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ARMY TACTICAL RADIO EQUIPMENT

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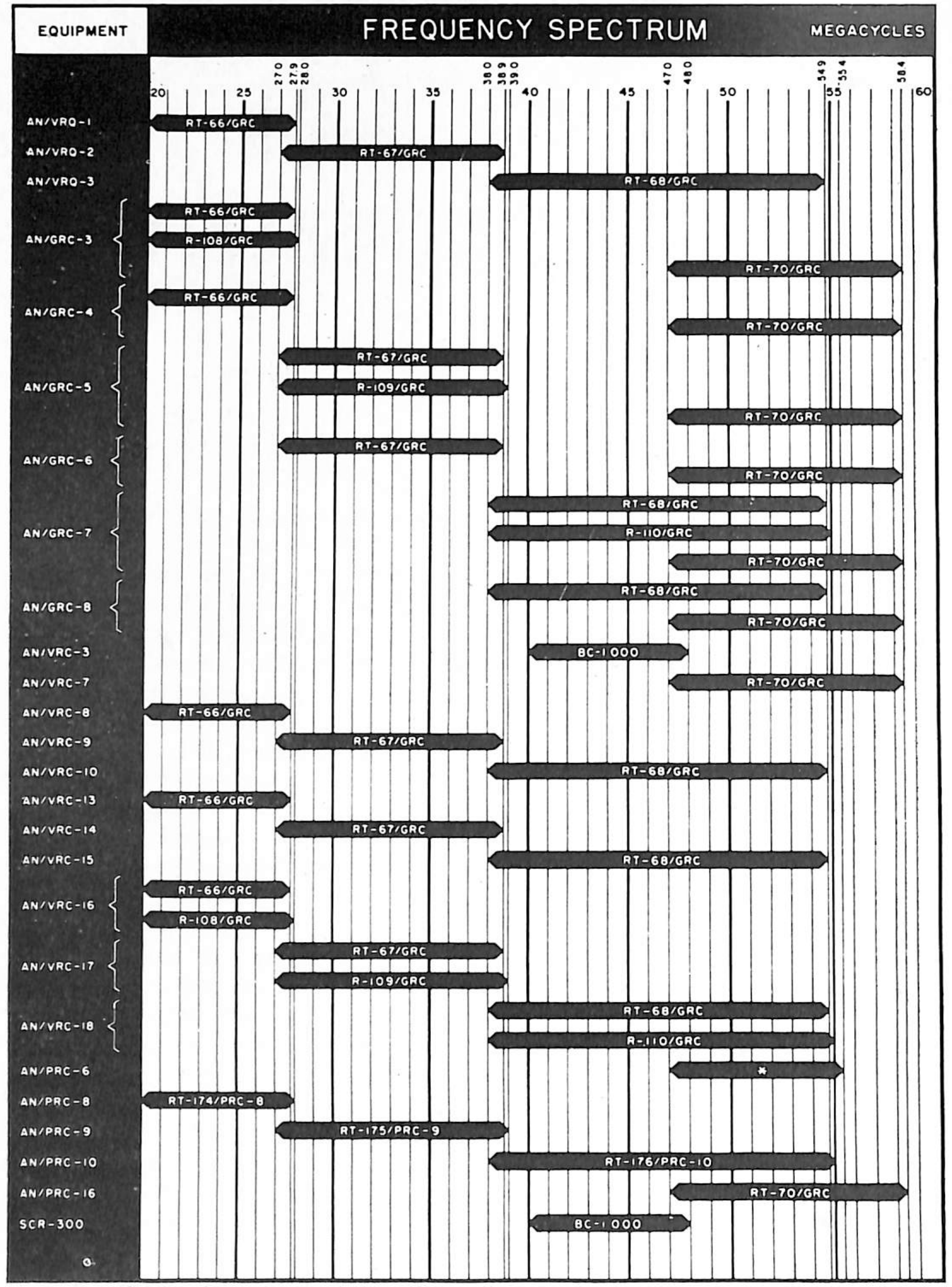
ARMY TACTICAL RADIO EQUIPMENT

by
Lt. Frederick H. Lamartin, USN
U. S. Naval Electronics Liaison Office
Fort Monmouth, N. J.

Within a year operational and repair personnel both afloat and ashore will begin to encounter several new items of radio equipment belonging to a new family of FM tactical radio sets developed by the U. S. Army Signal Corps and standardized for use by all Services. This series of components represents eight years of planning, study, development, and test by the Signal Corps Engineering Laboratories, Fort Monmouth, N. J.—the heart and core of electronics research and development for the Army. The equipment is presently being introduced to the field by New Equipment Introductory Teams available at the Signal Corps Engineering Laboratories.

During World War II a multitude of tactical communications equipment was designed and developed by the Services and placed in the field alongside many remaining pre-war units. Because of the large amount of existing equipment and because of differences in frequency range, in types of emission and modulation, and in channels and channel spacing, full and effective utilization of available equipment could not always be attained, and maintenance and logistics were a staggering problem. The new Signal Corps tactical series will at least partially solve these problems.

The major factors which will permit the new series to provide greater efficiency and utility and simultaneously to ease the maintenance and logistics problems are:



* ONE FIXED FREQUENCY DEPENDING UPON CRYSTAL USED.

FIGURE 1—Frequency spectrum of new tactical communication series.

1—Selection of overlapping frequency bands and provision of continuous tuning, permitting inter-service and inter-branch communication and facilitating channel shifting. (See Figure 1.)

2—Use of FM voice transmission throughout the series.

3—Provision of a larger number of available channels than in World War II sets.

4—Use of standard components as "building-blocks" for various assemblies.

5—Use of complete, standardized, interchangeable sub-assemblies.

6—Use of improved construction techniques to provide for rapid access and repair.

The tactical series covers the frequency range of 20-58.4 Mc and can be sub-divided into two groups: the portable and manpacked group, and the vehicular and ground group.

The portable and manpacked tactical FM group includes components which make up the AN/PRC–6 and the AN/PRC–8, –9, and –10. These will be briefly described in turn.

AN/PRC–6 (Figures 2 and 3) is an FM "Handie Talkie" type radio set; it is a complete operating assembly incorporating all operating components (rcvr/xmtr, battery, antenna, etc.) in one package weighing 6.5 pounds. The set is capable of FM operation on 1 of 43 channels in the range 47-55.4 Mc, with a ½-watt output for 1-mile average range.

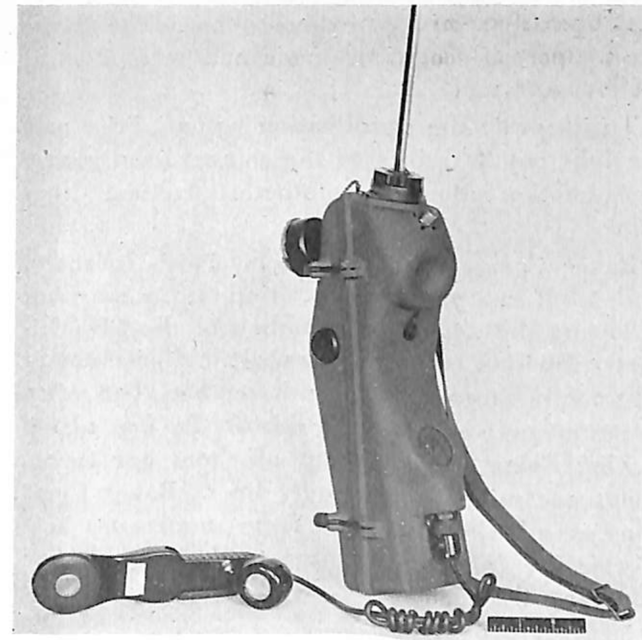


FIGURE 2 — Receiver and transmitter RT/PRC-6 (XC-4) showing single unit package with external handset attached.

FIGURE 3 — Same as Figure 2, showing single unit package in operating position.

The AN/PRC–6 can be held in the hand or slung over the shoulder for operation with an auxiliary handset. Battery life is 20 hours with a 1 to 10 transmit-receive ratio.

Radio Sets AN/PRC–8, –9, and –10 (Figure 4) are lightweight, portable, continuously tunable, battery operated, FM receiver-transmitters intended to provide manpack communications in the frequency band 20-54.9 Mc. The sets consist of one of three receivers, battery, battery case, antenna, hand set, etc. The receivers are: RT–174/PRC–8 (20-27.9 Mc); RT–175/PRC–9 (27-38.9 Mc); and RT–176/PRC–10 (38-54.9 Mc). They are physically similar, differing electrically only in the design of the r-f coil units. Each of the three complete assemblies weighs about 21 pounds and is about 16″ high, 9″ wide and 3″ deep. An effective range of 5 miles can be obtained by use of a 10-foot antenna, larger antennas giving longer possible ranges. Squelch operation is provided; thus, by utilizing a connecting cable two-way unattended relay use is possible.

The vehicular and ground series uses a "building-block" system which permits building up numerous types of assemblies with standardized components to suit the needs of the user. By proper selection of the standard components, many assemblies to serve different purposes can be obtained. Figure 5 shows how some of the major standard building-block components can be assembled to form certain standard sets which have been assigned AN nomenclature. For example, selection of RT–68/GRC as Set 1 and of R–110/GRC as an auxiliary receiver, and addition of Set 2, a-f amplifier, retransmission unit, etc., produces an AN/GRC–7. The AN/GRC–3, –4, –5, –6, –7, –8 assemblies, which are being procured for use by the Marine Corps and in amphibious vessels, are of primary interest to the Navy. Figure 6 shows a complete AN/GRC–3 assembly.

The major "building-blocks" are briefly described below:

1—Three Receiver-Transmitters, Set 1: RT–66/GRC (20-27.9 Mc), RT–67/GRC (27-38.9 Mc), and RT–68/GRC (38-54.9 Mc). These units permit choice of 80, 120, and 170 detented channels respectively at every 100 kc of the tuning range; two channels may be pre-set. Approximately 10 miles range can be obtained, with power outputs up to 16 watts. The weight is 35 pounds. These sets are very similar in structure, function, and detailed circuit and mechanical arrangement; they differ only in their operating frequencies and in their frequency-determining components.

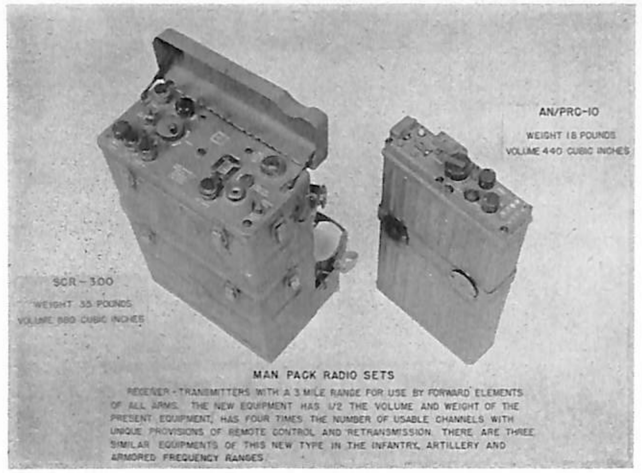


FIGURE 4—AN/PRC-10 compared to the SCR-300.

2—One Receiver-Transmitter, Set 2: RT–70/GRC (47-58.4 Mc). This unit provides continuous tuning, with detent provisions for pre-selection of any two operating frequencies. Approximately 1 mile range can be obtained, with power output up to 500 mw. The weight of the equipment is 25 pounds. This set is common to many standard assemblies and permits inter-communication between different assemblies.

3—Three Auxiliary Receivers: R–108/GRC (20-27.9 Mc), R–109/GRC (27-38.9 Mc), and R–110/GRC (38-54.9 Mc). Continuous tuning is provided, with a detent mechanism on each receiver for pre-setting any three frequencies. These receivers are very similar in structure, function, and detailed circuit and mechanical arrangement; they differ from each other only in their operating frequency ranges and in their frequency-determining components. These receivers duplicate the frequency band of Set 1 with which they are commonly used; thus, they permit one assembly to monitor two frequencies in the same band simultaneously.

4—One A-F Amplifier: AM–65/GRC is a common component in all AN/GRC assemblies using the above receivers and receiver-transmitters.

5—One Retransmission Unit: C–435/GRC extends the operational facilities of the radio sets to include full duplex operation and automatic retransmission between Sets 1 and 2.

6—Standardized power supplies, local and remote control boxes, mountings, antennas, cables, connectors, loudspeaker, handset, headset, etc. are also included in the series.

The future will probably see a steadily increasing use of the new tactical series by all Services. Naval personnel engaged in amphibious and in fire support operations will probably be the prime Naval users. In such operations coordination is of paramount importance.

To illustrate the coordination potentialities and the inherent flexibility of the standardized series, consider the following hypothetical tactical situation:

Baker Company, 1st Battalion, 114th Infantry, finds itself in a precarious position on the morning following the amphibious landing of the 14th Infantry Division on an enemy coast. After a steady advance, our forces had been driven back two miles by an enemy counterattack during the first night, leaving Baker Company cut off from our forces about one mile from friendly lines. Baker Company is suffering casualties from small arms and mortar fire from a ridge line to the east. Baker Company Commander decides to request artillery

	AN/GRC						AN/VRC										AN/VRQ				AN/UIC	AN/PRC
	3	4	5	6	7	8	7	8	9	10	13	14	15	16	17	18		1	2	3	1	16
Set 1 RT-66/GRC	1	1						1			1			1				2				
Set 1 RT-67/GRC			1	1					1			1			1				2			
Set 1 RT-68/GRC					1	1				1			1			1				2		
Set 2 RT-70/GRC	1	1	1	1	1	1	1															1
Aux. Rcvr R-108/GRC	1													1								
Aux. Rcvr R-109/GRC			1												1							
Aux. Rcvr R-110/GRC					1											1						
AF Amp. AM-65/GRC	1	1	1	1	1	1	1				1	1	1								1	
Retrans. Unit C-435/GRC	1	1	1	1	1	1												1	1	1		

FIGURE 5—"Building Blocks" used in various standard sets in tactical communication series.

or air support to neutralize the enemy emplacements on the ridge line.

Baker Company has communications with the 1st Battalion Command Post, one and a half miles south, by means of AN/PRC–10 (Infantry band 38-54.9 Mc). The Battalion Commander receives the request for support from Baker Company on Set 1 of his AN/GRC–7. Upon advice of Air and Artillery Liaison Officers that air support and artillery fire are not available, the Battalion Commander decides to use fire from DD–207, assigned to him by the Naval Gunfire Support Plan.

In order to permit maximum coordination of Naval gun fire and artillery, DD–207, along with the Artillery and the Naval Gunfire Liaison Officers, had been equipped with AN/GRC–5's (artillery band 27-38.9 Mc); artillery and Naval spotters had been supplied with AN/PRC–9's (27-38.9 Mc).

No spotter is available at Baker Company; however, the Battalion Commander upon advice of the Naval Gunfire Liaison Officer, decides to permit retransmission direct from Baker Company to DD–207 for indirect called fire observed by the Baker Company Commander. Accordingly, the following communications system is set up (See Figure 7). A pre-arranged emergency infantry-band channel is set up for transmission from Baker Company's AN/PRC–10 to Set 1 of an AN/GRC–7 at the 1st Battalion Command Post. Here the transmissions are automatically retransmitted by Set 2 of the AN/GRC–7 to Set 2 of the Naval Gunfire Liaison Officer's AN/GRC–5. Once again, automatic retransmission occurs, Set 1 of the AN/GRC–5 transmitting to Set 1 of the AN/GRC–5 on board DD–207. Transmissions from DD–207 follow the same path. During the fire mission the Battalion Commander continues to monitor transmissions in the infantry band (38-54.9 Mc) by means of auxiliary receiver R–110/GRC included in his AN/GRC–7; upon completion of the mission, the Battalion Commander rapidly shifts his AN/GRC–7 back to his Command Net, a pre-set channel in Set 1.

By such complete use of the flexibility of the tactical series, Baker Company was quickly placed in direct communication with its supporting vessel for the delivery of early and accurate neutralizing fire, and the Battalion Commander was able to return to his Command Net in a minimum of time. This coordination and flexibility is not a normal possibility with earlier tactical equipment.

The Signal Corps has expended much planning and study effort in developing the concept of a standardized series of tactical equipment. Years of effort will soon return large dividends. The overall use of FM, the selection of overlapping, wide frequency bands, and provisions for continuous tuning and rapid channel shifting are large strides towards maximum inter-arm and inter-service coordination, which is so essential to the most effective use of available forces. In addition, the use of standardized components and sub-assemblies and of other careful design aimed at easing maintenance and repair problems carries using agencies closer to their goals of reduced logistics and low outage time.

FIGURE 6—Jeep mounted AN/GRC-3 equipment.

