the desired effectiveness of this equipment.

A new type of small craft to be built and evaluated using special electronic equipment is the IFSS. This will be an Inshore Fire Support Ship and in addition to the normal electronics installation will include special mortar locating radar.

Carrier Conversion

A carrier conversion program was established to convert the Essex Class Ships to handle larger and heavier aircraft. In order to incorporate recommendations based upon World War II experience and to keep abreast of the rapid pace of naval aviation, many improvements were developed. The principal hull changes entailed strengthening of the flight deck, increase in the beam of the vessel's hull, increase in the gasoline stowage, capacity, improved catapults and airplane elevation, and addition of a new island tower incident to radar antenna rearrangement.

The hull conversions made it possibe for the Bureau of Ships to effect somewhat better arrangements of radio and radar antenna and equipment grouping in most operative spaces.

Radio I (or Radio Control—take your choice) was relocated from the island to a forward location on the galley deck. This change permitted Radio Control to be grouped as a receiver converter room, teletype room, and a main communication system control space resulting in improved operations.

These vessels are also being fitted with a Commanding Officer's Tactical Plot in conjunction with a C. O. Message Center providing all the electronic facility of an auxiliary CIC.

This configuration of a CV has been longest referred to as Project 27A. However, inasmuch as the class designation of CV 34 has been adopted for purposes of differentiating between the CV 9 class (original), and the Project 27A conversions, ships so converted are also known as the CV 34 class aircraft carrier. (Technicality: Since the USS ESSEX (CV9) has been converted under Project 27A, the existing USS ESSEX is no longer of either the USS ESSEX class or CV 9 class but is of the CV 34 class. On the other hand her name and bow number will remain unchanged.)

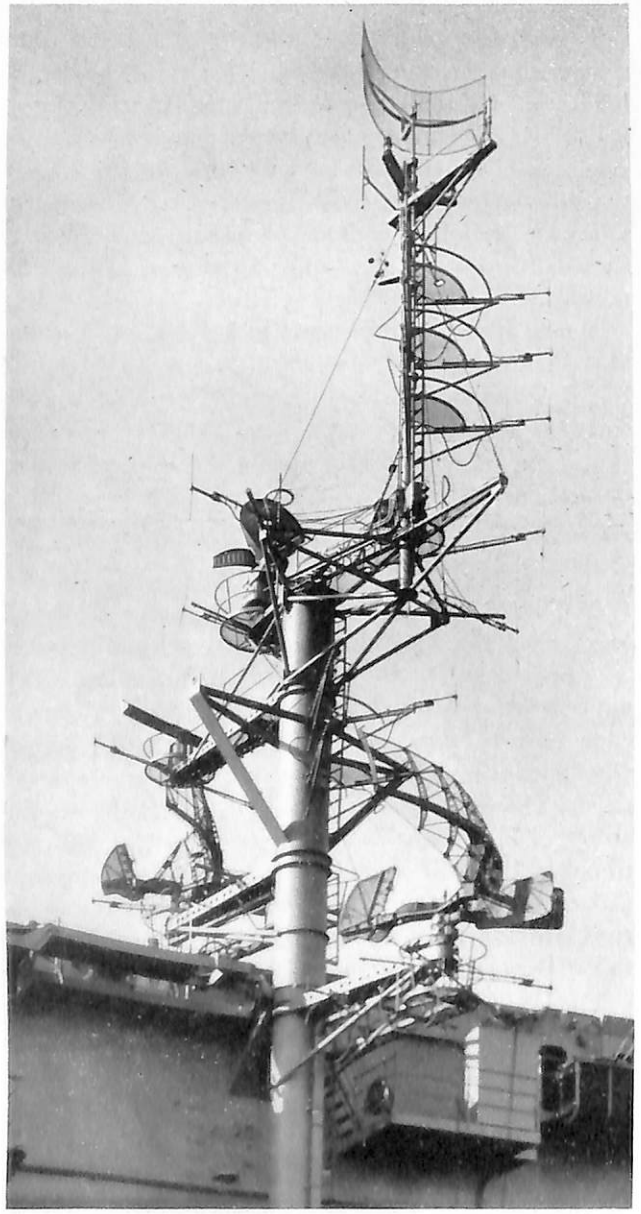


FIGURE 1—USS Oriskany (CV34) arrangement of antennas on stub mast (stub mast is shown stowed).

Among other installations, these ships will be the first aircraft carriers to have the ultimate allowance of UHF. One of the major difficulties of outfitting these vessels with the complete UHF allowance is the retention of sufficient VHF equipment to permit adequate operations during the interim. As can be seen from the mast (figure 1) of the CV 34, UHF antennas are mounted at every possible location. Mast is in a stowed position to allow passing under the Brooklyn Bridge, the coaxial cables are run inside of the mast and are provided with connectors for mast removal.

Improved UHF results are expected when presently planned multicoupler installations are accomplished and better antenna spacing can be provided. The VHF/UHF transmitters and receivers are grouped in five spaces known as Radio IV (UHF Room #2), Radio VII (VHF Room), Radio VIII (UHF Room #1), Radio IX and the Carrier Controlled Equipment Room.

