BUSHIPS JULY 1951

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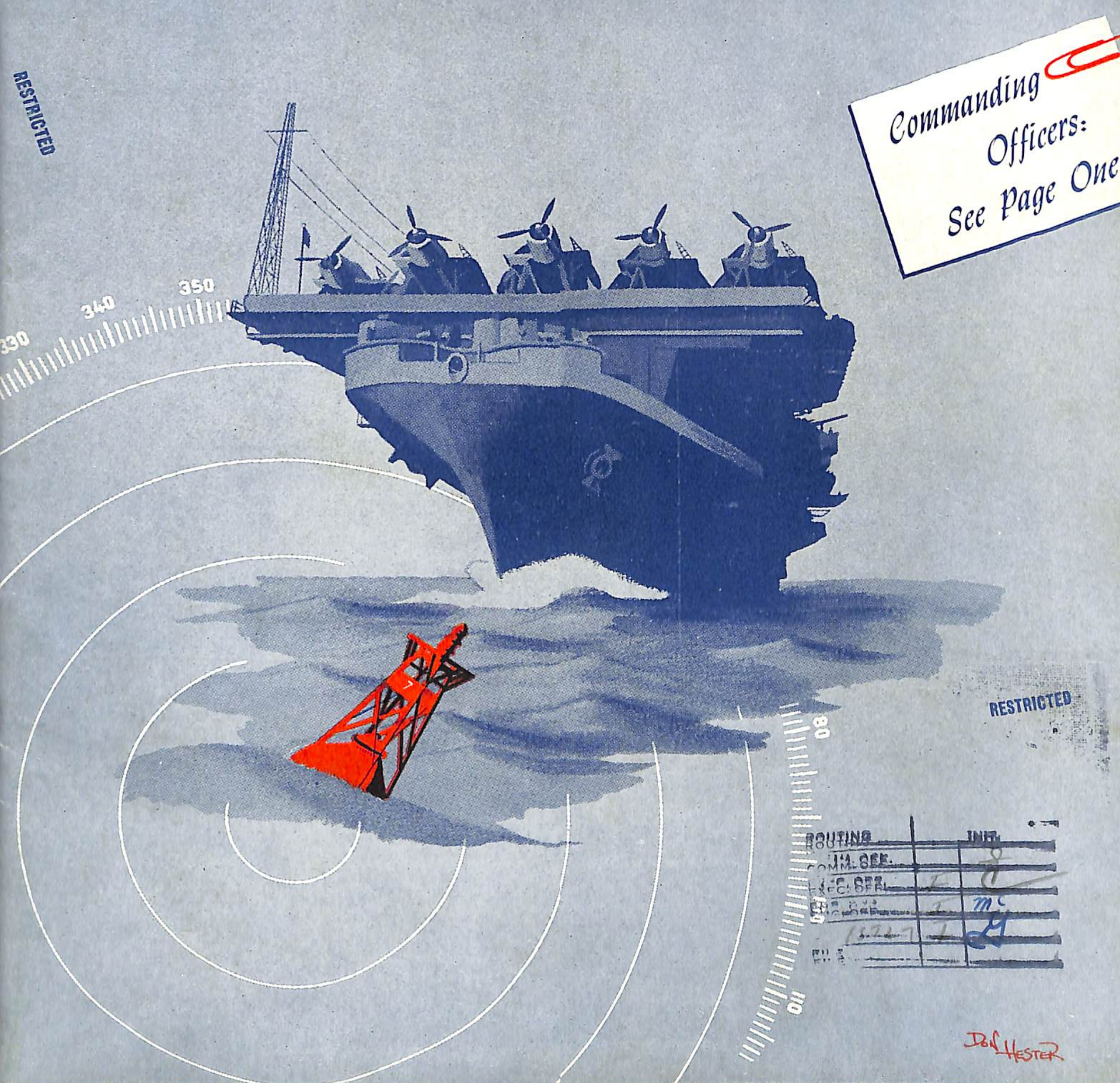

Commanding Officers: See Page One

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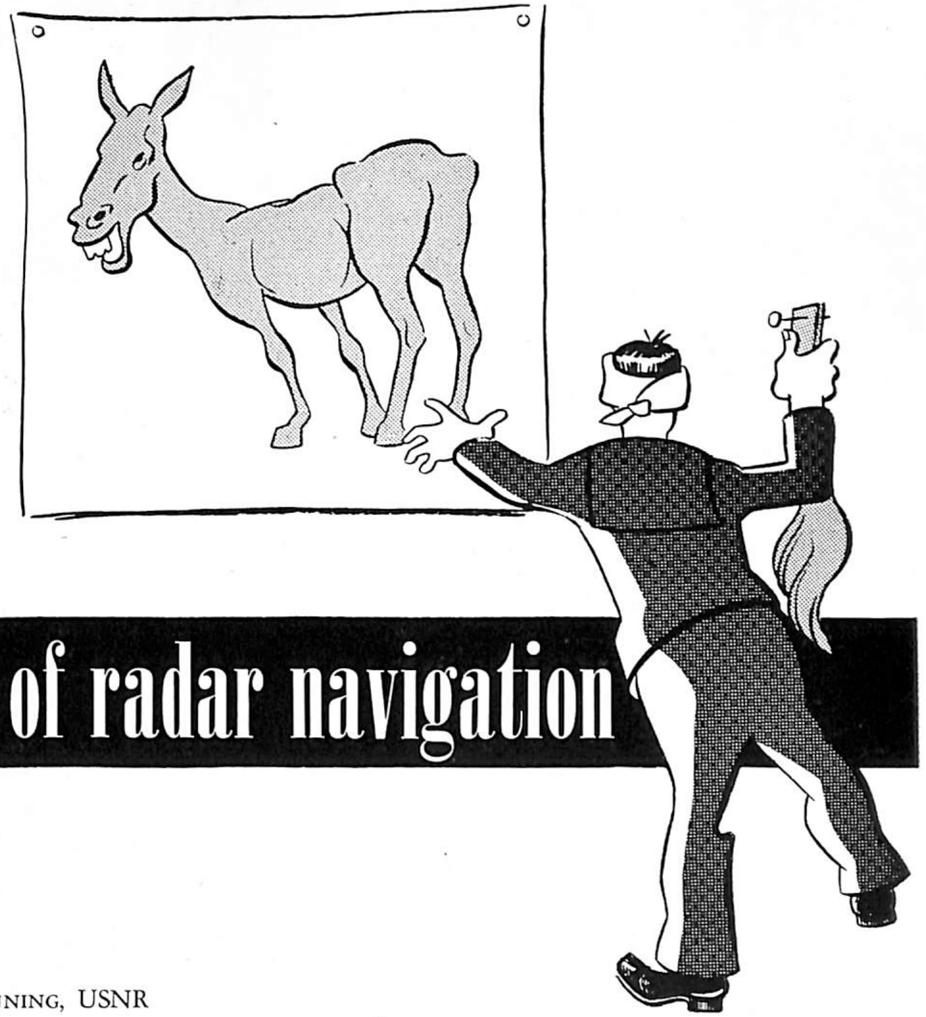

limitations of radar navigation

by
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Camden 2, N. J.

Radar has proven to be a highly effective navigational aid during periods of low visibility. Under certain conditions extreme radar ranges have been obtained with surprisingly accurate bearings. These results and their causes have been widely discussed in existing literature. However, the disproportionate emphasis placed upon unusually good radar performance has served to create the impression that all radars are supposed to give outstandingly good results all the time. Such, unfortunately, is not the case.

The performance of any radar is subject to many limiting factors, some of which are related to the design, construction, installation and adjustment of the system; while other considerations, external to the ship, determine what will happen to the transmitted signal after it leaves the antenna and before it returns to the antenna. Even though the transmitter and receiver are adjusted for peak performance, there will be no sign of an echo on the display tube if external conditions prevent the return of the transmitted signal. It is not always realized that radar navigation as well as any other navigational aid is subject to certain restrictions or limitations.

In coastal piloting it is possible for even good navigators to take the bearing of the wrong object. While this should be a rare occurrence, it does happen. Optical tangents taken at a distance are often faulty because the actual line where earth meets sea is obscured by mist or hidden by horizon dip. Similarly, one can never be sure of the precise range or bearing of a given section of land when establishing a radar "fix" because there is no way of determining which portion of the land is acting as the "reflector".

One should be extremely cautious in utilizing radar to establish "off shore" ranges (distances), since the radar may ignore low lying or gently sloping land and may indicate that the ship is farther off shore than is actually the case. If land rises abruptly from the sea, with essentially vertical development and with little or no shore, radar will indicate quite accurately the off-shore distance of the ship. On the other hand, radar cannot be relied upon to pick up reefs or shoal water. These constitute low-lying, poor radar targets, and will be detected at dangerously close range, if at all.

Radar tangents taken against an island are not reliable for accurate bearings because of two main errors which are inherent. All radar beams traveling in space have an angular width which varies from about one degree to twenty or more degrees depending upon antenna design. The width of the beam causes land to appear wider to the radar, therefore left tangents as read on the compass repeater tend to be "small" (fewer degrees) and right tangents large (greater number of degrees). Also, since radar ignores low-lying or sloping land, there will always be doubt as to whether the radar actually is showing the land tangent or some other point inland. This effect introduces a tendency to carry tangent bearing inland, making the left tangent too large (greater number of degrees) and the right tangent too small (too few degrees).

ON EXCEEDINGLY MURKY DAYS ONE HAS TO RESORT TO MANY DEVIOUS WAYS TO REACH ONE'S DESTINATION.

Again, every navigator knows that the range of his vision is determined by many variable factors. Low-lying islands or reefs may be masked by vapor or light fog. Familiar stars and planets are frequently clouded over. The horizon is but seldom clearly defined. These limitations on "visibility" are so pronounced that only for a few minutes each morning and evening will conditions be "just right" for obtaining a celestial "fix". Even when conditions are generally good it is not unusual to discover that a relatively "near by" planet is invisible while at the same time a far distant star will be shining brightly. When making landfall there are many occasions of sighting land fifty or more miles away, while at other times a ship will be practically in the harbor before any land can be seen. All these familiar happenings are related to external causes. The great differences in VISUAL RANGE obtained by any one individual under varying atmospheric conditions are so commonplace that they are not considered to be unusual. There is nothing mysterious about the fact that one can see a greater distance in clear weather than in foggy weather.

Nor should it be considered unusual or mysterious that RADAR RANGES are subject to wide variations because of atmospheric and other external considerations. Visible light, radio and radar waves are quite similar since they represent energy in electromagnetic form. They differ chiefly in energy content and frequency. Radar frequencies usually are much higher than radio, approaching the vibratory rate of light. Hence, it is only reasonable to expect that as the radar wave used for a given application increases in frequency, its behavior more closely approximates the behavior of light. Experience proves this to be true. As radar frequencies increase, the transmitted signal becomes increasingly subject to the well known optical effects of simple absorption, band absorption, reflection, refraction, cancellation, reinforcement, beam focus, beam divergence or scattering, penetration, etc. Little wonder then that the performance of the higher frequency radars should change so markedly from day to day.

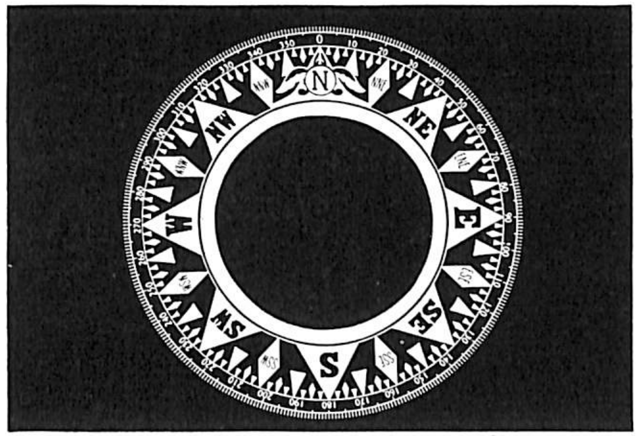
Low frequency radar often can "look through" a cloud or squall that would block-off the signals of a higher frequency radar. It is actually possible for a small ship to "hide" behind a squall and to be completely invisible to a high frequency radar while a lower frequency radar signal may "look through" the squall and will "see" the ship. It is to be expected, then, that different radars will react differently when operating in a given area. Any one radar may be expected to perform at a different level of effectiveness from day to day.

The experienced navigator is also aware that atmospheric effects will cause light waves to bend. It is possible to "see around a corner" if the corner angle is not too acute and if atmospheric conditions are just right. This effect has been encountered many times in radar applications during which echo signals have been returned by targets well beyond the dip of the horizon.

After a radar signal leaves the antenna and until a portion of the energy reflected by some distant target returns to the originating antenna, the signal is influenced by two complex factors. These are the meteorological influence of the weather upon the atmospheric path traversed by the signal and the nature of the target or reflecting substance.

The prevailing weather or atmospheric condition of the area between a radar and its target result in two classes of signal propagation, standard and non-standard. With standard propagation the radar waves are gradually bent downward, following the curvature of the earth. Under average weather conditions the horizon distance is increased by about fifteen (15) percent. Non-standard propagation includes conditions which reduce radar ranges below the normal expectancy and conditions which produce unusually long radar ranges.

The refraction or bending of radar waves is determined by the variation of temperature, moisture content and pressure of the atmosphere with changes in height of the signal path. Of these considerations the variations of moisture content is most important with temperature variation second in importance. A rapid decrease of moisture with height, known as a "moisture lapse" causes a pronounced downward bending of the signal. A rapid increase of temperature with height, known as a "temperature inversion" also produces downward refraction. If both conditions occur simultaneously a situation of super-refraction prevails and extremely long ranges may be obtained from low altitude targets. The above conditions produce a rapid decrease of the index of refraction with increase in height above the water or land surface. If the change in the index of refraction is in the opposite direction to that just discussed, the bending of the radar wave will be upwards and low altitude targets may be missed.



Conditions for extreme radar ranges are accordingly favorable if warm dry air is flowing over cold water. In this case a temperature inversion (increased temperature with height) is automatically present. Evaporation of surface water into the lower atmosphere produces a moisture lapse (decreased moisture with height). Over land, clear skies at night allow rapid cooling of the earth, in turn setting up conditions favorable to a temperature inversion, with a corresponding increase in radar ranges.

When the barometric pressure is HIGH an effect known as subsidence generally takes place. Masses of dry air sink vertically towards the earth and spread horizontally along the earth's surface. This condition is ideal for producing a temperature inversion. Thus, in an area of high barometric pressure, if warm dry air flows over colder water or land, producing much surface evaporation, one can expect extreme radar ranges.

A low barometer is usually accompanied by overcast skies and moderate to strong winds. Under these conditions it is not likely that a temperature inversion or a moisture lapse will occur. Consequently, it would be expected that radar ranges will be either normal or less than normal.

In the foregoing discussion it should be appreciated that the effects described are most pronounced for low altitude targets. Actually, super-ranges are to be expected only for targets having an angle of elevation somewhat less than two degrees, and then only when the conditions of barometric high, temperature inversion and moisture lapse occur simultaneously.

Assuming favorable atmospheric constituency, it is necessary for the target to be of suitable material, size, shape and angular disposition relative to the radar before a reflection echo can be obtained. These physical requirements for the target are more evident if the radar problem is compared to the optical problem of directing a sharply focused flashlight beam toward a distant mirror in such fashion that the light beam reflected by the mirror can be seen by the person holding the flashlight. A glass mirror would certainly be a better reflector than a wooden board, a flat surface mirror would be better than a spherical globe having the same surface area, and if the angle of the mirror is not properly adjusted it will not reflect the light beam back to the observer.

Radiation falling upon a surface is partly absorbed, partly reflected, and unless the substance is very thick or very opaque, it is partly transmitted through the substance. Absorptivity of a surface may vary from zero to nearly 100% depending upon the material, the frequency of the incident radiation and the temperature of the absorber. The energy absorbed by a target obviously cannot get back to the radar to produce an echo. Consequently, a substance which has a high absorption coefficient will make a poor radar target. Metallic substances in general are better reflectors than non-metallic materials. Good conductors are usually better targets than poor conductors. A metal ship makes a better target than a wooden ship. A small iron ship may make a better target than a large densely wooded island. Just as certain materials absorb certain colors, so too, will different targets be "frequency sensitive". If the target medium from which the reflection occurs has an absorption band for the particular frequencies being considered it may be impossible to obtain a radar echo until the range has been drastically reduced. This effect has often been noticed when ranging on islands covered with tropical vegetation and trees. One radar may give a very poor echo or no echo at all while another radar operating in a different frequency band will produce a strong echo signal. It is to be expected that a given radar will perform quite differently from time to time depending upon whether its target is barren, dry, rocky, moist, covered with vegetation, trees, melting snow or frozen ice, etc.

The size of the target is naturally a governing factor. Any object having electrical dimensions approximating a half wave length at the operating frequency may act as a reflector. In general, the larger the target the more effective it becomes as a mirror.

The shape of the target is also of consequence. A curved surface, with the exception of one or two special cases, does not make an effective target. The reflected energy is widely dispersed with little, if any, being returned directly to the originating antenna. A ship having many vertical and right angle surfaces is a better target than one in which the superstructure consists of plating disposed in curves. Where two plane surfaces meet at a right angle a "corner reflector" is formed. Regardless of the angle at which radiation strikes one of the surfaces, a substantial portion of the energy will be reflected directly back to the source. So many of these natural "corner reflectors" exist on a ship that one is tempted to believe the designer intended the ship to be a radar target.

The angular disposition of a target relative to the radar is most important, and is probably the largest single factor controlling the range that can be obtained. If the target were assumed to be a flat metal plate mounted at an angle of forty-five degrees to the line of fire of the radar, no energy would be returned to the radar. The relative angle of the target surface should be normal (right angles) to the line of fire of the radar. The case is similar to the use of a mirror for reflecting a light beam.

If one were to range on a mountainous island having a gentle slope on the west side and precipitous vertical cliffs on the east side it would be normal to expect a radar pick up distance of great range when approaching from the east, and a sharply reduced range when approaching from the west. If the sloping side of the mountain is covered with vegetation or snow it might be entirely in order to make radar contact while eighty miles distant to the east although radar contact from the west might not be established until within twenty miles of the island.

It is not sufficient that the reflected energy be directed towards the general vicinity of the radar ship; the reflected signal must be focused directly upon the radar antenna. A strong echo ten feet away from the antenna is completely wasted. Unless the returned energy strikes the radar antenna there will not be an indication on the radar picture tube.

The primary objective of this article has been to discuss those external variables which affect the performance of any radar. However, the electrical and mechanical functioning of radar equipment can only be determined by actual test with appropriate instruments. Power output should be determined by use of the directional-coupler and power measuring apparatus. Receiver sensitivity and noise level should be checked with standard equipment. The daily use of a resonance or echo box is a necessity to rapidly determine over-all effectiveness of the radar system.

From a detailed consideration of the factors discussed in this article, combined with the knowledge gained through actual measurement of transmitter and receiver energy levels, one can formulate his own estimates of what constitutes normal performance of any given radar. Meteorological effects and target characteristics should not be indiscriminately blamed for poor radar coverage.

LOW MODEL SS SENSITIVITY

A recent case of low sensitivity in the Model SS radar, when using the periscope antenna, was determined as being a result of trouble in the periscope itself. This was indicated when a neon bulb would light at the waveguide in the periscope well and at the top of the adapter but not at the periscope antenna window. The bottom plug assembly of the periscope was found defective after removing the periscope.

This merely draws attention to the bottom plug assembly and waveguide inside the periscope itself when the periscope antenna gives poor results and the rest of the equipment has been checked as satisfactory.

It is suggested that whenever the periscope is removed at a Naval shipyard for optical repairs, a job order be submitted to have the electrical portion of the periscope tested in accordance with data given in the "Submarine Periscope Manual" NavPers 16165 (Confidential). These electrical tests are quite complicated and special equipment is required. The test equipment is not found on tenders at present so it becomes a shipyard job to make these electrical tests.

