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HIGH FREQUENCY RADIO ECHOES

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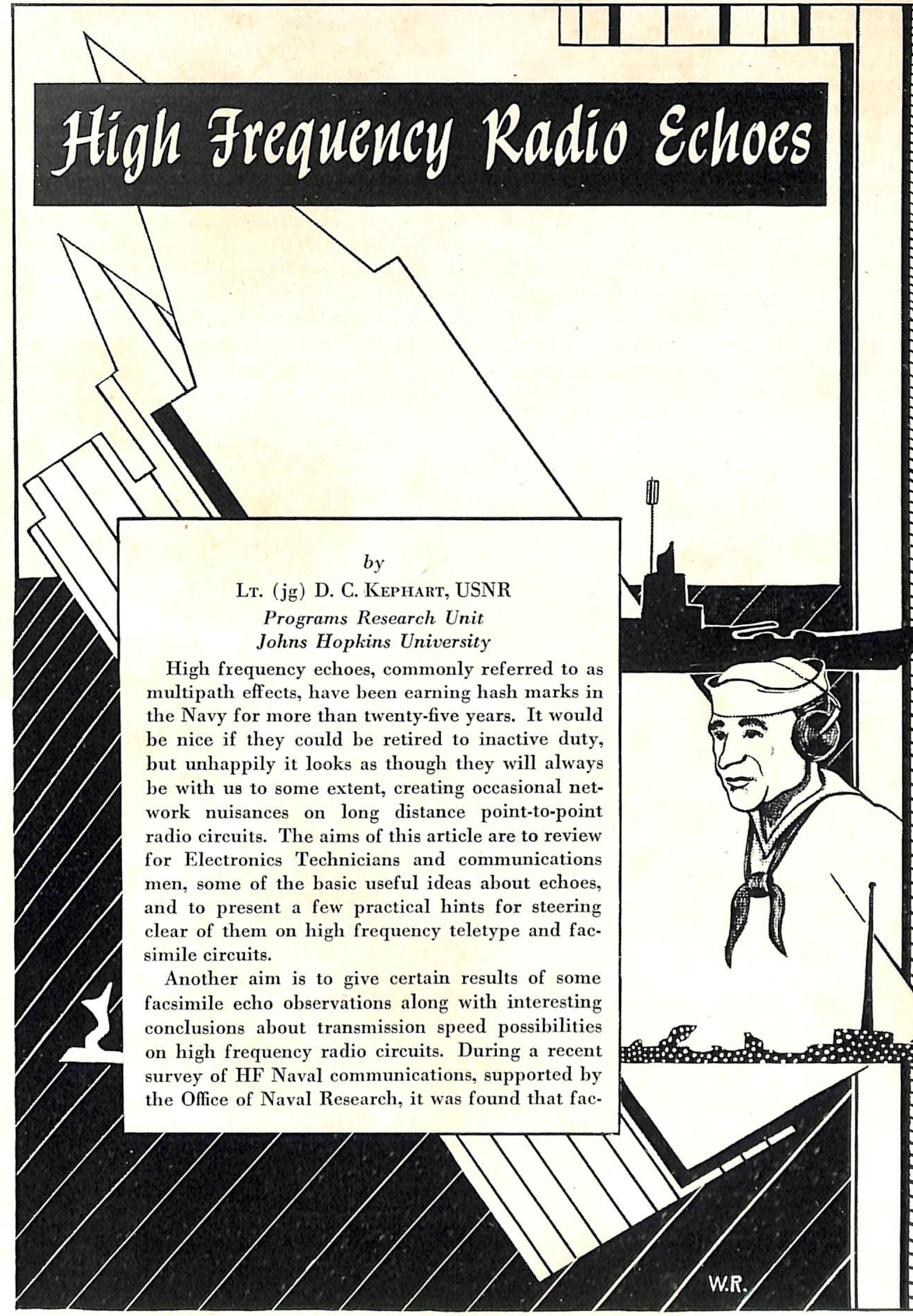
High Frequency Radio Echoes



by

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High frequency echoes, commonly referred to as multipath effects, have been earning hash marks in the Navy for more than twenty-five years. It would be nice if they could be retired to inactive duty, but unhappily it looks as though they will always be with us to some extent, creating occasional network nuisances on long distance point-to-point radio circuits. The aims of this article are to review for Electronics Technicians and communications men, some of the basic useful ideas about echoes, and to present a few practical hints for steering clear of them on high frequency teletype and facsimile circuits.

Another aim is to give certain results of some facsimile echo observations along with interesting conclusions about transmission speed possibilities on high frequency radio circuits. During a recent survey of HF Naval communications, supported by the Office of Naval Research, it was found that facsimile weather maps provide an excellent source of data for the study of echoes on long distance circuits. Facsimile maps transmitted to Washington from New York, San Francisco, Honolulu, and Guam were furnished from the files of the Washington Navy Radiophoto Activity through the cooperation of Lts. R. A. Langdon and C. D. Scallorn, who also participated in this study. Some facsimile map samples are illustrated in Figure 1. The top section is an example of good clear reception. The center section shows echoes delayed 20 and 40 milliseconds. Short echoes or "trailing edges" are pictured at the bottom. Echo delays can be measured in milliseconds directly from the facsimile pictures where distances in the direction of scanning are proportional to time.

Causes of Echoes

Echoes occur when radio energy reflected from the earth and from the ionosphere is broken up into separate packets or components which arrive at a receiver along a number of paths of different lengths. The result at the receiver will often be as in Figure 2, which pictures a typical oscillogram of a received signal element followed by a train of delayed echoes. Radio facsimile picture receptions will be blurred and teletype copy will be garbled when a single intelligence pulse is received more than one time. Where delays are so short that successive echo pulses overlap, the echo energies involved will be reinforced or cancelled according to phase. This amounts to a form of fading. Where delays are long, echoes may cause message errors

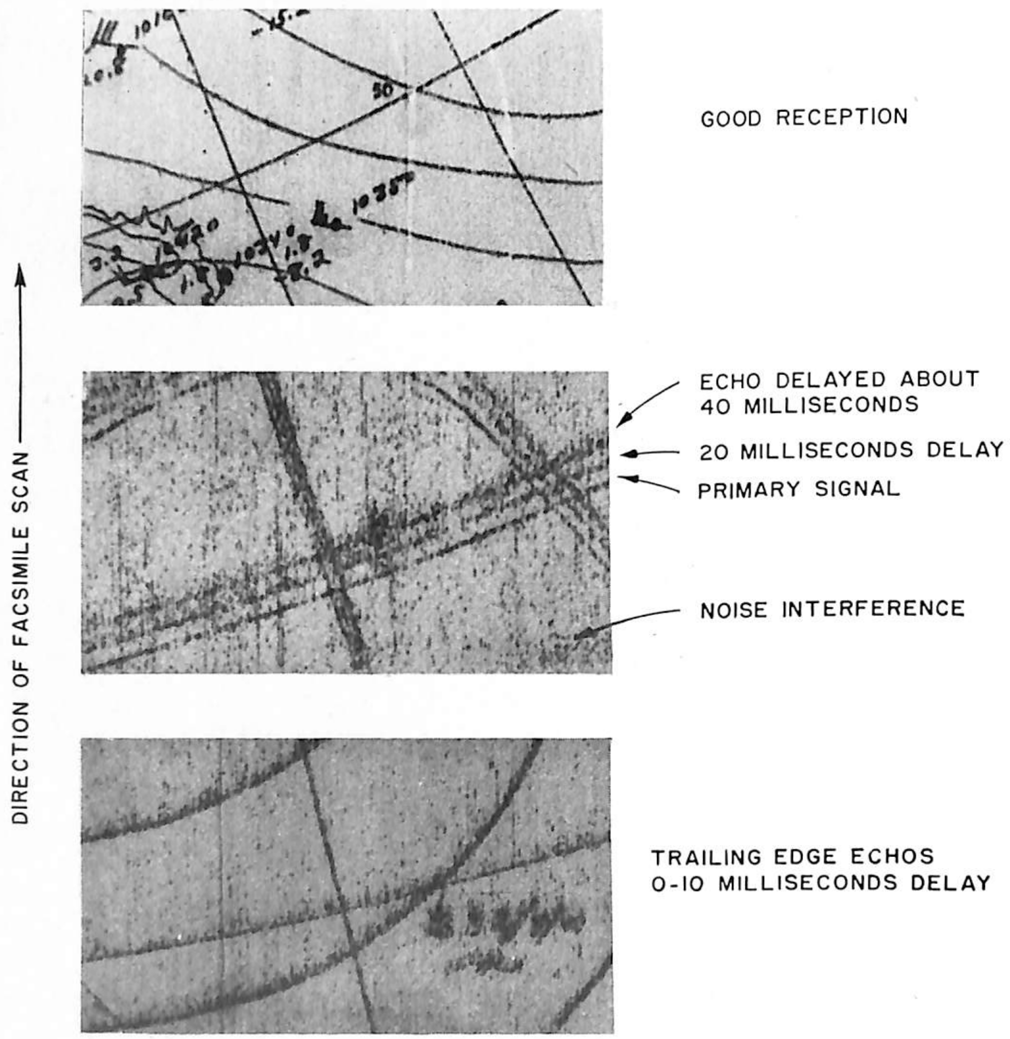


FIGURE 1—Sections of Navy facsimile maps received on high frequency point-to-point circuits, showing good reception, long delayed echoes and noise, and short-delay trailing-edge echoes.

when they masquerade as genuine intelligence bands and are received and recorded where none are intended.

It is possible to classify the more common echoes on the basis of their origin. Echoes arising from reflections between earth and ionosphere include:

1—Double-signals and around-the-world echo.

2—Back-scatter and ground-scatter.

3—Multiple mode transmission.

Echoes arising in the ionosphere alone, unaffected by the ground include:

4—Pedersen or high rays.

5—Magnetic splitting.

6—Sporadic E-scatter.

The sketches in Figure 3 will aid in providing an understanding of the geometry of some of the many types of high frequency echoes which can occur. Items (1) and (2) in the above list are instrumental in producing the long-delay or "spread" echoes while the latter four types usually combine in different amounts to produce short-delay echoes or "trailing edges" as they are often called on facsimile pictures.

Double-Signals and Around-the-World Echoes

Spread echoes caused by double-signals occur when a radio wave traverses both long and short great circle paths to reach a receiver in two components separated by a delay corresponding to the difference in path lengths. Either of these components may continue beyond the receiver as an around-the-world echo to reach the receiver again with a transit time delay of the order of 1/7 second.

Extensive double-signals and around-the-world echoes have been observed when the energy from transmitter to receiver travels along the twilight zone. Since the twilight zone shifts seasonally and moves with the earth's rotation, a particular radio circuit is affected only for short periods.