A new radio space (to be designated Radio XI) was provided in the island to house the "Bird Dog" . (Shipboard L.F. transmitter keyed as a long range beacon for the use of homing aircraft utilizing the planes ADF "Bird Dog") The new island design made it possible to rig a non-tilting antenna which is removed from the flight deck area thus permitting a reduced number of interruptions to the LF transmitter's operation. From its important function of homing aircraft it will be appreciated that continuous availability when needed is absolutely essential. Additional space is provided in the island for a supplementary radio facility.

The new rotary knob type switchboards are supplanting the receiver and transmitter remote control panels as rapidly as the new boards can be manufactured. The number of patch cords required for antenna transfer patching will be minimized by planned installations of receiver multicouplers scheduled to come in the near future.

Another significant electronics change will be the improved fighter-director radar AN/SPS-8. Although the first vessels of this project had the SX radar reinstalled, later conversions are expected to have two (2) AN/SPS-8 fighter director radars in the same position as a replacement interceptor control radar system; the two SPS-8's providing 360° of unobstructed air control coverage will be first installed on the USS LAKE CHAMPLAIN (CV39) converting at Newport News Shipbuilding and Dry Dock Co. This pair of radars will provide 4 simultaneous air control positions in CIC, two as the master control of the radars and two as remote positions. Those will replace presently installed SX consoles shown in figure 2. Synchronized pulsing and synchronized rotation 180° out of phase are being investigated to minimize mutual interference between the two AN/SPS-8 radars.

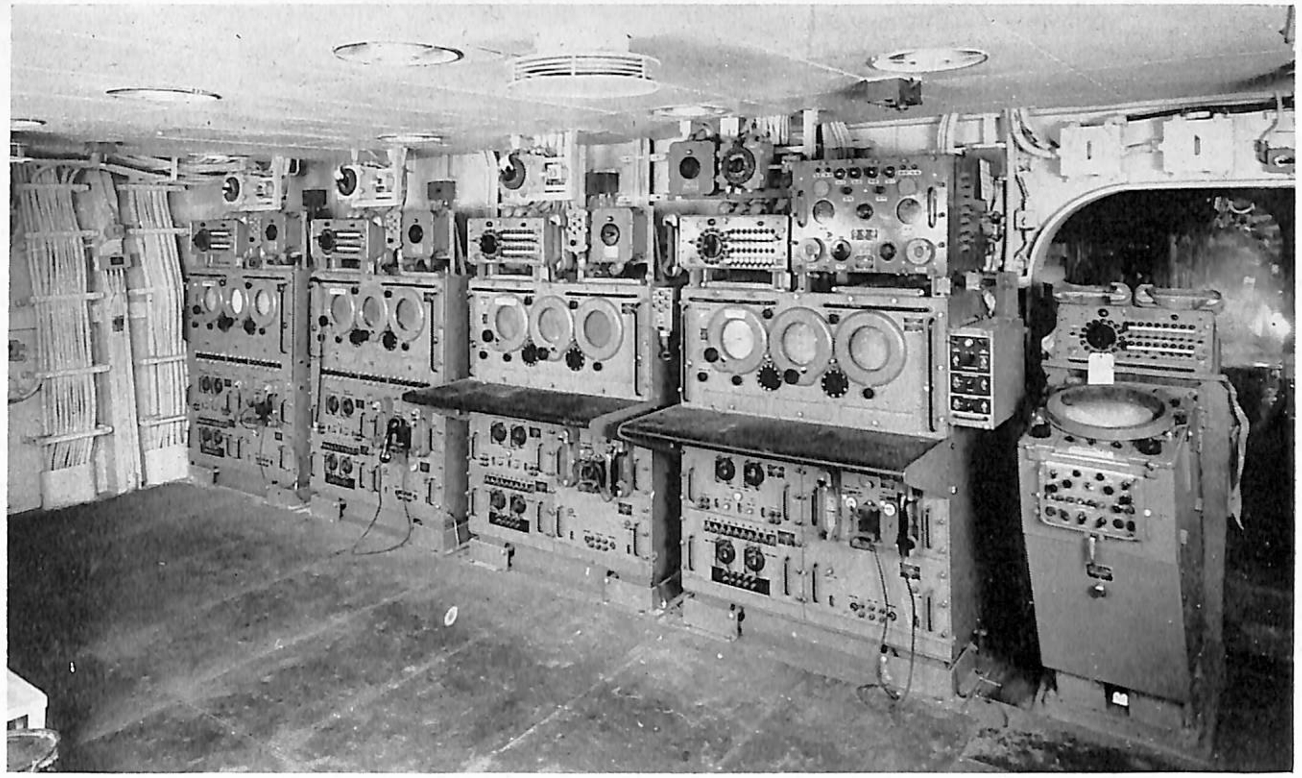


FIGURE 2—USS Oriskany (CV34) combat information center showing Model SX Radar Consoles.

In the past the sonar equipment for a carrier was limited to a fathometer. The CV-34 class is being provided with torpedo detection sonars and sonaramic receivers. In addition to the above sonar equipment the Fleet Force Flagship will be equipped with a bathythermograph system.