—SubFlotOne Newsletter

F.C. No. 1 - Radiacmeter IM-3/PD

Equipment Affected

Radiacmeter IM–3/PD, all serial numbers.

Purpose

To modify the spur gear for switch S–1 in order to prevent equipment failure due to internal shorts. The stop sections, as shown in Figure 1, on the present switch, S–1, of Radiacmeter IM–3/PD do not allow sufficient clearance for the snap action to operate properly. The force of the snap action causes the stops to break off. This breakage allows the switch to be turned in such a manner that the "B" supply of the equipment shorts out tube V–1, necessitating replacement of the entire ion chamber.

Time Required

Approximately two man-hours.

Materials Required

Supplied with field change—none.

To be supplied by installing activity—One (1) #6-32 round-head screw, 5/16″ long.

Tools

Installing activity will require a screwdriver, pliers, #36 drill and a tap for #6-32 threads.

Routine Instructions

Reference should be made to the Instruction Book for Radiacmeter IM–3/PD, NavShips 91032, and to Figures 1, 2 and 3, shown here, when making this change.

1—Remove the spur gear shown in Figures 2 and 3.

2—Install a #6-32 round head screw, 5/16″ long, as shown in Figures 2 and 3.

3—Replace the modified spur gear and check for proper operation.

Special Instructions

A limited stock of replacement gears, Standard Navy Stock Number N16–G–432090–371, has been procured and placed in stock by ESO. The replacement gear is supplied complete with an appropriate stop-pin. As the old gear presently in the equipments can easily be modified by the maintenance yards, these gears should be modified as described herein whenever practicable. However, in order to provide a readily available replacement, each maintenance yard should requisition a small quantity (not to exceed 3) of the new replacement gears. As the existing gear is removed and replaced with a new or modified gear, the old gear should in turn be modified in order to replenish the available replacement stock.

NOTE.

THESE PUNCHED OUT STOP SECTIONS (ON PRESENT SWITCHES) BREAK OFF UNDER NORMAL OPERATING CONDITIONS.

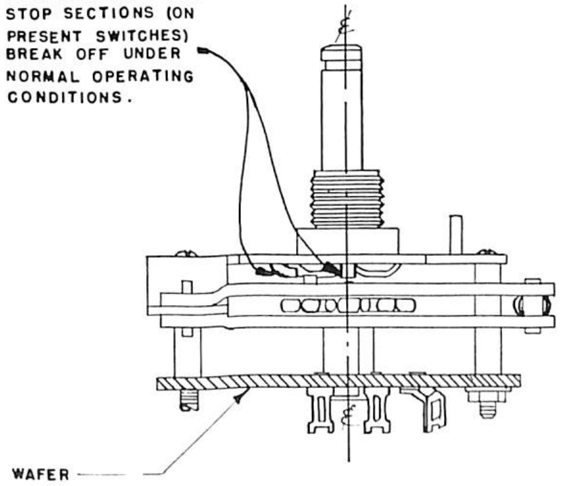


FIGURE 1—Battery Switch (Rotary Type—S1).

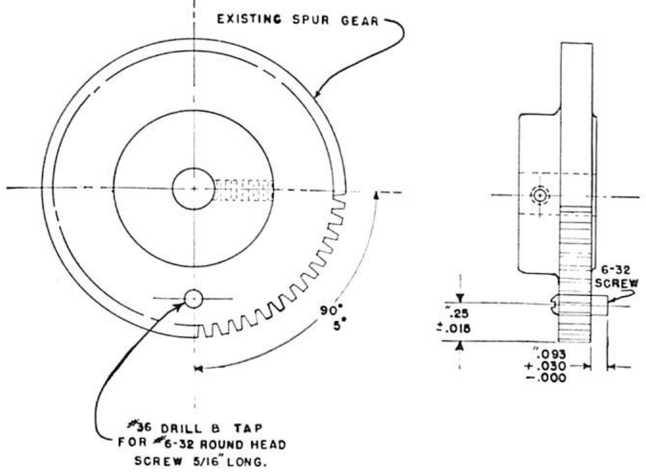


FIGURE 2—Gear Modification Data.

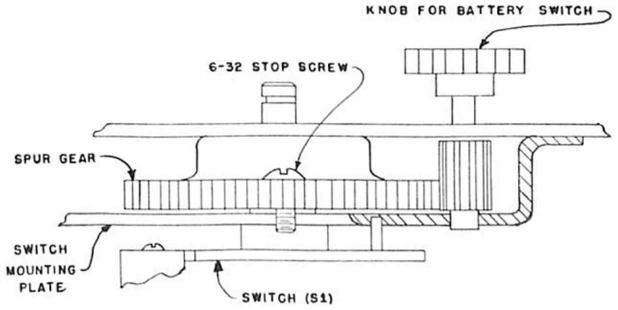


FIGURE 3—Assembly View.

Waveguide filters for pulse transmission studies

by P. A. Reiling

Transmission Research, Bell Telephone Laboratories

In connection with research in pulse modulation, it became necessary to separate a group of microwave channels transmitted in a waveguide into individual channels and subsequently to recombine them. Microwave filters which perform these functions have already been described. For the particular studies referred to, however, a somewhat different technique was chosen. A total of eight channels with 30-Mc separation between mid-bands of adjacent channels was provided by the filter array developed. Four of these channels were transmitted as a group in one waveguide, and another group of four at the same frequency in another waveguide. Both of these sets of four channels could be separated, or combined, independently in the same filter structure.

A simple block schematic indicating the filter functions is shown in Figure 1. Two signal bands, X and Y, are directed over separate paths to opposite ends of a waveguide array of separating filters. Here they are separated into eight channel bands, each of which is then passed through the individual channel apparatus, indicated by the dashed lines shown connecting the separating and combining filters. The combining filter array then inverts the separating process: the eight channel bands are combined to form the pair of composite signal bands, X and Y emerging from opposite ends of the combining filter array.

The separating filter array consists of four waveguide hybrid-type filters each of which diverts two channels with the same mid-band frequency to their respective channel apparatus. How this is accomplished is indicated schematically in Figure 2, which shows a circuit with a hybrid coil at each end, two channel reflecting networks, and two quarter wave length delay networks. Input applied to arm A1 of the hybrid coil is equally divided between the half-power arms B1 and C1; no direct transmission between arms A1 and D1 results. Energy at frequencies in the channel centered at frequency f1 is reflected by the two networks labeled f-1, but that in the lower arm passes through the one-quarter wave length delay network both before and after reflection. Thus the reflected energy returning toward the left in the lower branch is out of phase by 180 degrees with that in the upper branch. As a result, the reflections are in phase in the middle conductor and are thus transmitted out the branch D1. Energy outside the band f1, on the other hand, passes through the networks f1 and thus through the hybrid at the right, and appears at A1′, none being transmitted out branch D1′.

In an exactly similar manner, energy in the band f1 applied at A1′ would pass out branch D1′, while energy outside the band f1 would be transmitted through the circuit and out A1.

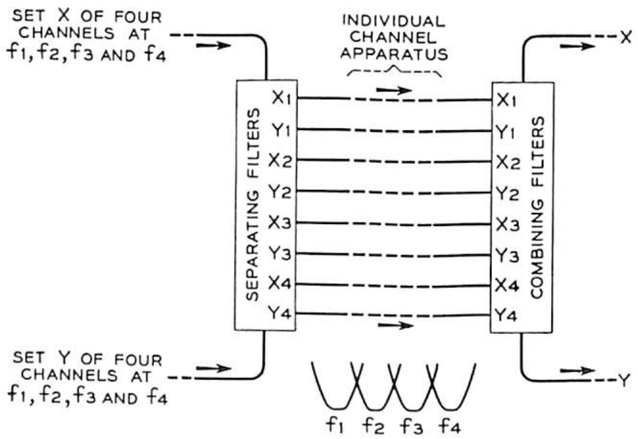


FIGURE 1—A set of four incoming channels is connected to one end of the separating filter chain, and another set of four to the other end, and the eight individual channels are separated by the filter. In a similar manner, the chain of combining filters takes eight individual channels and forms two groups of four.

Four such circuits, each designed for a different frequency are shown connected in tandem in Figure 3. If four channels, X1, X2, X3, and X4, are applied at the left of this circuit, and four channels Y1, Y2, Y3, and Y4, with the same mid-band frequencies as the respective X channels, are applied at the right of the circuit, the eight channels will be separated out over the side branches as indicated. Of the four channels entering at the left, X1 will be separated out by the first section, X2 by the second, X3 by the third, and X4 by the last, and no energy will remain to continue out the right-hand end of the circuit. Of the four channels entering at the right, Y4 will be separated out by the right-hand section, Y3 by the next, Y2 by the next, and Y1 by the left-hand section. Such an arrangement could thus serve as the separating filter of Figure 1 to distribute the eight composite channels into the eight individual channels.

It may also be seen from Figure 2, that were a single channel at frequency f1 applied to the branch D1, the energy would be out of phase in the upper and lower branches. After reflection from the filters in the two lower branches, however, the reflected energy would be in phase at A1 because the energy in the lower branch has been shifted 180 degrees in phase by the delay network. The channel entering at D1 therefore would pass out through A1. Similarly a channel at frequency f1 entering at D1′ would pass out through A1′. Eight channels applied at branches Y1, Y2, Y3, and Y4, and X1, X2, X3, and X4 respectively would in the circuit of Figure 3 thus be combined into two groups; the group consisting of Y1, Y2, Y3, and Y4 will flow out at the right, and that consisting of channels X1, X2, X3, and X4 would flow out at the left. The circuit could thus serve as a combining filter shown at the right of Figure 1, and would thus combine the separately amplified channels for transmission.

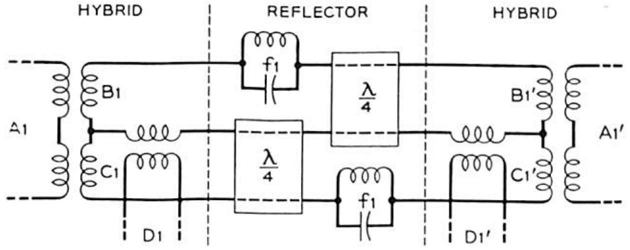


FIGURE 2—A wire circuit analogy of the chain of a separating or combining filter circuit.

The various elements comprising this circuit may be duplicated in waveguide structures in a variety of ways. In the pulse studies referred to above, however, the method differs from those previously employed. In the filter arrays the main waveguide is square in cross-section, but the branch taken off at one corner is standard oblong waveguide, being twice as wide as it is high. A photograph of this unit is shown in Figure 4. Within the square section is a diagonal septum as indicated in Figure 5. Waves entering either end of the square section with their electric vector at right angles to the septum, as indicated in the upper part of Figure 5, pass throug the guide and are not transmitted out the corner branch. Waves entering from the right and polarized parallel to the septum, on the other hand, will

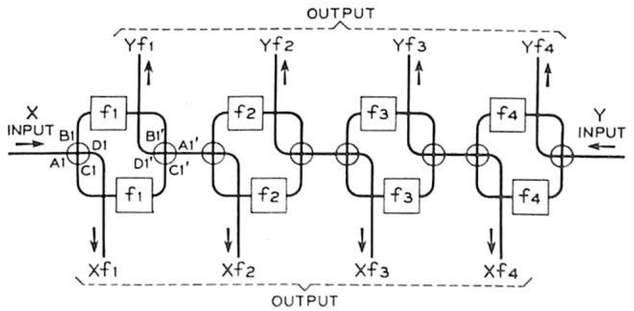
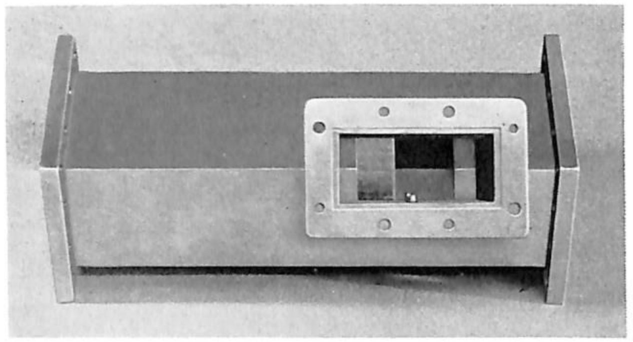


FIGURE 3—Block schematic of the chain of separating or combining filters.

not pass through the square guide but will pass out the corner branch.

If a waveguide structure capable of reflecting waves of frequencies in the vicinity of f1 and at the same time rotating their direction of polarization by 90 degrees were connected at the right end of the waveguide section shown in Figure 5, waves polarized as in the upper part of Figure 5 would be returned to the section polarized as indicated in the lower part of Figure 5. This reflected wave would then be transmitted out the corner branch and none would be transmitted through the square guide past the septum.



FIUGRE 4—One of the eight waveguide units forming a separating or combining filter.

This rotation of the polarization of the reflected wave is accomplished by quarter wave length sections of square waveguide and reflecting networks in the form of resonant cavities. The wave leaving the coupling section of Figure 5 is polarized diagonally across opposite corners, and may be considered as composed of two right angle components. This is indicated in Figure 6, where R represents the resultant electric field vector polarized diagonally and H and V the two right angle components. Two sets of reflecting cavities are emloyed; one to reflect the vertical component and one the horizontal component. Each set consists of two full-wave and two half-wave lengths of closed waveguide projecting perpendicularly from opposite sides of the square waveguide to which each are coupled by quarter wave sections as shown in Figure 7. The cavities reflecting the H component are offset one-quarter wave length from those reflecting the V component, thus corresponding to the reflecting sections of Figure 2. One component therefore travels one-quarter wave length further before reflection and one-quarter wave length further after reflection than the other component, and thus one component of the reflected wave will be 180 degrees behind the other. This turns over the direction of one reflected component so that a wave polarized as in the left-hand diagram of Figure 6 before reflection will be polarized as in the right-hand diagram after reflection. This reflected wave will thus pass out the corner branch as shown in the lower diagram of Figure 5.

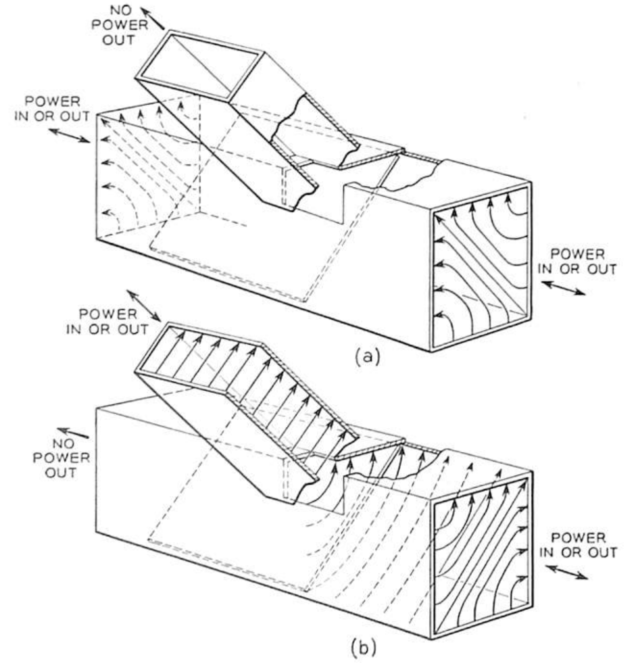


FIGURE 5—Perspective drawing of the waveguide hybrid unit showing its effect on entering waves polarized in two directions.

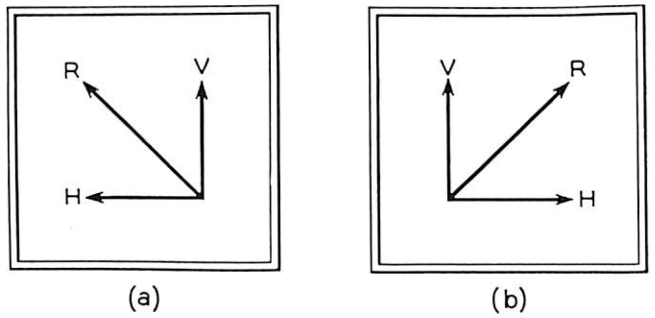


FIGURE 6—Cross-section of hybrid unit showing resolution of diagonally polarized waves.

The two wave components of Figure 6 correspond to the currents in the upper and lower branches of Figure 2, and on this basis the waveguide section shown in Figure 7 is closely analogous of the circuit of Figure 2. The complete waveguide separating filter consists of four sections such as Figure 7 connected together, and is shown in Figure 9. At each end is a coupling section through which the outputs from both of the waveguide transmission lines are supplied to the filter.

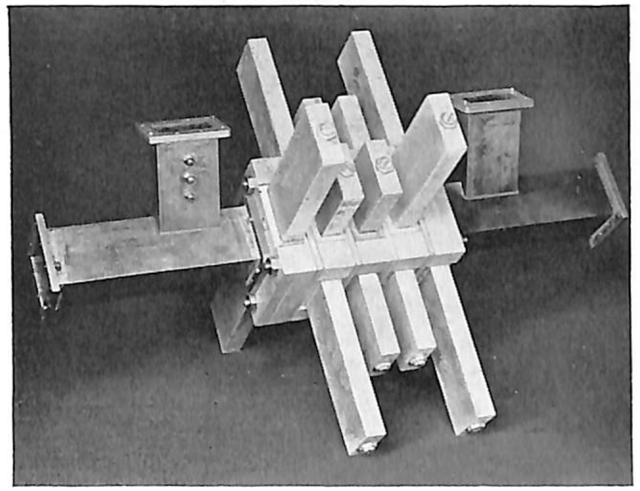


FIGURE 7—A waveguide hybrid unit on each side of a delay and reflecting unit is the equivalent of Figure 2.

Four sections like that of Figure 7 connected together to form the separating filter of Figure 9 and another set of four to form the combining filter would thus appear as in Figure 8, which is a waveguide counterpart of the block diagram of Figure 1. The combined four channels entering from the left at the top of Figure 8 are designated X1, X2, X3, and X4, and those entering from the left at the bottom have the same mid-band frequency and are designated Y1, Y2, Y3, and Y4. The paths of the X channels are indicated by light solid lines drawn inside the guides, and those of the Y channels are similarly indicated but by dashed lines. Keeping in mind the action of the hybrid section as indicated in Figure 5, one can readily visualize how the eight channels are diverted to their individual amplifying channels. After amplification and regeneration, these channels enter the combining filter at the right and follow the paths indicated. All the X channels are combined and leave at the top of the combining filter, while the Y channels are combined and leave at the bottom.

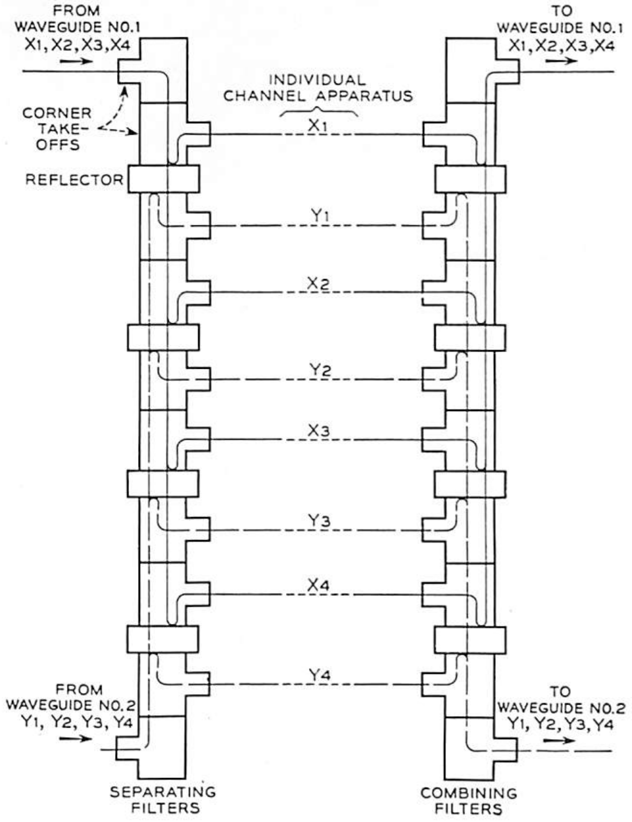


FIGURE 8—Arrangement of waveguide units corresponding to Figure 1.