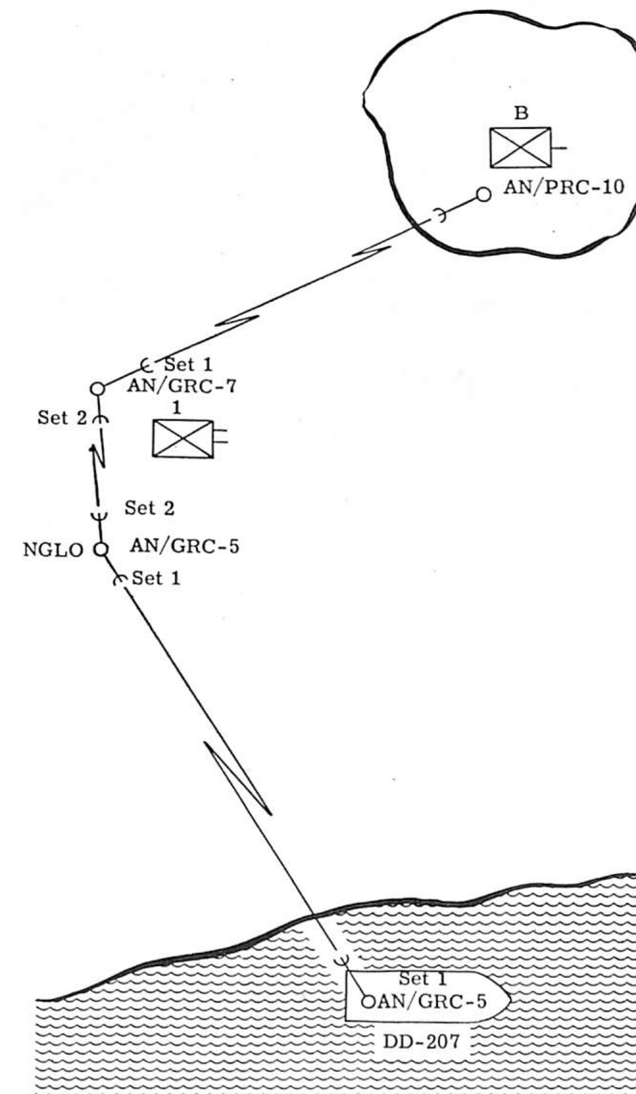
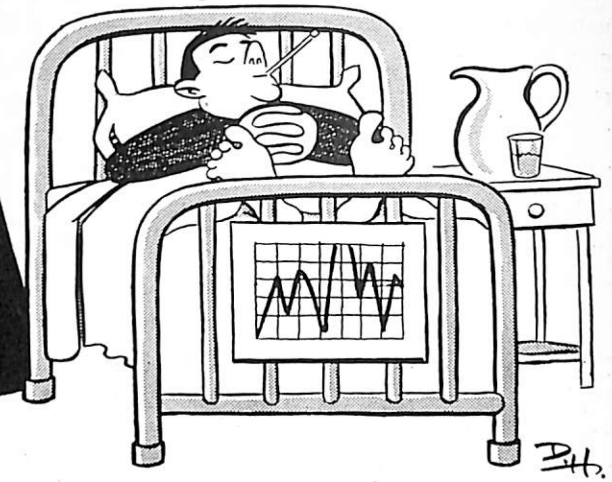


FIGURE 7—Hypothetical tactical situation showing use of new tactical radio series.

Monthly performance and operational report



In conformance with the Bureau of Ships request, vessels are submitting Monthly Performance and Operational Reports on certain electronic equipment. In order to facilitate the preparation of these reports, the Bureau is providing a new form, NavShips 3878 (11–50), which supersedes the forms used in reporting radar and sonar equipment and the form, NavShips 3642 (11–49), used in reporting radio, countermeasures and infra-red equipment. A sample of the new form is included with this article (see Figure 1). The new form, NavShips 3878 (11–50), should be requested as soon as possible and upon receipt, destroy the present supply of old forms. Order the new form from District Publication and Printing Offices.

It is essential that the Bureau receive these reports in order to keep informed on equipment performance and operation. These reports provide the Bureau with first hand information under actual operating conditions and are, therefore, of extreme value to the electronics program. Some of the details for the report may be obtained from Ships Electronic History Cards and Installation Records, which should be accurately maintained. The remainder of the form should be filled with data obtained during actual operation and performance.

Submit only the original copy of the report to the Bureau of Ships. If reports include radar fire control equipment, an extra copy should be sent to the Bureau of Ordnance. Coast Guard vessels submitting reports should send one extra copy to Commandant, Coast Guard. Additional copies of the report are to be made as directed by type or fleet commanders.

Information concerning the newest electronic equipment is desired for comparison with other types and as a check on their troubles and usefulness, etc. It is not desired that reports be made on all equipment. The list below covers electronic equipment, on which reports should be submitted. This list will be changed from time to time as data on equipment is required.

Radio

TS-587/U Noise-Field Intensity Meter
AN/URT-2
AN/URT-3
AN/URT-4
AN/USM-3 Test Tool Set (only for suggested new applications and general remarks)

Sonar

JT	AN/SQS (Series)
NGA/NGA-1	AN/SQG (Series)
NGB	AN/BQR-2
OKA	AN/BQR-3
QKA	AN/BQR-4
QHB/QHBa/QHB-1	AN/BQS-2
QLA/QLA-1	AN/BQS-3
QXB	AN/UQC-1
WFA/WFAa/WFA-1	AN/UQN-1

Radar

Mark 22 Mod 1	SG-3, 6	SV-2	SS Series	VL Series
" 25 and Mods	SO-4, 5, 6, 10	SV-3	ST "	
" 34 " "	SP	SX	VH "	
" 35 " "	SP-2	SX-2	VJ "	
" 39 " "	SR-2, 3, 6		VK "	

AN/BPS-1	AN/SPS-6 Series
AN/BPS-2	AN/SPS-8
AN/SPN-8	AN/SRR-4
AN/SPN-12	AN/SRR-6
AN/SPS-4	AN/UPX-1

It is not required that a report be submitted for the equipment listed above, if the equipment has

ELECTRONICS PERFORMANCE AND OPERATIONAL REPORT
NAVSHIPS 3878 (11-50)　　Submit original ONLY to Bureau　　51-29783

FROM: (1) (Ship's Name, Type and Hull No.)　(2) (FLEET)
TO: Chief, Bureau of Ships

CLASSIFICATION (Confidential, etc. (3)　Date (4)

PERIOD OF REPORT FROM (5) TO

CHECK EQUIPMENT CATEGORY REPORTED ON
☐ RADIO ☐ RADAR ☐ SONAR (6) ☐ OTHER

MODEL OR TYPE OF EQUIPMENT (7)

Serial Number	(8)					
Hours of Operation During Period of Report	(9)					
Hours NOT In Operating Condition During Period Of Report	(10)					
Overall Performance POOR 0 - 40% AVERAGE 40 - 70% GOOD 70 - 100%	(11) %	%	%	%	%	%
Applicable Field Changes NOT Accomplished To Date	(12)					
Maximum Reliable Range (Radio, countermeasures and infra-red)	(13)					
Maximum Reliable Radar Range*	MI (14) E	MI E	MI E	MI E	MI E	MI E
Minimum Reliable Radar Range*	YDS (15) E	YDS E	YDS E	YDS E	YDS E	YDS E
Altitude At Maximum Reliable Radar Range	(16)					
Average Echo Box Ring Time	(17)					
Average Voltage Standing Wave Ratio In Radar Transmission Line	(18)					
Maximum Echo Sonar Range	(19) YDS	YDS	YDS	YDS	YDS	YDS
Maximum Listening Sonar Range	(20) YDS	YDS	YDS	YDS	YDS	YDS
Maximum Sounding Sonar Range	(21) FMS	FMS	FMS	FMS	FMS	FMS

GENERAL REMARKS (Report Ambient and Equipment Temperature in DEGREES if undue heating occurs, interference encountered, voltage fluctuation, major failures, new applications, unusual propogation and oceanographic conditions, inadequacy of test equipment aboard, explanation of unusual performance of operational difficulties, etc.)

(22)

(23)　　SIGNATURE (24)

*NOTE: Report Signal to Noise Ratio in E Units　　CLASSIFICATION (Confidential, etc.) (25)　Report-Ships-192

FIGURE 1—New monthly Performance and Operational Report, NAVSHIPS 3878 (11-50).

not been in operation or if there is no operational or material data to be reported. In the future, it is not required to submit reports on TDZ, RDZ, MAR and RDR equipment.

Note that this form is to be used to report on all electronic equipment. A single form will accommodate six equipments of the same model or type.

An explanation of the items marked on the sample copy is as follows:

(1) Ship's Name, Type and Hull Number— It is important that the ship's name, type and hull number be completely given.

(2) Fleet— Enter either the word Atlantic or Pacific (fleet to which the vessel is assigned).

(3) Classification— Indicate the proper classification of the report.

(4) Date— Enter date that the form was filled out.

(5) Period of Report— Enter the period of time covered by this report.

(6) Equipment Category— Check the equipment category reported on. Only one category should be reported per sheet.

(7) Model or Type of Equipment— Indicate the model or type of equipment being reported. Only one model or type of equipment should be reported per sheet.

(8) Serial Number— Report the main serial number of the equipment. Do not include serial numbers of the component parts.

(9) Hours of Operation During Period of Report— Indicate the number of hours the equipment was in operation during the period of this report (Item 5) and not the total hours in operation since installation.

(10) Hours Not in Operating Condition During Period of Report— Indicate only the number of hours the equipment was not in operating condition *due to component and tube failures* or other troubles which prevented normal operation.

(11) Overall Performance— Indicate in percentage whether the performance of the equipment was good, average or poor, using the key listed on the form. Base the rating on such items as reliability, stability, ease of tuning, sensitivity, operation, etc. If equipment has a PPI, also base rating on target discernibility, persistence and clarity. If equipment reported on is sonar, the performance rating should also be based on range and bearing errors, sloppy train, return echoes from target, depths and continuous contact at limiting range.

(12) Applicable Field Changes Not Accomplished To Date— Indicate only the field changes which have not been accomplished to date of this report. This data should be taken directly from Electronic Equipment History Cards, NavShips 536, and Field Change Record Cards, NavShips 537. Complete lists of the field changes necessary to keep the equipment at optimum performance are given in sections of maintenance bulletins devoted to the particular equipment concerned.

Note: The data reported in the following items should be consistent with the purpose for which the equipment was designed.

(13) Maximum Reliable Range (Radio, Countermeasures and Infra-Red)— State the known maximum range at which reliable contact was maintained during the period of the report.

(14) Maximum Reliable Radar Range —The maximum reliable radar range is the range at which a particular distant target is first recognized as a definite target producing a consistent echo. This range should be reported in miles. For explanation of the "E" units see Item (23).

(15) Minimum Reliable Radar Range— The minimum reliable radar range is the range at which the echo begins to merge into the transmitted pulse, but is still consistent and recognizable. This range should be reported in yards. For explanation of "E" units see Item (23).

(16) Altitude At Maximum Reliable Radar Range— The altitude of the targets (planes or land) used in reporting the maximum reliable radar range should be listed.

(17) Average Echo Box Ring Time— Specify the average ring time in yards as computed from checks made during the period of this report.

(18) Average Voltage Standing Wave Ratio In Radar Transmission Line— Indicate the average voltage standing wave ratio (numerical value) in the transmission line of equipment reported as computed from checks made during the period of this report. Under general remarks (Item 22), report any unusual ratios.

(19) Maximum Echo Sonar Range— Indicate the maximum reliable echo range obtained under good water conditions as determined by Bathythermograph readings. The range should be reported in yards.

(20) Maximum Listening Sonar Range —Indicate the maximum reliable listening range obtained under good water conditions as determined by bathythermograph readings. The range should be reported in yards.

(21) Maximum Sounding Sonar Range— Indicate the maximum reliable sounding range obtained under conditions of a sea state of three or more. The range should be reported in fathoms.

(22) General Remarks— Include any comments, not covered in the above, such as those indicated under General Remarks on the form. Give detailed information as to any unusual trouble encountered in operation and exceptional maintenance required. Suggestions and comments relative to improvements in design features, test or service equipment usefulness, changes and new applications, adequacy of spare parts, tubes, instruction books, etc., should be submitted. In reporting sonar equipment, designate own ships speed and target type (surface ship or submarine) for ranges listed under Items (19) and (20). The Bureau also desires any information that may not be described herein, but that would be of value to the electronics program. This is not to be construed as authority to modify the equipment in any way.

This report is not to be confused with the failure report form. All activities should continue to report all failures of electronic equipment on the NavShips 383 Failure Report Form, whether or not a special operational report is submitted. Field Changes should be listed on the Field Change Record Card, NavShips 537. Field Change Report Card, NavShips 2369, should be mailed promptly upon completion of field change.

(23) Note "E" Units— The "E" unit indicating the signal-to-noise ratio is desirable when giving maximum and minimum reliable ranges. This can readily be determined by taking the ratio between the height of the echo being ranged and the average height of the noise level (grass). The radar signal-to-noise designation chart (Figure 2) was prepared in order to provide a standard signal-to-noise reference. The ratio of signal to noise is expressed in terms of the "E" units in the manner indicated in the chart.

When listing ranges or when indicating signal strength, include the code designation in "E" units. The "E" units and typical patterns are given for optimum control settings. When the "E" units are indicated for optimum settings, it will provide the Bureau with the information required to make a more accurate analysis of radar performance.

(24) Signature— The report should be signed by the Commanding Officer of the vessel.

(25) Classification— same as Item (3).

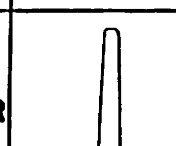
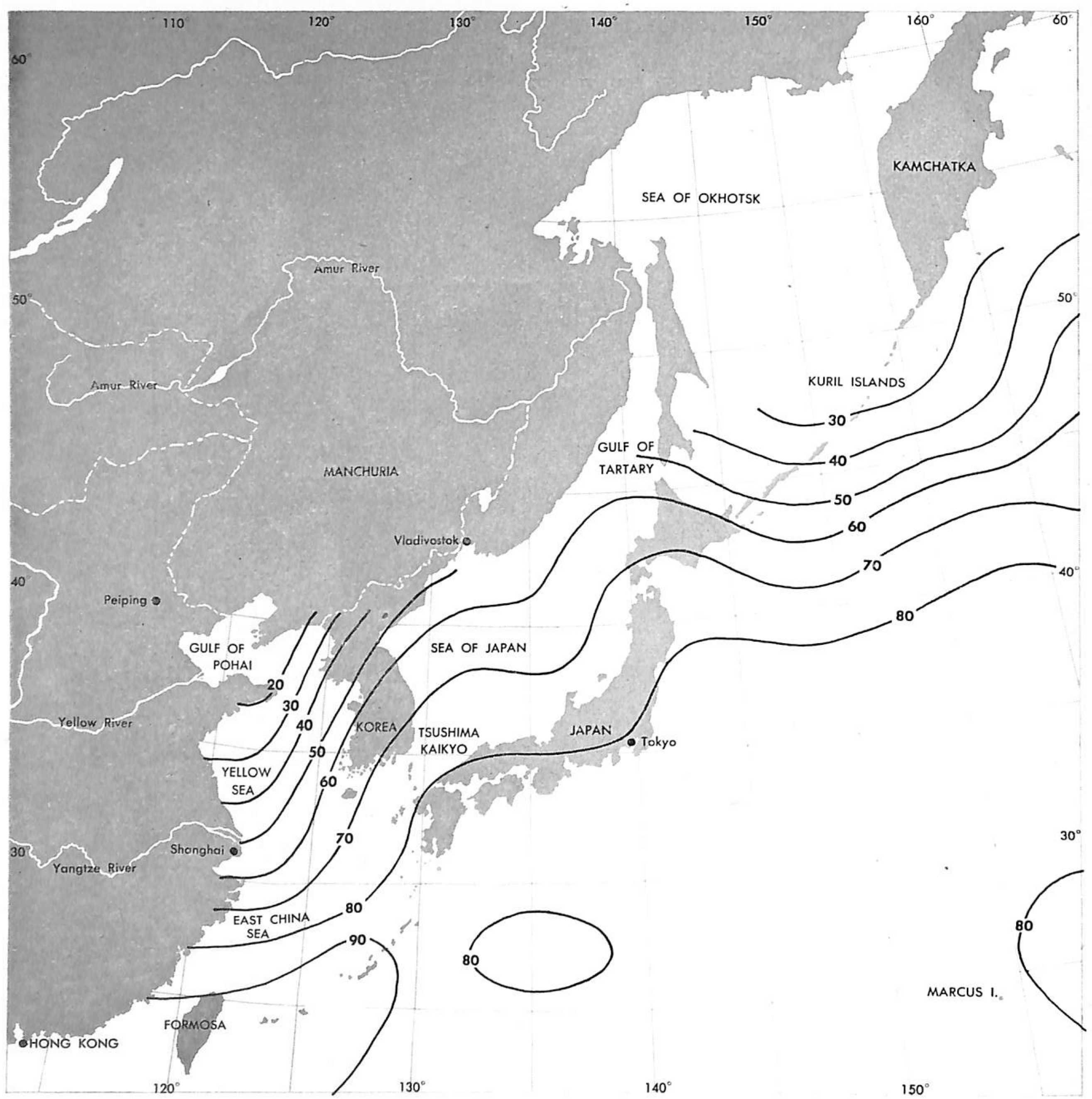
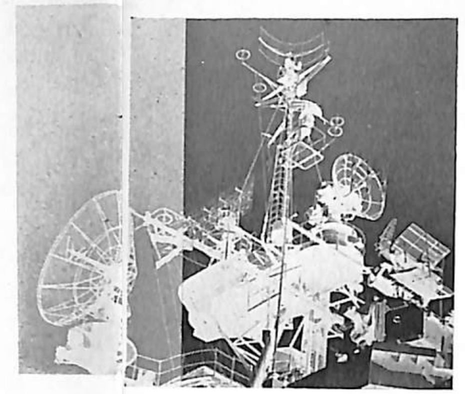
CODE DESIGNATION	SIGNAL TO NOISE RATIO	TYPICAL PATTERN	ECHO STRENGTH
E—1	1 TO 1 OR LESS		INTERMITTENT ECHO BARELY PERCEPTIBLE
E—2	2 TO 1		WEAK ECHO
E—3	4 TO 1		GOOD ECHO
E—4	8 TO 1		STRONG ECHO
E—5	16 TO 1 OR GREATER		VERY STRONG OR SATURATING ECHO

FIGURE 2—Radar signal-to-noise designation chart (E units).