Submarine Conversion

Submarine shipbuilding has made rapid strides in recent years. It might well be said that the post war years have seen more advances in this type of ship than any comparable period in history, for the submarine is in a state of metamorphosis from a ship that can on occasion submerge to one that on occasion may surface.

The first stage of this metamorphosis has come with the advent of the snorkel. With this breathing tube the submarine may proceed almost indefinitely under the surface with only a small pipe showing. In the not too distant future it is expected that the SSN 571, a nuclear powered submarine, will join the fleet, and then we will have a true submersible ship that no longer need expose any portion of its structure above the surface.

But these developments have brought new problems for the submarine electronic planners, for all the old needs for electronic equipments continue, but new and different equipments must be provided. Let us examine a few of these.

If the submarine is to operate other than as an isolated unit it must transmit and receive radio messages. The old electronic equipments suffice, but to keep the submarine below the surface suitable antennas must be provided. For medium and high frequencies 25 foot whips have been mounted on hydraulically operated masts. So, just as the periscopes have always been, the antennas are raised above the surface for communication and then with-drawn into the streamlined conning tower fairwater when no longer needed.

Similarly, with the VHF and UHF antennas; adaptations of bi-conical arrays are machined out of a basic cylinder whose diameter is that of another hydraulic mast. To economize in these masts, two and even three such antennas are stacked atop each other. An example of this stacking is the AS–493/B combination in which an AEW Beacon antenna is stacked atop an AEW link antenna, which, in turn is atop the AS–468/B, UHF antenna. Thus all three of these antennas are arranged structurally in the form of an extension to the mast itself and move freely in the mast supporting bearings.

And the well known, very low frequency, loop has been adapted to use at higher speeds (permitted by the new submarine propulsion) by building it in the form of a tear drop, the AT–274/BRR, and mounting it on a hydraulic mast. In this fashion reception of signals in the 5 kc range has been possible at submarine keel depths up to 100 feet.

As radio equipment must be modified, so must the radar and ECM equipment. New antennas or supports had to be provided to make the electronic equipment usable at periscope depth.

The change in the antennas may perhaps best be illustrated on a before and after basis. In 1945 the typical submarine had a hydraulically hoisted SV radar antenna, two periscopes, perhaps one whip antenna fixed-mounted on the conning tower fairwater, and three wire rope antennas running from the conning tower area to the bow of the ship.

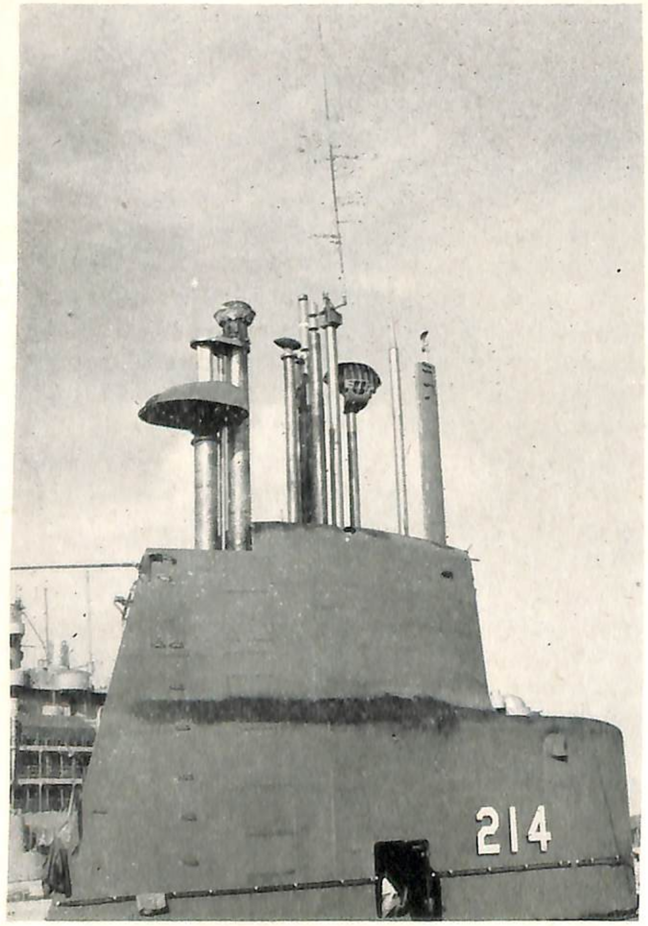


FIGURE 3—USS Grouper (SS 214) showing antennas in a partly extended position.

Now a whole forest of antennas and masts has sprung up. For example, the SSK (USS GROUPER) has the two periscopes, a whip antenna (nonretractable) mounted on a fixed base, and the SV radar mast of World War II days. But in addition, there are hydraulic masts for supporting (1) a second 25 foot whip, (2) the VLF loop, (3) a radio distance finding equipment antenna, (4) a UHF and ECM antenna and (5) a VHF-IFF antenna. And even the snorkel mast, which has fathered this revolution, is pressed into service to carry still another ECM antenna. This array is shown graphically in figure 3, a photograph of the USS GROUPER.