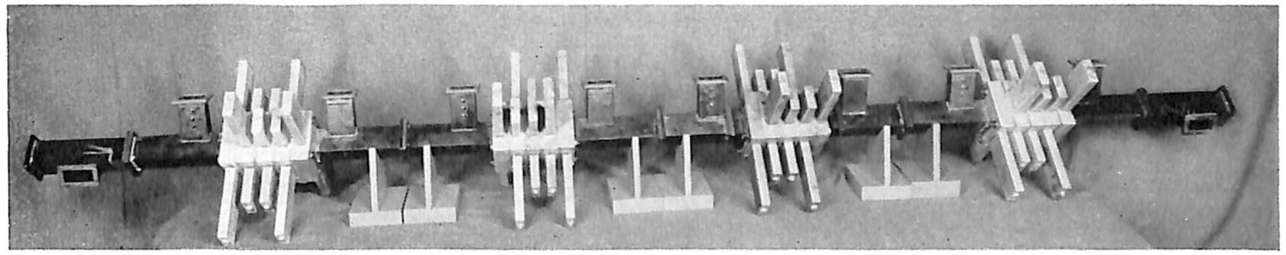
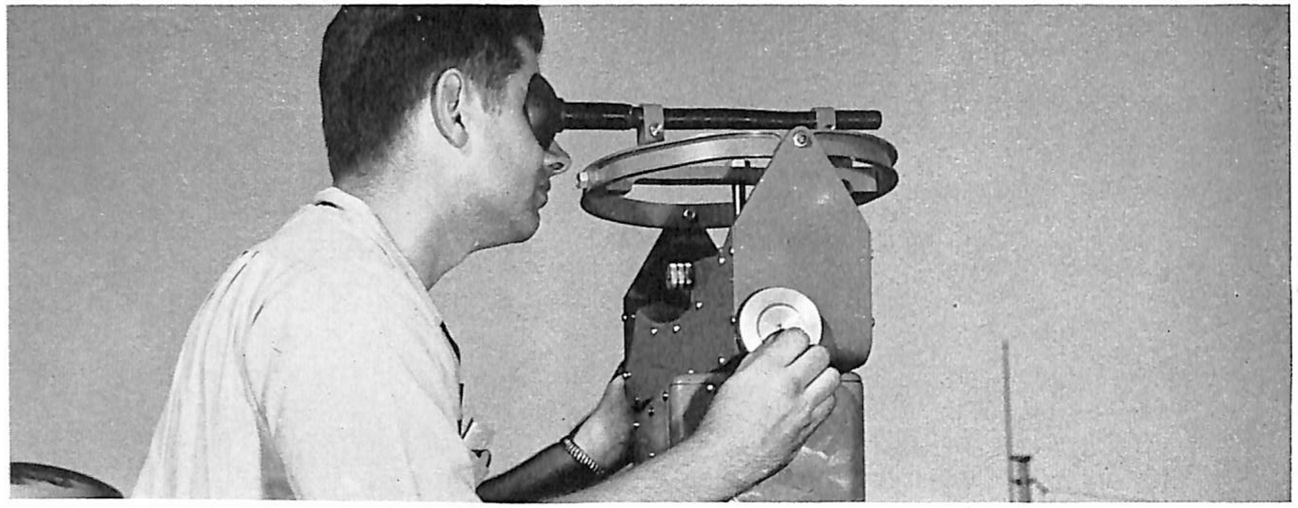


FIGURE 9—A complete separating or combining filter

The use of quadrature fields in square waveguide yielded filters with input and output sections which could be easily constructed. The filter elements depended only on linear dimensions making for relatively simple mechanical construction. Experimentally observed characteristics were in remarkably close agreement with theoretical characteristics established as performance requirements.

To answer the many questions that have arisen concerning the new electronic maintenance parts allowances, the Bureau has published NAVSHIPS 900,168 "The Shipboard Integrated Electronic Maintenance Parts System" which explains the program and the details of conversion from the old spare parts box system to the new method of bin stowage. All hands interested in this program are urged to read this pamphlet, copies of which are available upon request to the Bureau of Ships, Code 960.

nel notes:

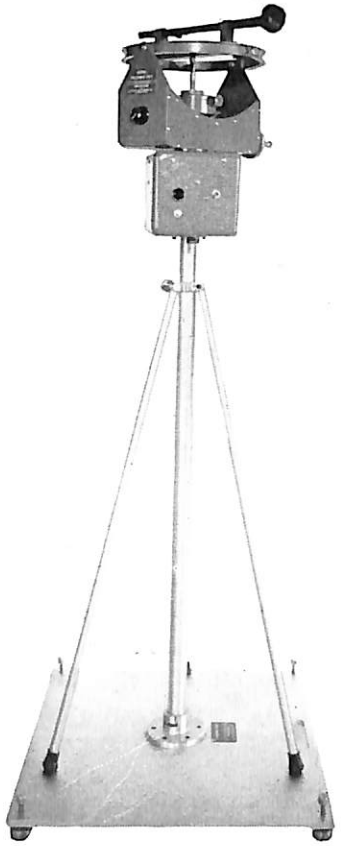


time-saving RDF calibrator

Calibration of RDF's, and the subsequent difficulty of keeping the calibration up-to-date in the face of inevitable topside structural changes, has always constituted a serious problem. But no longer. The Navy Electronics Laboratory has developed the Direction Finder Calibrator Set, AN/SRM-1 (XG-1), that promises to reduce drastically the time required for calibration. The new equipment is portable, easy to operate, and rugged in construction. It is applicable to either pip-type or null-type gear. Tests conducted at sea have demonstrated that with the device it is possible to calibrate the RDF in a fraction of the time required under present methods.

Time-consuming calibration procedures have long constituted a major disadvantage of RDF. Several days are usually required for the operation. Since it is difficult to allocate such protracted ship time to this relatively unimportant task, calibration is often delayed for weeks. As a result, the doubtful bearings obtained from uncalibrated equipment have given RDF techniques a reputation for unreliability. The new NEL-developed calibrator, by making possible more frequent calibrations, should overcome this major objection to RDF.

Under present calibration techniques, simultaneous visual and radio bearings are obtained on a transmitting target and relayed by voice tube or talker to a recorder. The three-way exchange of information limits the speed at which the calibrating run can be conducted and multiplies the opportunity for error. By contrast, the new AN/SRM-1 equipment provides automatic transmission of bearing information, and automatic and continuous plotting of the results. Bearing information from both visual observer and RDF operator is transmitted by a synchro system and recorded in the form of a polar plot on a special chart. This chart is so designed that it indicates directly the number of degrees to be added to, or subtracted from, the RDF dial reading to give the correct relative bearing of the target. Because of this automatic transmission and recording feature, the time in which a run can be made is limited only by the speed with which the ship can swing without excessive listing. A single 360-degree calibration run has been made in 3 minutes, and a full set of correction curves has been made in less than half a day.



AN/SRM-1 (XG-1) visual follower unit.

The central unit, the recorder, has two essential parts each light enough to be carried by one man. The units, including a recorder, radio follower, visual follower, and gyro follower, operate as a single equipment when connected by flexible plug-in cables and powered from the ship's own 60-cps 110-volt line.

The central unit, the recorder, has two essential parts—a polar chart and its drive assembly, and a recording pen and its driving mechanism. The polar chart is made to rotate in exact synchronism with the bearing of the RDF dial. The recorder pen is driven by a synchro whose output is proportional to the difference in the relative bearings from the RDF and visual follower.

With pip-type D/F's it is only necessary for the visual observer and the RDF operator to keep on target in order to produce on the chart a continuous deviation curve—a permanent record of deviation with no further plotting required.

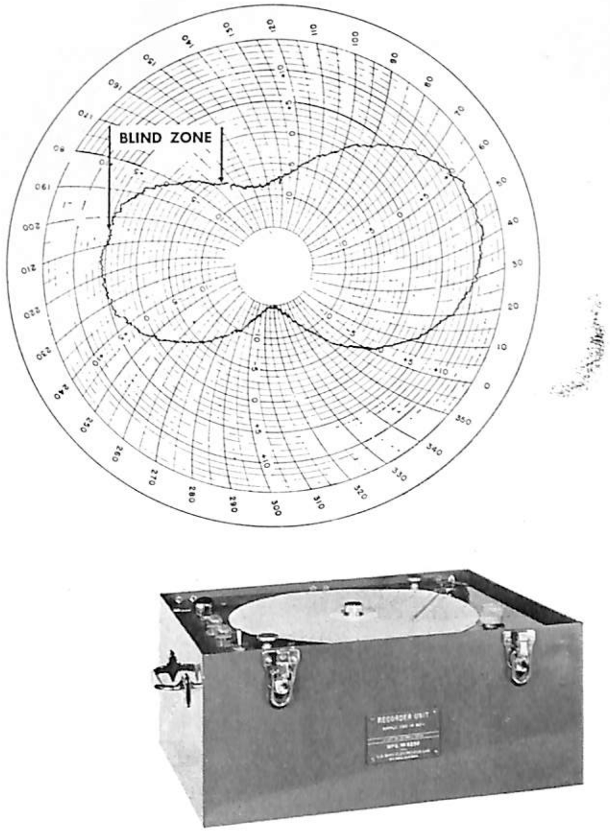
Procedures with null-type D/F's are only slightly more involved. In this case it is necessary for the RDF operator to sweep the antenna back and forth across the null. To prevent the pen from marking at any time save at a sharp null point, the pen normally rides above the paper. The operator, by pressing a switch, can lower the pen to mark the critical moment when he has obtained a null. The plot, in this case, is a series of dots through which a smooth curve can be readily drawn on completion of the calibration run.

RDF bearing information is normally obtained from the RDF dial of the radio receiver through a direct mechanical coupler. This coupler connects to the rear of the radio follower unit through a short shaft. The RDF dial is then operated through the follower by a hand wheel on the follower front.

The visual follower consists of a telescopic sight, a synchro transmitter mechanically coupled to the telescope, and a variable-speed reversible motor for rotating the telescope head through 360 degrees. The motor speed is adjustable so that the sight will approximately track the target, requiring only slight corrections applied through a handwheel.

On those occasions when the target is obscured by superstructure or other intervening objects, the gyro follower may be cut in to replace the visual follower, providing an alternate source of relative bearing information for these short periods.

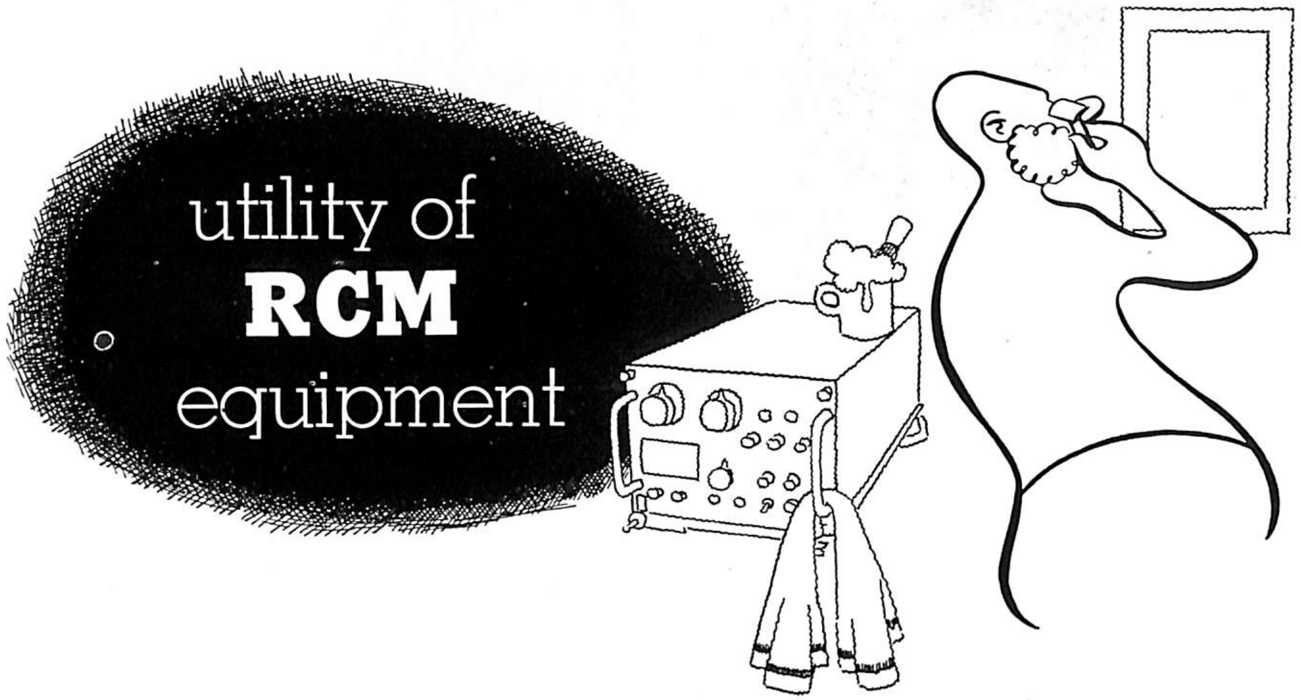
The Navy Electronics Laboratory has produced ten prototype equipments for delivery to the Bureau of Ships early in 1951. Subsequent to tests with these equipments, additional units will be produced and made available at central fleet servicing activities for requisitioning by forces afloat.



Recorder unit and typical correction curve.

Radio follower unit connected to dial of DAK-2 receiver.

utility of RCM equipment



by

C. R. Lake, ETCA

U.S.S. Agerholm (DD–826)

Lately, increasing emphasis is being placed on the use of RCM equipment. There are also other uses for ships RCM receivers, panoramic adaptors, and pulse analyzers for other than RCM exercises. Some of the most obvious are:

1—Check of ships radar (within P, L, and S band) for pulse width, shape and steadiness.

2—Check of ships interrogator (BM, BO, etc.) for frequency, pulse width, etc.

3—Checking to see that the ships responser (BK etc.) is transmitting.

Another important use of the panoramic adaptor (RDP, etc.) is to monitor the percentage of modulation of the ships VHF, UHF radio transmitters. The procedure is as follows:

1—Key the transmitter to be checked and tune in the RCM receiver (RDO, etc.), until a pulse appears on the panoramic adaptor (RDP). Leave the RDO gain at maximum and keep the RDP gain reduced as necessary to keep the pulse below saturation.

2—Turn the *sweep* control on the RDP towards *minimum* (CCW), until the pulse on the scope is about 2 inches wide. Turn the *center* control on the RDP as necessary to keep the presentation centered on the scope.

3—Have someone give a short count on the transmitter being checked. As the panoramic adaptor is essentially a plot of carrier amplitude against frequency, the downward excursion of the breaks in the carrier pulse represent the percentage of modulation. Figure 1 will clarify this. All transmitters should modulate over 50%, preferably 85% to 95%.

This enables the ET to actually show the operator who whispers into a microphone why he doesn't obtain good results from a TDQ transmitter, as most remote handsets require a normal speech level to sufficiently modulate a TDQ or TBS.

Every time the ship gets underway, in addition to taking the usual transmitter meter readings and power output checks with the ME–11/U wattmeter, we also check our TBS, TDZ, TDQ, and AN/ARC–1 transmitters for their percentage of modulation or for any noticeable distortion in their modulating circuits.

Granted that the TBS and TDQ have percentage of modulation meters installed, checking with the RDP will allow you to see what is actually on the air. It also affords you the opportunity of checking another ship's transmitter. Some time ago another ship called us to check our RDZ as they had 25 watts output on their TDZ and couldn't reach us. When we checked their TDZ on our RDP, it had about 5 to 10 percent modulation. ET's often use the carrier power as read on the ME–11/U wattmeter as the final word on a transmitter's ability to carry, overlooking the fact that you don't hear the carrier—only the modulation. Usually the ability of the AN/ARC–1 (8 watt) transmitter to equal or sometimes exceed the ranges obtained with a TDQ (40 watt) transmitter, is due to insufficient modulation of the TDQ. Most AN/ARC–1's have a very capable modulator section, normally producing 85 to 95 percent modulation.

A simple check of the accuracy of the RDP to indicate percentage of modulation can be effected by:

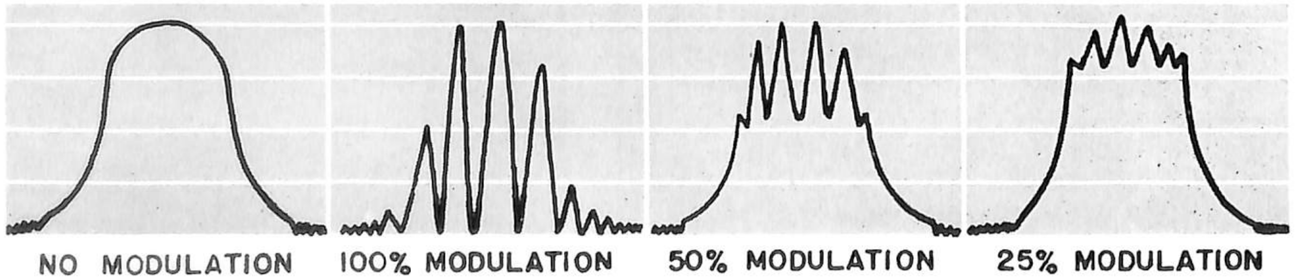
1—Set an LP (or any other r-f signal generator with a modulation meter) at 30 megacycles (input frequency of the RDP is 30 Mc).

2—Connect output of LP to r-f input of the RDP. Tune LP slightly for maximum on RDP.

3—Turn the RDP sweep the same as before for transmitter check (to minimum until pulse on RDP is about 2 inches high and wide).

4—Increase modulation (as read on the LP modulation meter) and check that the percentage of downward deflection on the RDP's presentation will be the same as the modulation on the LP.

Bureau Comment: This article is considered an excellent example of an electronic technician's initiative in applying equipment operational features to "check-out" the ship's electronic equipment.



Presentation on Model RDP indicating percent modulation of transmitter being tested.

MODEL TDQ DRAWER CONNECTOR CONTACT ALIGNMENT TOOL

A beneficial suggestion submitted by Ellis C. Harder and Verne C. Harris of the Mare Island Naval Shipyard makes provisions for aligning the spring contacts in the rear drawer connectors of the TDQ transmitter. By use of this contact alignment tool the porcelain connector may be assembled in much less time than normally required to align these twelve contacts and insert them into the top half of the porcelain connector.

The tool is composed of two pieces of 1/16″ sheet-brass formed as shown in Figure 1. The two comb-like pieces are inserted from adjacent sides of the contact assembly as shown in Figure 2. This compresses and aligns the spring contacts which allows the top half of the contact assembly to be easily placed in position. The tool is then withdrawn and the connector secured to the chassis in the required manner.

The tool can be made by station personnel from scrap pieces of brass.

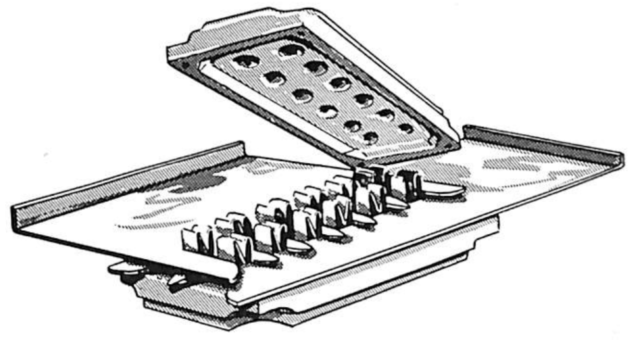


FIGURE 2.