Sample propagation expectancy chart for submarine S- and X-band radars operating in the northeastern Asiatic area in the month of January. Contours indicate per cent of total time that ranges longer than normal may be expected. Similar monthly charts are being prepared for surface ship antenna heights, for lower frequencies, and for other strategic areas.



nel notes:



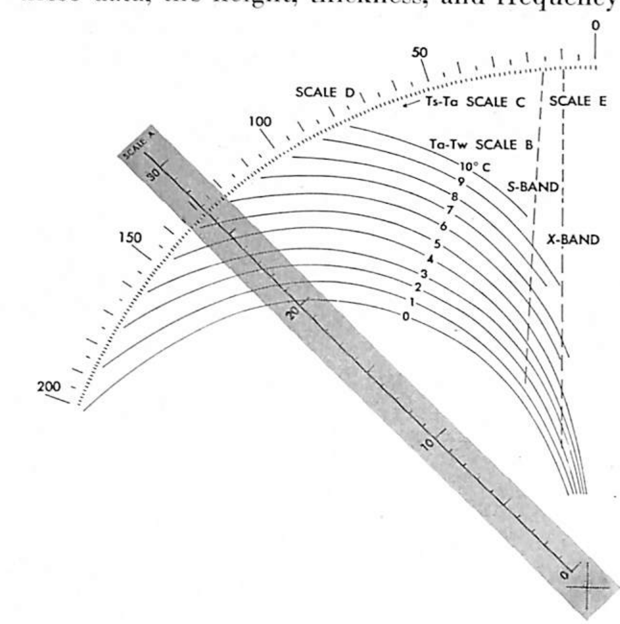
"crystal ball" radar range predictor

Two forecasting aids designed to provide Fleet units with a "crystal ball" for predicting favorable radar and u-h-f radio ranges are now being prepared by the U. S. Navy Electronics Laboratory. The first of these aids, which is intended for use aboard submarines, is a *radar duct calculator* that will enable submarine personnel to determine the extent of their S– and X–band radar coverage, even though no targets are available for a direct coverage estimate. The second forecasting aid, which can be utilized by both submarine and surface ships, is a series of *propagation expectancy charts* covering three strategic ocean areas. Each chart consists of contours showing the per cent of the total time, on the average, that propagation ranges longer than normal may be expected in the regions enclosed by the contours.

Both the calculator and the expectancy charts are based on studies that have been conducted over many years to determine the relationship between weather conditions and radio-radar propagation. From these studies, it has been found that one of the most important weather phenomena affecting radio-radar ranges is a condition known as an *atmospheric duct*, consisting generally of a layer of warm dry air overlying a region of cool moist air. The layer of warm air causes a downward refraction or bending of radio "rays," thus, in effect, channeling the radio energy around the curve of the earth. This results in radar or u-h-f radio ranges two or three times normal.

Unfortunately, the presence or absence of such a duct is seldom associated with any of the easily noticed weather phenomena such as clouds, rain, thunder, etc., so that it is usually impossible to determine from casual observation whether conditions are suitable for extended propagation ranges. the NEL duct calculator is designed to provide a means of determining, from simple measurements made on shipboard, the presence of very thin surface ducts of a type frequently encountered at sea. The measurements required are wet– and dry–bulb air temperatures, sea surface temperature, and wind velocity. Because this type of duct affects only high-frequency radars situated at heights of less than 50 feet, the calculator cannot be used for radars operating below S–band frequencies or for surface ship radars using masthead antennas. However, it should be very valuable for determining submarine S– and X–band radar coverage.

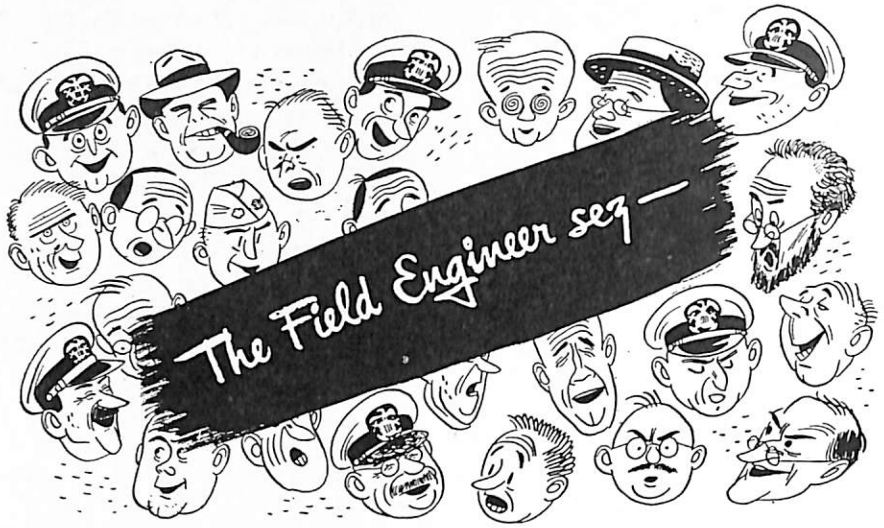
The propagation expectancy charts being prepared by NEL are based on past meteorological records indicating the occurrence of both surface-based and elevated ducts. Extensive meteorological data have been accumulated from radiosonde measurements made in all parts of the world over a period of many years. From a statistical study of these data, the height, thickness, and frequency of



Duct calculator for determining coverage of submarine S- and X-band radars.

occurrence of ducts can be determined, and propagation expectancy contours can be plotted for various frequencies and antenna heights. Three general regions are being covered at present: northeast Asia, southeast Asia, and the Middle East. Separate sets of twelve monthly charts are being prepared for each region, for each frequency range covered, and for both submarine and surface ship antenna heights. These charts are expected to be of interest to tactical planning groups, as well as to Fleet radio and radar personnel.

The submarine calculator will be made available to Fleet units in the very near future for test and evaluation. In order to allow correction of the calculator and the expectancy charts in the light of operational results, Fleet units using these forecasting aids are being requested to forward to NEL all operational data and results obtained in employing the devices.



MARK 34 MOD 2

U.S.S. Huntington (DD–781)

WE Company field engineers report that the Mark 34 Mod 2 radar equipment on board the *U.S.S. Huntington (DD–781)* had been completely saturated with salt water during heavy storms while returning to the United States. Prior to arrival the ship's technicians had started and almost completed cleaning the water-soaked equipment. WE Company engineers report that the very prompt attention given by ship's technicians to this clean up job undoubtedly saved many hours of overhaul work to the equipment. The field engineer was able to check out the equipment in adjustment for optimum performance in nine hours. This is an excellent example of the saving in time and material that can be effected by prompt attention to a maintenance problem.

U.S.S. Henley (DD–762)

In making Field Change No. 17 to the CW-23APW Range Unit it was found necessary to plane off .022″ from the base of Idler Assembly, BL–79227, in order to have it mesh properly with mating gears. The Oillite bearing on the rear end of the range unit drive shaft was replaced with an eccentric bearing 0.01″ off center in order for spur gear ESO–682513–21 to have proper clearance in gear teeth. This bearing was secured with a 5–40 allen cup point socket head set screw.

J. R. Yost

It is to be noted that changes to the subject Oillite bearings have been reported as necessary and accomplished by other field engineers on this equipment.

MODEL QGA

Fleet Sonar School

The following quotation is from the general notes of the Philco Field Engineers who checked over the QGA equipment at the Fleet Sonar School:

"All units were checked for cold solder joints and resoldering was done where necessary. As the equipment had been worked on by inexperienced personnel, much resoldering was required to preclude troubles now dormant. . . . The equipment at present, i.e., less the required field changes, is in excellent operating condition. In order to better maintain this condition, it is recommended that:

"1—A preventive maintenance schedule be inaugurated at the earliest opportunity and,

"2—Closer surveillance be kept on students performing repairs on the equipment.

"The latter would prevent, or minimize such occurrances as cold solder joints, incorrect wiring, etc."

—H. E. Norretti and E. R. Schnecker.

MK 25 MOD 2

U.S.S. Rochester (CA–124)

Range Error Detector Mk 31/0 D-153556

A very distorted wave shape was noted on range reference voltage. This feeds the range error detector and imposed a poor wave shape on T2 and the demodulator. The trouble was traced to a ground on the 115-volt range reference voltage, which was in turn traced to a ground on the ship's gyro.

D. O. Shuck

New Books

The following is a list of all instruction books distributed from 8 December 1950 to 1 April 1951. The most recent previous list of instruction books distributed appears in the March 1951 issue of BuShips Electron. The key to the abbreviations listed under the heading "*Edition*" appears below.

Supplementary lists will be published in BuShips Electron at regular intervals, as additional instruction books are distributed.

Abbreviation	*Edition*	*Abbreviation*	*Edition*
C	Commercial Publication.	MI	Maintenance Instructions
Ch.	Change	OH	Operators' Handbook
CI	Complimentary Instructions	P	Preliminary Instruction Book
DB	Descriptive Booklet	RS	Revision Sheets
FC	Field Change	S	Supplement
IB	Instruction Book	SIG M–8	MarCor Parts List
IH	Installation Handbook	SP	Spare Parts Catalogue
IS	Instruction Sheets	T	Temporary
MH	Maintenance Handbook	TM	Technical Manual

Model	*Short Title*	*Edition*
AN/FRT–4	NAVSHIPS 91169	Ch 1
AN/FRT–5	NAVSHIPS 91183	Ch 1
AN/GRC–13	NAVSHIPS 91235	Ch 1
AN/MPS–4	NAVSHIPS 91385	Maint. Prints
AN/PDR–8A	NAVSHIPS 91317	Ch 1
AN/PDR–27	NAVSHIPS 91341	IB
AN/SPA–4(XN–1)	NAVSHIPS 91276	IB and CH 1
AN/SPS–4(XN–1)	NAVSHIPS 91375	IB
AN/SPS–6	NAVSHIPS 91081	IB
AN/SPS–6	NAVSHIPS 91081.2	OH
AN/SPS–6	NAVSHIPS 91081.3	MH
AN/SPS–6	NAVSHIPS 91081.4	SP
AN/SPS–6	NAVSHIPS 91081	T–4
AN/SPS–6	NAVSHIPS 98185	FC #7
AN/SPS–6	NAVSHIPS 98186	FC #14
AN/SPS–6	NAVSHIPS 98184	FC #16
AN/SPS–7(XN–1)	NAVSHIPS 91324	IB
AN/TIP–2	365–1907	SIG M–8
AN/UQN–1	NAVSHIPS 91268	IB
AN/UQN–1A	NAVSHIPS 91360	IB
AN/URA–6	NAVSHIPS 91355	T–4
AN/URD–2	NAVSHIPS 98152	FC #1
AN/URD–2	NAVSHIPS 98210	FC #2
AN/URD–2	NAVSHIPS 98211	FC #3
AN/URD–2	NAVSHIPS 98212	FC #4
AN/URD–2	NAVSHIPS 91198	T–1, T–2, Ch 1
AN/URM–25A	NAVSHIPS 91379	IB
CP–87/U	NAVSHIPS 91387	IB
E–6/S	NAVSHIPS 91348	IB
E–6/S	NAVSHIPS 91348	T1
IM–58/U	NAVSHIPS 91386	IB, T–1 and T–2
JT	NAVSHIPS 98165	Ch 1
MAY	NAVSHIPS 91392	IB
OCJ	NAVSHIPS 900,996	Ch 1
OKA–1	NAVSHIPS 91333(A)	IB
OSA	NAVSHIPS 900,937(A)	T–1
PP–311A/PD	NAVSHIPS 91133	IB
PP–388/U	NAVSHIPS 91137	T–1
PP–388/U	NAVSHIPS 98207	FC #1
PP–671/PD and DT–62/PD	NAVSHIPS 91382	IB
RCO	NAVSHIPS 900.255.4	SP
SG–6b	NAVSHIPS 91384	IB
SG–6b	NAVSHIPS 91384.2	OH
SG–6b	NAVSHIPS 91384.3	MH
SG–6b	NAVSHIPS 91384.4	SP
SG–31/U	NAVSHIPS 91381	IB
SG–31/U	NAVSHIPS 91395	Maint. Prints
SP–600–JX	NAVSHIPS 91405	C IB
SR–3	NAVSHIPS 900.539	T–4
SR–3	NAVSHIPS 98187	FC #10
SR–3	NAVSHIPS 98182	FC #11
SR–6	NAVSHIPS 98188	FC #12
TBS Series	NAVSHIPS 900.590	T–1
TDZ Service and Repair Manual	NAVSHIPS 91328	T–1
TED	NAVSHIPS 91357	IB
TS–186B/UP	NAVSHIPS 91335	IB
TS–186C/UP	NAVSHIPS 91376	IB
TT–45/FG	NAVSHIPS 91241	IB
TT–47, 48, 59, 70/UG Tele-Typewriters	NAVSHIPS 91393	IB
TV–3/U	----------------	SIG M–8
TV–3/U	NAVSHIPS 91254	T/1 and T–2
VH	NAVSHIPS 900,934	T–1

Model	Short Title	Edition
VJ	NAVSHIPS 900,829(A)	T-1
VK	NAVSHIPS 900,986	Ch 2
VK	NAVSHIPS 900,986	Ch 3
VK	NAVSHIPS 98150	FC #2
VK	NAVSHIPS 98177	FC #4
VK-2	NAVSHIPS 91300	IB
VK-2	NAVSHIPS 91391	Maint. Prints
VL	NAVSHIPS 98176	FC#1
V-35/U	NAVSHIPS 91310.4	SP
CBGX-10563-A	NAVSHIPS 91368	IB
Navy Headset (49507A)		
Ultra-Ohmmeters	NAVSHIPS 91422	————

MEASURING SENSITIVITY OF MODEL RDO'S MODIFIED BY F.C. NO. 1

With the modification of Model RDO Radio Receiving Equipment by Field Change No. 2-RDO, which adds a preamplifier stage to the i-f input, a new procedure for sensitivity measurement is required. The stage gain sensitivity measurements given in Table I, Section 4, Paragraph 14, Page 26, of the Instruction Book for Radio Receiving Equipment, Model RDO (NavShips 900,527-IB are no longer applicable in this case.

The procedure described below is to be used to determine the overall sensitivity of the receiver. The procedure given in the instruction book for alignment of the i-f stages, Section 4, Paragraph 14, is not superseded by the procedure described below and must still be employed for receiver alignment.

1—Remove the Model RDO from the cabinet. Insert the TN-28/APR-1 tuner unit.

2—Remove the bottom shield cover from the IF-AF amplifier chassis.

3—Connect the positive test lead of a vacuum-tube voltmeter to Prong 5 of tube socket X-207 and ground the other test lead on the chassis. Set the vacuum-tube voltmeter on the lowest voltage range.

4—Connect the Model RDO receiver to the power source.

5—Connect the signal generator Model LAF series to the antenna input of the TN-2B/APR-1.

6—Set the signal generator to 200 Mc.

7—Tune the TN-2B/APR-1 to the signal generator output.

8—Set the following receiver controls:

a—The RECEPTION switch to AVC-OFF position.

b—The NOISE LIMITER-OUTPUT METER switch to OFF position.

9—Turn off the signal output of the signal generator and turn the receiver RF GAIN control to maximum.

10—Read the voltage as indicated by the vacuum-tube voltmeter connected to Prong 5 of the tube socket X-207 and record the value.

11—Set the RF GAIN control to a reading of 9 on the RF GAIN control marking.

12—Turn the signal generator output on and increase the signal generator output level until the voltage indicated by the vacuum-tube voltmeter is the same as that recorded in Step 10 above. Record the signal generator output level.

13—Increase the signal generator output level by 3 db. Record the voltage indicated by the vacuum-tube voltmeter.

14—Decrease the signal generator output level to approximately 80 db below 0.1 volt.

15—Turn the RF GAIN control to maximum.

16—Adjust the signal generator output level so that the voltage as indicated by the vacuum-tube voltmeter is the same as that recorded in Step 12 above.

17—Read the signal generator output level. It should not be less than 80 db below 0.1 volt.

18—If the sensitivity is below that given above, align the receiver by the procedure given in the instruction book, Section 4, Paragraph 14.

ERROR IN BULLETIN FOR F.C. NO. 7—AN/SPS-6/6A/6B

Field Change Bulletin (NavShips 98185) for Navy Field Change Number 7-AN/SPS-6, AN/SPS-6A, AN/SPS-6B specifies that the field change is equivalent to an alteration. This is in error and should be corrected as follows:

On Page 2, Paragraph No. 2 delete Lines 3 through 7 and insert "THIS FIELD CHANGE IS EQUIVALENT TO A REPAIR AND SHOULD BE ACCOMPLISHED AT THE EARLIEST OPPORTUNITY BY NAVAL SHIPYARD ELECTRONICS ENGINEERS OR FIELD ELECTRONICS ENGINEERS".