The USS GROUPER herself is a more cogent example of the manner in which electronics has grown with and influenced submarine construction. The newer more submersible submarines provide one of our most potent defense weapons, and have been proposed as perhaps the best counter to enemy undersea craft.

Accordingly, this new type submarine, with the USS GROUPER as a prototype, has been developed around new acoustic detection devices. This new type has been designated the SSK or, more dramatically, the hunter-killer submarine.

It has long been known to students of acoustics that an easy way to get increased listening sensitivity is to increase the size of the listening element. For a long time our thinking in sonar was limited to sonar as an independent box to be “stuck on” to the completed ship's structure. This concept then severely limited the size of our listening elements or transducers. But the Germans pioneered in the conformal type array with their Prinz Eugen installation. Here a large number of hydrophones were arranged in conformance with the hull structure. By suitable delay lines they were electrically straightened out to provide an extended hydrophone many time as large as could be installed on the “independent box’ basis.

This idea was picked up by our designers and adapted to the development of a long range listening equipment known as the AN/BQR–4. In this equipment 50 ten foot line hydrophones are arranged about the bow of a submarine and electrically integrated to form one highly sensitive listening equipment. The submarine carrying this equipment is, however, a small ship. But the SSK must have the best of electronic acoustic detection devices. Accordingly, the entire structure of the bow was changed and a large blunt bow was built on to it to house the AN/BQR–4 hydrophones. This bow can be seen in figure 4.

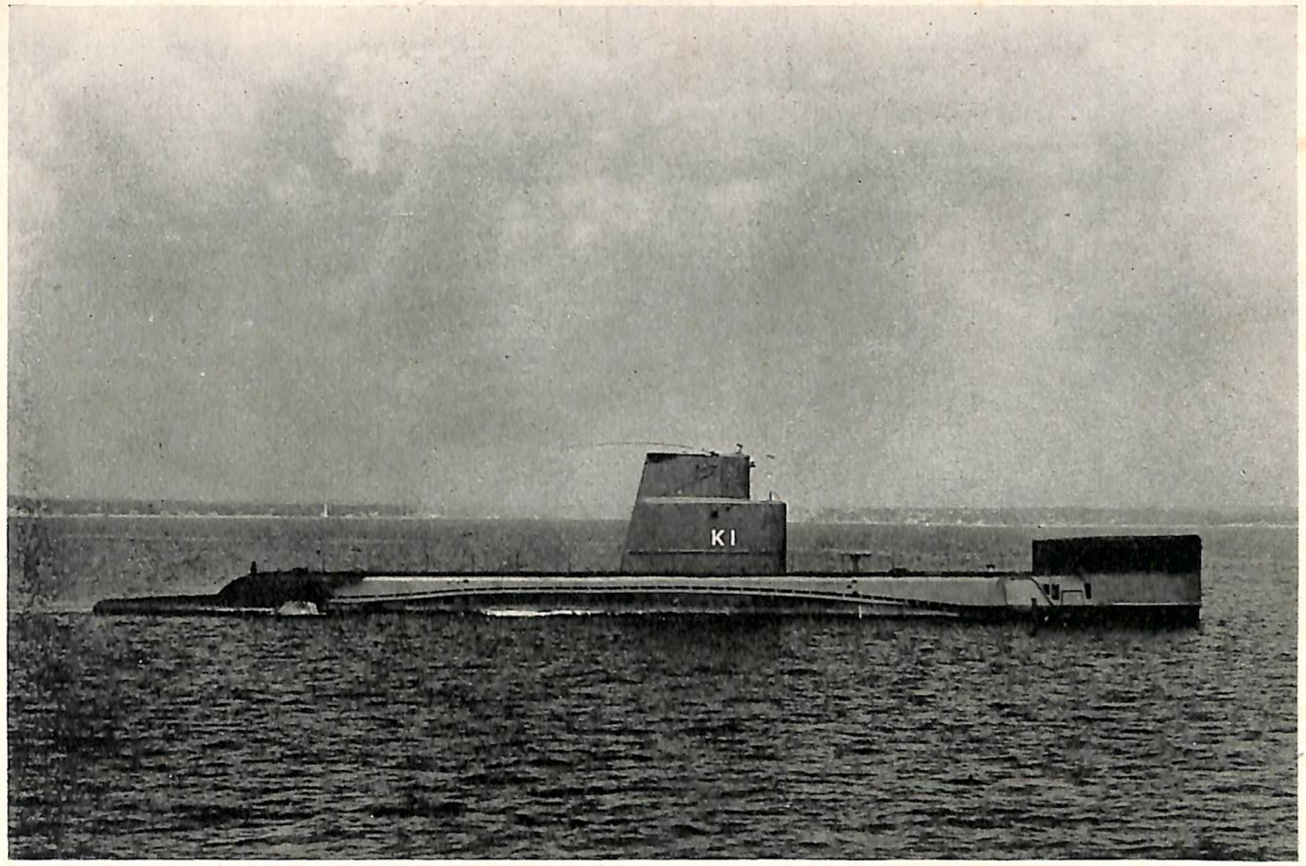


FIGURE 4—USS (KI) broadside view showing large blunt bow and antennas retracted into the streamlined conning tower fairwater.