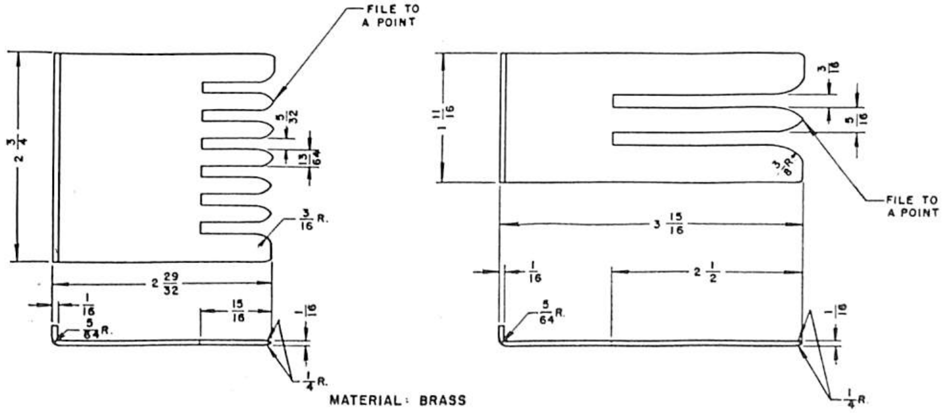
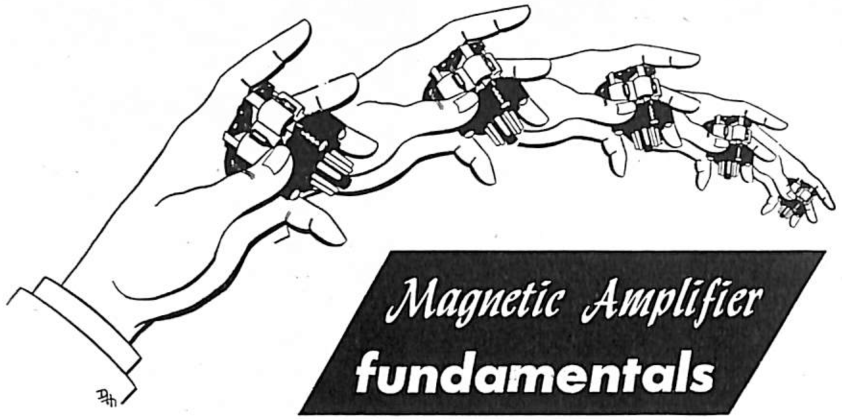


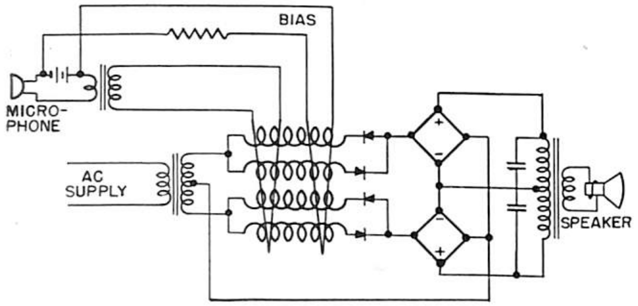
FIGURE I.



Magnetic Amplifier fundamentals

(*Continued from last month*)

Figure 29 is simply a basic sketch showing the principles of applying a magnetic amplifier to audio-frequency amplification. The a-c supply frequency must be sufficiently high to permit separation from the voice frequencies. Frequencies up to 20 kc at 100 watts have been amplified with this device, utilizing another magnetic amplifier as a frequency multiplier for a "plate" supply. Figure 30 shows a 100-watt 2-stage magnetic audio amplifier. Figure 31 shows oscillograms of the output with different input powers.



AUDIO FREQUENCY AMPLIFIER-(PROTOTYPE)

FIGURE 29.

It appears that with further development work audio magnetic amplifiers can be designed and constructed which will be superior to the present electronic amplifiers in the following respects:

1—More rugged.
2—Smaller size.
3—Less weight.
4—Less maintenance.

Figure 32 (a) is a schematic diagram of a controlled saturable reactor type magnetic amplifier having a sufficient amount of positive external feedback so as to cause instability or flip-flop action. This basic flip-flop circuit is not new, its principle having been described by Fitzgerald in 1936 (U.S. Patent 2,027,312). Using spirally wound ribbon cores of modern, ultra-thin molybdenum permalloy, and using toroidal windings, magnetic flip-flops have been made in the laboratories which have been triggered by one microsecond pulses at repetition rates as high as 400,000 transitions per second. The frequency of the a-c power supply for this magnetic amplifier type flip-flop was from 1 to 3 megacycles. With improved materials and components, even higher operating speeds are indicated to be possible.

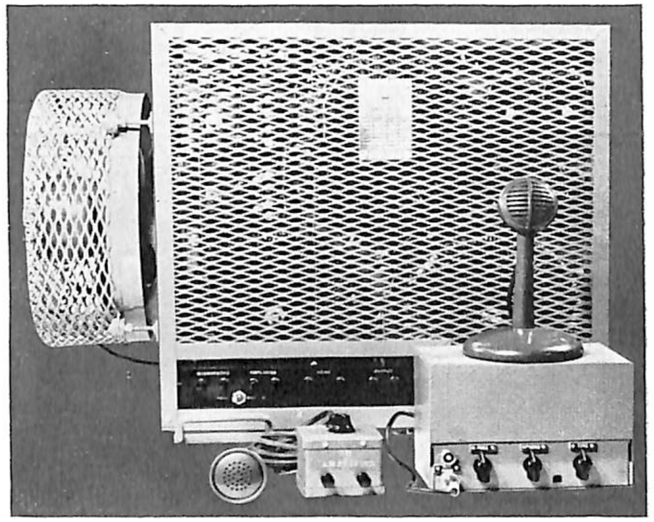


FIGURE 30—Enclosed magnetic audio amplifier with associated input equipment.

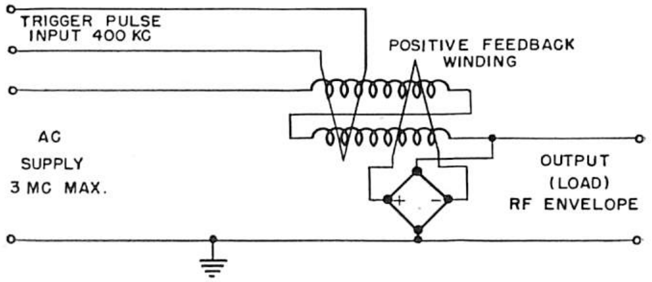


FIGURE 32 (a)—Saturable reactor used as a digital computer element.

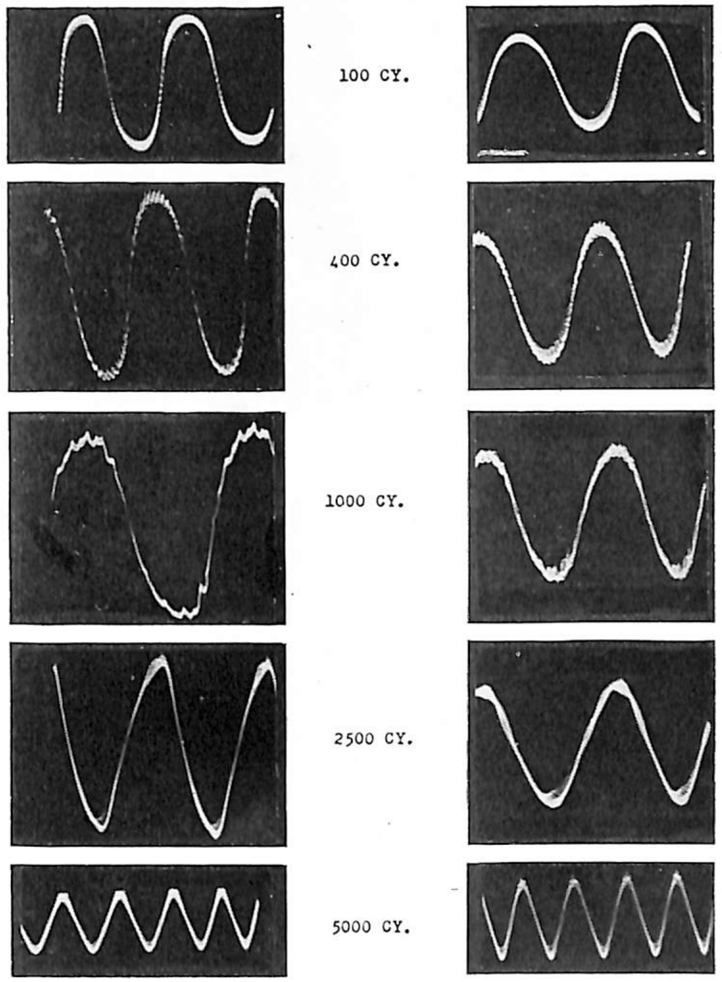


FIGURE 31—Oscillograms of output of amplifier shown in Figure 30.

Such high-speed magnetic amplifier circuits have many very desirable features. They are inherently low impedance devices (5 to 100 ohms) and they are inherently low power devices (milliwatts per stage). It is conceivable that many such units could be assembled into a relatively small, lightweight, rugged, permanent package as compared to an equivalent electron tube control circuit.

Magnetic flip-flops of the type described above have been combined to form basic circuits for use in digital computers. The circuits may have applications in radar and loran systems as pulse shapers, triggers, and counting and measuring circuits. As an example of the circuits used, Figures 32 (b) and (c) show pulse forming circuits for use with magnetic flip-flops to form counting and gating circuits for these applications. In laboratory tests, multiple stage magnetic binary counters have been operated at counting rates as high as 60,000 counts per

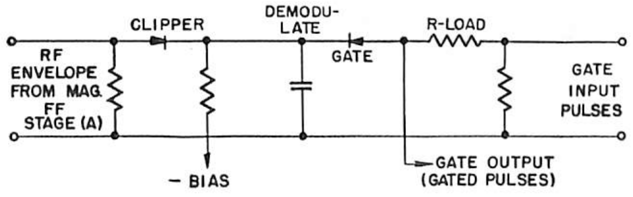


FIGURE 32 (b)—Magnetic "flip-flop" used to control a crystal diode gate.

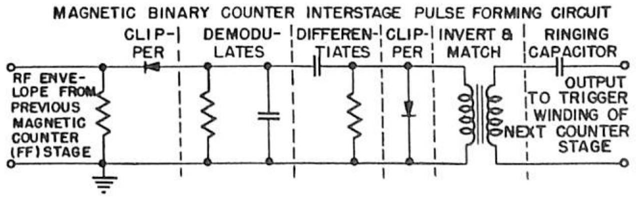


FIGURE 32 (c).

Input to Stage 1:
(Repetition Rate = 10,000 pps.)
The counter has been operated at 50,000 pps. into stage 1, though outputs are distorted.

Input to Stage 1:
(After C_c; Showing desired effect of coupling):

RF Envelope of Stage 1:
(Across Bridge Rectifier)
(RF = 1Mc)

Output of Stage 1:
(RF Envelope is clipped to save lower side; demodulated)

Input to Stage 2:
(Repetition Rate = 5,000 pps.)
(Output of Stage 1 is differentiated, clipped and inverted thru a step-down pulse transformer)

RF Envelope of Stage 2:
(Across Bridge Rectifier)
(RF = 1Mc)

Output of Stage 2:
(RF Envelope is clipped to save lower side, demodulated)

Input to Stage 3:
(Repetition Rate = 2,500 pps.)
(Output of Stage 2 is differentiated, clipped and inverted thru a step-down pulse transformer.

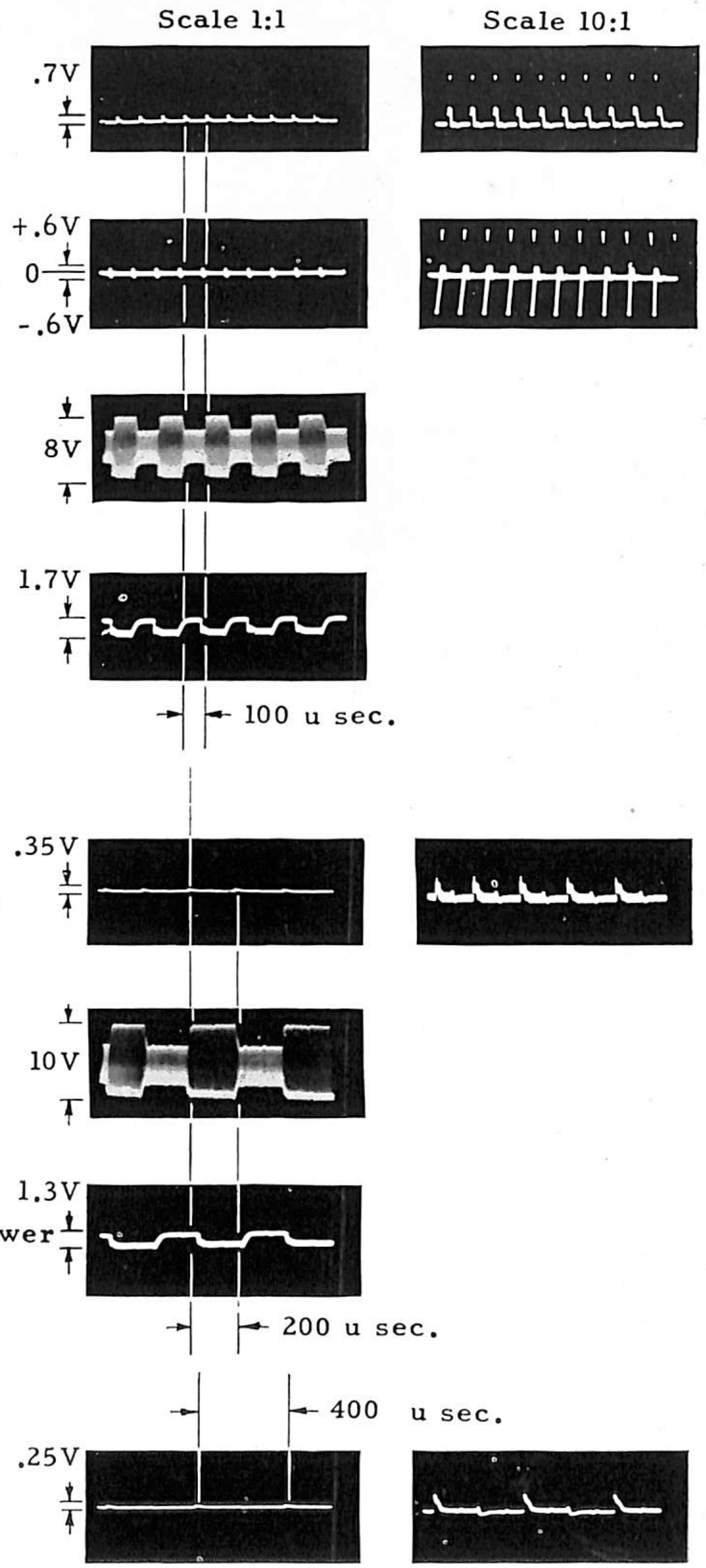


FIGURE 33—High-speed magnetic counter—Binary, two stages.

1. Pulse Repetition Rate = 2000 pps.
(Time between pulses = 500 u sec.)

Input Pulses:

Note: Input Pulses in each case are mininum amplitude required to set Flip Flop. Increased Pulse amplitude is required at higher rates.

RF Envelope:
(RF = 1.42 Mc.)

2. Pulse Repetition Rate = 20,000 pps.
(Time between pulses = 50 u sec.)

Input Pulses:

RF Envelope:
(RF = 1.32 Mc.)

3. Pulse Repetion Rate = 200,000 pps.
(Time between pulses = 5 u sec.)

Input Pulses:

RF Envelope:
(RF - 1.4 Mc.)

4. Pulse Repetition Rate = 400,000 pps.
(Time between pulses = 2.5 u sec.)

Input Pulses:

RF Envelope:
(RF = 1.5 Mc.)

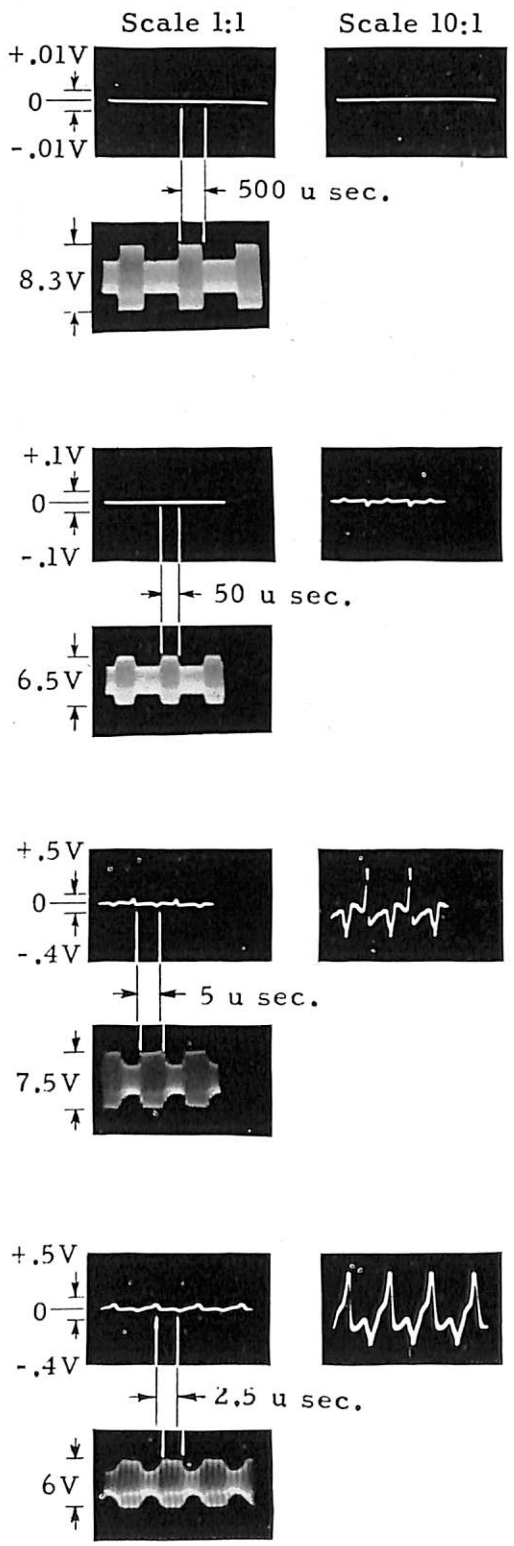


FIGURE 34—Magnetic "flip-flops" driven at high rates.