Examination of 76 Navy weather maps received by facsimile during September and October, 1949 on the Guam to Washington circuit disclosed no around-the-world echoes and only 5 occurrences of double-signals. The signal travelled 6800 nautical miles in one direction and about 15,000 nautical miles in the opposite direction. Resulting delay on the long path was about 50 milliseconds. Time of reception was about 2300 GMT during late September and early October, when much of the transmission path was along the edge of the twilight zone. A single-ended directive receiving antenna with a beam width of about 15° was employed. No double-signals or around-the-world echoes were observed on facsimile maps received from Guam during May, June and December, 1949. The echoes observed were not strong enough to cause appreciable distortion on the weather maps. However, they might have been troublesome on radio teletype or on more densely coded facsimile. Present indications are that the echoes should be encountered less than about 5% of the time on the Guam to Washington facsimile channel. No double-signals or around-the-world echoes were observed in a similar study of facsimile receptions on any of the other Navy point-to-point facsimile circuits.

Double-signals might arrive at the receiver with nearly equal intensities. Here improved antenna

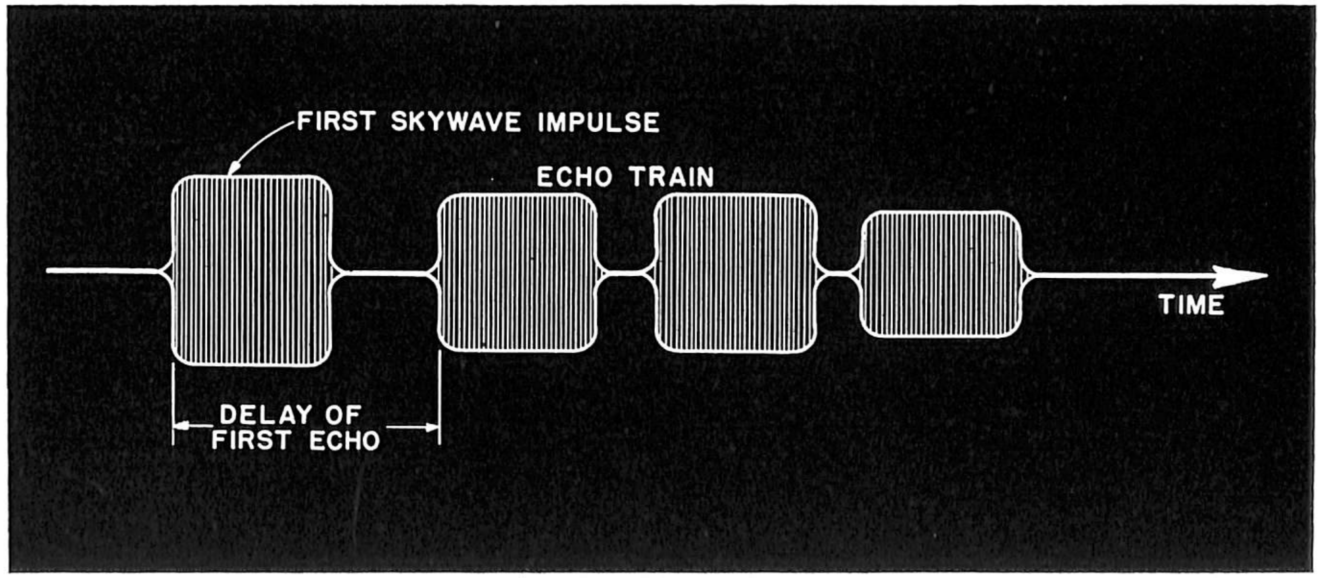


FIGURE 2—Typical oscillogram of received signal element with echo train.

directivity, and sometimes reduced transmitter power, may be employed to help eliminate the unwanted component.

The strength of an around-the-world high frequency echo is generally 12 to 15 db down in amplitude from the primary signal. In this case reduced transmitter power would eliminate the long delayed echo. Antenna directivity would not be very helpful since the echo may arrive from the direction of the transmitter.

Back-scatter and Ground-scatter

Echoes in this category are comprised of diffused, delayed energy returned to a receiver from regions in the path beyond the receiver and from reflecting protuberances on the earth's surface that lie within the transmitting antenna beam. Scatter echoes seen at the receiver are especially prevalent on transmission paths requiring one or more reflections from the earth's surface for propagation.

In a study of 110 facsimile maps sent from San Francisco to Washington about 40% were found to exhibit evidence of long delay echoes of about 20 milliseconds duration. These were probably due to backscatter. A typical case is shown in the center of Figure 1. Investigators have found that long delay echoes of this type may occur at all hours of the day. However, these studies of Naval circuits provided evidence that the occurrence of *very strong* back-scatter echoes may be associated with peculiar configurations of the ionosphere as the morning twilight zone passes over the center of a one-hop transmission path. A path of this type should therefore be avoided whenever possible.

Ground-scatter echo is especially prevalent on multihop circuits which must depend upon reflections from the earth's surface for propagation to the receiver. Normally, echo delays of not more than 5 or 6 milliseconds are produced. In exceptional cases where scatter is from points far from the great circle path between transmitter and receiver, echo delays can be 3 or 4 times this value. The degree of signal diffusion depends on the area over which reflection from the earth's surface occurs. The use of antennas which radiate relatively wide beams contributes to the magnitude of the effect. Other factors are the roughness of the earth's surface in the area of reflections and the number of earth-ionosphere hops required to reach the receiver.

Multiple Mode Transmission

Usually the most important short delay echoes are those resulting from multiple earth-ionosphere reflections. A transmitted wave is broken up into discrete modes or components, each encountering a characteristic delay in transit, depending upon the number of hops it requires to reach the receiver.

The concept of Maximum Usable Frequency (MUF) is useful in obtaining an adequate understanding of multiple mode transmission. The ideal frequency for successful long distance point-to-point communication is theoretically the highest frequency which can be reliably reflected from the F-layer of the ionosphere at the necessary angle for the particular distance involved. This is the maximum usable frequency for that distance. For a given great circle path, skywave transmission at maximum usable frequency can be had only in the minimum number of hops and at only one possible angle of departure. Frequencies higher than MUF would pass through the reflecting layer. As frequency is reduced, multiple modes of transmission appear. Below critical frequency, which is the highest frequency at which vertical reflection from the ionosphere is possible, the number of modes would become infinite but for absorption in the ionosphere.

The number and duration of multiple modes that may be encountered on a given path depend upon path distance, operating frequency, and ion density in the upper atmosphere. Very roughly, for transmission over a long path, Washington to Honolulu, 4200 nautical miles, at a poorly chosen frequency which is considerably lower than MUF, an echo train comprising as many as 5 multiple reflections persisting for about 3 milliseconds might be observed. On relatively short distances, 500 nautical miles or less, particularly at night when wave energy absorption is less than during the day, the wave train at frequencies well below MUF, may consist of as many as a dozen or more modes with a delay of 10 to 20 milliseconds after the arrival of the initial pulse.

One trouble with skywave transmission is that the ionosphere is an unstable reflecting medium. During the present part of the 11-year sun-spot cycle MUF for a given transmission path may vary over a range of as much as 20 Mc. in a 24-hour interval. Variation of MUF during each day is roughly cyclic—it reaches a minimum value during the early morning hours, while shortly after sunrise it climbs sharply to a midday maximum which is followed by a gradual descent to the nighttime low. It is generally desirable to operate at a frequency which will be always less than the maximum usable frequency, yet high enough to minimize the occurrence of multiple propagation modes. Experience has shown that the most reliable operating frequencies lie between 70 and 85 per cent of MUF.

A direct relationship between the 12-month running averages of critical frequency and Zurich sunspot number makes possible a technique for predicting, two to three months in advance, the medium value of maximum usable frequency for any transmission path at any time of the day. Prediction consists of estimating the degree of future solar activity and then deducing from collected data on past averages of MUF and critical frequency the corresponding trends in the geographical, seasonal and daily variations in ionospheric conditions.

MUF predictions are available to the Naval Service in a monthly publication, "Recommended Frequency Bands and Frequency Guide DNC–14". This publication lists suitable frequencies for use of ships at sea in communicating with Naval radio stations. Frequency tables for 16 widely scattered stations are given. Recommended frequencies are tabulated for each month and each hour of the day for four directions and for various distances up to 2500 nautical miles. Nomograms are also provided for use as a rough guide in the choice of wave lengths for communicating between any two points at distances up to 2000 nautical miles. Reports of the Bureau of Standards Central Radio Propagation Laboratory "D" series DNC–13 are recommended for transmission over longer paths and where frequency information more precise than that provided on nomograms is needed. The Navy furnishes curves of optimum working frequencies

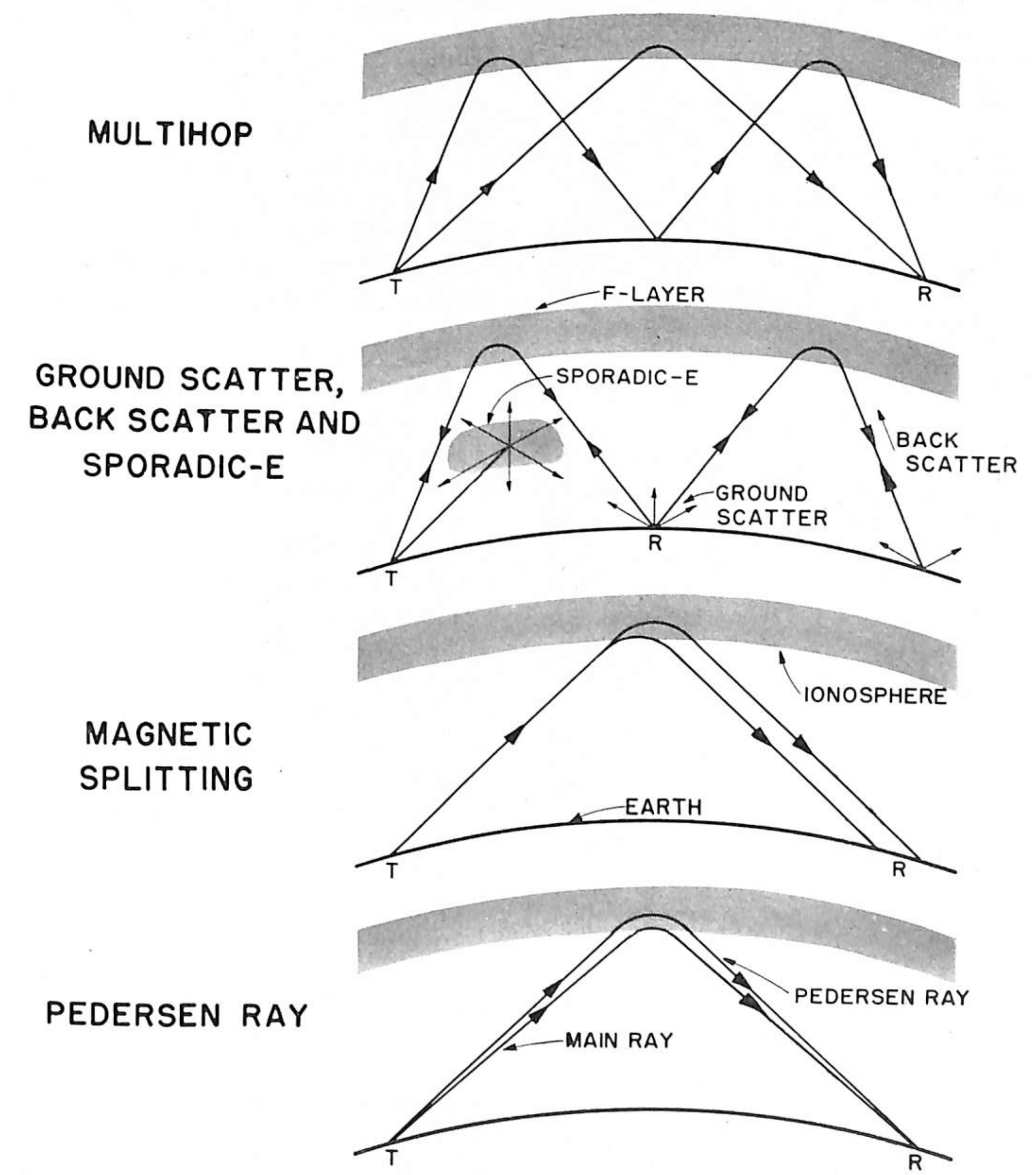


FIGURE 3—Geometry of high frequency echoes.