And, as the old electronic equipments have been revised in the light of new submarine propulsion plants, entirely new electronic equipments have been required for entirely new functions. The SSN 571 will carry a nuclear reactor to provide motive power. The radiation hazard makes remote control of the power plant necessary. A sensitive system for this control, as well as for warning of radiation danger, had to be devised for the atomic submarine. The versatile electron was called upon. And, at an estimated cost of $1,000,000 dollars, this system is being developed to provide reactor control and radiation warning.

Destroyer Conversion

After the close of World War II, it was found there was a definite need for more than just a general purpose destroyer (DD) and destroyer escort (DE). These thoughts were augmented in the development, conversion, and building of various classes of destroyer type ships for special purposes. The destroyer leader DL–1 (5500 tons), destroyer leader DL–2 (3650 tons), DE–1006 escort vessel, DDE (2100 and 2200 tons) destroyer escort conversions, DE and DD(ASW) anti-submarine warfare, DEC (amphibious control ships), and the DER and DDR classes of radar picket ships, each ship carrying out a special mission yet still being able to perform the original function and missions of the destroyer and destroyer escort.

World conditions as they are, it was found necessary to expedite the development of a destroyer capable of screening other surface units against attack by enemy air, sub-surface, and surface vessels and still be able to operate as a conventional DD within the limits of its capabilities. The existing DD692 class, 2200 ton long hull was selected to be converted to the DDR radar picket ship to accomplish this mission. On completion they will be able to carry out the following:

1. Detect and give early warning of enemy aircraft, guided missiles, sub-surface and surface ships.
2. Control combat air patrols for interception of

enemy aircraft at a distance from the force being screened.

3. Provide a reference point for friendly aircraft.

4. Provide the best practicable self defense against aircraft, surface, and submarine attack.

Installations for detecting and giving early warning of enemy aircraft and guided missiles consist of AEW systems (AN/SRR–4), air search radar system (AN/SPS–6), ECM systems (AN/SLR–2 and AN/ULR–1) and radar IFF system. Interception of sub-surface vessels is accomplished with the scanning sonar system (QHB or AN/SQS–10) and surface vessel warning given by the surface search radar (SG–6B) and ECM system.

The control of combat air patrols for interception of the enemy at a distance from the screened forces is accomplished with height finding radar system (AN/SPS–8) and the above air search radar.

Radar Beacons (AN/UPN–7 and AN/UPN–11), Radio Beacon (YG), UHF (AN/URD–4) and VHF (AN/URD–2) direction finder systems installed provide the reference point for friendly aircraft.

Integrated into the radar system are eight radar repeaters excluding the master repeaters of the air and surface search radars. In addition to the above electronic equipments, the DDR vessels will carry a full complement of loran, echo sounding, underwater telephone, bathythermograph equipment, infrared, radiac, teletype (UHF and HF system) and radio transmitting and receiving system.

AGC Conversion

One of the most interesting engineering projects conducted on Auxiliary vessels has been the antenna improvement program for AGC vessels. These vessels are communication vessels, primarily, which were designed on a crash basis during World War II. They have communication equipment which is in excess of that found in many shore stations. The space available for radio antennas on these vessels is very limited. Since the operation of communication equipment is dependent upon the antenna system, these installations left much to be desired.