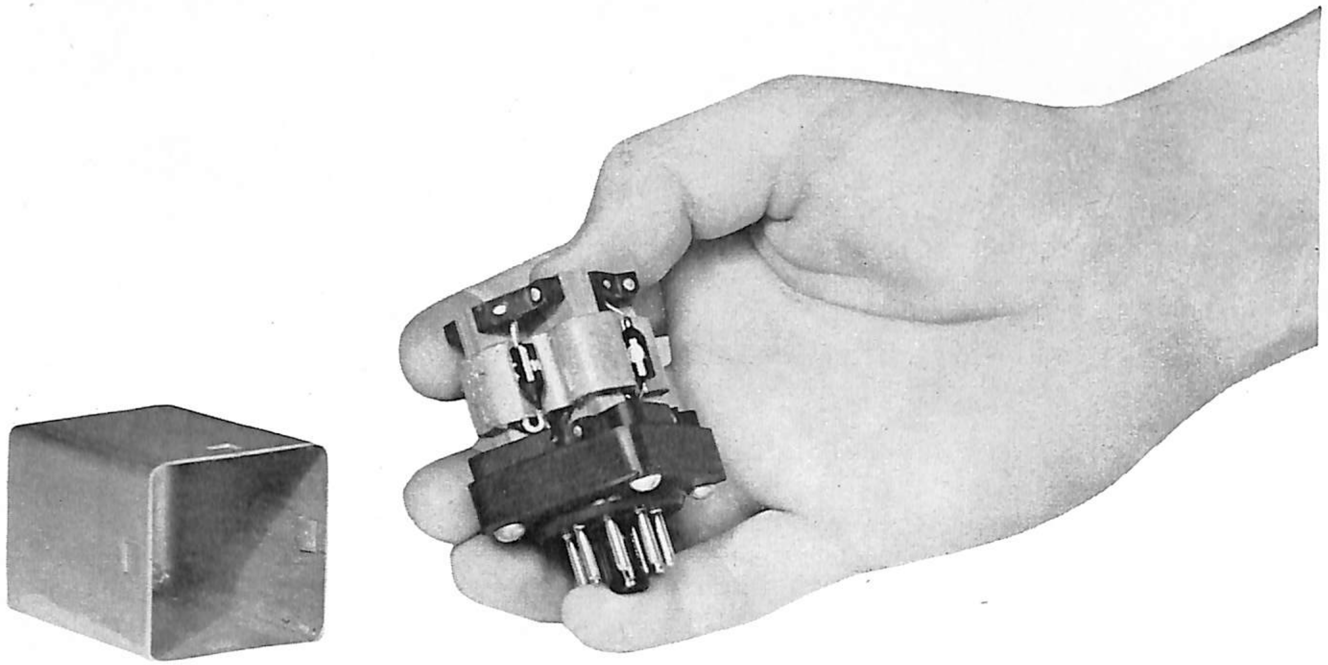


FIGURE 35—60-cycle Amplistat.

second. Figures 33 and 34 are oscillograms of the wave forms of the circuits shown in Figure 32.

Figures 35 and 36 show two production units made by the General Electric Co. Figure 37 shows a laboratory setup at the Carnegie Institute of Technology arranged to measure response time. Figure 38 shows a response curve plotted from a unit with a very high gain. Figure 39 is plotted from a unit with moderate gain, showing a lag of less than one half cycle of excitation frequency.

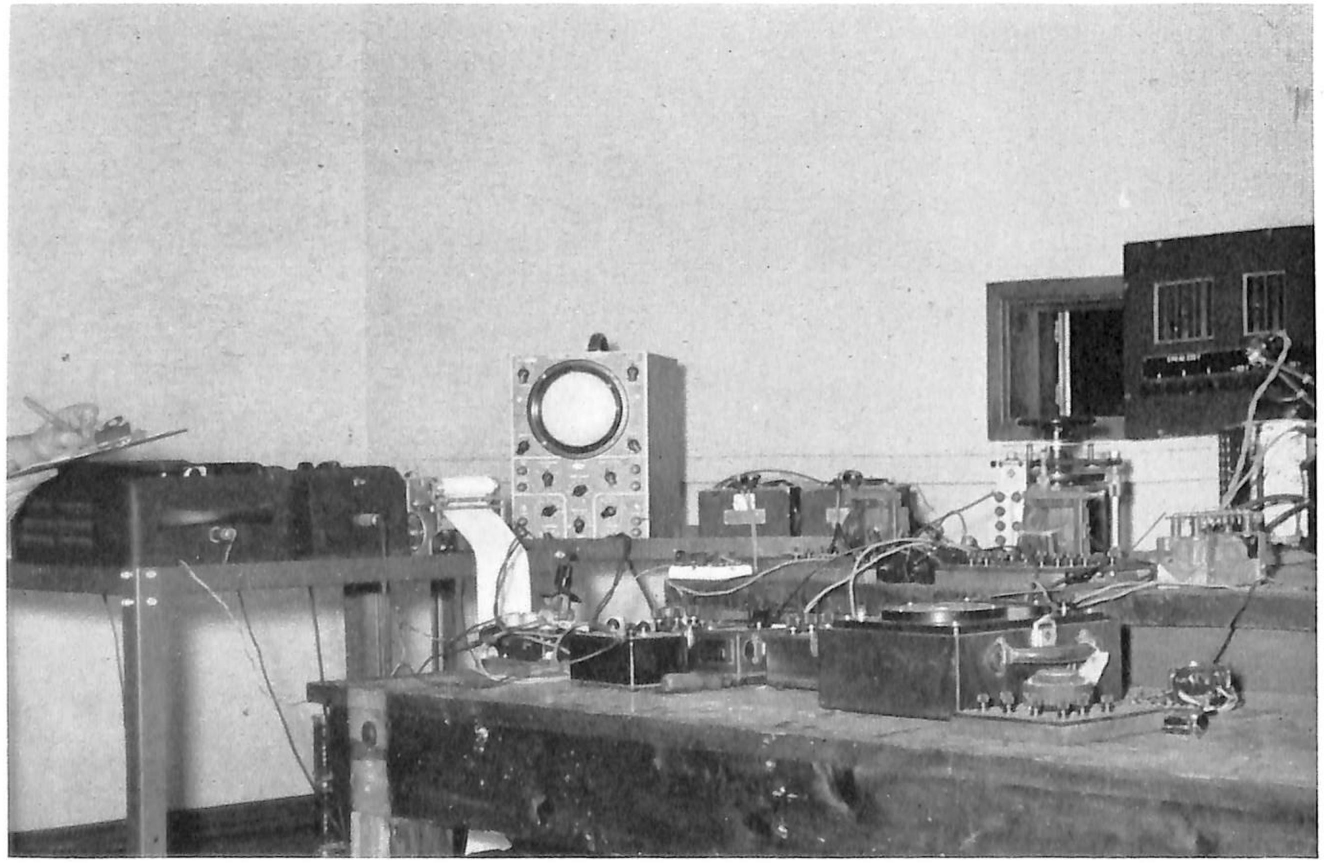


FIGURE 37.

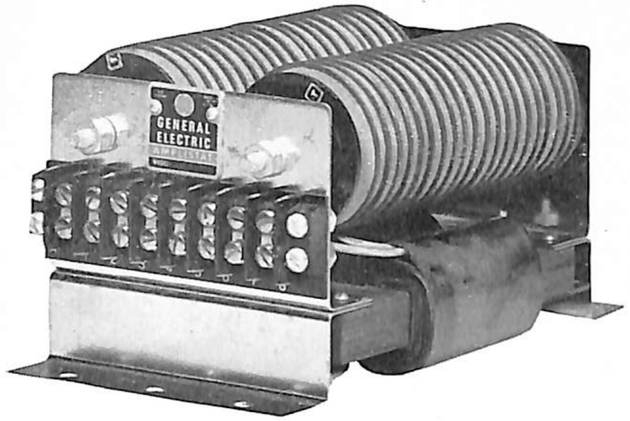


FIGURE 36—100 volt-ampere industrial Amplistat.

Figure 40 is a photograph of a popular type push-pull magnetic amplifier with characteristics as follows:

Gain—600,000.

Power output—10 watts (adequate to control fields of ¼-hp motors).

Anode voltage—115.

Rectifier—Silenium.

Hermetically sealed.

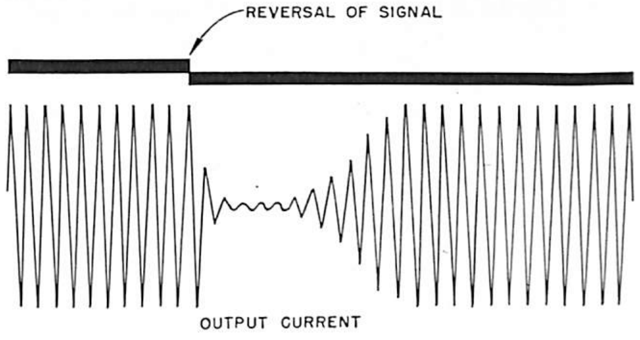


FIGURE 38—Response time of a high-gain amplifier.

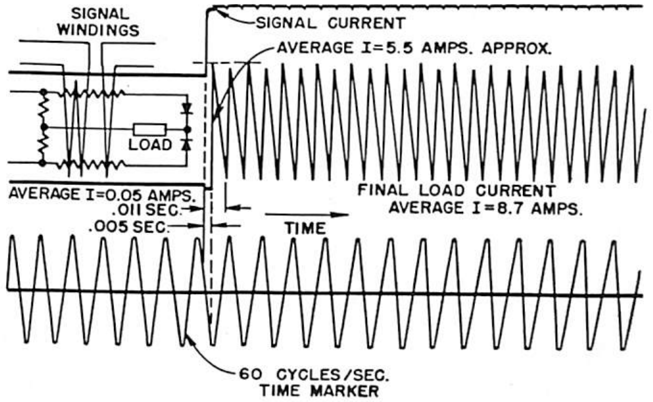


FIGURE 39—Response time of a moderate gain amplifier.

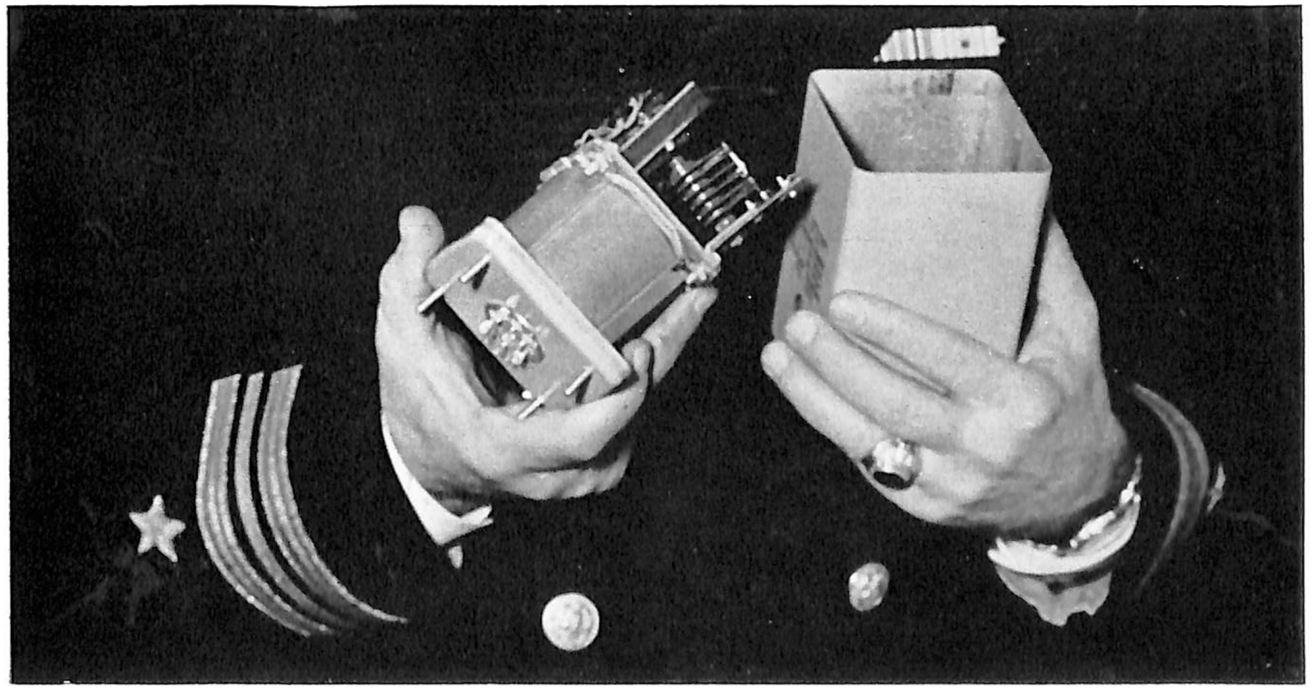


FIGURE 40—Photograph of a popular type push-pull amplifier.

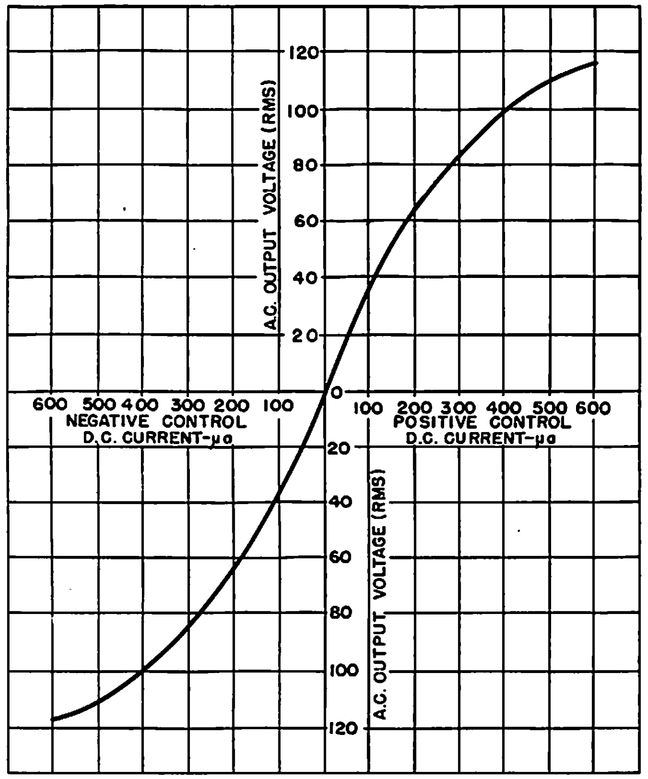


FIGURE 41.

The curve of Figure 41 shows the operating characteristics of this amplifier. An equivalent 2-tube push-pull class A/B electron tube amplifier might have a power gain of less than 100.

Magnetic Amplifier Versus Electron Tube Analogy

Before this article was undertaken, both officers and men in various electronics activities were questioned as to the general type of information desired. They agreed unanimously on one thing—leave out the mathematics in order to present a readily understandable picture of the possibilities of magnetic amplifiers. The detail theory material is available in other literature.

Another thing that was noted during the sampling of ideas from this group, was the predominant curiosity as to how this device functions as an audio-frequency amplifier. The general feeling seemed to be that once this was understood from an electron tube angle, even though the analogy be somewhat distorted, a better understanding among electronics personnel would result.

An attempt to analyze the magnetic amplifier in direct relation to an electron tube would require that certain assumptions be made as this type of amplifier differs considerably from one in which electron tubes are used. In an electron tube, good analytical treatment is possible for small signals because a more linear relationship can be obtained between the input and the output.

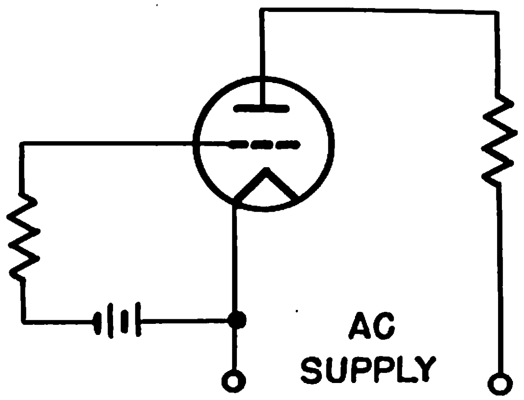


FIGURE 42 (a)—Single-ended tube.

In magnetic amplifiers, although workable on the somewhat linear part of the curve, good efficiency is not obtained unless control is maintained at the knee of the curve where abrupt saturation occurs. It is this non-linear section of the curve that makes high gain possible and also accounts for the analytical difficulties encountered in this device. However, for operational comparisons with a tube, the upper knee cannot be considered, as this is where tube saturation takes place. Comparisons therefore, will be made only on the linear section of the curves.

To attempt an analogy between the two amplifiers at audio frequencies, in the most elementary form, would require that a single ended tube be compared with a simple biased internal feedback saturable reactor as shown in Figure 42 (a) and (b).

To compare them in the same relationship, AC would have to be used as a power supply for both devices as the magnetic amplifier will not function on DC. The frequency of the power supply to both units would also have to be above audibility. Since they are single ended, comparisons would also have to be made as class "A" amplifiers, using the center of the straight portion of the characteristic curve.

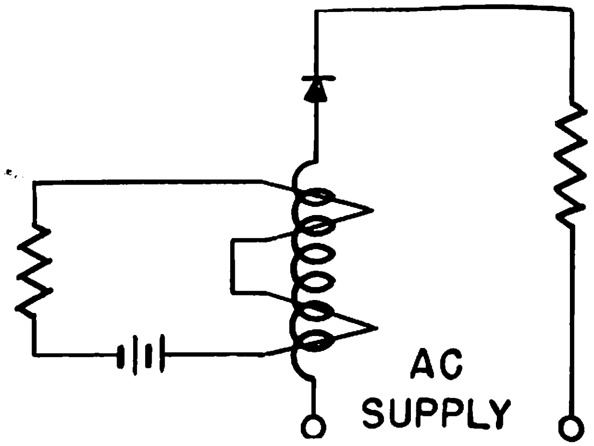
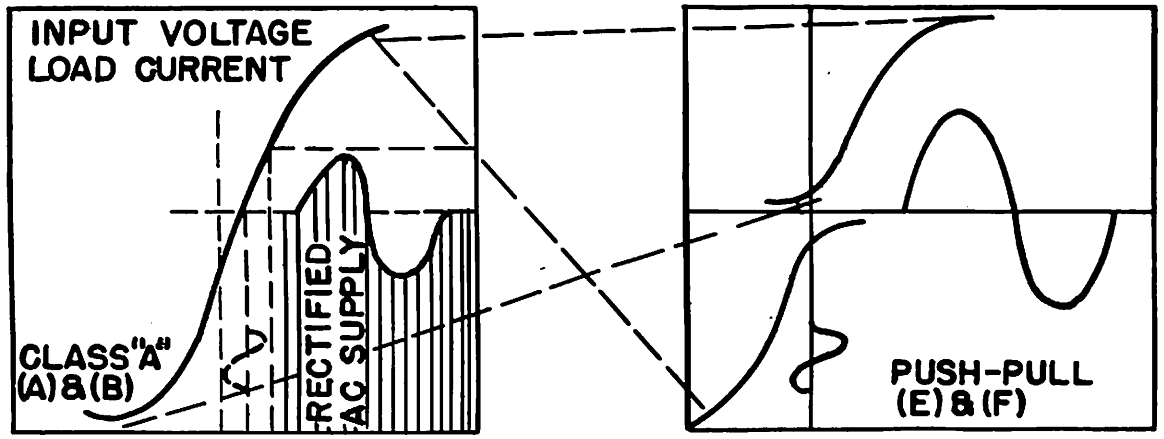


FIGURE 42 (b)—Biased internal feedback saturable reactor.



FIGURES 42 (c) and (d).

As previously mentioned, similar control voltage vs. load current curves can be used for both devices, as the magnetic amplifier anode impedance in relation to control voltage can be made very similar to that of a tube.

Load current will also have to be compared against control voltages as the grid of a tube operating as class "A" is not drawing current, while the input control winding of a magnetic amplifier is current actuated. A given amount of voltage across this coil will determine the amount of current, consequently, the saturation. Biases will also have to be included to open the "valves" of both units half way between cut off and saturation. In the tube, the negative voltages on the grid accomplish this. In the magnetic amplifier, the current circulating through the input resistance and the control coils, all of which are in series, accomplish essentially the same effect. This current partially saturates the core, maintaining the no signal load current at the center of the curve. With the input impedance of both devices made equal, both devices would follow closely within their parameters the input voltage/load current curve plotted in Figure 42 (c), i.e., modulating an inaudible carrier which is in series with the load. These amplifiers operating as class "A" would both be inefficient as power amplifiers. The demodulation of the carrier would also have to be considered.