for long distance communication circuits. These curves also indicate the possible use of transmissions via sporadic E-layer reflections when these reflections have a predicted reliability of above 80%. If the exact recommended frequency determined from a forecast is not authorized for use by the Navy, the next lower available frequency is used, since a higher frequency is likely to be unreliable.

Pedersen or High Ray

The main component of a radio wave enters the ionosphere at an optimum angle corresponding to the transmission path distance. Another component known as the Pedersen or high ray entering at a slightly steeper angle than the main ray penetrates more deeply into the ionosphere and encounters relatively greater delay and attenuation. It finally merges with the main ray near the point of reception, and when not too greatly weakened by absorption it contributes to echo distortion. The Pedersen ray often furnishes significant echo components at operating frequencies close to MUF. At lower frequencies the delay is longer but the high component is usually absorbed in the ionosphere. Operation at 75% or 80% of MUF usually suppresses the Pedersen ray without allowing multihop modes to occur. Pedersen ray echo delays do not normally exceed 3 or 4 milliseconds.

Magnetic Splitting

The earth's magnetic field causes a radio wave to be split into two modes, one of which is propagated along a different path and is delayed with respect to the other. This effect is associated with electron motions produced in the ionosphere by the electric field of the radio transmission. It is strongest near electron gyrofrequency (about 1400 kc.) and for rays which penetrate deeply into the ionosphere, such as the Pedersen ray near MUF. Magnetic splitting also depends on terrestrial magnetic intensity, hence varies with latitude. The chief difficulty due to magnetic splitting occurs when echoes from other sources are split into twins before arrival at the receiver. Echoes of this type usually do not exceed 3 or 4 milliseconds. They may be avoided to some extent by transmitting or relaying in a north-south direction. Relaying through stations located in low and middle latitudes helps to minimize communication troubles due to magnetic splitting and Aurora Borealis effects.

Sporadic E-scatter

Radio wave energy may be diffused due to reradiation from sporadically occurring ionic clouds in the E-region of the ionosphere. Scattered reflections of this nature have been adduced to explain particular anomalous effects which contribute to the ambiguous jumble of high frequency echoes. Delays usually do not exceed 1 or 2 milliseconds.

Diurnal Variation of Echoes

From the point of view of echo minimization, the quality of long distance point-to-point transmission at high frequencies may be classified into three general categories, depending on time of day over the transmission path:

Night Time Over Entire Path

Excellent transmission on operating frequencies which are 70 to 85% of maximum usable frequency. *One-hop* transmissions often show echoes with delay of less than one millisecond. *Multihop* transmissions show a somewhat diffuse echo train usually with a one to two millisecond delay. These conditions exist from the time the E-layer disappears from the center of the westernmost hop, usually about one or two hours after sunset and continue through early morning as long as the center of the easternmost hop is in darkness. Optimum night working frequency for a given path decreases as the night progresses due to ion recombination in the F-layer.

Day Time Over Entire Path

Transmissions near maximum usable frequency show diffuse echoes which appear as trailing edges on facsimile pictures, delay times often reaching 3 to 4 milliseconds.

Twilight Over All or Part of Path

Exceptionally good wave propagation on high transmitter power leads to echo trouble when the entire transmission path is in twilight due to occurrence of double-signals, around-the-world echoes and long delay backscatter echoes. Numerous long delay echoes have been observed on Navy facsimile pictures transmitted across the morning twilight zone. Around-the-world echoes and double-signals may occur regularly where both short and long great circle transmission paths lie in or close to the twilight zone. Reducing transmitter power or shifting antenna directivity is often an effective remedy for reduction of echo due to twilight path conditions. When transmission path is partly in darkness and partly in sunlight it is usually difficult to find a frequency for reliable propagation over the entire path. Excessive multipath or high signal attenuation or both can occur on a daylight-twilight path, depending upon the number of hops involved.

Speed Limitations Due to Echoes

The maximum radio communication speed postulated by modern communication theory for a given bandwidth and signal-to-noise ratio is seldom approached. When echoes are present they effectively limit the transmission speeds obtainable by the usual methods of automatic communication. Single channel radio teletype will begin to garble when the intelligence bauds are elongated by more than about 40 per cent maximum by their echo trains. This means that a teletype system operating at 45 bauds per second or 60 words per minute will falter when echo delay exceeds about 8.8 ms. At 30 wpm the same teletype might tolerate echo delays up to about 17.6 ms. In facsimile larger letter size and lower scanning rate may be needed to reduce distortion when multipath occurs. This is equivalent to decreasing transmitting speed.

In an investigation of transmission speed possibilities on long distance teletype and facsimile circuits, more than 1000 radio facsimile weather maps, transmitted to Washington during 1949, were closely examined for evidence of echo effects. It was found that the prevalence of echoes increases roughly with the transmission path distance. Results for the four circuits are given in Table I.

TABLE 1

Facsimile Circuit	Percentage of Maps Having Echo Delays: Between 0-2 ms	Between 2-4 ms	Greater than 4 ms	Naut. Miles	Freq. Mc.	No. of Maps
Guam to Washington	54%	35%	11%	6800	20.4	397
Honolulu to "	80	16	4	4150	20.4	348
San Fran. to "	84	12	4	2150	9.5	110
New York to "	100	0	0	185	5.0	103
Average of 4 circuits	72	21	7			

It should be pointed out here that the quality of the facsimile maps was degraded appreciably by echoes in only a small percentage of cases, where delays were greater than about 5 milliseconds.

The echo delay data in Table 1 have been quite useful in providing a basis for estimating possible transmission speeds obtainable on single channel radio teletype for these circuits. Table 2 lists two baud lengths and corresponding word speeds and gives the percentage of time during which communications would have been feasible in each category over different circuits. In making these estimates it is assumed that speed is limited by the condition in which baud length is two and one-half times the echo delay. For reference it may be stated that the baud length for single channel 60 wpm on-off teletype is 22 milliseconds.

TABLE 2

Echo time delay	0–2 ms	0–4 ms
Baud length assumed to be usable	5 ms	10 ms
Max. word speed (5 bauds/character)	400 wpm	200 wpm
Max. word speed (7½ bauds/character)	270 wpm	135 wpm

Circuits	Percentage of time circuits would be usable at the maximum radio teletype speeds indicated above.	
Guam to Washington	54%	89%
Honolulu to Washington	80	96
San Francisco to Washington	84	97
New York to Washington	100	100
Average of above circuits	72	93

The facsimile echo studies showed that speeds as high as 2000 wpm on a single teletype channel would probably be feasible at times if suitable terminal equipment were available. This is particularly applicable for short transmission paths.

Conclusions

Teletype and facsimile outages due to echoes are most likely to occur for transmissions through a twilight zone or during other times when radio energy encounters relatively low absorption in the ionosphere. The safest operating frequencies for avoiding echoes are in the region 70 to 85% of MUF or as recommended in the Recommended Frequency Bands and Frequency Guide DNC–14 series.

It should be remembered that echoes cannot be circumvented by "blasting" with added transmitter power. When echoes are present, increasing signal strength only aggravates and multiplies them. Relaying may help in sidestepping echoes but it ties up additional channels and equipment.

If all other measures fail the circuit transmission speed should be lowered and receiver output filter widths should be reduced. Where the speed can be made slow enough the message will always get through if echoes are the real source of circuit outage.

The advent of an outage, apparently due to "echoes" or "multipath", does not absolve the technician from his responsibility for checking his equipment for partial breakdowns and obscure troubles that might contribute to the low circuit performance.

The variation of minimum usable baud length with frequency, time of day, and transmission path distance may make it desirable in the future to employ variable speed terminal equipment on point-to-point high frequency automatic circuits so that large volumes of traffic may be handled during the times when high speeds are found to be possible while traffic may be cleared slowly but continuously when conditions are poor.

RTMA Preferred Values

by
Radio-Television Manufacturers Ass'n
RTMA Engineering Office,
New York, N. Y.

A question frequently heard among users of radio components is: why do resistors and other components have odd values such as 47,000 ohms instead of even figures (say 50,000 ohms). This booklet provides a brief discussion of this useful and important subject and therefore concerns everyone who designs, makes, buys or uses any radio or television parts. It takes up the reasons for PREFERRED VALUES, which are those selected values that are based on a series of PREFERRED NUMBERS. It is designed to help you understand how such a series came about, exactly what it is, and why it is used.

Preferred means first choice or most desirable. Numbers indicate size, count or value. Everyone uses numbers, a lot of numbers. Radio uses all kinds of numbers—some simple, some not so simple. Rarely do radio men have nice, rounded-out figures to deal with.

The Sales Department, which calls the signals, never gives a nice round selling price to shoot at; like $150 or $200. No, it's $149.95 or $199.50. And, by the time the dealer gets a nice series of discounts like 35, 5 and 2 (if he advertises, and pays his bills promptly), it is even more irregular.

The cost estimates radio engineers are supposed to work out, before they start spending company money, don't ever come out as an an even figure. And with all the deductions, even our pay is an odd value! So we have gotten accustomed to using odd values in most everything we do, and select the values we need by considerations other than getting even rounded out figures. Suppose we examine the problem of resistor values that was mentioned at the start. Carbon resistor production is one of the most systematized business in radio components.

Remember 25 years ago when practically all resistors were wire wound, and cost about 50¢ apiece? Shortly thereafter molded or carbon resistors came into wide use. All were the same size, about one watt (we thought). You could get any value you wanted on order. The 38,000 size was pink and the 1750 ohms was yellow. Replacements cost 5 to 10 times what they do today.