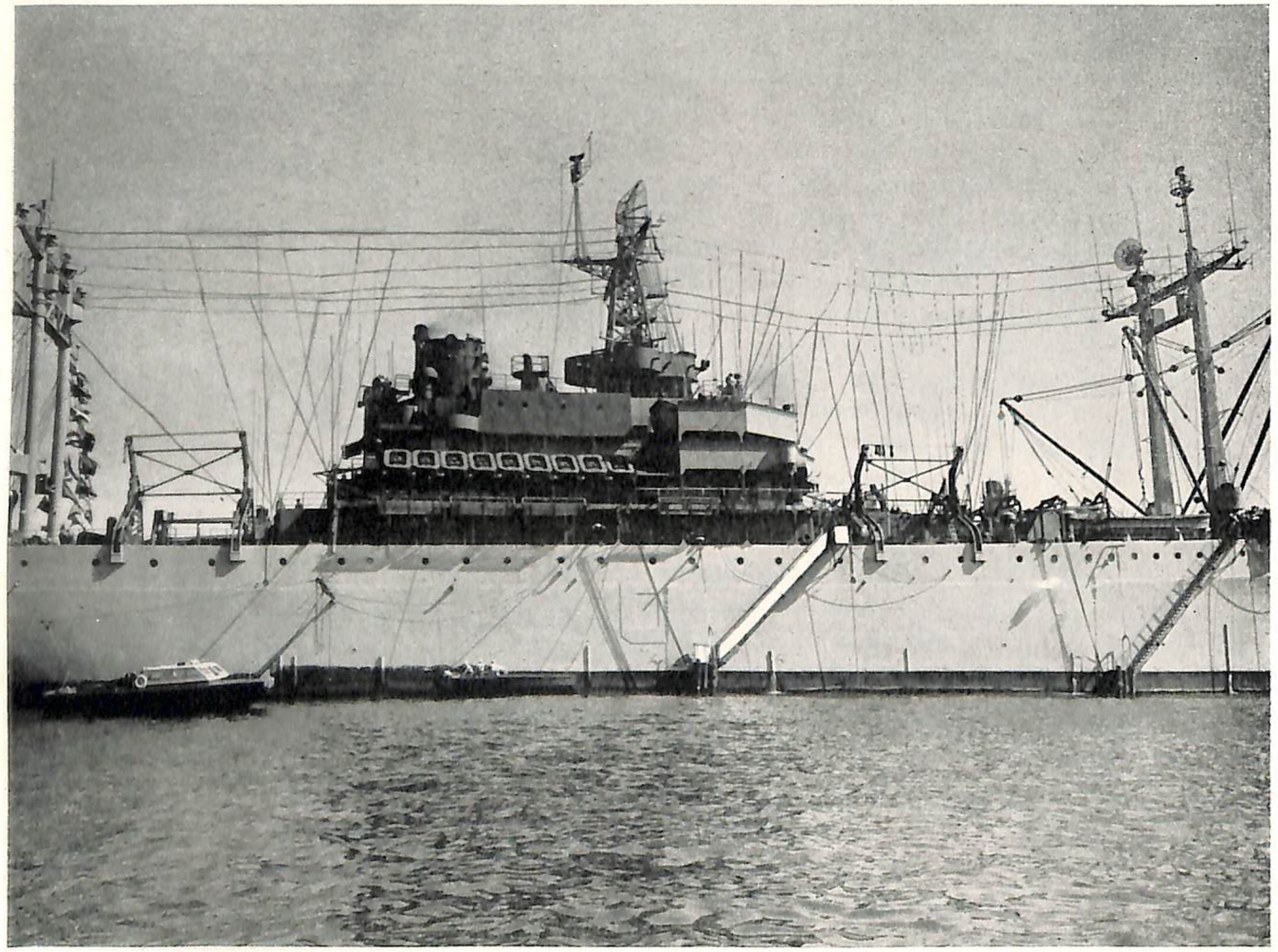


FIGURE 5—"Before" antenna system of the USS Mount McKinley previous to accomplishment of antenna modification project (note maze of antennas about the deck house).