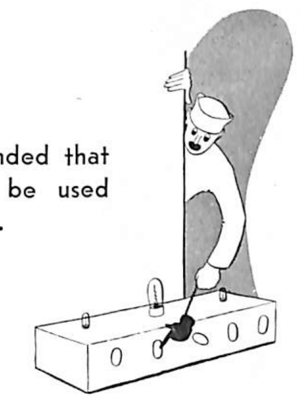
TUBE TESTER TV-3/U HAZARDS

All personnel working with Tube Tester TV-3/U are warned to exercise caution when testing metal shell and metal base tubes in octal socket X-107. A line voltage is present at Pin #1 of X-107 when short test switch S-113 is in any of the short test positions. Metal tubes have Pin #1 connected to the shell or base and consequently line voltage is present at the metal shell or base of the tube. In addition, when any of the selector switches are in the following positions:

FILAMENT	FILAMENT	GRID	PLATE	SCREEN	CATHODE	SUPPRESSOR
C	S	2	None	None	2	2

and SHORTS switch is in the TUBE TEST position, a fraction of the line voltage (through C-105, 0.1 mf) is present at the metal shell or base of the tube. These voltages are present regardless of the position of the line switch S-106. It is not removed by grounding the chassis of the tube tester.

. . . . . recommended that an insulated rod be used for tapping . . . . .



It is recommended that an insulated rod be used for tapping on the short test and that the operator make certain that the switches are not in any of the positions mentioned when inserting or removing a metal shell or base tube (NOTE: Filament switches will never normally be in this position. In most cases the suppressor switch will be in Position 2.)

The factors contributing to this hazard have been corrected in later equipments and are not present in the Model TV-3/U tube testers of serial 981 and above. To correct this hazard in Tube Tester TV-3/U's below serial 981, the Bureau of Ships is processing a field change.

SPECIAL COVERING NO LONGER NEEDED ON GERMANIUM CRYSTAL DIODES

Attention is called to the article relating to packaging of silicon and germanium crystal diodes on Page 30 of the February 1951 ELECTRON magazine.

The Bureau of Ships (Code 836c) has stated that, due to the higher current rating of germanium type crystals, no protective, non-magnetic type shielding is necessary for this type. Silicon type diodes, however, should continue to be protected.

TELETYPE PUNCH BLOCKS

Teletype punch block maintenance and repair has become a more difficult problem since materials have become scarce and costly. During maintenance of reperforators, it is found that the punch block sometimes becomes fouled with dirt, grease, and minute chaff from the tape. In order to clean it properly, it is necessary to take the block apart. Three precautions are advisable at this point.

1—Don't take off the guide plate.

2—Have extra springs ready for the stripper pins, as they have an unusual ability to get lost.

3—If the punch block is taken out for replacement, the entire item should be assembled with the die plate fastened to the body of the block with its screws. These parts are mated and if separated will cost extra to be matched again at the factory.

Separation may be averted by assembling the block with the screws provided for that purpose. This is a much better method than tying them together with string, rubber bands, or other makeshift methods which will probably become broken or separated when left to the effects of temperature, time, etc. Since these items are usually stored until there are enough of them to return to the factory, it is essential that the assembly remain intact indefinitely.

GREASE PENCILS FOR REFLECTION PLOTTERS

Grease pencils are available from standard Navy office supply stock for use with reflection plotters.

The pencils may be ordered through routine supply channels by Stock Number 53-P-28264-210 and black replacement leads are available under Stock Number 53-P-28026-600.

These two items are usually stocked in the office supplies issue storerooms of most Naval activities.

BISTABLE TRANSISTOR CIRCUITS

by

E. Eberhard, R. O. Endres *and* R. P. Moore
Radio Corporation of America

Bistable Multivibrator Using Two Transistors

The first transistor multivibrators to be described are analogous to the basic Eccles-Jordan type of circuit using vacuum tubes. In fact if the assumption is made that the base of the transistor corresponds to the grid of the tube and that the emitter of the transistor corresponds to the cathode of the tube, the circuit is seen to be quite similar to the Eccles-Jordan multivibrator (See Figure 1). In operation, if transistor #1 is conducting heavily its collector potential will be near ground, thus holding #2 in a state of low conduction by making its base potential positive with respect to its emitter. The application of a trigger pulse to both emitters will cause the circuit to revert to its other stable state with transistor #1 in low conduction and transistor #2 in high conduction. This operation will be clear from an analysis of the feedback loops.

However, the analogy with the Eccles-Jordan circuit is not nearly as close as might be expected from a superficial examination. There are two fundamental characteristics of transistors which make the circuit of Figure 1b differ from the vacuum tube circuit of Figure 1a. One of these differences arises from the odd shape of the transistor gain function. Figure 2 shows how the current gain changes with emitter current. A family of curves has been plotted to show also the variation of current gain with changes in collector current. (I_{C3} is the largest collector current and I_{C1}, the smallest). In a quiescent condition one transistor of the multivibrator will be in high conduction, operating on the right-hand portion of the curves in Figure 2. The other transistor will be in a low conduction and operating on the left-hand portion of the curves near zero emitter current. (This assumes that the current gain curves of Units 1 and 2 are similar to those of Figure 2.)

Since the high gain region lies to the left of the operating point of one transistor and to the right of the operating point of the other, the circuit can be triggered into operation with either positive or negative trigger pulses on the emitters. This action may be explained as follows: In order to trigger with positive pulses it is necessary for these pulses to have a greater effect on the transistor that is in low conduction than they have on the unit that is in high conduction. Conversely, to trigger with negative pulses the greater effect must be on the unit that is in high conduction. An examination of Figure 2 shows that this will be the case if both transistors have characteristics similar to those shown. The curves also indicate that negative input pulses are preferable since the current gain curves decrease much more rapidly on the negative side. In the experimental circuits this was found to be true.

Another difference between the transistor and the Eccles-Jordan multivibrator is that the resistor between base and ground, analogous to the grid resistor in the vacuum tube circuit, produces regeneration in each transistor. (As will be discussed later, each transistor may in fact have two stable states without reference to the other.) This regeneration may assist in the operation of the circuit but it often produces undesirable oscillations involving only one of the units. For this reason, the base return resistances must usually be kept less than 10,000 ohms. Hence, while the circuits seem to be identical, their operation involves somewhat different principles.

Practical values of constants for this circuit using a supply voltage of 45 volts are:

Collector Resistance	5,000-25,000 ohms
Base Resistance	3,000-10,000 ohms
Feedback Resistance	15,000-50,000 ohms
Emitter Resistance	500- 1,500 ohms

Capacitors may be used in parallel with the feedback resistors to increase the feedback at high frequencies.

Figure 3 is a variation of the circuit in Figure 1b which departs even more from the Eccles-Jordan multivibrator. Here, coupling C_2 has been added between the emitters of the two units and triggering may be accomplished by the application of positive or negative pulses to the base of the first transistor only. Briefly the action is as follows: With #1 in high conduction and #2 in low conduction, a positive trigger pulse at the input decreases the current in #1. The resulting regenerative action through the coupling resistor and the second transistor causes #1 to go into low conduction and #2 to go into high conduction. On the following input pulse the change back to the original condition is accomplished by a combination of a positive pulse coupled to the collector of #2 and a negative pulse on the emitter of #2 derived by differentiation of the trigger pulse C_2. Since differentiation is required, this part of the cycle must start at the trailing edge of the input trigger. Operation may consequently depend to some ex-

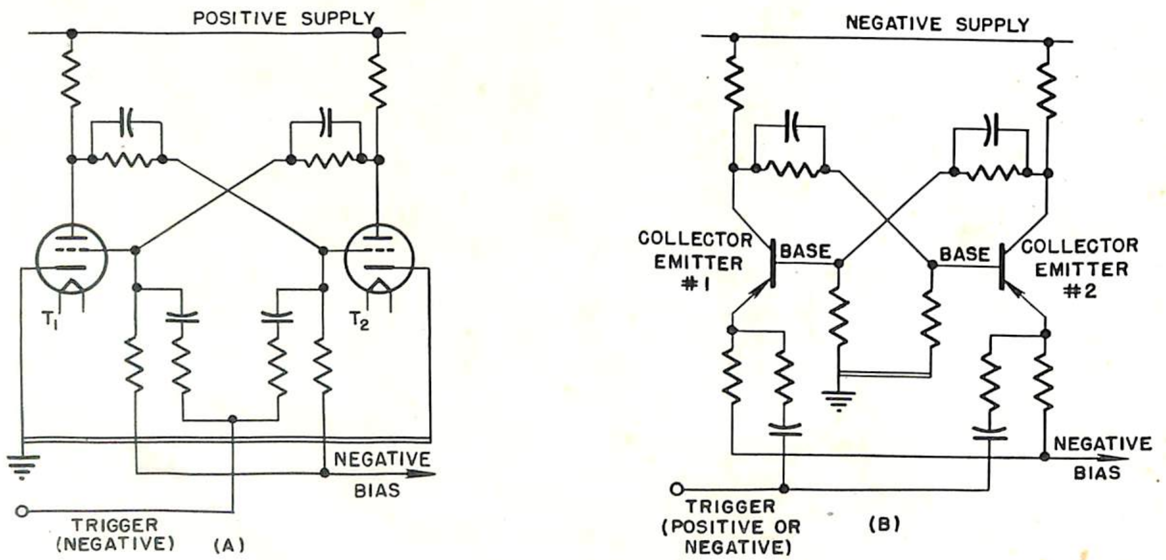


FIGURE 1—Comparison of transistor bistable multivibrator (b) with Eccles-Jordan circuit (a).

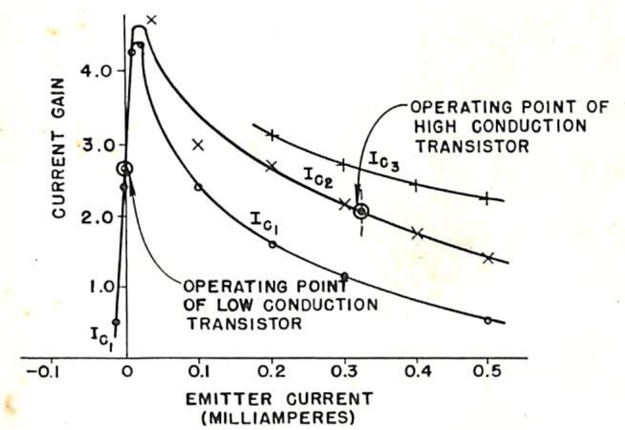


FIGURE 2—Transistor current gain as a function of emitter current. Curves for three values of collector current are shown.

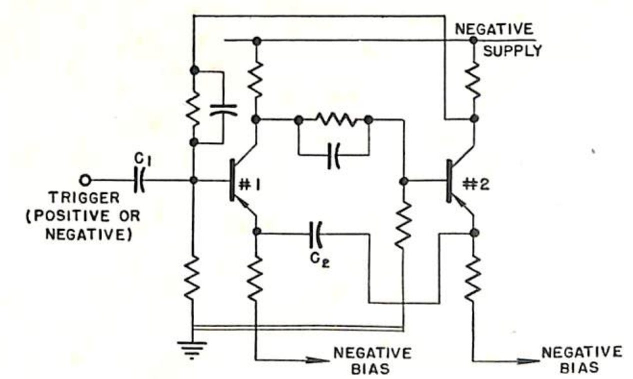


FIGURE 3—Variation of the basic transistor bistable multivibrator.

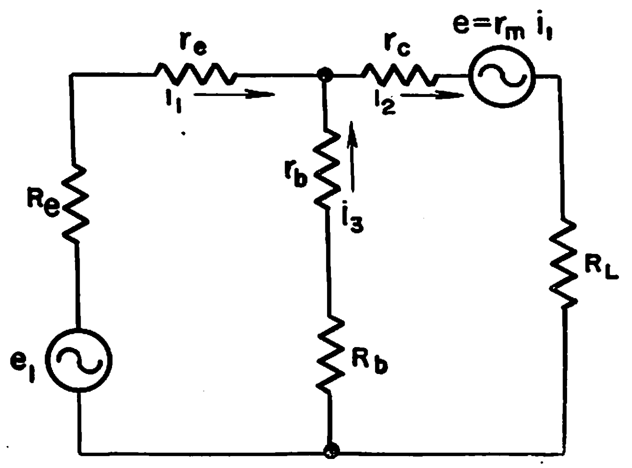


FIGURE 4—Schematic showing transistor equivalent T network with resistors in base and collector and a voltage generator in the emitter circuit.

tent on the shape of the trigger pulses. From a practical standpoint, however, this limitation is not severe and in several applications the modified circuit of Figure 3 has been found somewhat more stable than the circuit of Figure 1. Typical values using a supply voltage of 45 volts for this circuit are:

Collector Resistance	5,000-25,000 ohms
Feedback Resistance	10,000-50,000 ohms
Base Resistance	2,000-10,000 ohms
Emitter Resistance	500- 5,000 ohms

General Design Considerations

The multivibrator circuits that have been discussed above depend to a large extent on the direct-current characteristics of the transistors. Since these characteristics vary considerably between transistors, the circuits may often be asymmetrical for best operation. Both the circuits described are quite critical with respect to the values of the base resistors and emitter biases. However, once the proper constants are obtained and the circuit is operated from a single power supply, stability with respect to the supply voltage and the trigger amplitude is comparatively good. Variations of ± 10 to 20 per cent in supply voltage, and of several hundred per cent in trigger amplitude are usually permissible. Good operation can usually be obtained with trigger voltages as low as ½ volt.

The speed of transition from one state to the other varies considerably with different transistors. For units having good high-frequency response, the transition period (one direction only) may be between .25 and .1 microsecond while other transistors may give transition times as large as 2 microseconds. The circuit of Figure 1b was operated as a bistable counter up to about one megacycle. The operation at 500 kilocycles appeared to be quite satisfactory although the wave shape at one megacycle was hardly good enough to be differentiated into usable output pulses. However, by choosing transistors carefully it appears quite possible to build a circuit of this type to operate at frequencies up to one megacycle.

The transistor circuits shown in Figure 1 and Figure 3 were designed to operate at 45 volts. The current required is usually five to seven milliamperes resulting in a power drain of close to 250 milliwatts per stage. However, it is believed that this figure can be cut by a factor of two to four if lower supply voltages are used.

Bistable Multivibrator Using One Transistor

As mentioned above, it is possible to devise a bistable multivibrator using only one transistor. This circuit is of particular interest in that it differs considerably from those possible with vacuum tubes. In order to show clearly how this multivibrator can have two stable states the equivalent circuit approach, combined with measured curves of the transistor constants, will be used. It should be pointed out that although this analysis makes use of "small signal" or alternating-current transistor constants it is valid since these constants are measured over the entire range being explored and are only applied point by point to predict stability.

Figure 4 is a schematic using the T network, alternating-current equivalent circuit and showing a transistor with constants r_e, r_b, r_c, and r_m connected to a load resistance R_L, a base resistance R_b and an emitter resistance R_e. A source of driving voltage e_1 is shown in the emitter circuit. The application of Kirchhoff's laws to this network yields three independent equations whose solution gives the three currents. The output current i_2 can be shown to be:

$$i_2 = e_1 \frac{r_m + r_b + R_b}{(r_e+R_e)(r_c+R_L+r_b+R_b) + (r_b+R_b)(r_c+R_L-r_m)} \qquad (1)$$

Substituting r_b' for r_b+R_b and r_e' for r_e+R_e

$$i_2 = e_1 \frac{r_m + r_b'}{r_e'(r_c+R_L+r_b') + r_b'(r_c+R_L-r_m)} \qquad (2)$$

A point of instability obviously occurs when $i_2 \rightarrow \infty$ with e_1 finite or when

$$r_e(r_c+R_L+r_b') + r_b'(r_c+R_L-r_m) = 0, \qquad (3)$$

from which

$$r_m = \frac{(r_e'+r_b')(r_c+R_L)}{r_b'} + r_e'. \qquad (4)$$

This point is reached when the second term of Equation (3) becomes negative and equal to the first term. For this to occur r_m must be greater than $r_c + R_L$ and either r_b' or the difference between r_m and $r_c + R_L$ must be large. Note that both r_e' and R_L are positive terms and hence tend to preserve stability.

In the multivibrator circuit to be described, all circuit elements may be pure resistances, and a circuit identical with that of Figure 4 is obtained except that $e_1 = 0$. If R_b is made large enough and R_L and R_e small enough the conditions of Equation (3) can be satisfied in most cases so that the circuit becomes unstable. Both emitter and collector currents now tend to increase rapidly and would reach very high values if there were no limiting action. However several factors limit this increase. The positive resistances in both emitter and collector and the normal variation of r_m are all limiting factors. Referring to Figure 5, r_m (the solid curve) is shown to start low at negative values of emitter current, build up rapidly to a peak, (which occurs here at an emitter current of approximately 25 microamperes) and then decreases again as emitter current is increased still more. Curves for higher values of collector current would lie above the curve shown but will have approximately the same shape (see the current gain curves of Figure 2). Even at high collector currents the value of r_m falls quite low for high emitter currents. Consequently the regenerative process proceeds until the transistor is operating on the right-hand portion of its curve at higher emitter and collector currents.