That Old Bugaboo—Tolerance

No matter how precise the operation or process is, there is always some variation in the resulting product. A production run of 100-ohm resistors may vary anywhere from say 50 to 150 ohms (± 50%). Closer control however may hold them to ±20%, which is the usual "commercial" tolerance in electrical components.

Now, somebody may need a 10%, or maybe a 5% 100-ohm resistor. What happens to all the others in the batch? Average production may give us only 10 five per-centers, 20 ten per-centers, and 65 twenty per-centers in a batch of 100 resistors. Unless the whole hundred is sold, the rest are wasted and the cost of those sold must be increased to cover this waste.

It doesn't matter whether we are considering resistors, condensers, coils or control shafts; the same probabilities hold. The cost—and availability—of any kind of precision depends on the cost of the entire batch. The more logical we can make the groupings of precision (5%), close (10%), and commercial (20%) nominal values, the better chance we have of finding a use for all of the parts produced and thereby reduce all the prices.

What Groups to Select?

We tend to think in terms of twos, fives and tens. That's why 1, 2, 5, 10, 15, 20, etc. and their decimal fractions or multiples are "nice round numbers." Numbers like 377, 1.414, or .0059 are "difficult" numbers, and used only when necessary. It is understandable, therefore, why electrical circuit values started at nice, round numbers, and all other values were shunned. But when we take a series of numbers like 10, 15, 20, etc. and expand them into their 5, 10 and 20% production limits, we begin to learn why they are going out of style, economically and industrially, for example:

What brought the prices down, the quality up, and made it possible to meet the tremendous demand for components for radio, television and military equipment? Standardization of fewer values encouraged the extensive use of automatic production equipment. Fewer sizes resulted from the use of Preferred Values.

About 1935, manufacturers reached the conclusion that there were too many values floating around in radio circuits. To cut down these specials and still not penalize performance wasn't a new problem. Brown and Sharpe had it before the Civil War regarding copper wire sizes and as a result the B&S Wire Gauge was one of the earliest uses of Preferred Numbers.

Resistor manufacturers and users co-operated to give us this present series of preferred numbers for resistors some 15 years ago. The RTMA color coding system for resistance values came in about the same time. We've become so accustomed to the color bands and to these preferred values in resistors that we pretty much take them for granted. The idea has spread to other fields: preferred values in mica condensers, in ceramic and molded condensers; and now for wire wound resistors.

What has this Preferred Value system go that prompted so much activity? Now, you've asked a good question—in fact, a many-million-dollar question! That's what simplification means to radio and television today; more availability, faster schedules, and millions of dollars in lower costs.

Who Selected the Values in This Series?

Probably not the engineer who figures to three place accuracy and wants a 50-ohm resistor, then finds he has to use 47 ohms, if he wants the cheapest, or 51 ohms if he's willing to pay more. But its terrific economic value makes it inevitable in this cost-conscious business. It's the radio, television and parts manufacturers who install them, and the servicemen who find that a smaller stock of replacement units will fit most of the circuit requirements.

Arithmetic Numbers and Limits

If we select a series with say 20 equidistant values there would be 18 steps of 5s from 10 to 95 in this series. The same would apply regardless of the position of the decimal point, 0.1 to 10 million. At the lower end of the series, we see that there are big gaps between the consecutive 5% limits. The gap closes in the middle of the 10% series, but begins to overlap terrifically at the upper end of the 20% range.

−5	Nom.	+5	−10	Nom.	+10	−20	Nom.	+20
9.5	10	10.5	27	30	33	40	50	60
14.25	15	15.75	31.5	35	38.5	44	55	66
19	20	21	36	40	44	48	60	72
22.5	25	27.5	41.5	44	49.5	52	65	78
28.5	30	31.5	45	50	55	56	70	84
	etc.			etc.			etc.	

It doesn't take a statistician to see that steps of 5 are too close for ±20% grouping in the upper range and too far apart for ±5% groups in the lower range. There is waste (1) by having too many groups, and (2) by having the gapped values for which there is no use.

The Problem Is Not New

The ancient Romans had too many sizes of pipe. In those days when 3.65 had to be expressed as 3 plus 7/12, plus 1/24, plus 1/48, they had a job on their hands. Nevertheless, before 100 A.D., they worked out a "20" series of pipe that is our first known use of preferred numbers.

About 1856 Brown and Sharpe gave us their Wire Gauge listing a graded series of wire sizes which we still use. Then in 1879 a Frenchman named Renard used such a series for his balloon cables and called these numbers "preferred numbers."

How Is Such a Series Selected?

If we start with the nice, round number of 10, and increase it 20%, we get 12. If we do the same with 12, and so on until we hit 100, we get a series of numbers like this: 10, 12, 14.4, 17.28, 20.73, 14.88, 29.86, etc., but when we approach 100 we don't come very close to that exact value. And if we were to start at 100 and figure the series backwards, we don't do any better.

In looking around, we find that the mathematicians have worked out a progression very nicely for us based on the 12th root of 10, each value being 21.15% more than the one immediately below it. It works out right, both going up and coming down. When rounded off to two digits, we get the ±10% series of Preferred Values, that is, 10% up and 10% down.

Apparently from earliest recorded history musicians have set up scales with tones set at "preferred" values. Thus in another art—music—we find the same problem of producing subdivisions of an octave. An octave is a 2:1 difference to divide up, whereas in our production schedule we wish to divide up a 10:1 interval. Earliest music had many systems of scales.

However, it is remarkable that as far back as the first part of the 16th century an equal-tempered scale based on the 12th root of 2 was proposed. This scale is now universally used. Each octave has 12 intervals, just as our preferred number scale has 12 intervals between our decade mileposts. Each note on a piano is a definite percentage higher than the preceding note. A similar condition exists in the RTMA preferred number series.

RTMA PREFERRED NUMBERS

6 Series ±20%	12 Series ±10%	24 Series ±5%	Nearest Decimal System Numbers
10	10	10	10
—	—	11	
—	12	12	
—	—	13	
15	15	15	
—	—	16	
—	18	18	
—	—	20	20
22	22	22	
—	—	24	
—	27	27	
—	—	30	30
33	33	33	
—	—	36	
—	39	39	40
—	—	43	
47	47	47	
—	—	51	50
—	56	56	
—	—	62	60
68	68	68	
—	—	75	70
—	82	82	80
—	—	91	90
100	100	100	100

Now, if we take every other number in the 12 step "close tolerance" 10% series, we get the 20% "commercial" series with only 6 numbers. These are derived from the 6th root of 10 or 46.76% up and down. Then, if we take the twelve 10% numbers and figure the steps in between them from the 24th root of ten, or 10.06% up and down, we get 24 steps with approximately ±5% intervals for the "precision" values, like those shown in the accompanying RTMA Preferred Numbers chart.

To get lower or higher values, you just move the decimal point. Note the simplicity of just 6 basic numbers for the commercial values; one-third as many as we started out with. Also, that 24 values are necessary to complete the precision series, where you need these in-between values.

Now, if you will look at the last column, headed "Decimal System Numbers," you can readily see how the values are spread out in the small values and compressed in the large values, compared with those in the preferred series. This comparison should tell you more than any amount of mathematical explanation why preferred values are popular in radio manufacturing.

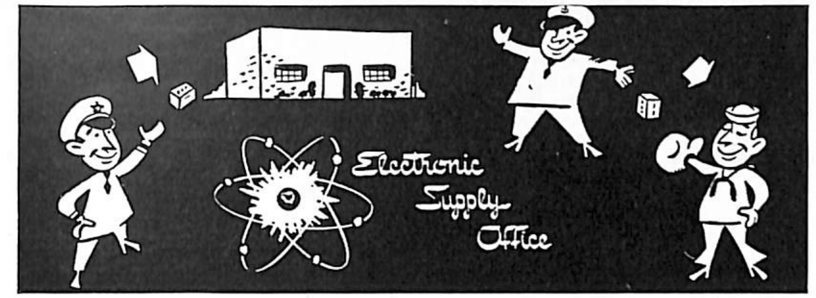
With these numbers, we have a complete spread of values with practically no overlap, no gaps and no waste. Costs are therefore reduced to the minimum. We also have the simplest possible spread of values in each series, which means better availability. And, we have a workable standard that can be applied to any item that can be evaluated by a number.

In Conclusion

Thus having seen that there is no mystery about the selection of values that go into this series, one can see that the numbers themselves are not "sacred." It is evident that a great many other series, equally logical, could be devised, using say the 11th root of 10, or the 10th root of 10, or what have you. In fact the latter series serves admirably in some fields.

As production processes are improved it would be quite possible to provide more groups of some components, with closer tolerances. This would involve the use of higher "root" values. But the electronic industry has found this series highly useful and has geared all production, cataloging and even the color codes to its use. When closer tolerance values are needed the 24-unit series mentioned before, is available, and, in the future, further subdivisions using a 48-unit series may be added. The higher the precision requirements of any application the greater the number of preferred values that would be ideally suited for that use. Thus it is reasonable that there is no one set of figures that makes up the ideal series for all industries. In the grading of apples a different set of values would probably be better, but the basic principle of preferred values would still hold.

—*Engineering Bulletin No. 40.*



E.S.O. MONTHLY COLUMN

BUSHIPS SECTIONS, PART II, CATALOGUE OF NAVY MATERIAL BEING REVISED

Due to the rapid acceleration of the electronic supply program and establishment of new activities, bulk stocks of several ESO publications have been depleted. The following publications are being brought up to date and will be distributed to the Fleet in the very near future:

Section 16–702	Fixed Composition Resistors
" 16–703	Fixed Wirewound Resistors
" 16–820	Electron Tube Types Cross Index
	ESO Standard Price List dated 1 July 1950

It is requested that vessels now on the distribution list review their needs for all ESO publications and inform the Electronic Supply Officer, Attention Code 7, of any changes required.

STANDARD NAVY STOCK NUMBER CORRECTION

The ESO Monthly Column in the March 1951 ELECTRON contained an item entitled "Motor Conversion," which pertained to the conversion of Model 15 Printers from a series to a synchronous motor under Bureau of Ships Allocation Order No. 800–92790. The Standard Navy Stock Numbers for the motor and gear set were transposed. This information should have read as follows:

ITEM	TELETYPE PART No.	SNS NUMBER
Motor	MU–4	F17–T–350001–103
Gear Set	80437	N17–T–350002–255

Send in your problems to the Editor and see if you can stump him. A sincere effort will be made to answer your questions in "Letters to the Editor".