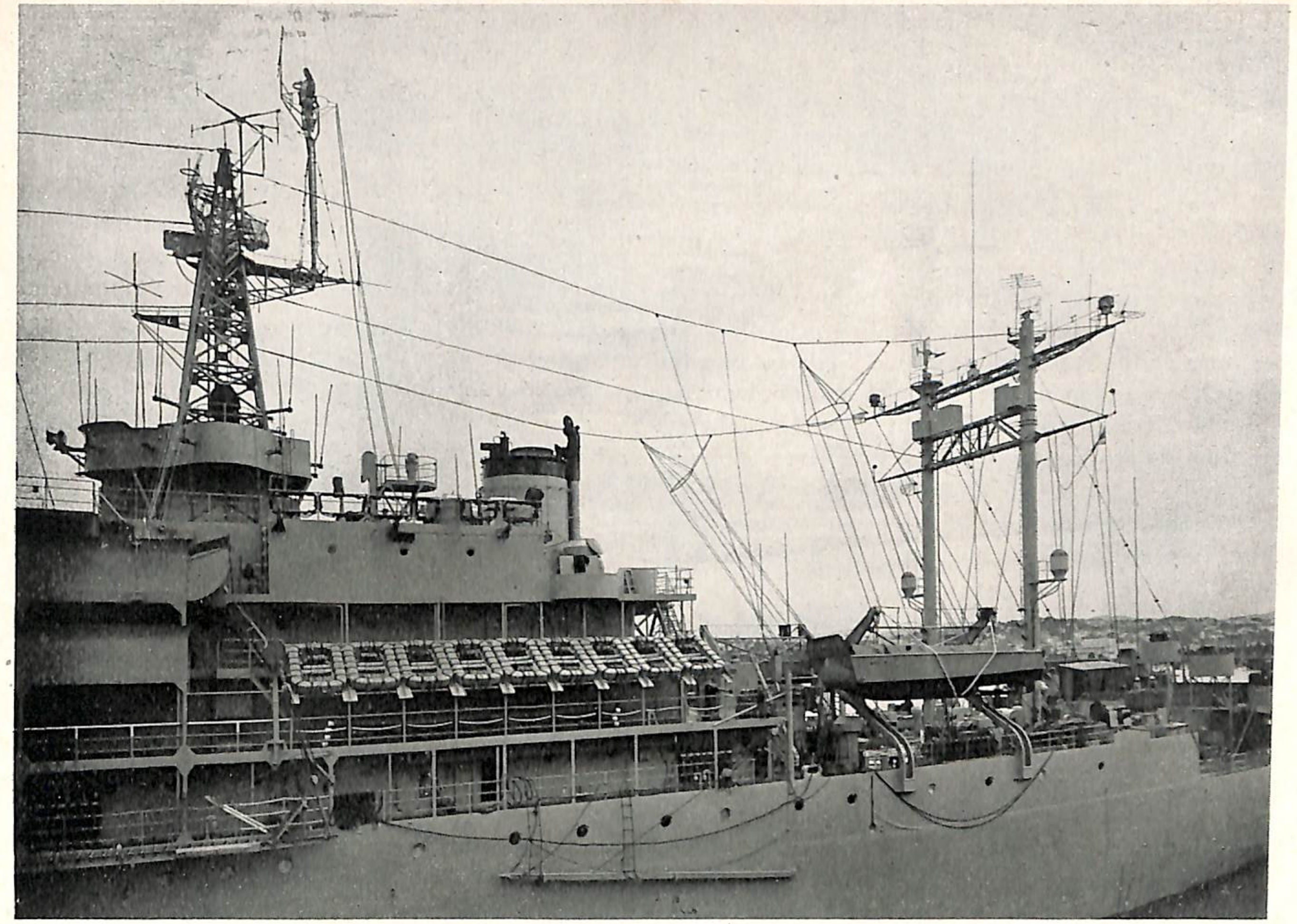


FIGURE 6—"After" the new antenna system of the USS Mount McKinley (note the clean cut appearance).

The first large scale antenna reduction experiment has been made on the USS MOUNT McKINLEY (AGC7). The Bureau of Ships and the Naval Electronic Laboratory have collaborated in making a prototype antenna installation on this vessel. The basic idea behind the project was to eliminate as many antennas as possible and replace them with a few well-located antennas and to use them more efficiently. The MOUNT McKINLEY is equipped with 25 transmitters. Their output range from 50 watts to 1000 watts and their frequency range from 175 kilocycles to 18 megacycles. These transmitters were fed into the reduced number antenna through a series of multicouplers. The idea of multicoupling several transmitters into one antenna is not new, but the present technique or method of accomplishing the result is new. The particular multicouplers employed were developed by NEL and are a pair of complimentary filters; each multicoupler consisting of a low-pass and a high-pass filter. The exact electrical parameters of the individual filter depends upon the frequency range covered. A multicoupler employing complimentary filters is itself a simple device, but its application requires very careful engineering. To obtain an efficient transfer of power from the filter to the antenna, requires careful matching of impedances. It would be very desirable to employ broad band antennas for this purpose, since they maintain relatively constant input impedance of a considerable frequency range. However, in the case of the USS MOUNT McKINLEY, space was not available to install this form of antenna. Since the normal wire antenna is a narrow frequency band device whose input impedances varies greatly, very careful engineering was necessary.

The Figures 5 and 6 are "before" and "after" photographs. It will be noted that the "before" shows the vessel with a maze of antennas. The "after" photograph shows a much cleaner antenna arrangement. The present installation was recently completed, and is presently undergoing service evaluation.

New Icebreaker

Another project presently under consideration is that of a new icebreaker of improved performance, the AGB–4. It is expected that this icebreaker will be the prototype of many future vessels of this type. These vessels require communication facilities quite different from that of a normal surface vessel.

These ships operate in the Arctic or Auroral zone. In this region, low frequency were found to be more reliable than the normal high frequency generally employed for Naval communication. This low frequency equipment poses a difficult problem due to the large antenna and large powers required for successful operation. A preliminary investigation of the communication problem in these vessels was started on the USS ATKA (AGB3). The first multicoupler installation in the Navy was made on this vessel late in 1950. One multicoupler was used which permitted the operation of the low frequency transmitter and a high frequency transmitter on the same antenna. In addition, 4 multicouplers were used for the receivers. In operation, the receiving multicouplers were highly successful. In addition to accomplishing their normal common antenna working operation, they provided a measure of protection to the receivers from the high powered low frequency transmitter. The transmitting multicoupler, however, has not been fully successful, but has been subject to various failures, due largely to component failure. It is expected, however, that these difficulties will be ironed out. The new icebreaker, AGB4, will take full advantage of these investigations, and will likewise incorporate the techniques found successful on the AGB3 class icebreaker. In addition to the regular antenna system, a Kytoon supported low frequency antenna may be employed when conditions are extremely severe, or when communication is extremely urgent.

Conclusion

The foregoing describes very briefly the part electronics plays in a few types of vessels in the new fleet. The speed of present day aircraft and the contemplated speed of future aircraft is a barometer of the tempo of modern and future warfare. This emphasizes the necessity to eliminate as much as possible any human errors or delays which would enable enemy planes or vessels to attack a task force without being detected. In regard to this, the Navy Department is endeavoring to furnish the fleet with the best electronic equipment possible and yet to simplify this equipment to enable the fleet to carry out effectively its missions, and at the same time to protect the fleet against enemy attacks.

TRAINING FILM ON SAFETY

Safety precautions for electronics personnel is the subject of a fifteen-minute training film recently completed under the sponsorship of the Bureau of Naval Personnel.