The curves of Figure 5 and Figure 6 have been plotted to show how several factors combine to permit two stable states of operation. In Figure 5, the heavy curve is a plot of measured values of r_m for a certain transistor operated as indicated. Figure 6 shows the measured values of r_c and r_e for the same transistor over the same operating range. These values were obtained with very small alternating currents. The dotted curves of Figure 5 were plotted from the solution of Equation (4), hence they represent the values of r_m at the edge of stability. All r_m values higher than these indicate unstable conditions and lower values represent stable conditions. The point at which the actual r_m curve crosses the dotted curves determines where the transition from one stable state to the other would be expected to

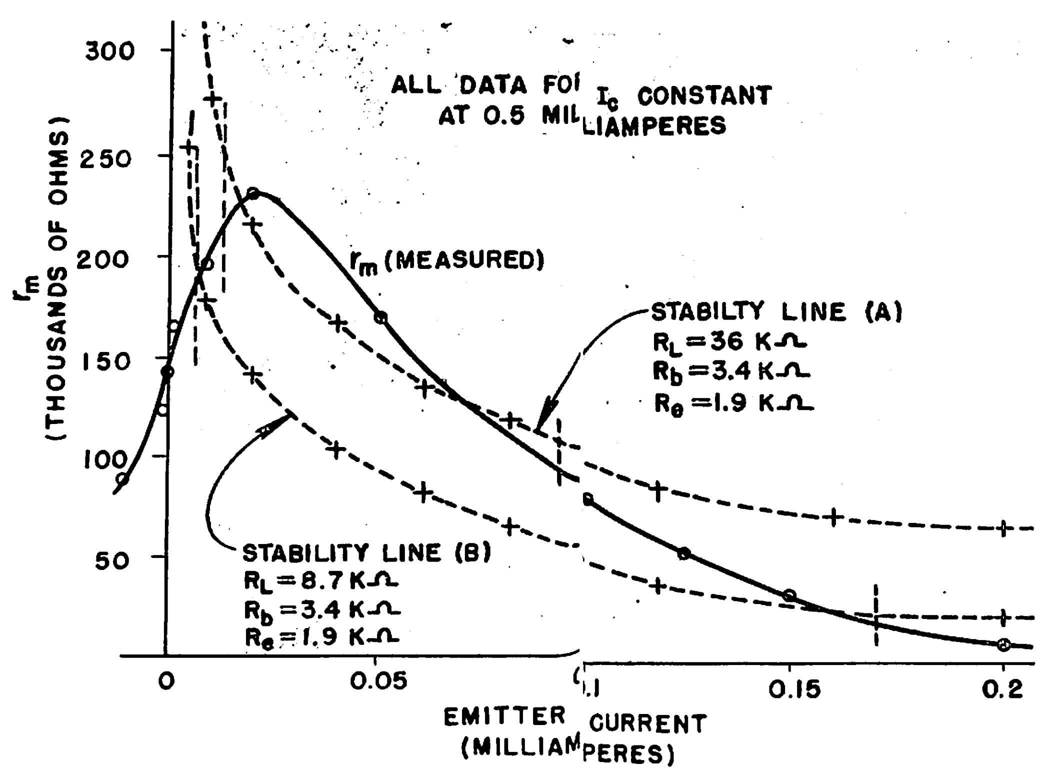


FIGURE 5—Curve showing r_m as a function of I_e and indicating stability limits for two values of R_L.

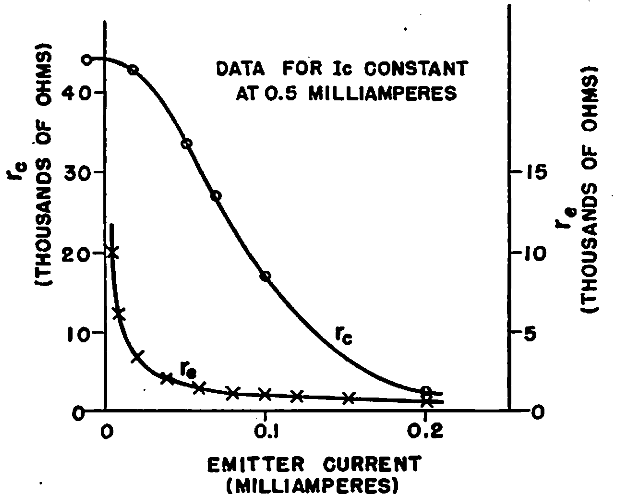


FIGURE 6—Plot of R_e and r_c as functions of I_e for the transistor of Figure 5.

start. Note that the dotted curves at low values of emitter current are controlled largely by the rapidly changing values of r_e, while at the right on the plot r_e is essentially the only remaining variable.

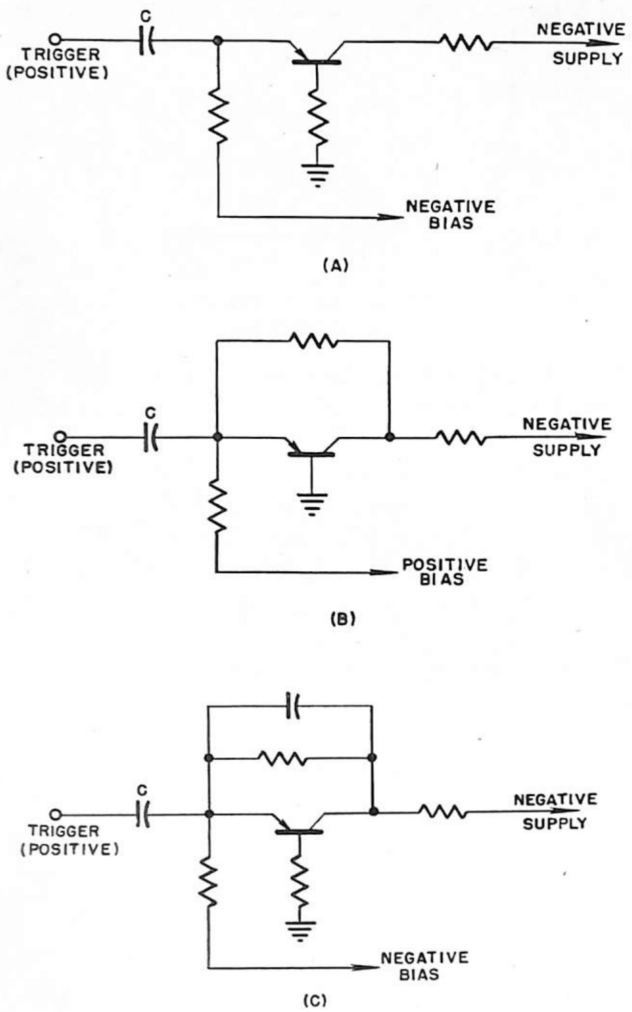


FIGURE 7—Basic single-transistor bistable circuits.

Experimental checks have been made of the transition points with the circuit constants of lines A and B. These points are indicated in Figure 5 by the short, vertical, dotted lines. Note that in every case the points occurred on the stable side of the predicted transition value. This discrepancy is very probably due to inherent transistor noise which causes the circuit to "trigger" over into the unstable region slightly before the conditions of Equation (3) are satisfied. As would be expected the agreement between the actual transition point and the predicted transition point is better on the low current side since the two curves intersect at a much steeper angle.

Thus, it has been shown that the existence of the two stable states and the transition from one to the other may be predicted with reasonable accuracy by the application of equivalent circuit theory and experimental measurements of the transistor constants. Although an analysis of a given bistable circuit by this method requires rather complete knowledge of the transistor characteristics it should nevertheless furnish valuable correlation between the commonly known transistor constants and this type of circuit operation.

Not all transistors have the high peak of r_m at low emitter currents as shown in Figure 5. As a result, not all transistors exhibit bistable operation in the circuits to be described. As indicated by Equation (4) the condition of instability is satisfied with a minimum value of r_m when R_L and R_e are both zero. Even under these conditions, transistors having r_m curves without the peak of Figure 5 do not exhibit two stable states.

Figure 7a shows the basic circuit suggested by the mathematical analysis. Figure 7b shows another circuit which is capable of two stable states by virtue of the positive feedback directly from collector to emitter. Those familiar with the transistor field will recognize that the addition of this feedback path is very similar to increasing the r_b of the transistor equivalent circuit, therefore, the circuit of Figure 7b may be analyzed in much the same manner as that of Figure 7a. The former has a disadvantage in that a high impedance collector is coupled back to a low impedance emitter. It has been found that a circuit combining both of these principles is somewhat more stable than either circuit by itself. Such a circuit is shown in Figure 7c. Here a capacitor has been included across the feedback resistor from collector to emitter. This increases the high frequency coupling between emitter and collector and tends to decrease the transition time from one state to the other. In all of these circuits, triggering has been shown on the emitter by means of positive input pulses. It is obvious that this will produce the transition from low conduction to high conduction. However, the change from high conduction to low conduction may only be accomplished by a negative pulse. This is obtained by allowing the input pulse to develop a negative overshoot by differentiation. Hence, in the circuit shown, differentiation must occur in condenser C for the circuit to trigger from high conduction to low conduction. This might seem to introduce dependence on input pulse width and shape, however, as in the two-transistor circuits, impedance changes at the emitter tend to aid the desired effect (See the emitter impedance curve of Figure 6) and from a practical viewpoint the circuit has good stability.

Figure 8 shows one complete stage of a decade counter. This is the circuit found most satisfactory as a single-transistor counter stage. The circuit of Figure 7c has been modified slightly by the introduction of the trigger pulses to the collector, the addition of a capacitor from collector to ground, and the addition of a crystal diode which passes a single positive pulse to the next stage. In this case, triggering from high to low conduction is obtained by differentiation of the pulse which appears on the emitter, and integration of the pulse which appears on the collector. The combination of these two effects gives good trigering from high to low conduction and the circuit does not seem to be unduly sensitive to either trigger amplitude or shape.

Operationally, the single-transistor counter stage exhibits somewhat the same characteristics as the two-unit circuit. Constants are quite critical for a given transistor but when the complete circuit is in operation from a single voltage source good stability with respect to trigger amplitude and supply voltage is again obtained. Typical circuit constants for operation with a 45-volt supply are:

Collector Resistance	10,000-30,000	ohms
Base Resistance....	3,000-10,000	ohms
Feedback Resistance	15,000-50,000	ohms
Emitter Resistance..	500- 5,000	ohms
C_2	100- 500	micromicrofarads
C_3	100- 800	micromicrofarads

The transition time from low conduction to high conduction is quite rapid. For transistors with good high frequency response it may be 1/10 microsecond. From high conduction to low the transition time is apt to be longer and will of necessity start at the trailing edge of the trigger pulse. This tends to limit the upper frequency of operation. A single stage as shown in Figure 8 (except that the diode circuit has been omitted) was operated successfully up to 250 kilocycles. It appears probable that with a carefully selected transistor such a circuit could be operated at frequencies up to 500 kilocycles.

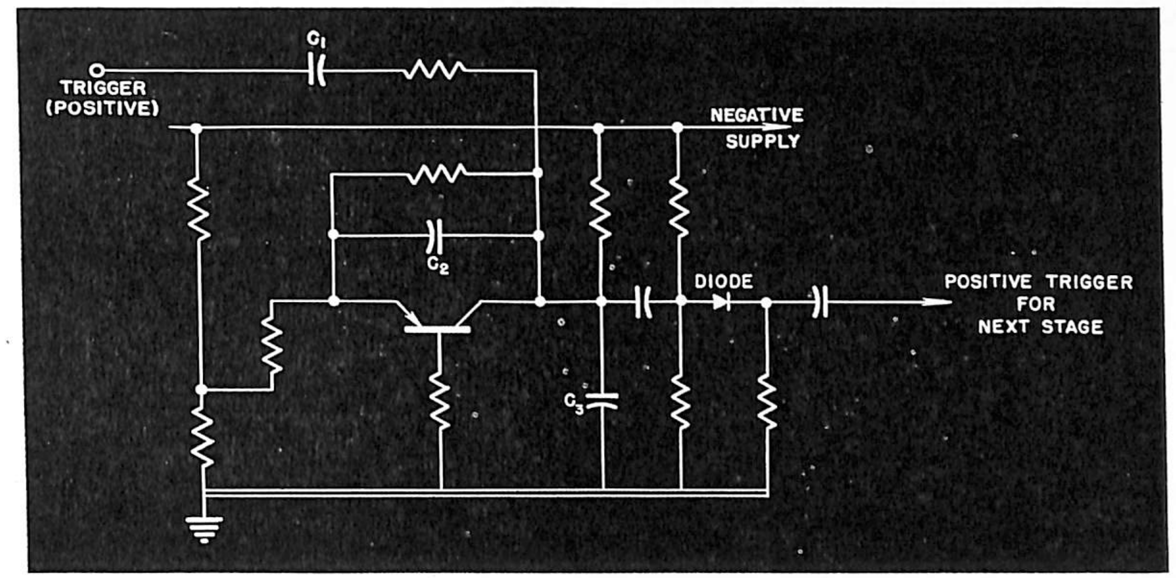


FIGURE 8—One stage of a pulse counter.

When operated from a 45-volt source this circuit takes a current of about two milliamperes for a power drain of 90 milliwatts. Here again, a considerable power saving might be effected by reducing the supply voltage. A circuit similar to Figure 7c has been operated as a single-stage counter with a three-volt supply.

Other Counter Circuits

For many counter applications circuits other than the bistable types just described, are required. These circuits fall into two general classes, astable and monostable (astable referring to the free-running type, and monostable referring to the type that must be triggered once for each cycle of operation). In general, the circuits to be discussed may be either of these types, depending upon the bias voltages applied. While multivibrators of these types using two transistors have been built, they seem to have no advantage over circuits that use one transistor; consequently only the latter will be discussed here.

These circuits also have the requirements for oscillation stated mathematically in Equation (3). However, in this case, the transition from one stable state of conduction to another is accomplished by incorporating a time constant (either RC or RL) into the circuit. These circuit constants compel the unit to pass into the unstable region (indicated in Figure 5) at regular intervals. When operated in a monostable condition the circuit is so biased as to have one continuously stable state.

Triggering pulses must then be provided to drive the unit into the unstable region.

Three basic astable or monostable oscillator circuits are shown in Figure 9. The circuits of Figures 9a and 9b differ from the bistable multivibrator of Figure 7a only by the addition of shunt capacitance in the collector of the emitter. The circuit of Figure 9a functions in much the same manner as a single gas-tube oscillator. When in an astable condition, condenser C alternately charges and discharges. It charges when the transistor is in its low conduction state and discharges when the transistor is in its high conduction state. This action produces a sawtooth collector voltage wave and approximately rectangular pulses at the base and the emitter. Synchronization may be achieved by the introduction of an external pulse somewhat before the time the circuit would normally reach the transition point. For this purpose, positive pulses may be applied to the emitter, or negative pulses may be applied to the base.

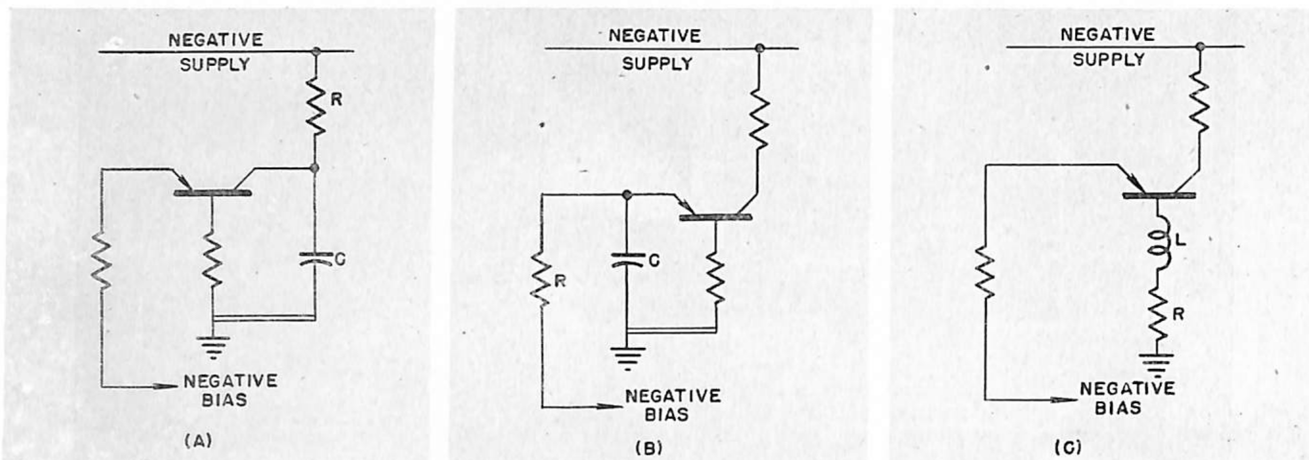


FIGURE 9—Three basic relaxation oscillator circuits.

In the circuit of Figure 9b, the time constant is employed in the emitter circuit. However, its operation is similar to that of the circuit of Figure 9a, except that in this case the capacitance charges to its greatest negative voltage while the transistor is in a state of high conduction.

A somewhat different type of operation is characterized by the circuit of Figure 9c. Here an inductance replaces the resistance in the base, and frequency is determined by the time constant afforded by L and the resistance of the transistor and its associated components. Operation is brought about by the voltage variation on the base caused by the change in the rate of current flow through the inductance as the unit passes through the unstable region.

These circuits have an unusual feature in that they may be designed to be quiescent either in high or low conduction. This follows from the peaked r_m and current gain curves shown in Figures 2 and 5. The low current condition is generally preferred in practice, due to its greater inherent stability and for reasons of power economy. For triggering at a given point in the circuit, the two modes of operation offer a degree of freedom in selecting trigger pulse polarity. Generally speaking, this is not a great advantage because the oscillator may be triggered by a pulse of either polarity depending upon the point of application. In a like manner, a pulse of either polarity may be obtained from each operating condition depending upon where the output is taken. In general, output pulses of from one microsecond to several thousand microseconds in width are available from these circuits. Astable operation can readily be obtained up to frequencies of at least three megacycles.

Frequency Divider Circuits

The relaxation oscillator circuits described above have, with some modifications, been found to be suited to frequency division of pulses. This requires that they be operated in an astable condition and synchronized with incoming pulses. Without further modifications, each of the circuits of Figure 9 may be useful for dividing by two, three or four with some degree of stability, but for a division rate of more than four some means must be found to stabilize operation.