BUSHIPS SECTIONS, PART II, CATALOGUE OF NAVY MATERIAL DISTRIBUTED TO FIELD ACTIVITIES TO DATE

Activities receiving BuShips Section, Part II (Electronics) Catalogue of Navy Material are advised that they should now have 20 sections in their possession. The sections previously distributed and those now being distributed are as follows:

Section 16–003	Sig Corps to SNSN Cross Index
" 16–004	SNSN Cross Index to Air Material Command
" 16–100	Fixed Mica Capacitors
" 16–101	Fixed Paper Capacitors
" 16–102	Fixed Electrolytic Capacitors
" 16–103	Fixed Ceramic Capacitors
" 16–602	Networks and Filters
" 16–702	Fixed Composition Resistors
" 16–703	Fixed Wirewound Resistors
" 16–704	Variable Composition and Wirewound Resistors
" 16–705	Fixed Precision Resistors
" 16–820	Electron Tubes
" 17–070	Terminal Boards
" 17–150	Contacts
" 17–405	Insulators
" 17–600	Motors
" 17–716	Relays
" 17–806	AF Transformers
" 17–807	IF Transformers
" 17–811	RE Fixed Transformers

Catalogue Section 16–1001, "Introduction to the BuShips Section, Part II (Electronics), Catalogue of Navy Material," will contain a complete listing and index of all sections distributed as well as those sections or commodities of material being processed.

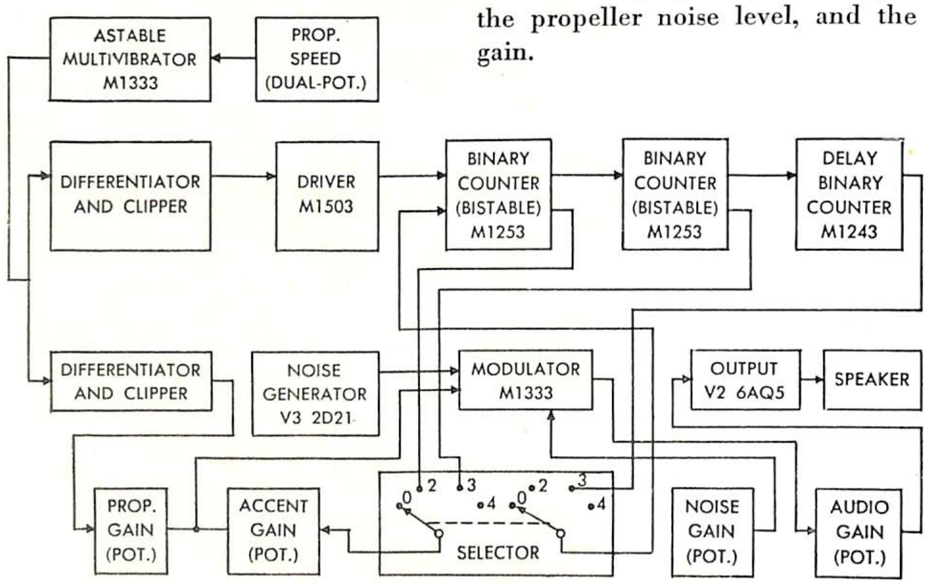
nel notes:

THE PROPELLER BEAT SIMULATOR

A useful aid to the training of submarine sonar operators aboard ship has been developed by the Navy Electronics Laboratory, San Diego, California. The Propeller Beat Simulator, SM–41/UQQ–T, simulates the sounds of two-, three-, or four-bladed propellers as they are heard over sonar listening equipment. The new device was developed originally as a unit of a complex sonar training equipment to be used at sonar training schools. It was immediately apparent, however, that with a suitable problem generator, the Propeller Beat Simulator could be used to feed target information directly into submarine listening gear. Thus, whether the boat were underway or in port, the Propeller Beat Simulator would make possible training in the fundamentals of target detection in the presence of noise, turn counting, target identification, reporting procedures, and general equipment operation. This type of training was previously possible only when the boat was underway and suitable targets were present in the area.

Development of the problem generator to accompany the Propeller Beat Simulator is now in progress, and the two portable units will be available for testing and evaluation both ashore and afloat early in 1952.

The simulator, which is small and light enough to be completely portable, can be operated on a ship's 117-volt 60-cycle supply. The control panel contains a 4-inch speaker flanked by the Prop Beat Selector and the Prop Speed controls; mounted in a line below the speaker are four gain controls and a pilot light. These gain controls control the degree of accent of one blade of the propeller, the background noise level, the propeller noise level, and the over-all audio gain.



Block Diagram of Propeller Beat Simulator.

The entire equipment is constructed of only 46 components. Plug-in units are used in nearly all the circuits. These include an oscillator, driver, modulator, delay multivibrator, and two binary counters. Thus, a minimum of components are mounted on the chassis, ensuring easy maintenance.

The propeller beat simulation is accomplished by modulating a noise signal with "accent" and "deaccent" pulses. The deaccent pulses produce the simulation of individual propeller blades by dropping the noise level for the length of the pulse. The accent pulses produce the effect of accenting one blade by raising the entire noise level for a time interval which includes one of the deaccent pulses.

The noise signal originates in a 2D21 thyratron random noise generator. The level of this noise signal is controlled by the Noise Gain potentiometer, and the signal is fed directly to the modulator.

The source of the accent and deaccent pulses is a free-running multivibrator whose frequency is determined by the propeller speed potentiometer. The square-wave output of this multivibrator is fed simultaneously through two different channels: the propeller sound channel and the binary counter chain.

The square wave fed to the propeller sound channel is passed through a differentiating and clipping circuit and appears as medium-sharp (4-to-5 microsecond fall time) negative deaccent pips across the Prop Gain potentiometer. The desired amplitude of these pips (as determined by the potentiometer setting) is then mixed with the positive-pulse accent output of the Accent Gain potentiometer and fed to the modulator.

The square-wave fed to the binary counter chain passes through a similar differentiating and clipping stage, but comes out with medium-sharp positive pips. These pips are fed to a driver stage whose output is a series of very sharp (total width of approximately 2 microseconds) negative pips, which are used to trigger the binary counter stages.

Front panel and controls of Propeller Beat Simulator.

The two binary counter stages, in connection with the delay binary counter stage, are used as frequency dividers and provide simulation of different numbers of blades on the propellers. The Prop Beat Selector provides a choice of four possible outputs from the counter chain. In position 0, the counter chain is open-circuited and is not used. In position 2, the output of the first counter provides a signal at half the fundamental frequency of the incoming pips from the free-running multivibrator. In position 3, the delay counter is switched into the circuit, and the output of the second binary counter stage becomes one-third the fundamental frequency. In position 4, the output of the second stage (the delay counter is again disconnected) is one-fourth of the fundamental frequency.

The selected output from the counter chain is fed through a differentiator and clipper, and the resulting positive-pulse accent output is developed across the Accent Gain potentiometer. Depending upon the position of the potentiometer arm, a varying amount of this output passes through suitable isolating resistors, is mixed with the output of the Prop Gain potentiometer (as previously mentioned), and appears at both grids of the modulator.

The modulator output is connected through a transformer and the Audio Gain potentiometer to the output stage, which drives the speaker.

Effective shipboard use of this equipment is assured because the type of circuitry used is quite insensitive to minor variations in the input voltage; no appreciable changes in operation occur when the supply voltage is varied between 100 and 130 volts. The all-electronic design of the unit eliminates the undesirable characteristics of the complex mechanical systems which have been employed for this purpose in the past; yet the use of plug-in units and the simplicity of construction and operation minimize maintenance time and permit the use of the equipment as a training aid where skilled personnel are not available. Thus, it can be used for training purposes at almost all naval facilities.

Seventeen of the Propeller Beat Simulators and 9 problem generators will be built for initial testing and evaluation. It is anticipated that a quantity of the two equipments will be manufactured subsequently and made available to training activities and forces afloat.

ESS Standardization Program

by

L. H. Wright, *Specification Review Section, Technical Division, ESO*

The Electronic Supply Office is presently engaged in a standardization program expected to aid materially in obtaining and supplying items and material where and when needed to maintain Navy electronic equipments. This standardization program is designed to decrease procurement and supply operations by reducing the number of supply items. Items subject to standardization under this program must necessarily be those used many times in many equipments.

Standard Items of Supply (SIS) are being selected for preferred characteristics to determine their versatility in replacing non-standard items. In this present program, the characteristics of these items must conform to military specifications, which form the basis for determining quality under known tests and fabrication methods; moreover, these items must be procured from manufacturers approved by the Armed Services Electro Standards Agency (ASESA). At the present time this activity is selecting SIS from only those items meeting the high standards of ASESA, with the result that in some categories of material very few SIS are obtainable.

The Electronic Supply System (ESS) standardization program, a part of the service-wide standardization program sponsored by ASESA, is aimed toward stocking as few items as possible. This is an effort of immediate consequence, since it will affect maintenance on equipments now in use; whereas, the parent ASESA standardization program is concerned with standardization of parts in new equipment design.

ASESA has published lists of preferred items (Armed Services Preferred Parts Lists for Electronic Components) for various categories of materials to assist in implementing standardization for design, development and manufacture of new equipments. These lists have been a guide to ESO in the selection of SIS. It is understood that standardization efforts are restricted by the obligation of this activity to keep existing equipments operating. An example of this problem is in the use of Style CP 40 paper capacitor which, though not desirable for new equipment design, must be included in the Standard Items of Supply List by ESO because of replacement requirements.

While some commercial manufacturers maintain standards equal to JAN specification standards, it has yet to be ascertained which of these will be sufficiently reliable in the preservation of these standards. A study is being made as to the possibility of approving certain commercial items as acceptable substitutes for SIS. This approval would entail careful selection of such items, and careful review of their characteristics, as well as faith that the descriptions published by the manufacturer accurately reflect the characteristics of these items. Meanwhile, ASESA is endeavoring to narrow the existing gap between present specifications and present average commercial practice, so that more widely-used items will be available as SIS.

As previously stated, the standardization program is at present confined to selecting SIS which meet the military specifications and have approved suppliers. As the purpose of this program is to concentrate the activity in maintenance items to as few as possible, SIS are generally better than those items which have been used in the construction of electronic equipments. This means that SIS have a relatively narrow tolerance in order that they may be acceptable as replacement in as many equipments as possible. For instance, commonly used resistors and capacitors may vary as much as ±20% from their optimum or "rated" values. 10% tolerance items are also widely used. Narrower tolerances of ±5%, 2% and 1% are also used, but in smaller quantities and in a limited variety of applications. Consequently, the Standard Items of Supply are chosen to have tolerances narrower than 20% and broader than 1%.

This tolerance selected for SIS is based on such factors as frequency of use, availability and cost.

The tolerance decided for SIS fixed composition resistors is ±10%. It had been originally planned at ±5% so as to replace practically all requirements, since ±5% is the narrowest tolerance composition resistor having wide use; however, at this point the factors of cost and availability oppose the factor of frequency of use.

Due to the advanced manufacturing procedures mica capacitors may be held to closer tolerance without substantially increasing production cost; as a result, ±5% was chosen for standard items mica capacitors. However, a number of ±10% mica capacitors (not SIS) are being procured for wide-tolerance applications.

Tolerance values are not the only consideration among the electrical characteristics of the item. For instance, the effects of capacity or resistance change resulting from temperature change are being selected to be as small as is considered practicable on the basis of the standardization program policy.