This film entitled "Safety Precautions for Electronics Personnel—Introduction" demonstrates the hazards encountered in servicing or adjusting electronic equipment and the precautions necessary to avoid death or injury as a result of these hazards. Prints of MN6754 are available at District Training Aids Sections.

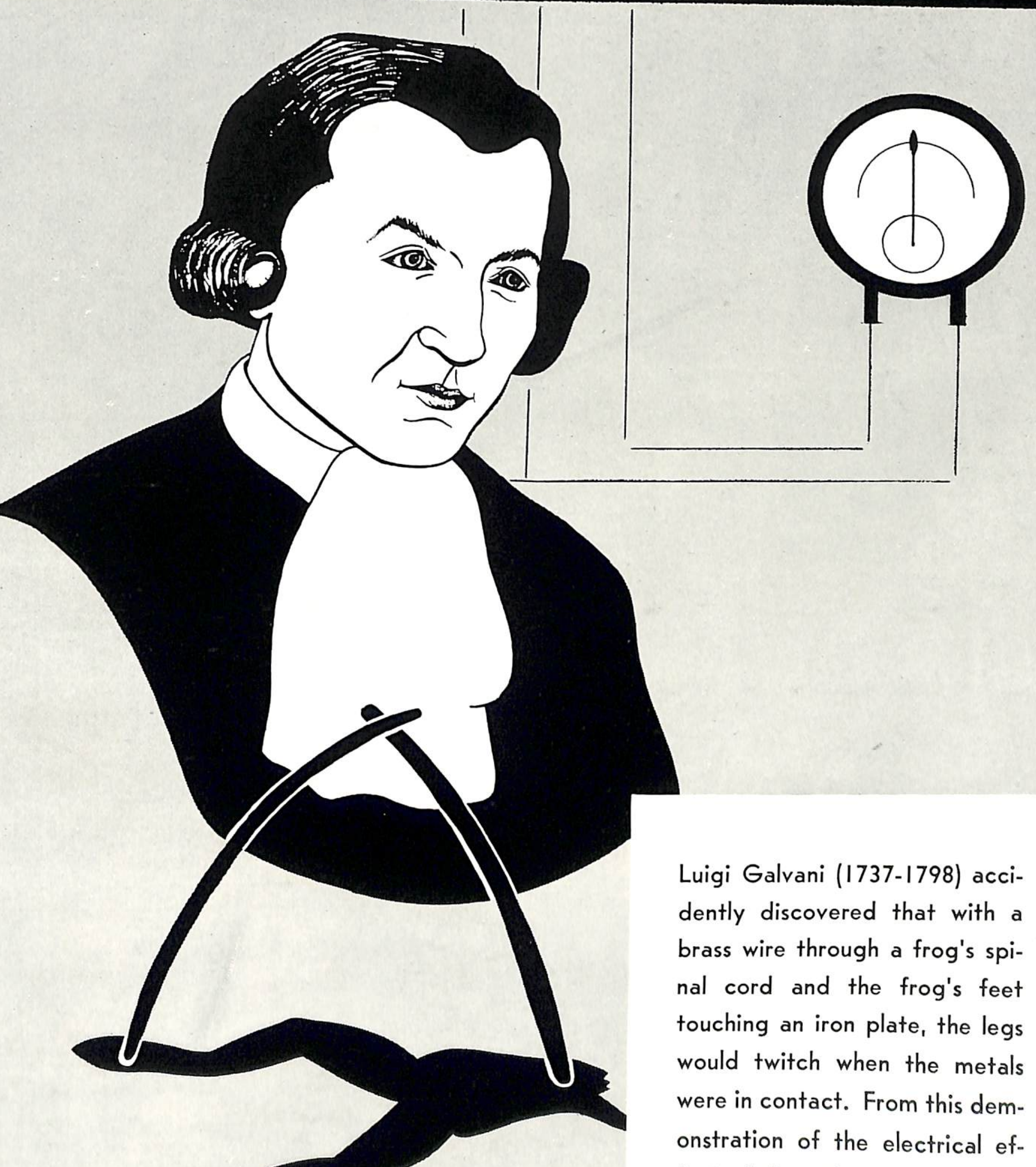
Corrections to the March 1952 ELECTRON—page 17, item 7 in table 1 under Transistor should read "high output impedance".

IMPORTANT ANNOUNCEMENT IN NEXT ISSUE!!!

HOISTING BATHYTHERMOGRAPHS

A considerable number of bathythermographs have been lost due to careless handling, and due to rough seas, during the hoisting operation at sea. To reduce these losses, it is recommended that the final thirty (30) feet of hoisting be accomplished by use of the hand crank supplied with the bathythermograph winch. Care should be taken that the winch is not energized while the hand crank is being used.

FAMOUS FIRSTS IN ELECTRONICS



Luigi Galvani (1737-1798) accidently discovered that with a brass wire through a frog's spinal cord and the frog's feet touching an iron plate, the legs would twitch when the metals were in contact. From this demonstration of the electrical effect of dissimilar metals in contact, Volta developed the first electric battery.

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DON'T BE SHOCKED

Don't make accidental discoveries using yourself as a subject! Galvani used a frog for his experiment. (see inside back cover)

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