To this end several stabilized divider circuits have been devised. The simplest scheme is shown in Figure 10. Greater stability has been achieved here by the use of two RC networks. The circuit may be triggered by positive pulses on the emitter as shown, or by negative pulses on the base. Triggering may also be accomplished by the application of negative pulses to the collector, but this scheme is not as desirable as the other methods,

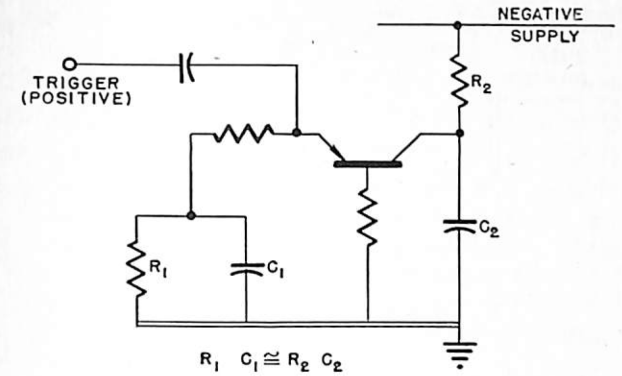


FIGURE 10—Frequency divider stage using two RC circuits.

since a pulse of greater amplitude is required. Even better stabilization may be obtained by adding an inductance as suggested by Figure 9c.

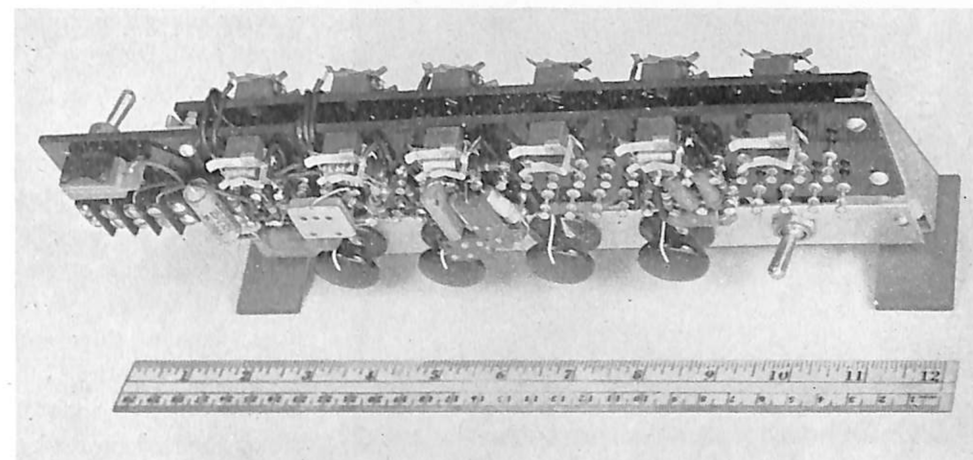


FIGURE 12—An experimental decade counter using only transistors and crystal diodes. (Four unused sockets are shown.)

Figure 11 indicates a divider circuit exhibiting very stable properties. RC networks are employed as shown in Figure 10 and the base impedance is replaced by a parallel resonant circuit. Greatest stability is obtained if the time constant of the emitter circuit (R_1C_1) is made approximately equal to the time constant of the collector circuit (R_2C_2) and the resonant frequency of the tuned circuit is made equal to, or some multiple of, the desired output pulse repetition rate. When the circuit is triggered an oscillation is set up in the base resonant circuit, observable in Figure 17c. When this circuit is adjusted so that triggering occurs on a negative going portion of this sine wave, a considerable degree of stabilization may be obtained. This particular circuit is especially useful since it is capable of dividing by ten with good stability and up to 40 with decreasing reliability.

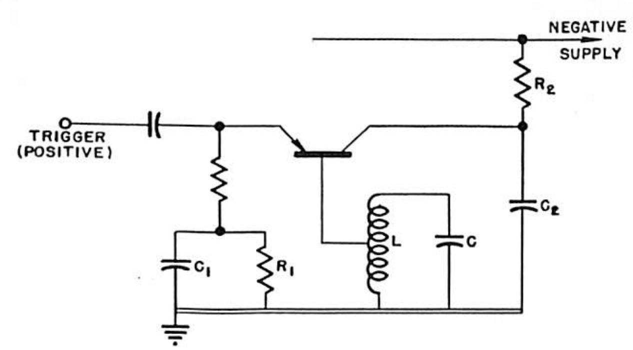


FIGURE 11—Frequency divider stage using two RC circuits and a resonant base circuit.

The divider circuits discussed here exhibit exceptional power economy each requiring from 0.5 to 1.5 milliamperes or a power drain of 25 to 60 milliwatts. This includes power dissipated in load resistors. Positive triggering action can usually be obtained with half-volt pulses applied to either emitter or base. These circuits have one disadvantage in that the high transistor noise tends to introduce a variation in the time delay of the output pulse. This variation accumulates and may amount to a few tenths of a microsecond after the pulse has been passed through several divider stages.

Demonstration Circuits

Two experimental counters employing the circuits suggested above have been built to indicate possible fields to which the transistors may be applied. One of these is a decade counter and the other a frequency divider. The first to be discussed will be the decade counter.

A photograph of the counter is shown in Figure 12. It consists of a series of four bistable and two monostable multivibrators. They are arranged as indicated in the block diagram of Figure 13. Voltage wave forms which

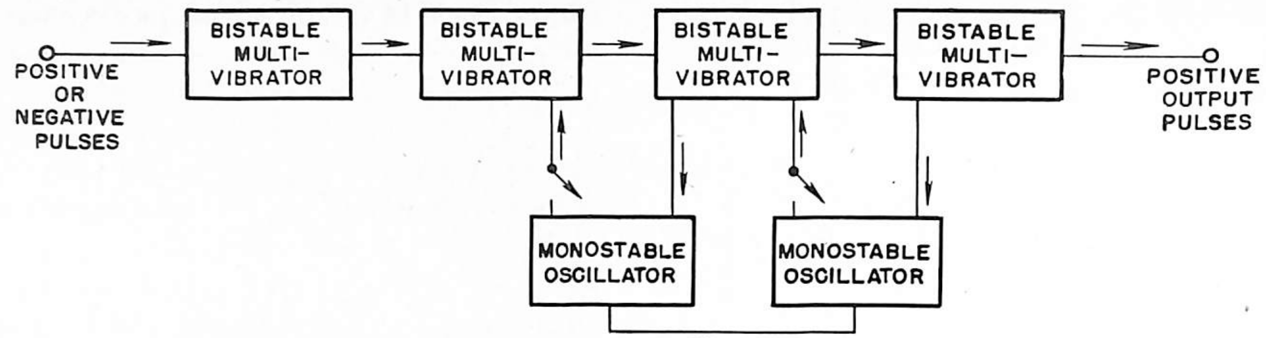


FIGURE 13—Block diagram of experimental decade counter.

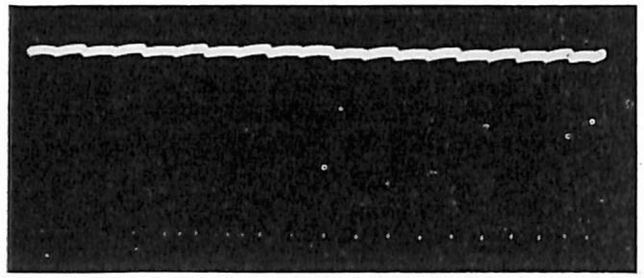


FIGURE 14a—Input pulses to counter (1 kc).

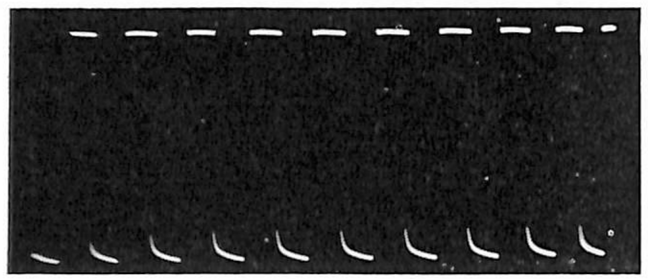


FIGURE 14b—Voltage wave on the collector of the second transistor of the first stage.

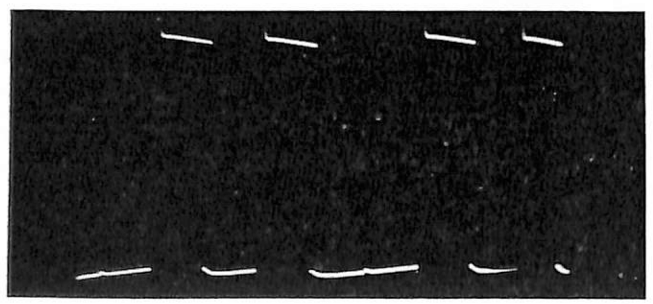


FIGURE 14c—Voltage wave on the collector of the second transistor of the second stage. Note the sharp pulse when this unit is stepped back.

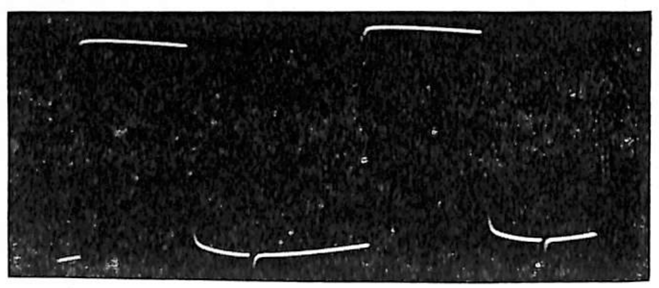


FIGURE 14d—Voltage wave on the collector of the third stage. Note the sharp pulse when this unit is stepped back.

are present at various points in the circuit are shown in Figure 14.

The input to the first stage of the counter may be either positive or negative pulses. Successive stages are triggered by positive pulses obtained by differentiating the collector square wave. Crystal diodes are used between stages to eliminate undesired parts of this differentiated wave. The first two stages are double transistor units of the type shown in Figure 3 while the last two are single transistor units of the type shown in Figure 8.

A cascade of four bistable multivibrators will give one output pulse for every 16 input pulses. As is common practice in this art, in order to change this count to one in ten, two feedback circuits are added as indicated in the block diagram. Switches are provided to switch the feedback in and out. Monostable oscillators, as indicated in Figure 9a, are included in these feedback circuits in order to isolate the stages from each other and to obtain a pulse of sufficient amplitude to retrigger a preceding stage. Both of these monostable circuits are triggered with negative pulses obtained by differentiation of the bistable collector wave shape. Those acquainted with this method of feedback in decade counters will recall that there is a possibility of returning a pulse through the first feedback circuit at the moment that the second feedback circuit is stepping the counter back. To avoid this difficulty, a blanking pulse is coupled from the second monostable oscillator to the first in such a manner as to stop the first from triggering at the undesired moment.

Because of changes in the direct-current characteristics of the transistor with both time and temperature, it was found desirable to incorporate several variable elements into the counter. These controls which may be observed along the base of the stand in Figure 12, are used to vary the bias on individual units. Generally speaking, some of the controls may have to be adjusted each time the counter is started. Once started, several further adjustments may be necessary until the transistors reach a stable condition. Once this point is reached, little further adjustment is needed except when there is a large change in the ambient temperature.

The counter of Figure 13 would operate only in the frequency range of 500 cycles to about 10 kilocycles. However, these limits were set by circuit constants rather than by limitations of the transistors. The entire circuit operates from a 45-volt supply and requires about 850 milliwatts of power. This by no means represents the minimum power consumption possible. Operation at a lower supply voltage and the use of only single unit multivibrators would both tend to reduce the power drain.

The second experimental counter constructed is the frequency divider pictured in Figure 15. The block diagram of Figure 16 indicates the arrangement of the nine transistors used in this circuit. The photographs of voltage wave forms present at various points in the circuit are shown in Figure 17.

The first stage of this circuit is a crystal-controlled oscillator operating at 100 kilocycles. The sine wave output is employed to drive a pulse generator whose circuit is similar to that of Figure 9c. This stage produces positive pulses at the frequency of the oscillator. As indicated in Figure 17b the output from this stage consists of sharp pulses having a rise time of less than 1/4 microsecond. The frequency of these pulses is next reduced by a factor of ten in a divider circuit as shown in Figure 11.

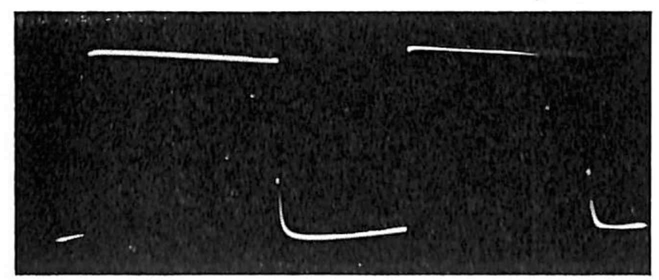


FIGURE 14e—Voltage wave on the collector of the fourth unit.

The following two stages are similar to the circuit of Figure 10 and each divides the frequency by five. At this point, the variation in delay introduced by the noise of the preceding stages, has become appreciable. Accordingly, in order to preserve the inherent stability of the crystal oscillator, the principle of selecting one of the original sharp pulses with a gate pulse is employed. This is accomplished in two stages, the first of which is a monostable oscillator, and the second a coincidence amplifier. The gate pulse (about 12 microseconds wide) and pulses from the pulse generator are mixed at the emitter of the coincidence amplifier. Note the resemblance between the voltage wave forms in Figures 17b and g. The frequency of the gated pulse is 400 cycles per second. The following two units each divide this frequency by four giving output pulses at 25 per second.

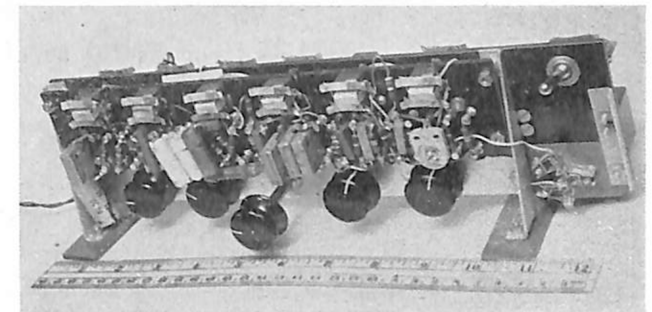


FIGURE 15—Frequency divider: The last three stages are mounted on the reverse side. The base of the 100-kc crystal may be observed mounted at the lower right.

For the same reason as in the decade counter, it was found desirable to include several variable elements. In Figure 15, these controls may be observed along the lower portion of the chassis. Usually some minor adjustment has to be made to one or more of these controls each time the divider is started. In general, once operating, no further adjustment is necessary. It appears that these circuits are not as critical to temperature changes as the bistable circuits of the first experimental counter.

The entire circuit, operating from a 45-volt source, draws about 675 milliwatts of power. As before it is reasonable to suppose that the divider could be designed to operate at a much lower power consumption.

FIGURE 14—Wave forms taken at several points in the experimental decade counter.

Conclusions

This investigation shows that transistors can be used in several basic types of relaxation oscillators. In fact, some of their unique characteristics make possible the design of circuits having greater flexibility than an analogous vacuum-tube circuit. These characteristics allow the circuits to be stable in either high or low conduction and to be triggered by either positive or negative pulses at the same input point. The experiments demonstrated that the power capabilities are adequate for operating one stage into the next and that the average frequency response is good enough to allow counter operation to at least one megacycle. The high internal noise of the transistor may produce a variation in the circuit delay but this is not an unsurmountable problem. However, present transistors have two faults that prohibit their application to practical counters. One of these is their instability with respect to time and temperature and the other is the very wide variation in characteristics between different units. When these difficulties are overcome, the transistor should find widespread application in this field.—*RCA Review*

FIGURE 16—Block diagram of experimental frequency divider.

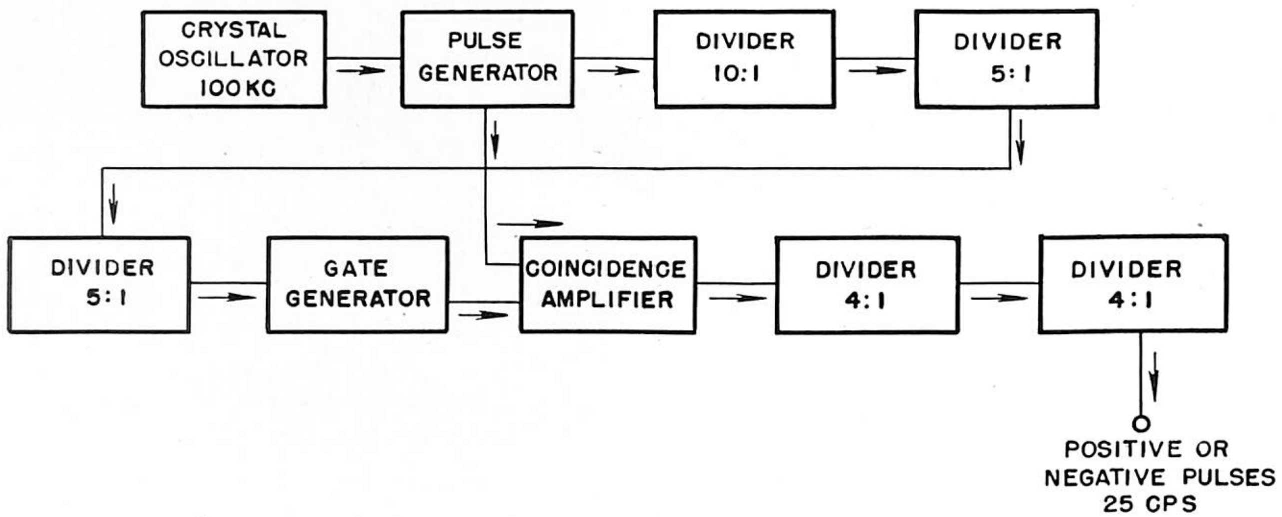


FIGURE 17—Wave forms taken at several points in the experimental frequency divider.