Attention to all these factors make the SIS a fitting replacement for as many presently-used items as are equal or less stringent in their characteristics. Activities cannot expect to receive only standard items of supply immediately; there are many non-standard items now in stock, and, even if procurement is largely limited to SIS, more non-standard items will yet be stocked in the system because of such items being found in spare-parts boxes during breakdown. Issue Precedence Substitution Lists are designed to aid activities in issuing non-standard items first to remove them from the system as soon as possible.

The purpose of the standardization program is not to change the design of equipments or to replace existing items with items having different characteristics, but rather to emphasize procurement actions in such a way that these SIS will be procured in large quantities because they will be widely used in ESS. It is also because these SIS can substitute for many others more quickly than the others could be obtained.

Categories which have been reviewed for standardization include resistors, fixed, composition; resistors, fixed, wirewound; resistors, variable, wirewound; resistors, precision; capacitors, mica; capacitors, paper; capacitors, ceramic; capacitors, electrolytic; insulators; meters; switches; sockets.

The substitution possibilities of SIS have an important bearing on the provisions of the standard supply specifications. As an example, SIS as outlined by the standard specification for mica capacitors are limited to case sizes CM20, CM30, CM40, CM50, CM55, and CM 60. The CM20 and CM30 are considered as replacements for the CM25 where capacity values are the same. Similarly, CM20, CM30, or CM40 are considered as replacements for CM35, where capacity values are equal. Even though such substitutions (for example, of CM40 and CM35) result in increased physical dimensions, this small increase in size is considered acceptable for maintenance purposes.

CM55 and CM60 are considered as substitutes for CM56 and CM61, since the former differ from the latter in that the former have threaded inserts, whereas the latter have clearance hole inserts. The threads readily may be reamed out to provide clearance holes if needed.

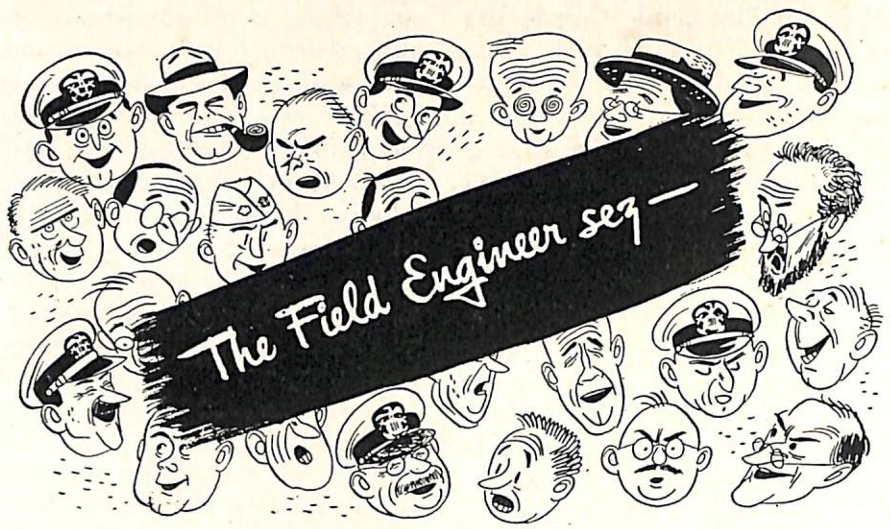
Slight variations in size among different types of ceramic capacitors (all electrical characteristics being equal) are considered acceptable, since the only discrepancy in performance would be a lag in capacity change over a short period of time while the ambient temperature was changing. In normal usage this is considered a negligible difference.

It is intended by ASESA that in the future manufacturers be encouraged to "give an eye" to the use of SIS when evolving new designs, and that this and the other policies of the ESS standardization program can reduce unnecessary supply transactions to a minimum, thereby effecting substantial savings in time and cost. As an example, approximately 3600 stock numbered items have been replaced by 495 standard items of supply in one representative category of material.

It is important that standardization be consonant with maintenance policies. To insure this, the maintenance section of the Bureau of Ships reviews all lists of proposed standard items of supply; and it is equally important that BuShips design personnel be furnished the SIS lists in order that as many SIS as possible can be included in new Navy equipment designs. Standardization of electronic parts is not to be considered as an end, but rather as an expedient toward efficient supply, design and maintenance of our military electronic equipment.

MODEL QHB TRANSFORMER AND CAPACITOR REPLACEMENTS

The request in a previous issue of this publication that defective transformers and capacitors from Model QHB equipments be shipped to the Sangamo Electric Company has served its purpose and is hereby cancelled. Information obtained from the components forwarded to Sangamo enabled the manufacturer to modify his production methods to correct the defects found in early components.



MK 39 MOD 3

USS Oglethorpe (AKA–100)

After this equipment had been operating approximately 3½ hours, two 30-ampere fuses located in a box in the radar control room disintegrated; smoke poured from the box, and all power went off. Power was secured at I.C. board and inspection showed that the DHFA–9 cable supplying power to the radar was also operating at an abnormally high temperature.

The equipment plans do not show any provision for this line to be fused in the control room; no fuses are indicated other than those installed in the equipment. The switch and fuse box installed was manufactured by Arrow-Hare & Hegeman Electric Co., Hartford, Conn. The nameplate was stamped as follows: 2PST Cat. No. 27367 2 pole 30 Amps–250 volts Fuses 2.

Cognizant Yard engineers were advised and it was recommended that a regular Navy type snap switch be installed and that the DHFA–9 cable be replaced with a larger cable. Design engineers concurred that the switch should be replaced; however, a replacement cable was not provided.

Shop 51 installed the proper switch; at this point Raytheon measured the circular mil area of the cable installed and found it to be above 9000 circular mils which is normal. According to electrical tables this cable should handle 41 amperes at 50 degrees C. The cable run was 65 feet. Calculations show that a voltage drop of 3.5% is normal approximating a load of 23 amperes. Calculations were further proved by measuring.

This engineer's initial recommendation was to replace the subject cable with another DHFA–9. However, it is believed that the replacement cable will eventually also fail, particularly if the ship operates in a tropical climate. This cable runs through an exhaust vent and therefore, only a larger cable would ensure troublefree operation.

Mark 6 Mod 1

While making adjustments on the radar range unit Mark 6 Mod 1, it was found that the range counters would jam at approximately 20,000 yards indicated range. Inspection revealed that the range counter drive shaft, Submarine Signal Company #1072–246, had too much end play, causing the bevel pinion gear to disengage from the bevel gear on the range counter. Excessive end play was due to improper installation of the collar, Submarine Signal Company #1072–129, on the range counter drive shaft. Although the collar is normally pinned to the shaft, this collar was held in place by a small allen head set screw.

The collar was properly adjusted to prevent jamming; however, it is believed that the collar will eventually have to be pinned to the shaft.

C. W. Hunter, H. N. Hodges, J. W. Johnson.

SO–8

U.S.S. Greenlet (ASR–10)

The transmitter–receiver (receiver strip, Type CRP–46ACA–1) was thoroughly examined, and all components were found to be in good condition. However, a heavy oxidization of the silver plated contacting fingers on the bottom shield of the receiver strip was noted. Crocus cloth was used to remove all trace of the oxide and to clean the contacting surface on the strip chassis. The unit was reassembled and reinstalled in the transmitter-receiver housing. The condition was corrected, and normal control of receiver gain was restored.

—J. M. Van Cott

Testing Amplidynes and Servo Amplifiers

by

R. G. Walker, *Philco Field Engineer*

In amplidyne training on servo systems the technician is often faced with the problem of trying to decide whether or not the amplidyne is at fault. You can connect an ammeter in series with the amplidyne and d-c drive motor armature and a voltmeter across the armature terminals to check whether or not the amplidyne is putting out its rated power. There are several pitfalls to this method; first, there may be something wrong with the control amplifier or synchro system which does not allow it to apply proper signal voltage to the amplidyne control fields and second, the d-c drive motor does not provide a constant load on the amplidyne. The first problem can be solved by checking error voltage to the control amplifier and the voltage applied to the amplidyne control fields while the second problem can be solved by disconnecting the d-c drive motor from the amplidyne armature and substituting a more or less constant load. Ordinary 120-volt light bulbs provide a convenient means of loading the amplidyne so as to check the voltage and current output. Since most shipboard amplidynes put out about 230 to 250 volts at full load, you may connect two bulbs in series for a 250-volt load. Choose bulbs of the proper wattage so that the total wattage of the light bulbs equals the wattage rating of the amplidyne. (The two series connected bulbs must have the same wattage rating with the sum as nearly the same as the rated power output of the machine as is practical.) For larger amplidynes where a greater load is needed, additional series connected pairs of bulbs may be paralleled across the amplidyne until the total wattage of the bulbs is close enough. The rated power output of the amplidyne may be found in the instruction book either in the corrective maintenance section or in the drawing which lists the amplidyne specifications and ratings.

For example, the SG–1b train amplidyne may be loaded to full load by connecting two 120-volt 100-watt light bulbs in series across the armature terminals (C1 and C4). With 10 volts applied to either control field (between F1 and F2 or between F3 and F4) the output voltage should be about 165 volts across the load. With 20 volts applied to either field the output should be about 230 volts across the bulbs. For a quick test for full power output, connect a 22.5-volt "B" battery across each control field and check the voltage across the load —you should read about 230 to 250 volts. You may use this same method on other amplidynes—load the amplidyne armature with series connected bulbs (or series-parallel combinations if more power must be dissipated) and hook a 22.5-volt "B" across each control field and check the output voltage with first one field and then the other. The voltage should be at least 230 volts for most amplidynes since most of them put out full power with 15 to 20 volts applied to each control field. You may have to calculate the voltage needed from the control field resistance values and field current required as given in the instruction book. For example in the SG–1b, the resistance of each control field should be about 933 ohms (within 10 percent) and full output voltage, 230 volts, is obtained with 24 ma through the control field. The required control field voltage then comes to about 22.5 volts.

In the event the amplidyne does not put out the required power, check the current drawn by the a-c motor portion and measure the speed with a revolution counter or tachometer. Consult the instruction book for the full load current and rpm's. For example, an SG amplidyne draws 4.5 to 5 amperes from the a-c line and turns about 3450 rpm at full load. If motor speed and current are normal check the control field resistance which should be 840 to 1025 ohms per winding in an SG. Low motor speed and excessive motor current indicate either shorted motor stator windings or excessive friction due to broken or rusted ball bearings or the rotor dragging against the stator due to misaligned end bells. These troubles usually cause the motor end of the amplidyne to overheat and will eventually burn out the motor stator insulation. Should the motor current be slightly low and the speed be slightly high while the generator output voltage is low you can suspect that the amplidyne armature is defective (assuming that the control field resistance tests are O.K.). In this event the amplidyne should be disassembled according to the procedure given in the instruction book and bar-to-bar tests made on the generator armature. Connect 110 volts d.c. in series with a 115-volt, 1000-watt light bulb across opposite commutator bars and measure the voltage drop between adjacent commutator bars. If the armature is alright, the voltages between adjacent bars will be nearly equal and a low value of about .5 to 1 volt. An appreciably lower voltage between two bars indicates that the coil connected to it is shorted—look for a burnt spot in the armature winding. An abnormally higher voltage between adjacent bars indicates that the coil is open.