A much more satisfactory method for comparing the two amplifiers would be to connect them in push-pull. 42 (c) could then be used to outline both halves of the push-pull circuits 42 (e) and (f) as shown in 42 (d). The efficiency would then be high and demodulation would present no difficulties. With push-pull the power output could be increased several times over that of the single ended devices with less harmonic distortion. The carrier frequency in the output circuit would also be doubled, due to using both halves of the a-c supply voltage. This reduces heterodyne effects between the audio

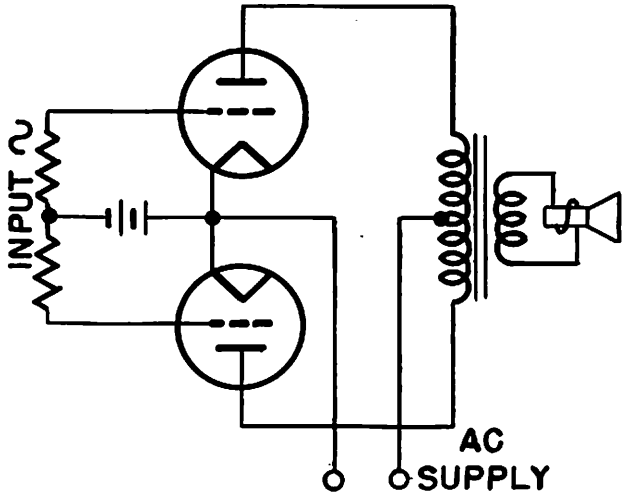


FIGURE 42 (e)—Push-pull tube.

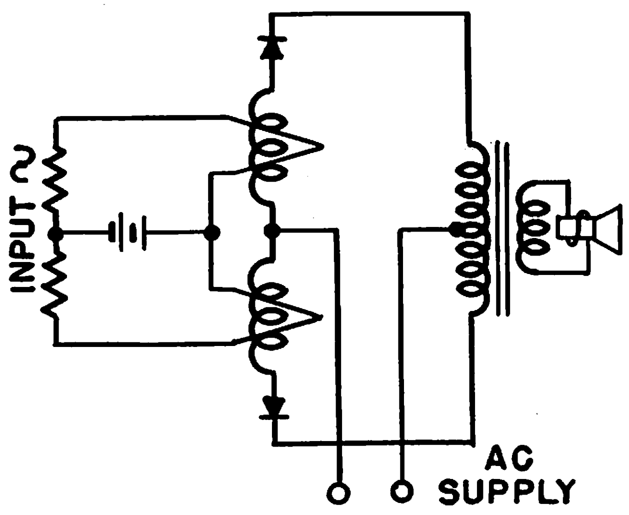


FIGURE 42 (f)—Push-pull type magnetic amplifier.

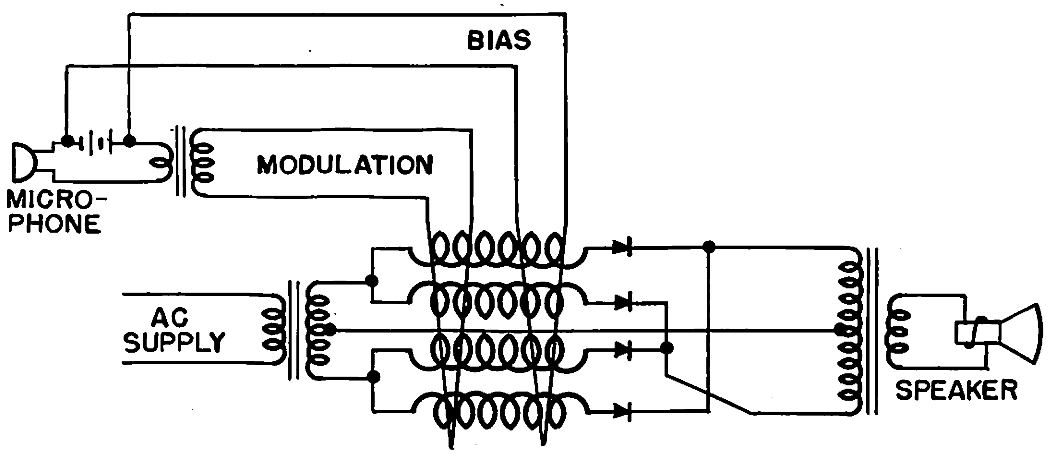


FIGURE 43—Commercial prototype of an a-f amplifier.

signals and the high frequency power supply. Figure 43 is a further development of 42 (f). Figure 29 shows a more practical, although still somewhat basic circuit employing this principle. Figure 31 is an oscillogram showing the output wave form of a 100-watt audio frequency magnetic amplifier. Note the HF carrier superimposed on the sine wave. This HF is of course inaudible. Although the magnetic amplifier was not intended as a competitive device at audio frequencies, work along this line is being done toward producing a rugged, maintenance free amplifier for intercommunication and public address services.

One commercial radio firm constructed a complete broadcast receiver using the magnetic amplifier for the audio and i-f system, with germanium crystal transistors for the r-f and oscillator stages. Crystals were used for detectors. A magnetic static device was used as a frequency multiplier power supply. This broadcast receiver, it is understood, was constructed primarily for publicity purposes to show that a relatively intricate electronic device could be made without the use of electronic tubes. The transistor, incidentally, may also be developed into a competitive tubeless amplifier in the near future. The transistor is primarily a low power device limited to 25 milliwatt output. The gain per stage is around 100 at frequencies up to 10 megacycles.

New Development

Figure 44 shows a basic sketch of a rather interesting magnetic amplifier development recently disclosed by Dr. Robert A. Ramey of the Naval Research Laboratory.

This approach to the magnetic amplifier has resulted from a recognition that the amplifier is a voltage sensitive device and not as generally believed a current sensitive device. The only truly independent variable is the control voltage.

The remarkable fact that the time of response of this series amplifier does not depend upon the inductance of the transformers as reactors seems to be adequately shown by analysis.

A preliminary review indicates that this amplifier may have the following advantages:*

1—Response time is constant, independent of gain. (Always less than 1 cycle of supply frequency.)

2—Lighter and smaller for the same power output.

3—The output is a linear function of the control voltage.

4—Greater power sensitivity; the control source need not supply power to the amplifier control. Power is absorbed instead.

5—Independent of variations in supply voltages.

6—Single core reactors may be used without reaction into the control winding.

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* This circuit has not as yet been evaluated by the Bureau.

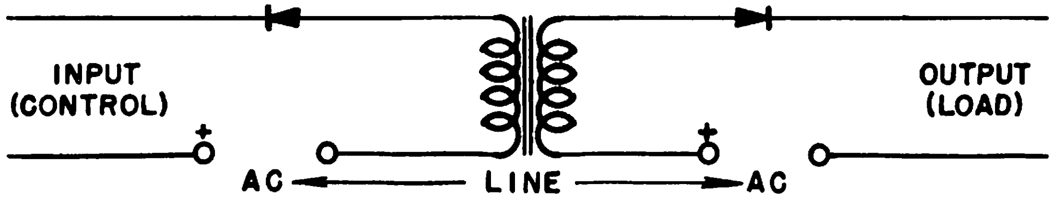
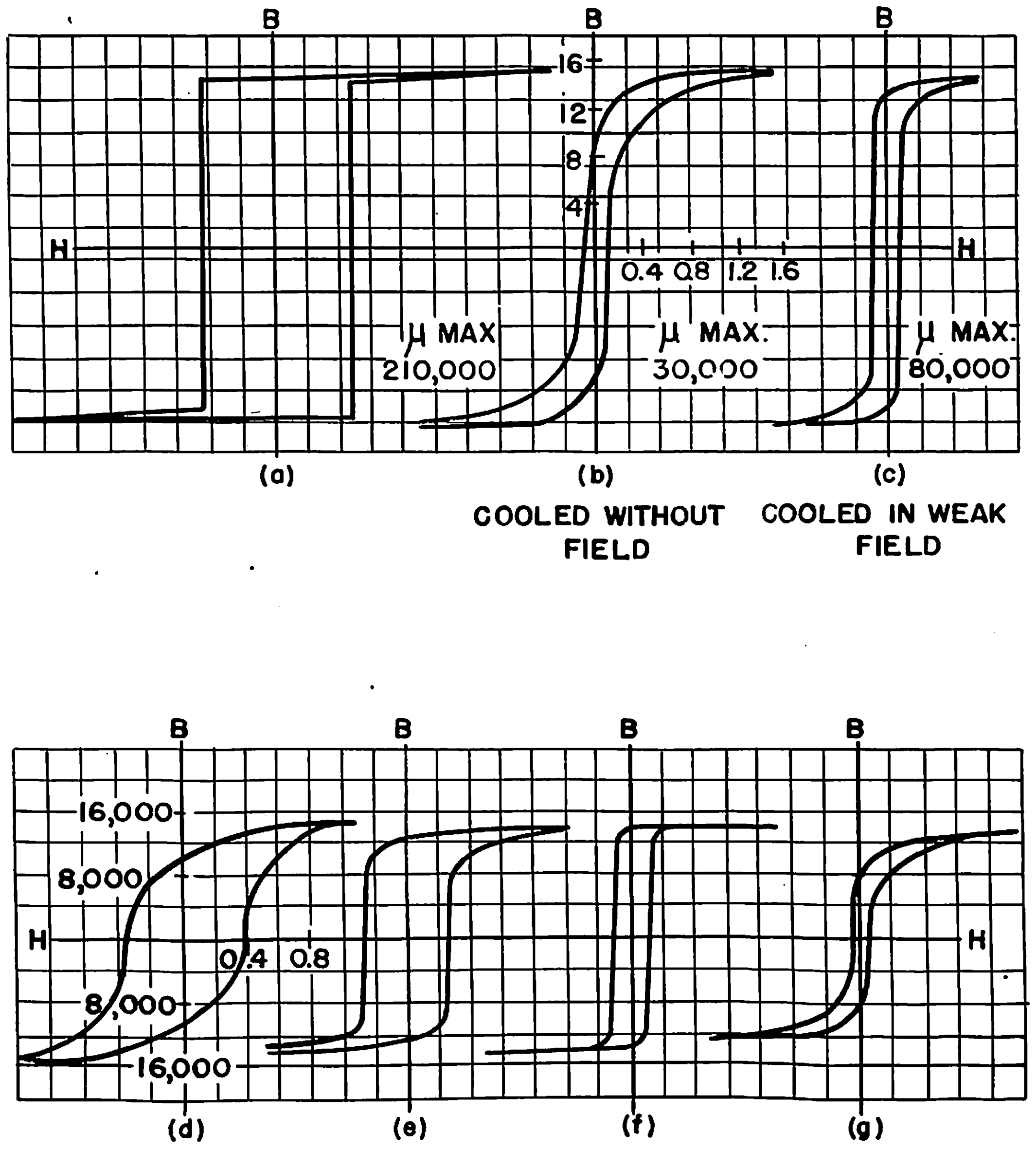


FIGURE 44.



HYSTERESIS LOOP - 50% NICKEL - 50% IRON

FIGURE 45.

Core Material

The magnetic core is the heart of the magnetic amplifier. It is the reaction of this core to magnetic influence that determines the performance of the device. The excellence of magnetic material cannot be over emphasized. Contrary to the general impression, it is not the ingredients of the material used in the melt, but to a greater degree the treatment after smelting that determines its excellence. Most of the core materials used in magnetic amplifiers today are usually composed of equal parts of iron and nickel—a common ratio for conventional radio transformers. It is the purity of this material, coupled with controlled annealing under magnetic fields that has a marked influence on the final shape of the magnetization curve as shown in Figure 45. Dr. Mihara of Japan altered the characteristics of a simple silicon iron core by special annealing in a weak field of the same order of magnitude as the earth's magnetic field. Figure 45 (a) shows the B-H curve obtained with this material. Figure 45 (b) and (c) show curves of two identical cores—(b) was slowly cooled without applied field, and (c) was slowly cooled under a weak field of one oersted parallel to the direction of rolling. Figure 45 (d), (e), (f) and (g) shows hysteresis loops for grain oriented 50 percent nickel-iron cores. All are of identical material, rolled from the same melt with drastic cold reduction—(d) untreated, (e) annealed for 2 hours at 975°C and (g) at 1175°C. The rectangu-

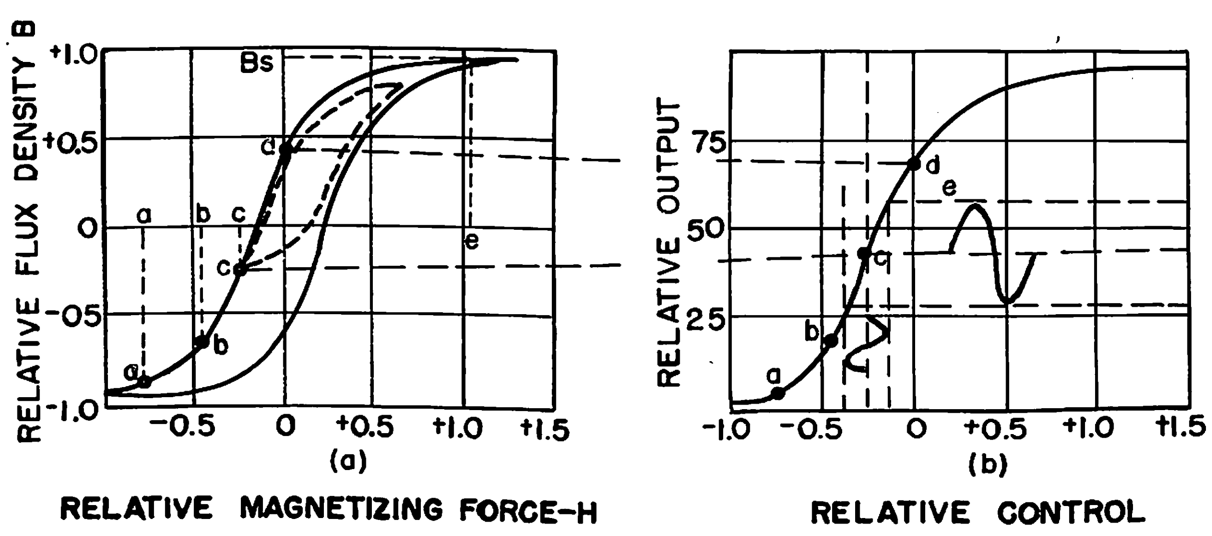


FIGURE 46.

lar characteristics are lost when annealed at still higher temperatures. Figure 45 shows only hysteresis loops. Figure 46 is submitted to show how these loops are related to an actual operating curve.

The permeability of a magnetic material is the ratio of B to H where B is the flux density and H is the magnetizing force. The relationship of B to H varies with the material and is usually indicated by the magnetization or B-H curve for that material. The actual magnetization curves have shapes indicated in Figures 45 and 46. At low values of flux density the permeability will have a moderate value and will increase to a maximum value at the knee of the curve and then drop sharply at high flux density values. Since B is proportional to the voltage across the inductance, and H is proportional to the current through the inductance, it follows that permeability is directly proportional to reactance, and vice versa. To permit smaller cores the flux density at saturation should be high. Silicon steels have a high flux density but the permeability is low and saturation is not abrupt. Therefore, iron nickel alloys, in spite of their lower flux densities, are preferred. Cross saturating with minimum power requires less control. The value of incremental permeability under any set of conditions depends not only on the magnetic characteristics of the material but also on such factors as the presence of d-c bias mmf., presence of a-c mmf. swing, the past magnetic "history" of the material, etc. Effective incremental permeability might also take eddy current effects into consideration.

New developments in the theory of ferro-magnetic domains which are the result of experiments with magnetic alloys in crystalline form indicate that conclusions may be reached in the near future which may be of considerable value when applied to magnetic amplifiers. Investigations in this field are apparently leading to the following conclusions: The Barkhausen effect is due principally to impurities. That the absence of impurities would result in practically zero hysteresis loss. Further details can be found in handbooks on magnetic materials. Most of the above information on magnetic material was obtained from papers presented at the Naval Ordnance Laboratory symposium, Washington, D. C., 15 June 1948. This Laboratory has contributed considerably towards the revival of the magnetic amplifier in the United States, principally in the investigation of core material. The efforts of the Magnetic Section of this Laboratory are under the guidance of Dr. Elmen, who was formerly connected with the magnetic development project of the Bell Telephone Laboratories. Dr. Elmen is also responsible for the development of Permalloy.

To describe the dynamic behavior of the core requires that the detailed characteristics of the core material be considered. As these characteristics become more precise, the mathematical equations become more complicated. In fact, a general analytical solution, when attempting to solve for anything except for the straight part of the operating curve, extends almost to the stage of unsolvability. The formulas even though carefully worked out would not necessarily accurately predict the final performance of the production unit. Manufacturers may be supplied with identical core material and still turn out units with different characteristics. Fabricating processes sometimes affect the final performance. Shock and strains during punching, shearing and winding may change core characteristics. Lamination insulation, type winding and rectifier characteristics all have a direct bearing on the final performance. A method was recently published for relieving stresses incurred during fabricating. This process consists of a low temperature anneal after the coil has been wound and fabrication is complete. This restores the magnetic properties altered during manufacture and contributes considerably towards uniform, predictable performance.

The better type cores not only result in an increased efficiency but also in less wave distortion as indicated in Figure 3. In small sized units toroidal wound coils result in an appreciable saving in volume. In addition, for a given volume and core material, the performance is about twice that obtained from conventional noncontinuous stampings. The ability to utilize the full advantage of grain orientated mechanically annealed material is more pronounced in toroidal structure. The difficulties encountered in winding the toroidals or any continuous core limits their applications.

Ferramics

Another magnetic amplifier core material that is gaining popularity, especially in HF application, is magnetic ferrite. This is commonly confused with powdered iron. Ordinarily powdered iron cores used in r-f transformers cannot be used efficiently in magnetic amplifiers because the iron particles are suspended in an insulation which acts as an air gap. Ferramics, however, a related composition, consisting only of metallic oxides, have a high volume of resistivity and high permeability, but low losses, making for reduction in size and weight in HF magnetic circuits.

Ferromagnetic ferrites are compounds of various metal oxides (not metals). Physically, they are crystalline material having a spinal structure. Mechanical properties are similar to those of dry process porcelain except that the specific gravity is between 4 and 5.

The natural ferro-ferrite, magnetite, or load stone, was discovered before the Christian era and was one of the first substances to arouse scientific curiosity. Thales of Miletus mentions this material in 624 B.C. The first patents on this material were granted in Germany in 1909, followed by several Japanese technical articles on theory and developments.

The difference between powdered irons and ferrites should be emphasized. In the former, the desirable properties of high volume resistivity is achieved by bonding finely divided metal particles in an organic insulating binder, thereby sacrificing permeability as the core is full of "airgaps". Ferrite material does not have to be powdered, therefore the permeability is not diluted. Any organic material would be fired out in the 2300°F kiln. Ferrites, like porcelain, must be preformed to size prior to firing. Machining operations after firing are limited practically to silicon-carbide grinding wheels under water. Ferrites, like iron alloy cores, can be developed to reflect various families of hysteresis loops. Cores of either material are superior within their own parameters. Ferrites are superior in specialized applications in high response circuitry, responding effectively to frequencies up to 20 Mc or more.

Other properties of ferrites make them suitable for such remote applications as waveguides (reducing its size by a factor of 10), supersonic delay lines, and magnetostrictive oscillators and transducers at sonic and supersonic frequencies.

Magnetic and physical characteristics of ferramic materials cover such a wide range that no attempt is made to include them in this review.[9]

Rectifiers

Figure 47 shows the characteristic curves of a conventional germanium and a miniature selenium rectifier. These are reproduced mainly to give a rough idea of the rectifying relationship between the two devices. They may be obtained in greater power handling capacities as shown below.