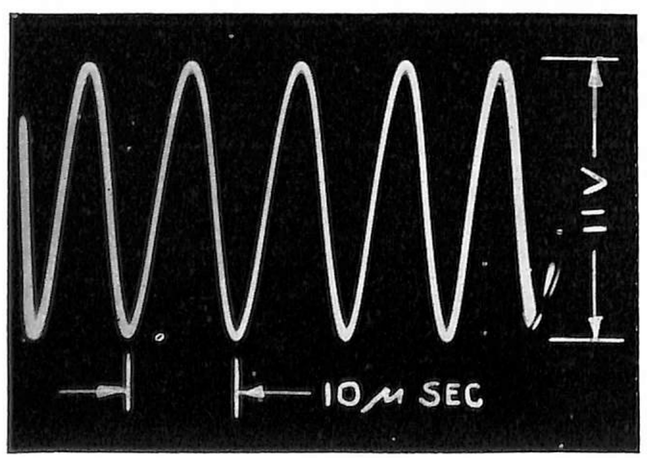


FIGURE 17a—Sine wave on the emitter of the crystal oscillator.

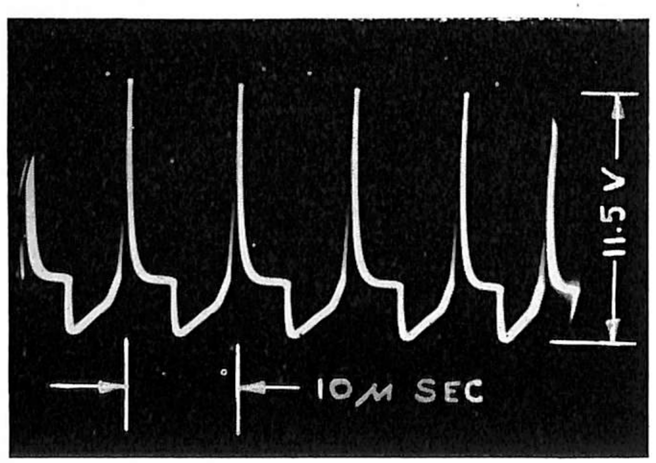


FIGURE 17b—Output pulses of the pulse generator after differentiation.

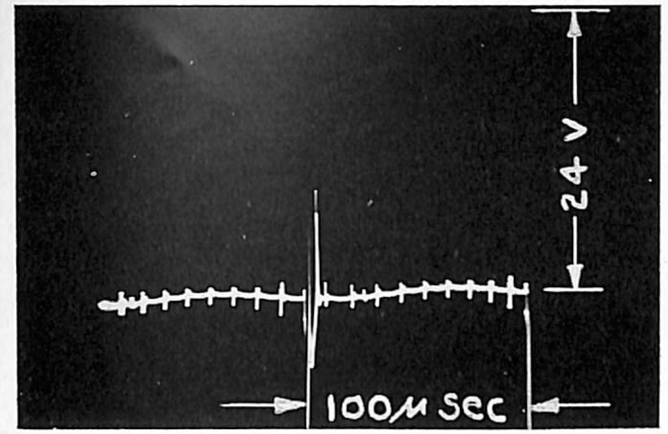


FIGURE 17c—Voltage wave on the base of the first divider. Note the sine wave of the base resonant circuit.

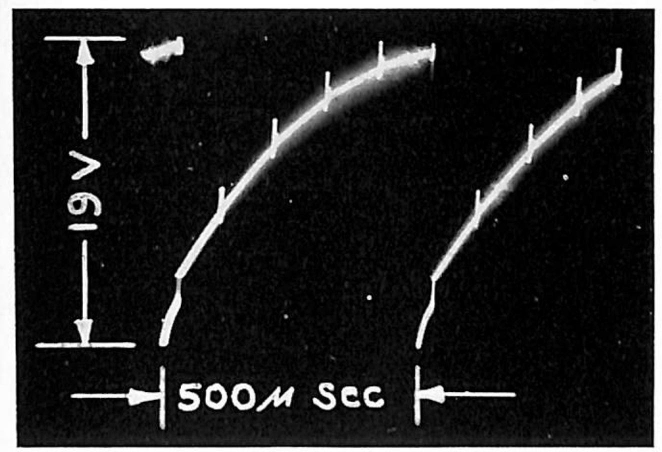


FIGURE 17d—Voltage wave on the emitter of the second divider.

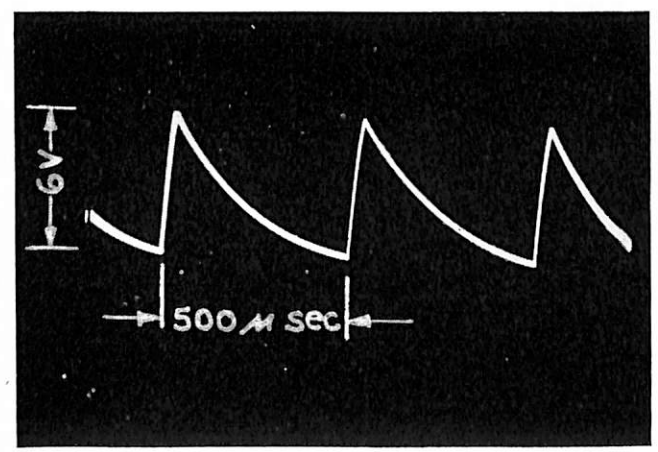


FIGURE 17e—Voltage wave on the collector of the second divider.

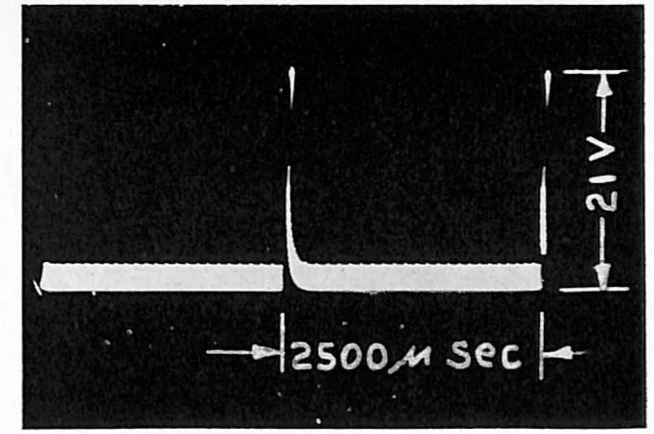


FIGURE 17f—Gating pulse at the collector of the gate generator.

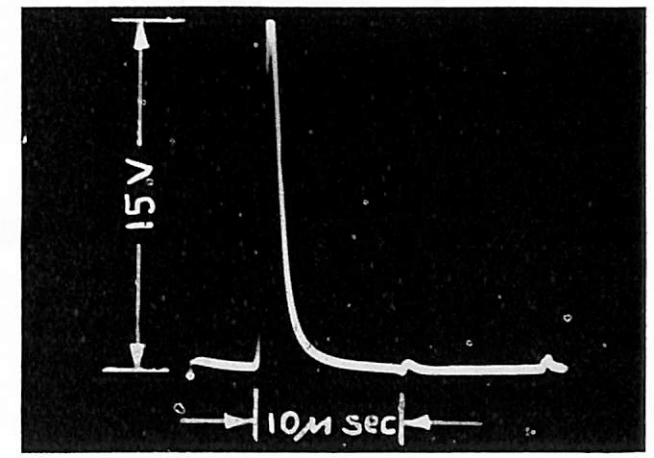


FIGURE 17g—Output pulse at the collector of the coincidence amplifier. Note residual pulses not in coincidence with gating pulse.

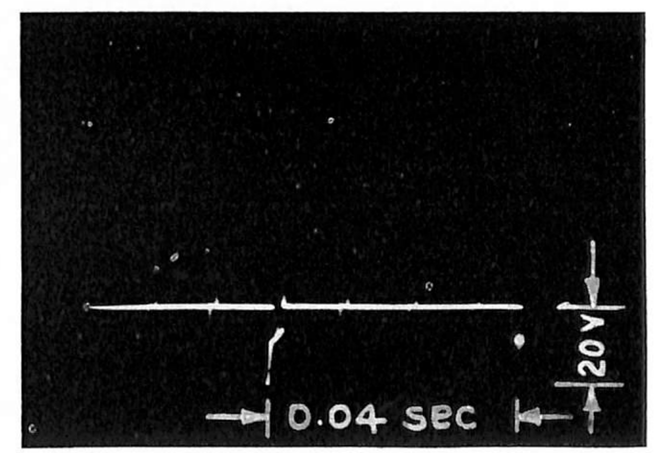


FIGURE 17h—Voltage wave at the base of the last divider. A strong positive pulse, too rapid to show here, is present at the trailing edge of the negative pulse.

USN USL notes

A UNIVERSAL ARRAY SIMULATOR

The investigation of various problems relating to sonar beam formation can be facilitated by means of a laboratory device which will simulate the signals arriving from a group of transducer elements receiving energy from an underwater sound source. Devices of this nature, operating on various principles, have been utilized in the past, and each has had its own advantages and limitations. With these advantages and limitations in mind, T. G. Bell, of the Underwater Sound Laboratory staff, has devised a method of simulation which combines certain desirable features and makes possible a number of new applications for this type of instrument.

Included in the array simulator are the following advantages:

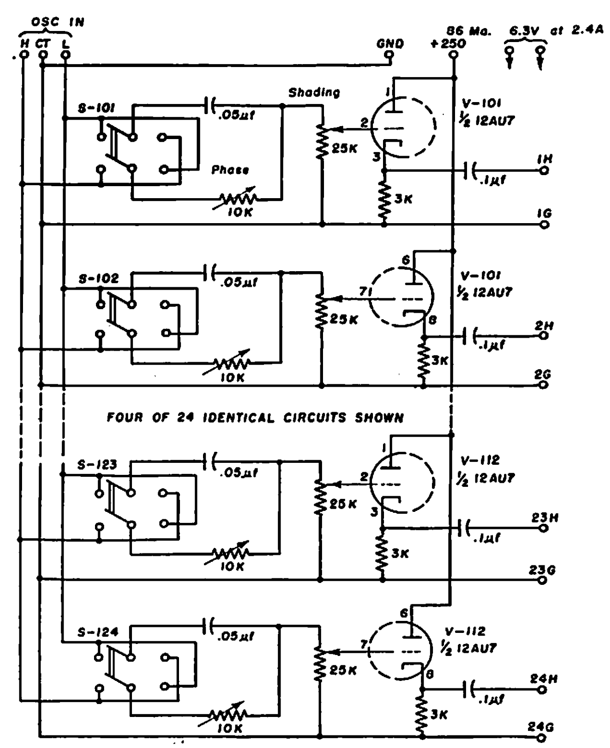
1—Any given orientation of the elements of the array with respect to the sound source can be simulated.

2—The phase and amplitude of each signal can be adjusted as precisely as standard measuring methods will allow.

3—The device may be used at any single frequency commonly employed in sonar systems.

4—The circuit is simple and economical to construct, and the unit is reasonable with respect to size and weight.

The simplicity of the circuit (see Figure 1) is illustrated by the following brief description of the manner in which it functions. A center-tapped low-impedance oscillator output feeds 24 conventional reactance-bridge phase-shift sections. Each section is adjustable over 180° of phase shift, and a reversing switch permits a 180-degree addition, with the result that a full 360° of phase shift is covered. Isolation from the load is achieved by a cathode-follower output for each circuit, and the necessary shading is introduced in the grid circuit. The cathode resistance is made high enough to keep the total B+ current required below 100 milliamperes. An output impedance of the order of 800 ohms is furnished by the cathode-follower circuit.



NOTES:
1.—RESISTORS ½ WATT.
2.—CAPACITOR VOLTAGES DO NOT EXCEED 10 VOLT PEAK.
3.—10K POTS ARE LOGARITHMIC.

FIGURE 1—Circuit diagram of array simulator.

The most efficient procedure for adjusting the phases and amplitudes is as follows:

1—Determine the desired attenuations and relative phase lags for the simulator output signals and convert the phases to dial readings on a standard lag line.

2—Set up the phase-measuring equipment as shown in the accompanying block diagram, Figure 2.

3—Adjust all amplitude potentiometers for maximum signal output.

4—Set the phase for each signal by setting in the desired phase-lag value on a standard lag line and adjusting the corresponding phase potentiometer on the simulator until the scope indicates zero phasing difference.

5—Adjust the amplitudes by means of a Ballantine voltmeter.

When a low-impedance load is used, some change in phase may be noted as the amplitudes are adjusted. In this event, it may be necessary to adjust the phase settings slightly after the amplitudes have been set. The change in phase is caused by the fact that the cathode-follower bias, and therefore the output impedance, is affected by the grid resistance due to such effects as grid emission. If it is not possible to work into a high-impedance load, no phase change will take place.

Although the phase-shift sections were designed for 25.5-kc operation, they should be capable of operating at any of the common sonic or ultrasonic sonar frequencies. The simulator has been utilized in Laboratory investigations of interpolation errors caused by QHB scanning switches and in an empirical investigation of the effect of transducer phase errors on bearing accuracy. It is thought that other uses for the device will be suggested in the future.

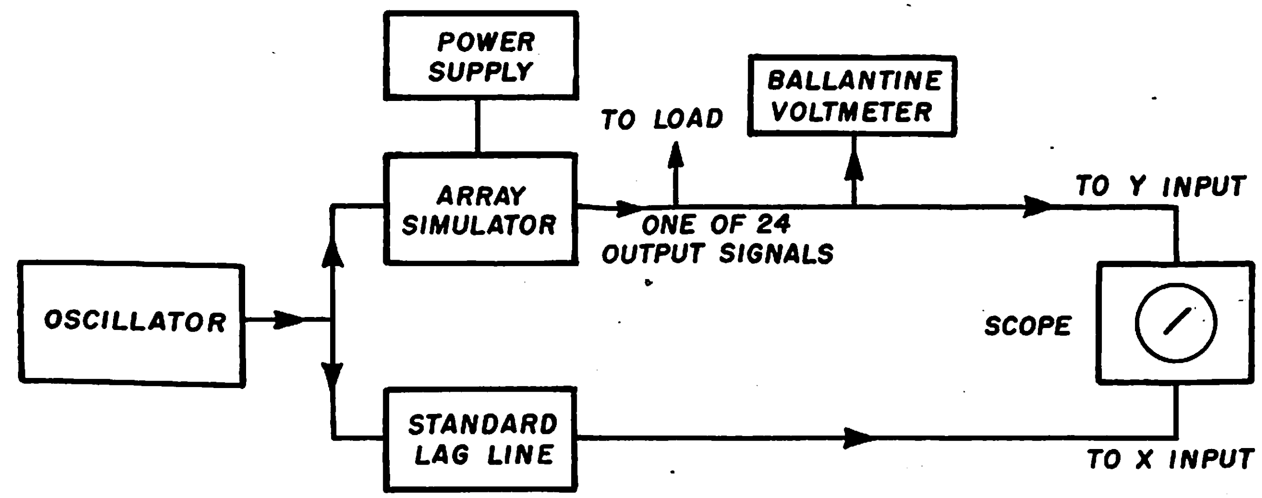


FIGURE 2—Setup for adjusting array simulator signals.

SUBSTITUTE MATERIAL FOR ANTENNA TRUNKS

The substitution of aluminum for copper-clad steel in the construction of shipboard radio transmitter antenna trunks is permissible when the latter is not readily available. This was authorized in Bureau of Ships multiaddress letter serial U-982-2107 dated 9 June 1948. Excerpts from this letter are reprinted below:

"The current general requirements for Radio Antenna Systems, Bureau of Ships Specification RE 66A 430B, specify that transmitter antenna trunks shall be fabricated from steel having a minimum thickness of .094″ and having a copper-nickel or copper plating of .008″ minimum thickness (two sides or inside only). A number of activities have reported difficulty in procuring this material (copper clad steel).

"In the future, when the above copper-clad steel is not readily available, it will be satisfactory to substitute aluminum for use in fabricating radio transmitter antenna trunks. The aluminum should be 61 ST 6 in accordance with Navy Specification 47A 12, condition T, and shall have a minimum thickness of .125″. The inside and outside of the fabricated trunks shall be treated with a zinc chromate primer, the outside to be painted as required."

R-F BAND DESIGNATION

In "Letters to the Editor" in the August, 1951, BuShips Electron magazine, letter and letter-sub-letter designations for the various r-f bands were given. It has come to the attention of the Chief of Naval Operations that confusion exists in regard to the letter and letter-sub-letter designations of radio-frequency bands and that there appear to be various systems in use.

Accordingly, except as specified below, the use of these letter and letter-sub-letter designations to indicate radio frequencies, or frequency bands shall be discontinued in official Naval communications and in lieu thereof, kilocycles, megacycles or the widely known band designations as listed below shall be used as appropriate:

Designation of radio waves according to frequency	Authorized abbreviations	Frequency in kilocycles per second
Very low	VLF	Below 30
Low	LF	30 to 300
Medium	MF	300 to 3,000
High	HF	3,000 to 30,000
Very high	VHF	30,000 to 300,000
Ultra high	UHF	300,000 to 3,000,000
Super high	SHF	3,000,000 to 30,000,000
Extremely high	EHF	30,000,000 to 300,000,000

The following broad band single letter designations only may be used as a matter of convenience in conversation or where reference to a general rather than a specific frequency is to be made such as in tactical publications or general instructions:

P 200-Mc region	X 10000-Mc region
L 1000-Mc region	K 30000-Mc region
S 3000-Mc region	V 50000-Mc region

THE ABOVE INFORMATION IS UNCLASSIFIED.