Needless to say you should meg all armature field and motor windings to ground and either bake out or rewind any windings that read megohms or less to ground. Also meg the contridge type brush holders to ground since the fiber insulating sleeves occasionally break down. This may not show up in a power output test, but it sure can raise hob with the anti-hunt circuit and adjustment in some antenna positioning systems. These same test methods may be used on other train motor-generators such as that used in the SRa—although technically the machine may not be called an "amplidyne", it still makes like one and may be treated like an amplidyne.

If your ship has several amplidynes or other servo amplifiers you may find it convenient to make up a test panel with 2, 4 or 6 lamp sockets mounted breadboard style. Use as many sockets and bulbs connected in series-parallel as you need to load down the largest amplidyne you want to test; then unscrew any bulbs that are not needed in testing smaller amplidynes or servo amplifiers. In addition to testing amplidynes, the test panel may be used to check the power output versus error voltage in thyratron type servo amplifiers such as those used in the AN/SPS-6, SG-6, SO-4/10, SU series and others. A 0-5 ampere meter is also desirable on the panel. This test panel is of great help in trouble shooting servo systems.

ServLant Monthly Bulletin

FLEET AND FORCE MAINTENANCE

Formal and informal inspections, by SERVPAC Electronics Officers and by personnel of Mobile Electronics Technical Unit No. 1, of electronic equipment installations on SERVPAC ships continue to indicate that only a comparatively few ships carry on a systematic program of preventive maintenance. These inspections reveal dirt and often corrosion inside equipments which could not have collected had the equipment been opened, dusted and wiped out at reasonable intervals. The cabinets and faceplates of equipments also have been found dirty and corroded even though not located in an exposed place.

Some equipments, on smaller ships, may have to be mounted near ports or other openings to the weather where they are subjected to salt spray. If these equipments are kept covered except when actually in use and are cleaned frequently the rust and corrosion can be eliminated.

Most SERVPAC ships have few ET's, in many cases not enough to carry on both the repair and the maintenance work on equipment. Too often the ET has several other jobs which occupy a portion of his time. For this reason a proper program of preventive maintenance must be coordinated between the ET and the operating personnel. Physical cleanliness of the interior and exterior of equipment should be a responsibility of the personnel operating the equipment. Operating personnel also should accomplish all the preventive maintenance, and routine testing.

An equipment is seldom opened for cleaning but that some minor fault is discovered, such as a loose connection, a frayed wire, a melted capacitor, a gassy tube, or a loose interlock. The early detection and correction of such incipient sources of trouble will prevent a major breakdown and greatly increase the reliability of the equipment.

RESERVE FLEET ELECTRON TUBES

Tests made by a commercial firm under Navy contract on four DE's reactivated from the reserve fleet show that of 2,029 receiving-type tubes tested, 96% were good. A TV-3/U tube tester was used. Defective tubes were scattered as to type and in practically all cases the tubes which were found defective were not in the original cartons. Future tests are underway and results will be reported periodically.

by

Lt. John P. Jennings, USNR
ComDesFlot TWO Staff

It is an old Navy custom to refer to a tender, or other repair activity, that puts out an exceptional amount of work, as having a "Can Do" attitude. This same spirit in a ship's Electronic Repair Division is an almost sure indication of a top notch organization. It is something that should be cultivated by every Electronics Officer and technician in the fleet.

An attitude is a hard thing to describe or examine. It is a frame of mind which can best be illustrated by examples. A case in point is a Chief Electronics Technician who served in the Pacific Fleet during World War Two. He had a well earned reputation as a red hot radar trouble shooter, though by formal standards he had not been particularly well equipped to study electronics. His high school education was interrupted by the necessity of his working to support his family. Discontented with a number of unskilled jobs, he continued his education by correspondence and learned radio repairing. At the outbreak of the war, he enlisted in the Navy and was rated on the basis of past experience as a radio repairman; but because of his limited education, he was not sent to Class "A" school. As a result, when he reported to his first ship he had never seen any radar, sonar or fire control equipment.

In a similar situation the average man would have felt so handicapped he would have been inclined to leave everything but radios to his better educated shipmates. This Chief was average in everything except attitude. He had unlimited confidence in himself; and by studying instruction books and NavShips electronics publications, learned radar and fire control equipment the hard way. He became an accomplished trouble shooter who could fix anything.

There is a difference between being cocky and being confident. It is confidence that should be cultivated. Today, when it is easy to get the services of civilian technicians as soon as a ship makes port, many Navy ET's are leaving their tough problems for an upkeep period and then requesting civilian help. It is true that some of the contract technicians are very able men, with more experience on a particular type of gear in which they specialize than the average Navy technician. It is also true that on their particular gear they can probably solve a tough problem quicker than a Navy man; but when they do the work, you don't learn as much since you don't have to reason the problem through. You are also developing the very opposite of a "Can Do" attitude, with "Let George Do It" thinking.

Of course, there is a place for help from civilian technicians. When you have to repair gear in a hurry for operating reasons, or when you have honestly tried to do it yourself and can't, you need help. In a great many cases today, however, Navy technicians are giving up too soon. A really difficult problem should be an intellectual and professional challenge. When the cause of trouble is obvious, correcting it amounts to little more than routine maintenance, requiring very little intelligence. Electronics technician strikers, however, are selected on the basis of above average mental ability. Before you give up on a tough job this ability should be exercised.

You haven't really tried to solve a problem until you have made a systematic and thorough attempt to locate and correct the trouble. The instruction book and schematics should be carefully studied before you even open up the equipment. If necessary, review background theory in the many excellent technical publications you have on board. Then, use all your applicable test equipment carefully and intelligently to locate and analyze the trouble. This of course requires a thorough knowledge of all the test equipment on your allowance. Once the casualty is pinpointed, correcting it is often a simple matter. The solution to the most complicated and unusual troubles can be found by a persistent, systematic and intelligent effort.

An example of this approach paid off recently in an Atlantic Fleet destroyer. The ship was troubled with poor sensitivity in its AN/SPS-6B radar. Ship's technicians made all the usual checks, but sensitivity did not improve. Civilian technicians were called in, but could not locate the trouble. The ship's Electronics Officer believed the trouble must be in the waveguide. None of the ship's technicians "knew anything about waveguides". The Electronics Officer didn't either, but he broke out NavShips 903-5, Microwaves and Waveguides, and did some studying. Armed with even a little knowledge of a broad and complicated subject, he made a survey of his waveguide run. The trouble was traced to radiation losses in a bad coupling joint and corrected. In retrospect, such action by the ship's force seems simple and logical. Undoubtedly, there are hundreds of other cases which could be cited, but unfortunately, they are the exceptions rather than the rule.

Navy electronics technicians should remember two things. First, they have been furnished one of the finest and most complete technical educations in electronics available anywhere. Many of the contract technicians are former Navy men. Second, with proper test equipment, a full allowance of technical publications, and the necessary repair parts, a ship's force can "fix anything" if they try hard enough and think they can.

Today, more than ever, it is important to cultivate a positive, confident attitude towards solving our own problems. No one can say when we may find ourselves in a forward area, with the chips down, and no "George" within a thousand miles to "let do it."

TYPE ALLOWANCE BOOK REVISIONS

The Bureau of Ships is in the process of revising TAB (Type Allowance Book) which pertains to all types of Naval vessels, with emphasis to complete that task as soon as possible. To distinguish the new allowances from those now in effect, the revisions are being printed on green paper. The first new revisions were distributed during September 1951.

FIELD CHANGE KITS FOR COMMUNICATION EQUIPMENT

BuShips letter 867-(18)-9(881AK) Ser. 881A-5514 of 15 August 1950 provided that approval by the Bureau of Ships for the issuance of Field Change Kits in certain categories was no longer required and that the Electronic Supply Officer implement the reporting of these issues. Accordingly, the cognizance designator is being changed from "F" to "N" and the reporting activities will filter such items into the QSSR in the stock number ranges established by E.S.O.

The categories affected are field change kits for:

1—Communication Transmitters
2—Communication Transceivers
3—Communication Receivers
4—Radio Direction Finders (Except ECM)
5—Radio Homing Beacons
6—Loran
7—Teletype
8—Frequency Shift Keyers

Appropriate requisitions will reflect the following information in addition to the standard information:

1—The Electronics Installation Bulletin (EIB) number (or other authority) authorizing the field change.

2—Model and serial number of the equipment on which the installation is to be made.

3—Certification that the field change has not been previously installed. (This certification will preclude the unnecessary reordering of a complete field change after initial installation, when only replacement of a part of the original field change is required).

All echelons of supply will insure that requisitions for subject field changes reflect the information above, before issue or passing the action on to the next echelon of supply.

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 would like to know if the Navy Department purchases the rights to specific inventions or copyrights that are relative to Navy equipments or processes. The reason I request this information is that I recently obtained patent rights on an electronic design and now wish to sell it. Any information on this subject will be greatly appreciated.

W. R., ET 1

The Navy Department has, in the past, purchased patent rights under many patents. These patents must be to applicants and inventors who are not in the employment or service of the Government. The law as defined in 28 U. S. C. 1498 provides in defining the jurisdiction of the Court of Claims in patent cases that "This section shall not confer a right of action on any patentee who, when he makes such a claim, is in the employment or service of the United States, or any assignee of such patentee, and shall not apply to any device discovered or invented by an employee during the time of such employment or service.

Therefore, since you are in the service of the United States, the Navy Department can not purchase any patent rights from you which have been acquired during the time of your service.

Have you considered your invention in the light of a beneficial suggestion? If interested, send your idea, as such suggestion, through channels to Bureau of Ships, Code 265.

Editor

Editor
BuShips Electron
Sir:

Recently the allowance list of this activity was revised to include one Type SK-1m mobile radar unit. The equipment has been received but there are several questions that have us in doubt. Perhaps you can help.

There is no record of any field changes or modifications having been made to the equipment. Can you furnish us with a listing of all field changes and/or modifications so that we can check the equipment for these changes.

The equipment was supplied with temporary stopgap instruction books which contain no pictures, etc. I feel sure that by now a permanent instruction book has been supplied and we would appreciate a copy when available.

We are having a very difficult time in maintaining dry air pressure in the antenna itself due to old and leaky gaskets, etc. Will the lack of such pressure affect the efficiency of the equipment?

The transmitter itself has the bad habit of burning out Type 527 oscillator tubes in short order. Is this common in this type of equipment or does the moving of the equipment shorten the life? Most common troubles are internal shorts, gassiness and tube breakage due to binding in the supports. Perhaps a field change has corrected some of this trouble.

We enjoy the ELECTRON very much and it passes through all interested parties. Believe this new feature of "Letters to the Editor" will be highly beneficial to all concerned. We'll have more questions for you later.