Operating characteristics of two currently advertised units are as follows:

	GERMANIUM (WELDED) 1N69	SELENIUM-(C-K) STI. (STACKS)	
		HV	LV
Peak inverse voltage	75	440	35 Volts
Average current	40 Ma	65	600 Amp.
Peak current	125 Ma	71	660 Amp.
Surge current	400 Ma	130	1200 Amp.
Rectifier drop forward	2	5	2 Volts
Working temperature	70°C	85°C	85°C

Rectifiers play a very important part in the end performance of magnetic amplifiers. Low forward resistance and high reverse impedance is important. Even a small amount of reverse current has a noticeable effect on the efficiency of the amplifier. The leakage current reflects inverse feedback which is not exactly detrimental, except that it increases the amount of control current required. Germanium crystal rectifiers are often used in the control winding as these windings are of high impedance. Selenium and copper oxide rectifiers, due to their low resistance and high power capacity, are usually used in the load circuit although in HF applications, crystals may be used for both purposes.

Germanium crystals are currently gaining popularity in their own right as components in electronic equipment. They are now being used as a substitute for electron tubes as detectors, clamping diodes, d-c restorers, diode modulators, switching circuits, etc., in both military and commercial equipment.

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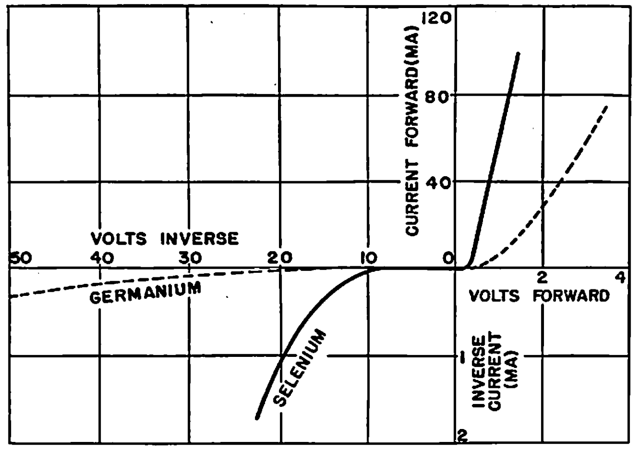
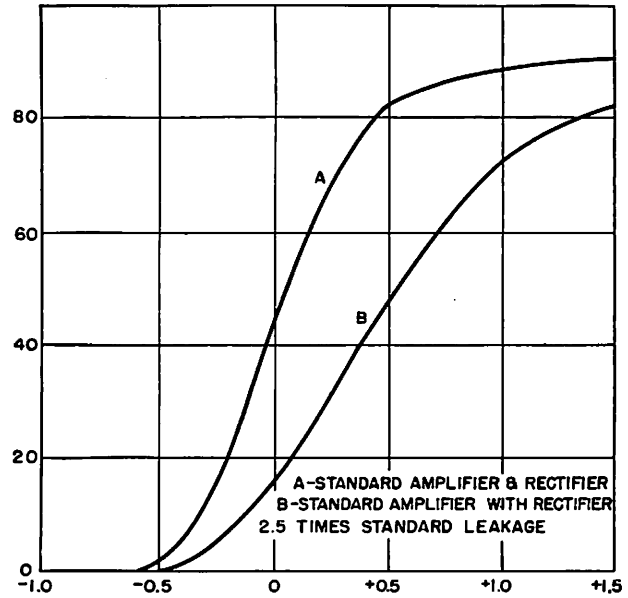
[9] See Item No. 20, bibliography.





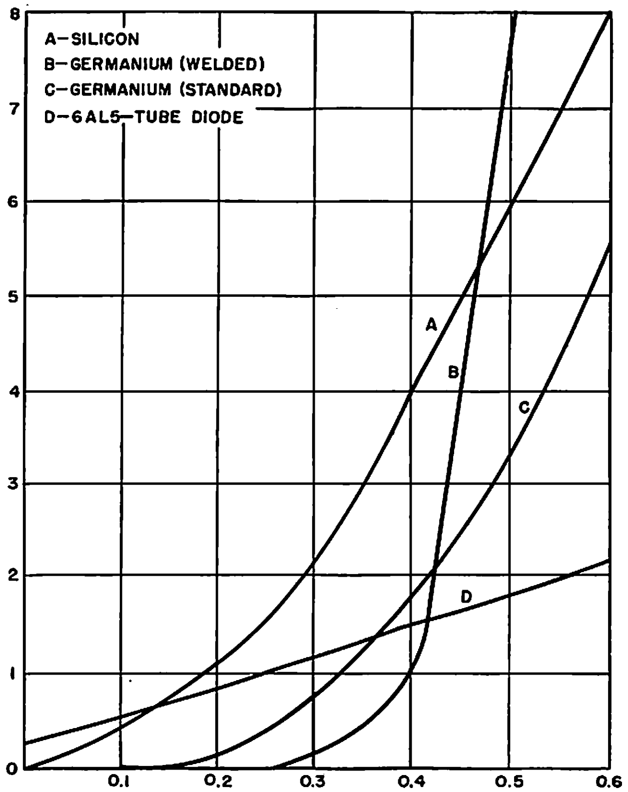


FIGURE 47—Characteristic curves of various rectifiers.

Non Linear Devices

Glow tubes, thyrites, thermistors, aluminites, etc.

Non-linear devices may also be used with magnetic amplifiers. In certain applications they may be applied to increase the control sensitivity several hundred percent. They may also be used as a protective device against input surges and output reactive loads.

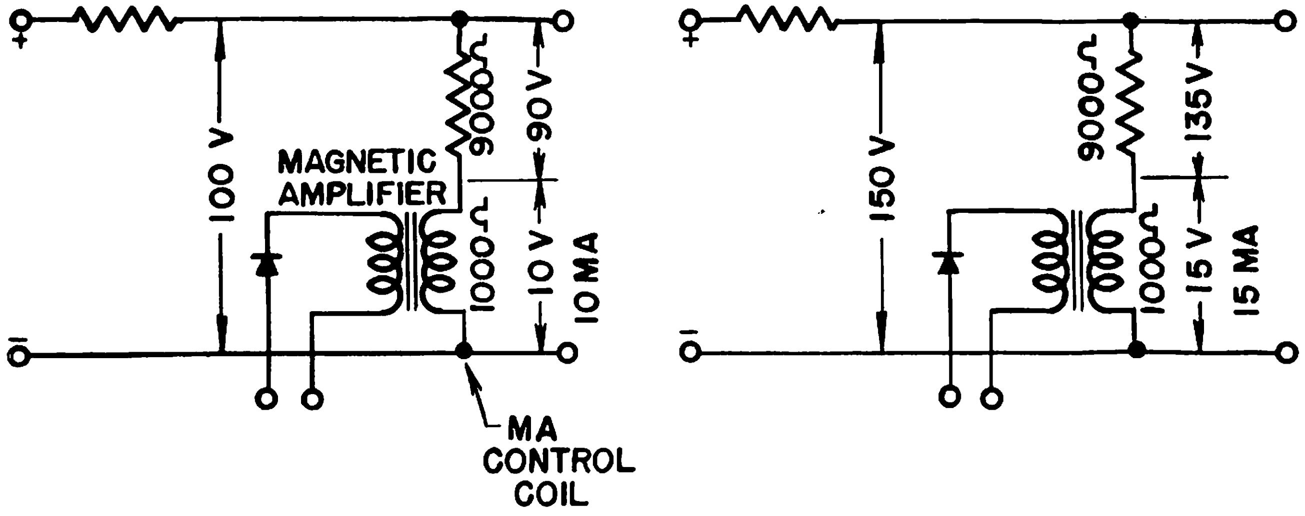


FIGURE 48 (a).

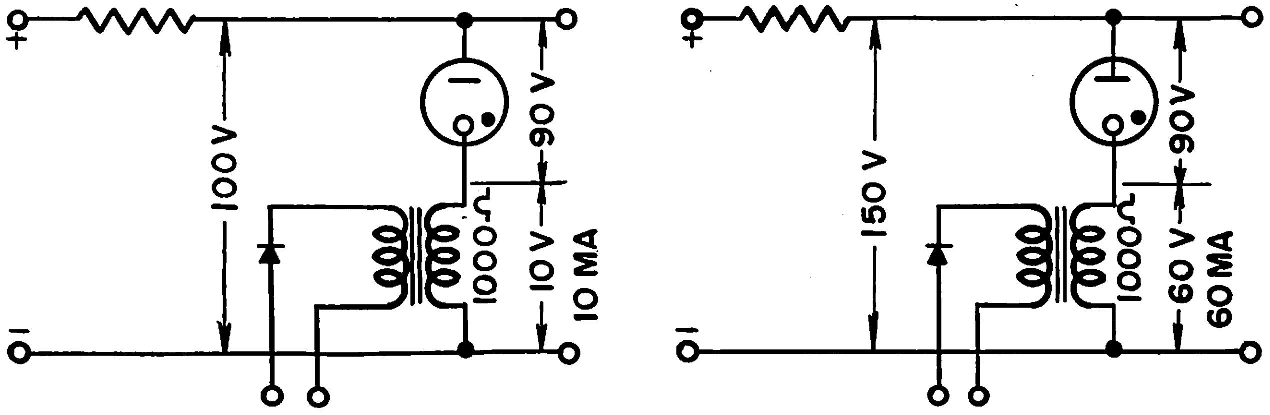


FIGURE 48 (b)—Non-linear devices—principle of operation.

The amplication feature of these devices is shown in Figure 48.

In this instance the glow tube increased the sensitivity several hundred percent. Other non-linear devices can be applied to low voltage applications, and, with certain types, directly across AC. Characteristic curves of other types are shown in Figure 49.

This review has been limited principally to reactance type magnetic amplifiers as they are the most commonly used, although only one of the numerous types now under development.

Nowhere in the broad art of this development has a report appeared which described and summarized, in general terms, the various possible types and forms of magnetic amplifiers. In most of the writings only one

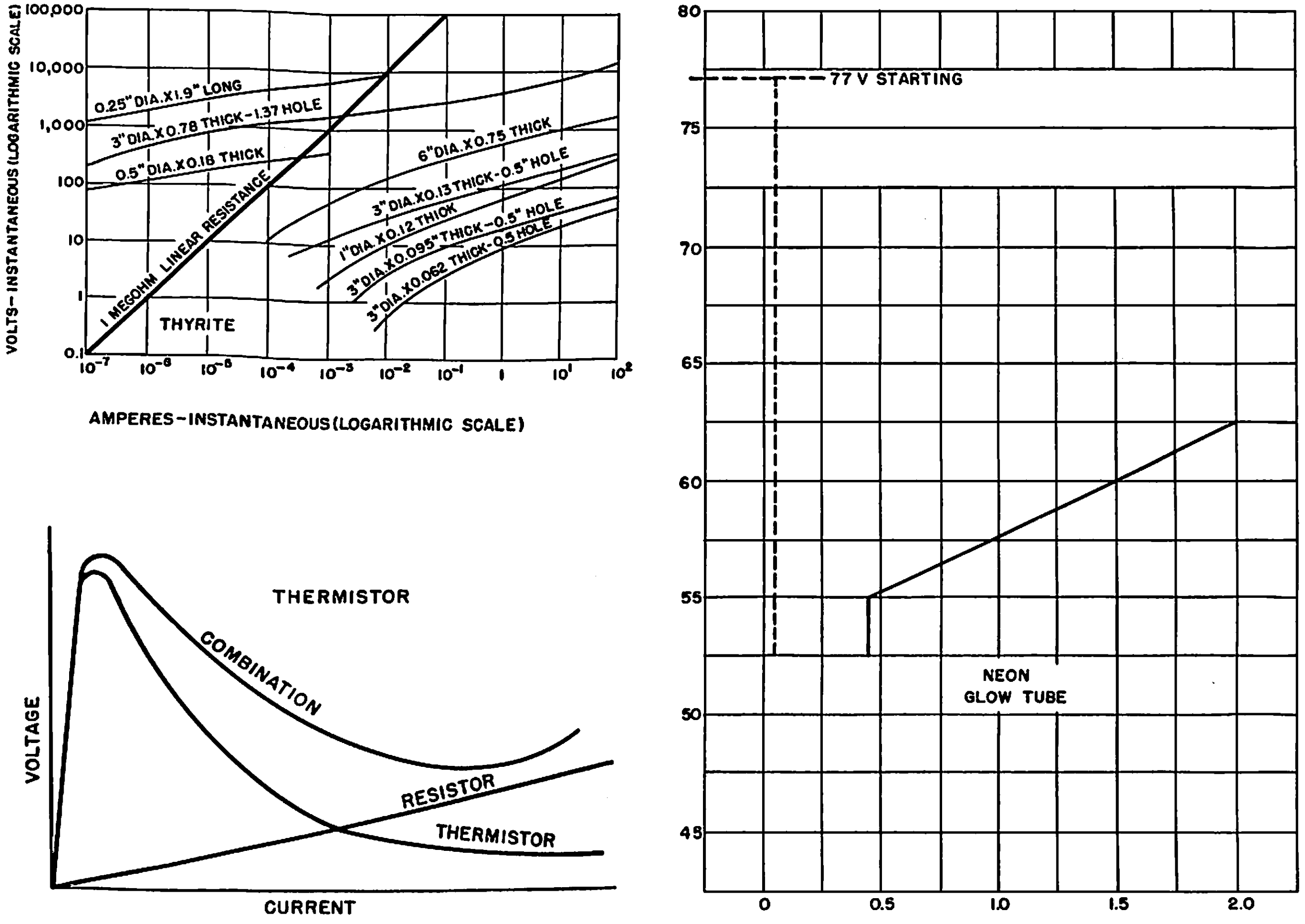


FIGURE 49—Characteristic curves of other non-linear devices.

type of magnetic amplifier is discussed, ignoring references to other types. Mr. J. C. Miles, of Engineering Associates, has proposed broad classes including forms of:

1—Saturable reactors controlled by signal mmf.
2—Saturable transformers controlled by signal mmf.

Each of the broad classes (1) and (2) contains specific circuit types as "polarized" and "non polarized" types comprising:

1—Single ended circuits.
2—Push-pull circuits.
3—Wheatstone-bridge type circuits.
4—Special magnetic amplifier circuits (such as flip-flops comprising cross-connected pairs of magnetic amplifiers, etc.)

Further, amplifier sensitivity, stability and linearity may be effected by incorporating any one or more of the following means as desired:

1—External feedback (including a means whereby part of the final output or load signal is coupled back into either the power or control coils.)
2—Internal feedback (including amplistats.)
3—Unidirectional bias mmf, of fixed magnitude.
4—Off-resonance and ferroresonant means.

Field activities should feel free to contact the Bureau of Ships, Code 815, for further information on this device. Reprints of this article will be made available if sufficient requests are received.

The writer gratefully acknowledges the helpful criticisms of Dr. L. A. Finzi, Carnegie Institute of Technology, Mr. F. G. Logan of Vickers Inc., Mr. F. Spencer of Eclipse-Pioneer, Mr. Herz of Magnetic Amplifiers Inc., and Mr. J. C. Miles of Engineering Associates. Mr. Miles also contributed the section on HF flip-flop applications.

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ERRORS IN BULLETIN FOR F. C. NO. 42—SU–1

Discrepancies in Field Change Bulletin Navships 98172 for Field Change No. 42 for Model SU–1 equipments have been brought to the attention of the Bureau and are submitted for information:

The sketch on Page 2 should be changed such that the wire tagged "Existing" should be tagged "Add" and the terminal marked "5" should be marked "18". Under "Procedure" on Page 2, the following paragraph should be corrected to read:

"a—Pick up the spare lead (usually WB) in Cable 2R–ER–3 (See Fig. 7–74 in SU–1 Instruction Book Navships 900,882) and connect it to a spare terminal (Number 18). A second spare lead which should be marked R–ER–64 is required in Cable 2R–ER–3 to connect terminal Number 64 in the modulator to a spare terminal (Number 64) in the indicator.

"b—From the inner side of the terminal board, connect one piece of Number 18 wire to the spare terminal (Number 18) and connect a second piece of Number 18 wire to terminal Number 64.

"c—In the modulator, pick up the spare lead in Cable 2R–ER–3 (check for continuity to the spare terminal Number 18 in the indicator) and connect to terminal Number 113 and mark R–ER–113 WB".

The instructions contained in "Temporary Correction to Instruction Book for Model SU–1 Radar Equipment NAvships 900,882" should be modified as outlined above to agree with action taken.

GCA saves

The following are some typical GCA "saves" as received from operational units:

GCA Unit #17 NAS Jacksonville, Fla.

This unit had a surprise visit by a "Constitution" during the 1950 Xmas holidays. The weather around the Jacksonville area was down to GCA minimums for almost a week, so it was a "saved" approach. The ability of the pilot to fly the huge aircraft was amazing. The approach controller will now admit, however, that had he known there were 134 persons aboard he would have sweated just a little more that dark and foggy night.

GCA Unit #26 NAS Minneapolis, Minn.

On 19 May 1950 at 0300 the unit was alerted for an air force C–47 that requested GCA when 20 miles from Wold Chamberlain Field. The reported weather at the time was visibility 1/8 mile, heavy fog, ceiling obscured. The aircraft made an excellent approach and was landed to touchdown at 0050. The aircraft stopped on the runway and waited for an air force jeep, which could well have used radar control, to find the aircraft and direct it to the parking area. Both pilots and passengers were well pleased with the landing.

GCA Unit #32 NAS St. Louis, Mo.

At 0945 on 13 January 1951 GCA Unit #32 was alerted by Lambert Field tower in an attempt to locate a Cub Pacer that had reported to Lambert tower that the pilot was lost above the overcast somewhere near St. Louis, Missouri. The pilot reported that he had three hours of fuel and was flying five hundred feet on top. He reported the overcast top at sixty-five hundred feet. At 0950 a VHF/DF bearing was obtained on the plane and the aircraft was subsequently brought over Lambert Feld and held over the field on VHF/DF. Due to the Cub being on frequency 122.1 Mc, all instructions had to be relayed by Lambert control tower. At 1015, while pilot was circling the field, he stated that he had only an airspeed indicator, an altimeter, a magnetic compass and a turn and bank indicator. He also stated that his instrument training and experience were nil. Believing that a safe GCA approach could not be conducted under the circumstances, the GCA officer requested permission from the commanding officer to dispatch two station pilots in a JRB to climb above the overcast and lead the Cub to safety below. At 1025, LCDR W. C. Griese and LT. (jg) Cletus Futrell took off in JRB BUNO 67202, climbed above the overcast at seventy-five hundred feet and joined up on the Cub Pacer. After approximately twenty minutes of formation instruction, LCDR Griese informed Lambert tower and GCA Unit #32 that the Cub pilot was sufficiently qualified in formation flying to commence the instrument letdown and the GCA final approach. At 1100 St. Louis approach control informed LCDR Griese that the control zone was cleared of all aircraft and that he was cleared to commence his descent. At 1103 LCDR Griese commenced an instrument descent out the east leg of St. Louis radio range with the Cub Pacer flying on his starboard wing in formation. When the two planes reached a distance of twenty-two miles from the field, control of the letdown was taken over by GCA and the two aircraft completed a normal GCA final approach with the JRB being brought in two hundred feet to the left side of the runway. This procedure allowed the Cub to be lined up with the runway. Upon breaking out of the overcast, the JRB was given a waveoff and the Cub was landed. The JRB then circled the field and landed a short time later. Pilot of the Cub Pacer was W. R. Wickersham of Phoenix, Arizona who had recently participated in a search for a Navy plane believed lost in Grand Canyon. Wickersham had never flown a minute of formation prior to this GCA letdown.

GCA Unit #25 NAS Glenview, Ill.

On 31 January 1951 this unit made two emergency approaches without incident.

On the first emergency two P–86 Sabre Jets were vectored to this field after a missed DF approach into O'Hare Field. The planes were given a straight-in PPI approach into Runway 32 at the pilots' request. Both aircraft landed safely with less than 10 minutes fuel remaining. Ceiling and visibility at this time were 1500 feet and 1/2 mile.