REACTIVATION OF CATHODE-RAY TUBES

During the testing of cathode-ray tubes received on roll-back by the Repair and Renovation Laboratory, Naval Supply Center, Oakland, California, it was found that approximately 90% of the tubes tested bad had low anode current and a very weak trace. Until recently these tubes have been surveyed as not fit for further use, at considerable financial loss to the Navy. Mr. Walter R. Noonan of the Repair and Renovation Laboratory suggested applying a voltage of 15 volts a.c. to the heaters, which normally operate at 6.3 volts a.c., and maintaining the higher voltage for a period of 15 seconds, thus reactivating the tube. When tested after this procedure a large majority of the tubes showed proper average current and a normally brilliant trace.

The Bureau of Ships and the manufacturer of the tubes concur in the adoption of this reactivation process, which is simple, rapid and may be done at the time of testing the tubes. Out of an original group of 860 tubes so treated 828 responded to this process.

The Bureau of Ships, however, while endorsing this procedure cautions all activities concerned that it is an emergency measure for Naval vessels and that tubes so processed should not be issued to Naval vessels where new tubes are available. The procedure is desirable and necessary because of the unknown life of the tubes and can be a routine one for fixed shore activities. However, ships should be provided with the best available tubes, i.e. new ones, whenever possible.

SURFACE VESSEL B/T RECALIBRATION PROGRAM

A report received from COMDESFLOT TWO enclosing a "Combined B/T Sounding Graph" and "Combined Oceanographic Log Sheet Entries", showed results of eight simultaneous bathythermograph readings taken at approximately lat. 36° 40′N, long. 74° 30′W. These simultaneous BT records differed so widely as to cause concern as to the accuracies of the instruments. It is noted, however, that these readings were taken in the Gulf Stream and while the ships were in column 500 yards apart. It might be reasonable to expect some variance in the readings at the edge of the Gulf Stream. Further, it is possible that ships in column would have a tendency to "mix" the water so as to affect the temperatures recorded by the BT of each succeeding ship in the column.

However, these tests indicate the desirability of frequent shipboard checks and periodic shipyard recalibrations of all BT's. Ship's force personnel should check the calibration of their BT's in accordance with the method given in Section 6 of NavShips 91151 and NavShips 91340, the instruction books for the Model OC series BT instruments. Inaccurate BT's as indicated in Section 3 of instruction books (zero shift more than 4° or shifts from reading to reading) should be turned in to the nearest E.O. for replacement.

In order to provide for periodic shipyard recalibration of all BT's, each BT should be turned in to the nearest E.O. for replacement after it has been on board eighteen months. The instruments will then be forwarded to one of the three BT repair faiclities (Boston, MI, or PH Naval Shipyard) for overhaul, recalibration, and return to stock.

STOCK STATUS, ISSUE OF COMMUNICATION HANDSETS

The Electronic Supply System is now stocking handsets separate from the associated plugs and cables. This allows handsets, formerly stocked as complete "sets" with cable assemblies and plugs included, to be stocked under one Navy type number instead of three. This Navy type number, representing the handset minus accessory plugs and cable assemblies, is NT–51007.

Cable assemblies CX–1846/U, and CX–1848/U are also stocked as separate units. The practice of stocking assembled handsets will be discontinued when the present stock is exhausted.

This handset, electrical connections and cable leads are color coded to facilitate wiring at the end activity. The cable assembly (plug included), the handset, or the cable and plug separately, are also available as units. The cable can be obtained in any specified lengths, but as part of CX assemblies it will be furnished 51½ inches in length. Breakdown information is as follows:

NT–51007	Handset unit	Stk. #N17–H–20001–1017
NT–51081	Handset complete	Stk. #N17–H–20001–1005 consists of:
	1—NT–51007 Handset unit	Stk. #N17–C–919761–103
	2—NT–49118 Cable	Stk. #N17–C–70600–1135
	3—Plug, Type AN–3106–14S–5P, with type AN–5037–6	Stk. #N17–C–781366–251 Cable Clamp
	Cable assembly comparable to items 2 and 3. CX–1846/U, BuShips dwg RE49B605–A	Stk. #N17–C–48695–3741
NT–51082	Handset complete	Stk. #N17–H–20001!1030 consists of:
	1—NT–51007 Handset unit	
	2—NT–49118 Cable	
	3—NT–49619 Plug	Stk. #N17–C–71512–3100
	Cable assembly comparable to items 2 and 3. CX–1847/U, BuShips dwg RE49B606–A	Stk. #N17–C–48695–3721
NT–51083	Handset complete	Stk. #N17–H–20001–1003 consists of:
	1—NT–51007 Handset unit	
	2—NT–49118 Cable	
	3—NT–49928 Plug	Stk. #N17–C–71483–5120
	Cable assembly comparable to items 2 and 3. CX–1848/U, BuShips dwg RE49B607–A	Stk. #N17–C–48695–3746
NT–51084	Handset complete	Stk. #N17–H–20001–1000 consists of:
	1—NT–51007 Handset unit	
	2—NT–49110 Cable	
	3—NT–49210 Plug	Stk. #N17–C–71189–6402

(NT–51084 will no longer be procured as a complete item, per BuShips speed ltr S67/16 (18) (839) serial 839D2–290)

Further breakdown of NT–49118 Cable:

1—Type MMOP–5	SNSN N15–C–10956–75, or GSO 15–C–10956–75
2—Solder lugs, RC part #K–819230 or equal	SNSN N17–T–26714–7705

REUSE OF VRF RECORDING FILM

A report has been received from Commander, Charleston Naval Shipyard, describing a method of reusing VRF recording film, which has been developed and used successfully at U. S. Auxiliary Air Station, Saufley Field, Pensacola, Fla.

After recording on one side of the tape has been completed, the tape is reversed in the following manner:

1—The operation requires two men, one for holding the tape to be reversed and one for reversing the tape.

2—Remove one turn from the inside and one turn from the outside of the tape to be reversed, to allow sufficient working length of tape during the rewinding procedure.

3—Reverse the tape, unwound in Step 2 above, so as to place the recorded face of the tape on the outside.

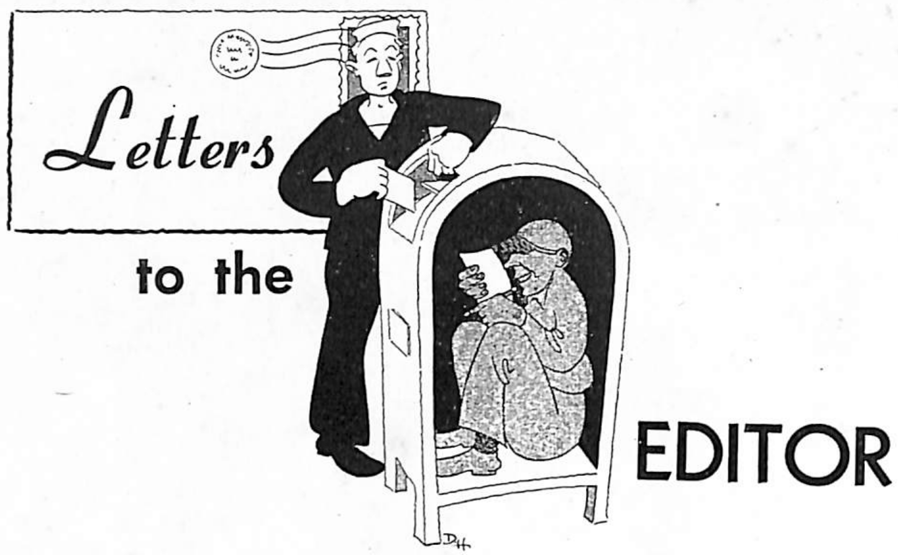
4—With the tape reversed, make a loop approximately the size of the roll to be reversed.

5—One man holds the tape with thumbs inside of the coil. Turns of the tape are then removed from the outside of the roll only, very much as unwinding yarn from a skein, until all of the tape has been rerolled with the tape reversed. If during the rewinding process, additional twists develop, the twists can be removed by manipulation of the tape as rewinding continues. With a little experience, the above process requires approximately 5 minutes per roll.

6—The reversed tape may be reinstalled in recording machines and utilized in the usual manner with reference to the green dot appearing on the tape.

Bureau comment: In some cases where adjustment and condition of the equipment permit, it is possible to reuse the reverse side of the film. This procedure is recommended only where a recording containing additional background noise can be tolerated and when the economy of reducing the cost of recording material is important.

Cellulose acetate film (clear) for IC/VRF–3 is available from GSSO under Standard Stock No. 17–F–1630.



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:

Considerable difficulty has been encountered on my ship in utilizing the Standard Navy Stock Number system for electronic maintenance parts due to the substitution of new numbers for old. Upon reactivation many parts were found to be deficient or unidentifiable.

Requisitions have been submitted for the deficient items using available stock numbers. As parts have come aboard they have been stowed by stock number. (It is sometimes necessary to consult many reference books in order to assign a stock number.) It has been discovered, however, that many of the numbers are new and do not appear in the allowance lists or the Stock Number Identification Tables. Hence with regard to use when the need arises, many of these parts may as well not be aboard.

I believe it would be of considerable help if lists were distributed which give the new stock numbers for those that have been changed; first a compilation to date, and then, periodically as changes are made.

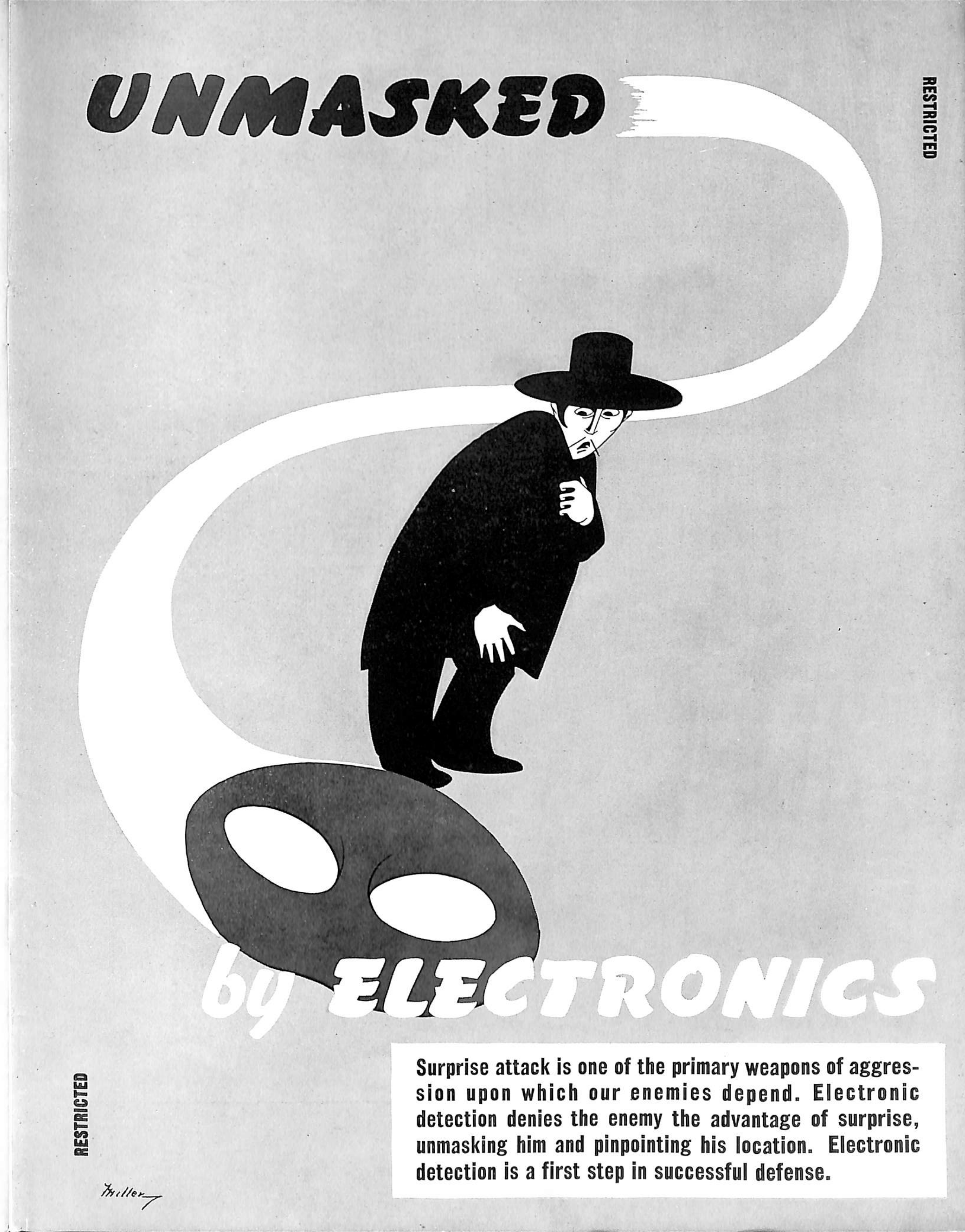
M. H. P., Ens., USNR

The following is quoted from "The Shipboard Integrated Electronic Maintenance Parts System", NavShips 900,168:

"D. Changes in SNSN. *SNSN assignments to electronic materials have been subject to changes beyond the control of the Bureau of Ships. Information on such changes is furnished by the Electronic Supply Office to certain supply depots and shipyards. Except for tenders and issue ships, other fleet vessels will be unable to keep currently correct Standard Navy Stock Numbers. Until purification of these numbers is achieved, issues of certain materials from stock will not be in agreement with requisition SNSN's. To insure delivery of the desired items, it is recommended that equipment application and circuit symbol be included on the requisition in addition to the SNSN. The latest SNSN appearing on an invoice will most likely be correct. If desired, ships may correct bin tags, allowance lists, stock records, etc., to correspond, until new allowance lists are furnished by the Bureau. As insurance, ships are advised to list both old and new SNSN's for requisitioned items."*

In addition to the above, make sure that you do not permit the correlation between old numbers and new numbers for parts aboard your vessel to become lost. If it does, many of your parts will become unidentifiable.

Editor



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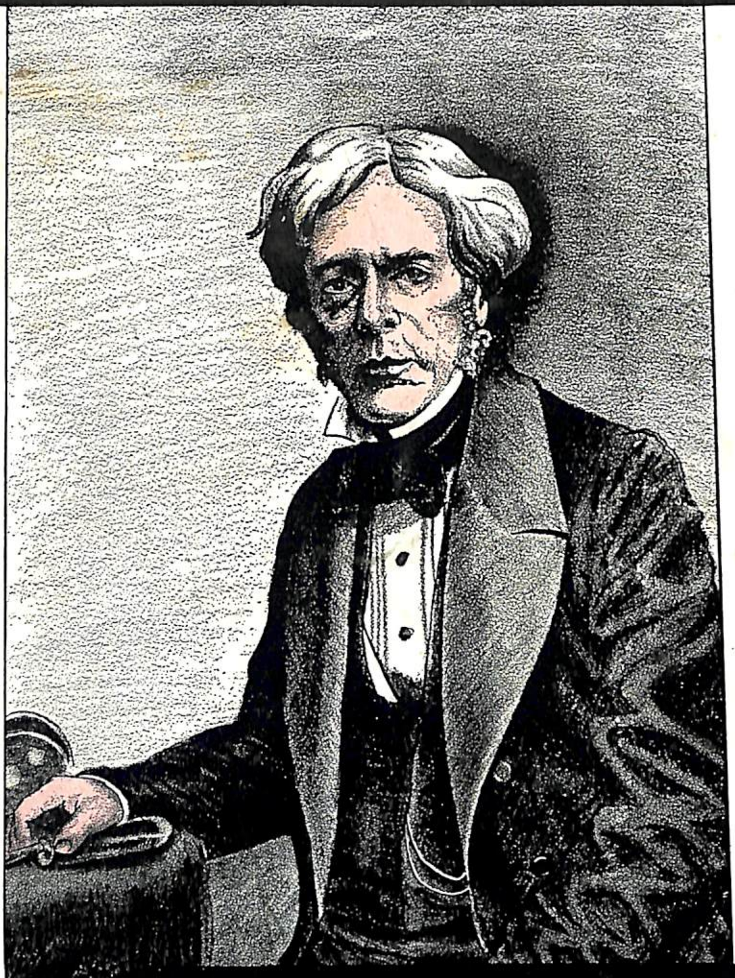

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Michael Faraday (1791-1867), a brilliant English physicist and chemist, is best known for his research in the field of magnetism and the relationship between magnetism and electricity. Faraday strongly suspected that some connection between electricity and magnetism existed. After many experiments he finally succeeded in proving the relationship when he plunged a bar magnet through a coil of wire and found that a current was generated in the wire by the motion of the magnet. This discovery has proved to be the basis for all electric motor and generator theory and many other electromagnetic devices. It was Faraday, also, who discovered the principle of the transformer. Without transformers nearly all modern electrical and electronic equipment which operates on alternating current, and the transmission of electric power over great distances would be impossible. The researches of Michael Faraday resulted in the discovery of some of the most fundamental principles of electricity and electronics.

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