B. R. T., RMNC, O-1, USNR

1—No field changes have been issued to date for the SK-1m mobile radar unit.

2—Instruction book for the SK-1m equipment is NavShips 900,484, Advance Instruction Book for Radar Equipment Navy Model SK-1m under Contract NXsr-29461. The Spare Parts Catalogue for the SK-1m, NavShips 900,485-1 has been cancelled. NavShips 900,484 should be requested from the nearest District Publication and Printing Office.

3—Dry air pressure should be maintained in the antenna if at all possible to prevent the accumulation of moisture and consequent accumulation of corrosion and dirt. However, if the antenna is maintained clear of corrosion and dirt, normal atmospheric humidity will not decrease the efficiency of the equipment.

4—The difficulty you are experiencing with the Type 527 oscillator tubes is something with which the Bureau is familiar and the manufacturer is presently making some efforts toward a solution of this problem.

When additional information on your inquiries is available the cognizant technical codes at the Bureau of Ships will supply the information to the field via BUSHIPS ELECTRON *and/or the Radar Maintenance Bulletin.*

Editor

Maintenance of Radar Duplexers

by

VAUGHN KELLY
Pearl Harbor Naval Shipyard

Pearl Harbor Naval Shipyard reports that ships continue to arrive at Pearl Harbor with radars incapable of fully satisfactory operation because of improper maintenance of duplexing systems. This applies especially to SG-1b, AN/SPS-6, SR-3, SR-6, SX, and SP radars. Statements by ships' personnel who are responsible for maintenance of radars indicate that there is disagreement among various training activities and repair activities as to recommended maintenance methods. In general, equipment instruction books give either no special instructions, inadequate instructions or instructions which we consider to be incorrect.

It is believed that maximum efficiency of radar operation in the fleet depends on the employment of suitable maintenance procedures by all concerned. Since the presently available information in regard to duplexing tubes appears inadequate in the opinion of personnel at this activity, the following procedures are recommended:

Cleaning of Duplexing Tubes

In order to insure optimum operation of tubes which make contact with duplexing cavities by means of metallic fins, it is imperative that the fins be clean. This means that they must be free from any material, such as grease or corrosion products, which would interfere with low-resistance contact. New tubes which have gold-plated fins and are packed in sealed cellophane packages should not require any cleaning before installation. New tubes which have silver-plated fins will require cleaning to remove the silver sulfide or other corrosion products which may be present. Any tubes which have been previously used or which have been exposed to the atmosphere may be assumed to carry a film of grease, and will require cleaning. This cleaning should be accomplished by gentle application of a neutral silver polish, followed by rinsing with hot water. Excess water may be shaken off, and the tube then dried by means of clean tissue paper. Lacking a suitable silver polish, tooth paste or tooth powder moistened with water may be used in similar fashion. The dentrifice used should be preferably one of those containing a non-curdling detergent, such as Pepsodent. Extremely old tubes whose fins appear to be neither silver nor gold plated were probably originally silver plated but have lost their silver through chemical or abrasive action. Such tubes should not be used except in emergency, and when used should be cleaned as above. After having been cleaned, the fins of any tubes should not be allowed to come into contact with substances, such as the human skin, which will recontaminate them with grease or corrosive chemicals.

Cleaning of Duplexing Cavities

Those portions of the cavity structures (herein called the cavity "lips") which come into contact with the fins of the tubes must be free from any foreign material which would interfere with good contact. In general, the same cleaning methods should be used on these parts as on the duplexer tube fins. However, certain mechanical features will in some cases interfere with efficient cleaning. In the SR-3, SR-6 and AN/SPS-6, the cavity cannot readily be cleaned without removing the duplexer assembly. If the assembly is removed for cleaning, care must be exercised to keep water and other foreign matter out of the cavity, and care must also be taken to reinstall the assembly in its proper position. In the case of the SG-1b, the entire gold-plated waveguide assembly should be removed, after which the cavity lips can be cleaned easily. Rinsing can be done by putting the whole assembly under a water faucet, if desired. After they have once been made thoroughly clean, cavity lips may be expected to stay clean, provided that:

1—They are not recontaminated by insertion of a dirty tube.

2—They are not exposed to airborne dirt.

3—They have not corroded nor tarnished.

4—They are not improperly handled.

Installation of Tubes

Tubes must be carefully inserted in the cavities in such a manner that the fins make proper contact with the cavity lips. In the case of the SG-1b, it is possible to place the tube in such a position that one fin is on the outside of its corresponding lip and the other fin is on the inside of its lip. Duplexing action in such a case will be very poor. It is also possible to insert the tube properly in one half of the split cavity and improperly in the other half. This also will result in very poor operation and probably in destruction of the tube. In the case of the AN/SPS-6, SR-3 and SR-6, care must be taken to insert the ball tip of the tube properly in the contactor inside the cavity. Undue sidewise pressure on the contact fingers may spread them so that they will not make firm contact with the ball tip. Experience shows that in many cases the fingers are not tight enough to make good contact. This condition, if present, should be corrected by slightly compressing the fingers. The rings which clamp the tube fins against the cavity lips must be screwed in tightly. It is generally insufficient to screw these in by hand. Therefore, a large pair of pliers ("water-pump" or "battery" pliers) should be used, and considerable force should be used to insure firm contact. In the case of the split cavities in the SG-1b, it is advisable, after preliminary tightening of the cavity clamps, to loosen the two cavity-joining screws one-quarter turn and then retighten the cavity clamps. The cavity-joining screws should then be retightened. The purpose of this latter procedure is to diminish the possibility that a burr in a thread will prevent the clamp from seating properly. In the case of SR-3, SR-6, and AN/SPS-6, it is highly important that Field Change 9, 11, or 5, respectively, be accomplished. This field change adds two spacers, one of metal and one of Neoprene, which improve the contact between tube fin and cavity lip. It is essential that the spacers be inserted in their proper order; that is, the tube should be inserted first, then the Neoprene spacer, then the metal spacer. (Note that the applicable field change bulletins provide for putting the spacers in the reverse order. However, it has been found in practice that installation of the Neoprene spacer next to the clamp may result in rolling up or bunching of the spacer.) Some cases have been encountered where the spacers have been installed between the tube fin and the cavity lip, causing poor contact both at the cavity lip and at the ball tip.

Procedures to be Avoided

Don't attempt to clean any part of a duplexer with rubber eraser. Rubber erasers may contain abrasive material which will injure the plating. They may contain sulfur which will corrode the metal. They are certain to leave a film of non-conducting material (rubber). (Note that NavShips 900,531, the final SG series instruction book, recommends use of rubber eraser.) *Don't use carbon tetrachloride or any other organic solvent as a final cleansing agent for contact surfaces.* To do so will practically insure a thin coaing of oil or grease, since these solvents are very apt to have picked up such soluble matter during storage or previous use. In addition, there is some reason to believe that use of carbon tetrachloride promotes corrosion of brass and copper. *Don't use crocus cloth to clean contact surfaces.* Crocus cloth is apt to injure plated surfaces, and also leaves a film of non-conducting material (iron oxide). Don't expect a TR cavity to tune properly unless the contacting surfaces are clean and tight. The sharpness of resonance of a tuned circuit goes down when Q goes down. And Q goes down when ohmic resistance goes up. Dirty or loose contact surfaces are bound to increase ohmic resistance.

NEW COUNTERMEASURES RECEIVING EQUIPMENT

The new radar countermeasures receiving equipments being procured by the Bureau of Ships are the Radio Receiving Sets AN/SLR-2, AN/SLR-3, and AN/BLR-1. The Collins Radio Corporation is manufacturing these equipments, less the antenna systems, under Contracts NObsr-52150 and 52471. Delivery of these equipments is not expected until after 1952.

The AN/SLR-2, AN/SLR-3, and AN/BLR-1 equipments consist of remotely-controlled motor-driven tuning units, mixer-amplifiers, indicator-control units, remote switching units, D/F control units, servo amplifiers, and power supplies. These units are common to all three equipments. The major differences between the AN/SLR-2, AN/SLR-3 and AN/BLR-1 are the number of the above units employed, their system arrangement and cabling, and the antennas used.

The AN/SLR-2 equipment, for use on surface vessels, covers the frequency range of 90–10,750 Mc. in a series of eight tuning units. Three mixer-amplifiers and two indicator-control units are employed. The equipment is divided at 1000 Mc. into a low-frequency and a high-frequency system. One indicator-control unit is used with each system. The high-frequency system employs one mixer-amplifier, while the low-frequency system requires two mixer-amplifiers of different i-f frequencies. Each system has its own power supply, D/F control unit and servo amplifier.

The antenna system consists of four D/F antennas and omni-directional antennas, including the antennas CAGW-66131 and CAGW-66132.

The antennas and r-f tuning units are remotely switched from the indicator-control unit.

All controls for the equipment are located on the front panel of the indicator-control unit and on the D/F control unit which is to be mounted on top of the indicator-control unit. All cabling enters the rear of the equipment units.

The equipment operates from 115-volt 60-cycle, 1-phase AC and requires approximately 3 kw including the D/F control units. For dimensions and cabling, refer to BuShips restricted drawings RE 100D 2013 and RE 100F 2011.

The AN/SLR-3 covers the frequency range of 1000–10,750 Mc. using the four highest frequency tuning units of the AN/SLR-2. This equipment is a system for use primarily on PT boats. Only one mixer-amplifier and one indicator-control unit are required. The antenna system consists of one D/F antenna and the AS-371/S omni-directional antenna. Remote switching of the r-f tuning units and antennas is employed.

The equipment operates from 115-volt, 60-cycle, 1-phase AC and requires about 1500 watts. All units except the antennas are the same as those employed in the AN/SLR-2. For dimensions and cabling refer to BuShips restricted drawings RE 100D 2022 and RE 8D 2013.

The AN/BLR-1 covers the frequency range of 90–10750 Mc. using eight r-f tuning units. This equipment is the countermeasures system for submarines. It employs the units of the AN/SLR-2, but uses an antenna system designed especially for submarines. Only two mixer-amplifiers, one indicator-control unit, and one D/F control unit and servo amplifier are employed. The equipment requires approximately 1500 watts including the D/F control unit. For dimensions and cabling refer to BuShips restricted drawings RE 100F 2000 and RE 100F 2001.

More complete information including outline and mounting dimension drawings will be made available at a later date after the construction of the first production model by Collins Radio Corporation.

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Famous First in Electronics

RESTRICTED

Joseph Henry, American physicist (1797-1878) devoted his entire life to scientific work. Of his many experiments, he is known best for the development of the electromagnet, the principle of the electromagnetic motor and telegraph, and experiments on induced currents. His name will endure for all time, since the word "henry" is the standard unit of inductance.

RESTRICTED

ELECTRONICS

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As Quick

As St. Nick

The Editor and Staff of ELECTRON
extend

Season's Greetings

to

"All Hands"

Miller

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