The second emergency involved an Air Force T–6 which made a normal approach. When the plane was turned over to GCA control the pilot reported 10 gallons of fuel remaining. The pilot landed with no difficulty although the wheel warning horn was blowing throughout the approach. The plane ran out of gas taxiing into the line. Ceiling and visibility at the time of this approach were 500 feet and less than a quarter of a mile.

Modification of FSA FSK for Radiophoto/Facsimile Operation

Introduction

Radio facsimile transmission requires a linear relation between keying, or modulating voltage, and frequency deviation, or shift. In other words, rather than abruptly shifting the frequency between "Mark" and "Space", the facsimile signal frequency modulates the radio-frequency carrier. The frequency deviation is a function of the shade of the copy being scanned by the facsimile transceiver at any instant. When the copy shade varies from extreme black to extreme white in a gradual manner, the frequency is required to shift in a like manner.

The facsimile transceiver output signal is unsuitable for application as keying voltage to a frequency-shift keyer. The facsimile signal is an 1800-cycle amplitude-modulated voltage. The frequency-shift keyer requires a d-c keying voltage whose magnitude varies directly with the modulating or envelope frequency of the facsimile transceiver signal. Keyer adapter, KY–44 performs this function of demodulation and extracts the required modulating frequency from the facsimile transceiver output signal. For the reasons outlined, to operate an FSA keyer for facsimile operation, modification of the FSA is necessary as well as the use of the keyer adapter KY–44.

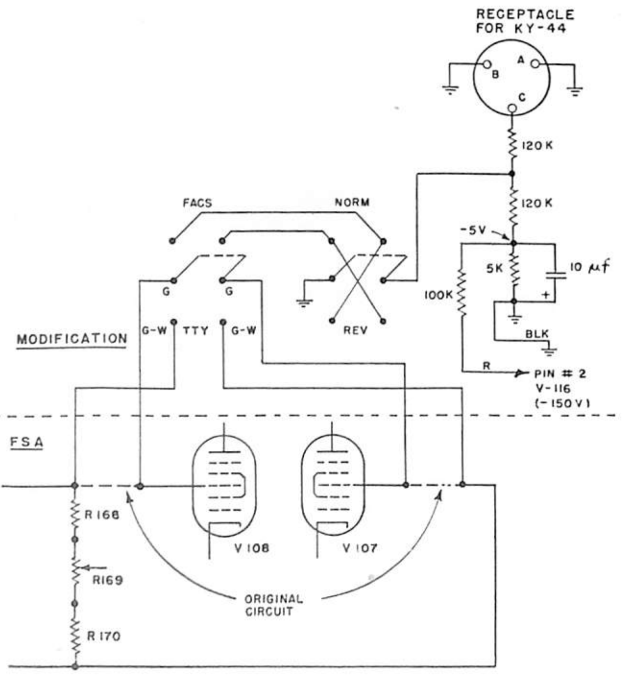

FIGURE I.

Installation

The modification chassis is mounted on the right rear corner (looking from the front) of the FSA oven, directly over V–107.

Two mounting ears are provided. One will mount under the middle fillister head screw on the right side of the rear oven plate. The other will mount under the round head screw which secures the right hand lifting bar to the chassis proper.

A one-half inch hole is drilled one-fourth inch to the rear of and in line with X–107 to allow for passage of leads. The supplied rubber grommet is inserted for protection of the leads.

The leads between pin #8 of V–107 and R–170 and between pin #8 of V–108 and R–168, are removed. Leads from the modification chassis are then connected as shown in the schematic diagram, Figure 1.

Operation

Figue 2 is a block diagram showing the equipment sequence for facsimile transmission. For shore installations the KY–44 would be rack-mounted in one of the cabinets at the control position. It has a 600-ohm output and is capable of simultaneously keying four or more modified FSA keyers.

The pulsating d-c voltage output of the KY–44 has a positive polarity and is applied to the keying signal grid (pin #8) of either of the two reactance modulators, V–107 or V–108, of the FSA. Pin #8 of the other tube is then grounded. In order to obtain a substantially linear relation between keying voltage and frequency deviation, the biasing arrangement shown in the schematic diagram is used. A negative five volts, plus or minus one-half volt is desired at the junction of the 120K, 100K and 5K resistors. The voltage at this junction may be too high in some installations, in which case shunting the 5K resistor with a suitable resistor (10K—20K) will bring it down to the required five volts.

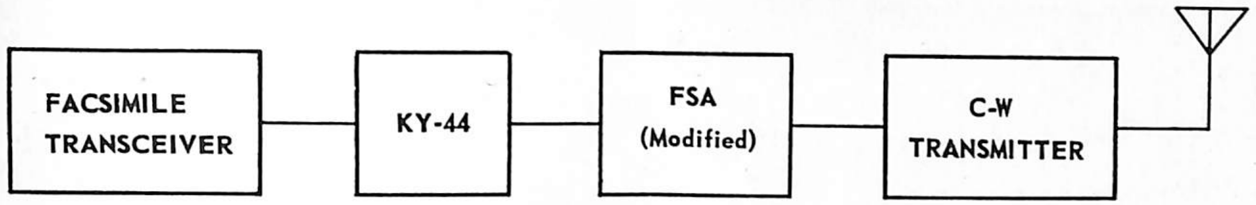

FIGURE 2.

Two toggle switches are used; one to set up the keyer for facsimile or teletype operation, the other to apply the facsimile keying signal to one or the other of the reactance modulators, V–107 and V–108. Throwing this switch from REV to NORM causes the white and black radiated frequencies to be interchanged. With the TTY-FACS switch in the TTY position, the FSA is restored to its original circuitry.

Tuning Adjustments

1—Patch the facsimile transceiver output to the input of the KY–44.

2—With the facsimile transceiver set up for plus 2 db. output, adjust the gain control of the KY–44 for 10 volts output.

3—At the transmitter, patch the KY–44 output into the keying signal jack located on the modification chassis.

4—Place the TTY-FACS switch in the FACS position.

5—Place the REV-NORM switch in the NORM position.

6—Tune the FSA keyer and the F/S coupler in the same manner as when setting up for radioteletype operation.

7—Set the frequency meter up on the transmitter output frequency, *plus* 400 cycles.

8—Adjust the FREQ CONTROL knob on the FSA for zero beat.

9—Reduce the KY–44 output to 2.5 volts and adjust the FREQ SHIFT control on the FSA for a 800-cycle shift*.

10—Repeat steps (7), (8) and (9) until the shift is correct and a zero beat is obtained as in (8).

If unable to obtain the required 800-cycle shift with the keyer shift control fully advanced, reduce the TRANS MULT FACTOR switch on the FSA one division.

The above modification applies to shore installations. In order to accomplish this change in shipboard equipments, the Bureau is providing a modification kit, MX–1220/SX. This kit modifies the FSA to FSA–b for facsimile use, eliminating the necessity for the KY–44/FX Keyer Adapter. Kits are now in production, and are being distributed by the Bureau of Ships as directed by the Chief of Naval Operations.

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* Shift measurement can readily be made by tuning the signal in on a local C-W receiver and applying the audio beat note to the vertical plates of an oscilloscope. The output of a calibrated audio oscillator is applied to the horizontal plates. Set the oscillator for 2000 cycles and adjust the receiver tuning for a circular scope pattern. Then reduce the KY–44 output from 10 volts to 2.5 volts. Without touching the receiver, vary the audio oscillator frequency until the circular pattern is restored. The difference between the original 2000-cycle oscillator setting and the new setting represents the shift, in cycles, of the transmitter.

TBL BLOWER MOTOR FAILURES

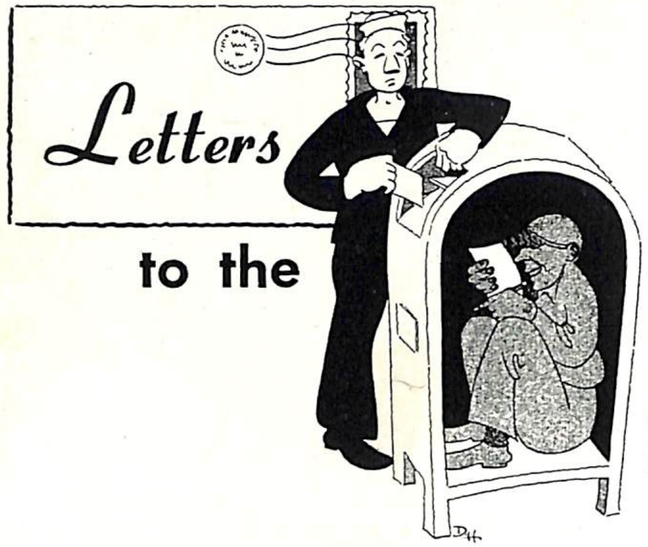
The following letter from Commander Submarine Force, United States Atlantic Fleet, is printed in its entirety because of the unusual damage described:

"1—A recent report from a submarine of this Force describes the damage resulting from a frozen bearing in the blower motor of a TBL series transmitter. In this case, the following damage was done:

Burnt out armature
Blower motor brushes ruined
Two choke coils burned beyond repair
Two heaters destroyed
Three terminal boards burned
Four resistors burned
One relay destroyed
Three switches burned
One thermostatic relay assembly destroyed
Thirty interconnecting wires burned
Felt insulation burned

"2—It is believed that an inspection of the TBL blower motors installed in submarines of this Force will disclose several inoperative or defective motors. It is directed that these blower motors be inspected for free rotation and cleanliness, and that these inspections be repeated at intervals of not more than one month.

"3—Failure of these components, as well as other electronic items, must be reported to the Bureau of Ships using the customary Failure Report Card."



Letters to the EDITOR

This new feature is the answer to numerous suggestions and requests from fleet and shore personnel for a medium of presenting their individual problems, gripes and questions on electronics matters and obtaining answers to such queries.

As a matter of convenience, it is suggested you write directly to:

The Editor
BuShips Electron
Code 993
Bureau of Ships
Navy Department
Washington 25, D. C.

Editor
BuShips Electron
Sir:

I have been unable to find adequate information on the new Electron maintenance parts and electron tubes allowance lists.

What is the procedure for getting the allowance lists corrected after new equipment has been installed? I have assumed that the Bureau corrects the allowance lists to support all equipment installed automatically when the Navships 4110 has been corrected. Am I correct?

R. R. W., ET1, USN

Information on electronic maintenance parts and tube allowance lists is contained in NavShips 900,168 "THE SHIPBOARD INTEGRATED ELECTRONIC MAINTENANCE PARTS SYSTEM", copies of which are available from the Bureau upon request to Code 960.

Significant changes in installed equipment are usually accomplished during a ship's availability. The Bureau furnishes revised allowances to ships to support changes in installed equipment made during a regularly scheduled availability. To assure receipt of revised allowances, particularly when equipment changes are made outside of regular scheduled availabilities, it is recommended that Code 960 of the Bureau be advised of such changes as far in advance as possible.

Editor

Editor
BuShips Electron
Sir:

In the February 1950 issue of BuShips Electron, an article entitled "Bringing Mahomet to the Mountain" described a proposed Electronic Repair Craft designated AN/SSM-1C for use at advanced bases.

At the time of the article, the information was only of passing interest, but in the past few months conditions have developed that cause us here at the Electronic Repair Facility at Guantanamo Bay to become greatly interested in procuring such a craft.

Can you furnish information as to whether the plans of the AN/SSM-1C have been firmed up to a point of production and what BuShips Code should be contacted to initiate possible procurement action?

J. F. P., Electronics Engineer

The plans have been firmed up to the production point, although no AN/SSM-1C are yet available. It would be entirely fitting, however, for your activity to request one from the Chief of the Bureau of Ships, Code 917.

Editor

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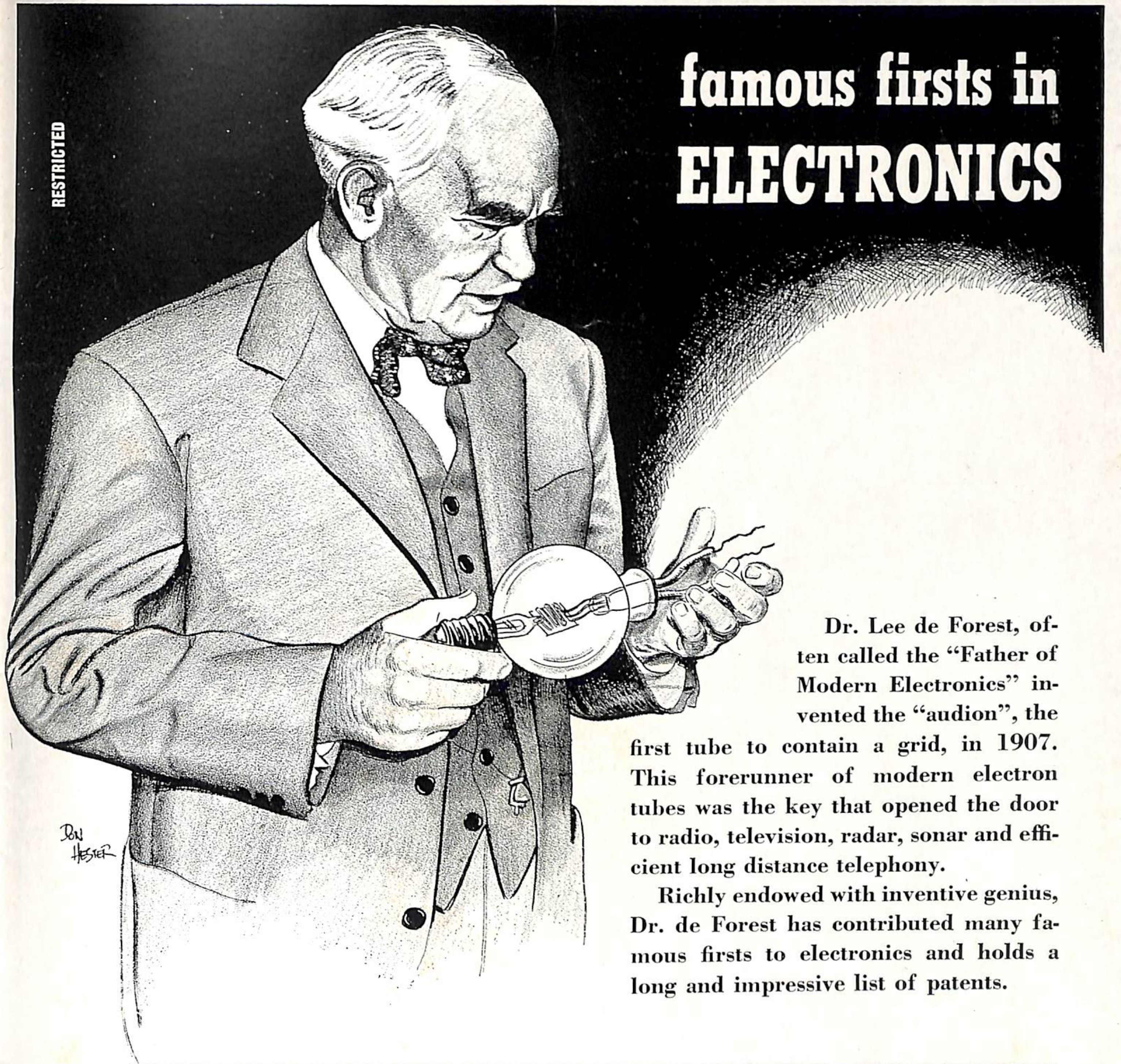
famous firsts in ELECTRONICS



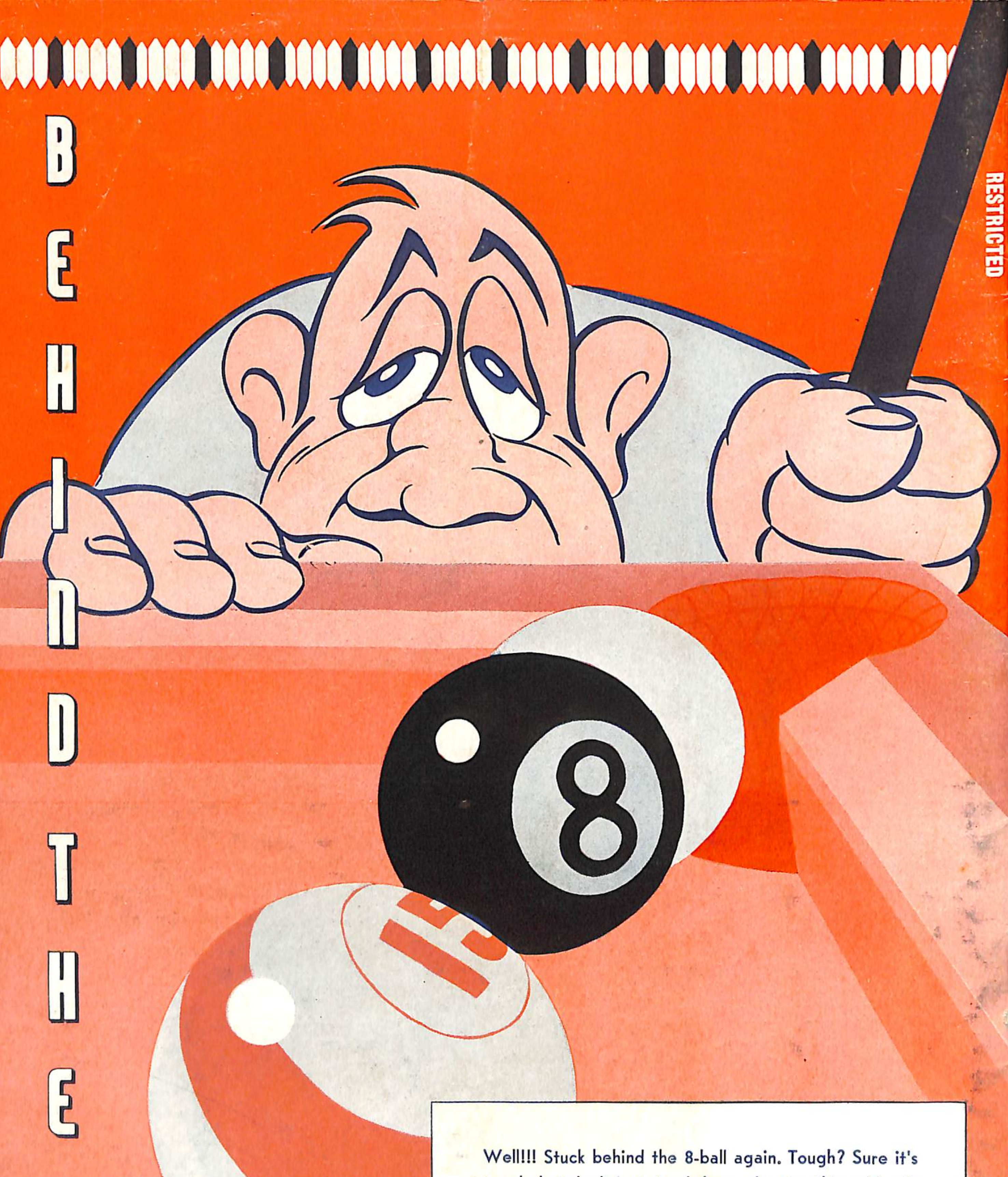
Dr. Lee de Forest, often called the "Father of Modern Electronics" invented the "audion", the first tube to contain a grid, in 1907. This forerunner of modern electron tubes was the key that opened the door to radio, television, radar, sonar and efficient long distance telephony.

Richly endowed with inventive genius, Dr. de Forest has contributed many famous firsts to electronics and holds a long and impressive list of patents.

Lee de Forest

Through "Famous Firsts in Electronics" ELECTRON brings you great moments in the history of electronic development.

BEHIND THE 8 BALL?



Well!!! Stuck behind the 8-ball again. Tough? Sure it's tough, but don't just stand there; do something. Here's your cue! Grab a pencil and paper and send your little 8-ball to the editor of ELECTRON. If he can't call your shot, there are lots of people in the Bureau of Ships who can.