operation electron

RMS Bellevue

RMS

OPERATION ELECTRON

Radio Materiel School

Bellevue Washington D.C.

OPERATION ELECTRON

The decision of the conference was clear.

Never in the history of the Navy would so few men be required to do so much—and those few men so difficult to obtain. The war had forced the services into fields they had never entered before—organization of millions of men, large-scale business, scientific research and development. The last had been the most productive, and one of its greatest products had been radio detection and ranging, the still-infant radar.

But just as complex as the scientific experiments on it was the mechanism itself. Its vacuum tubes, deflection tubes, tank circuits, ultra-high frequencies were understood by a very few. But, somehow, men had to be trained—and trained quickly—to use and maintain the new equipment.

This was the problem confronting the Navy Department in those early days. The answer: an educational project of a scope equaling that of a large university, an undertaking of a necessity and urgency only dimly realized even now when it is seen what would have happened to the military without the trained men who conducted the scientific campaigns.

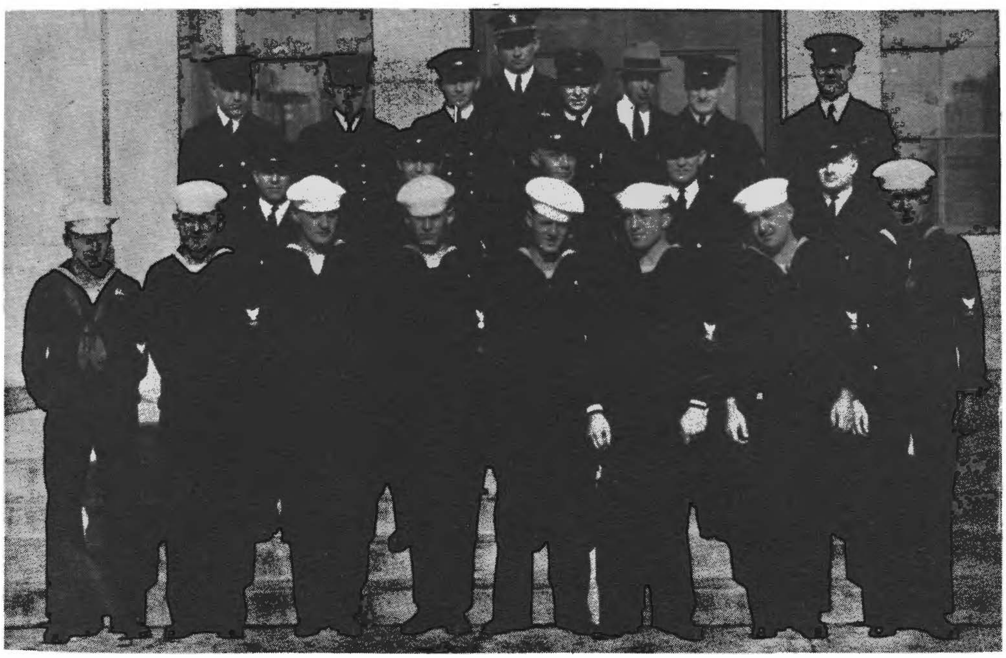
Those trained men were the result of Operation Electron—the proof of its value as an educational experiment. They had been its goal, and they had justified its effort. Never before in the history of the Navy had so few men been required to learn so much—and never had they been obtained and taught so rapidly and well.

GIVEN

D*id they have to start from scratch?*

A project of such scope could not be its own beginning. Before this experiment there had been other tests, other trials, other findings. As different as it was, it was not without precedent. For 15 years there had been a school of radio in a corner of the District and for 15 years it had been the testing ground for what became the background material of the experiment. It was there that they turned for the data that was necessary. They had to know just what had been done, what definite results lay behind, what had been the outcome of these earlier efforts. With that the experiment could begin.

They started with the GIVEN . . .



CLASS ONE—RADIO MATERIEL SCHOOL

1924—They helped Radio grow up

ONCE UPON A TIME WAY OUT IN THE COUNTRY
there were a few buildings . . .

BACK in 1923 there were a few houses erected out in the country near Washington, D. C. They looked pretty bleak and bare standing there all alone, but even the casual visitor was impressed when he was met at the gate by a Marine who demanded identification and credentials. For even then the Naval Research Laboratory was regarded as a secret and mighty important part of the Navy Department's scientific research program.

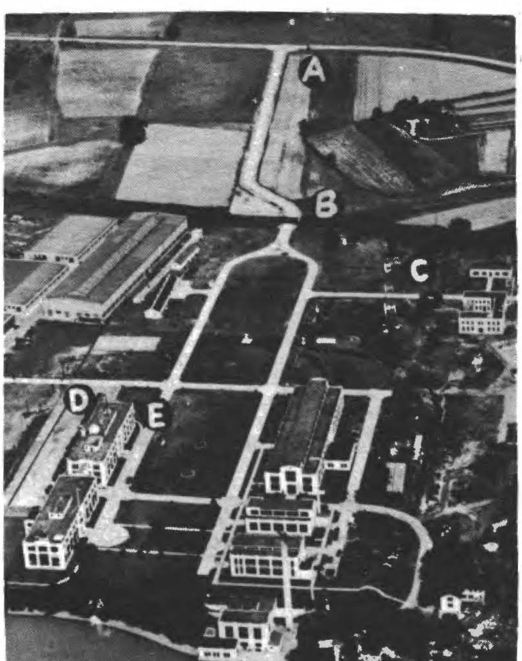
And it was in December of 1924 that twenty students and their instructor assembled on the steps of Building 1 in that Laboratory to make an historical photograph now lettered simply "Class One. Radio Materiel School." Such a school had been established in that year to provide the personnel to maintain vacuum tube communication equipment and underwater sound equipment, and these were its first graduates. The following June there was another class and so it was for several years, one class in session at a time, the sessions lasting six months.

This was to be known throughout the service as the Radio Materiel School, Naval Research Laboratory, and it was administered by an Officer-in-Charge assisted by one or two Chief Warrant Officers and about six enlisted instructors. The students were hand-picked, being Radiomen First Class with several years of Fleet experience.

It went on that way for the rest of the twenties—all of the thirties. The school, in later years, had enlarged only somewhat—moving to the first deck of Building 12, but they were still quartered in a wooden barracks of World War One design along with the Marine Guard and an Electrical Communications School.

Then it all started. In the summer of 1940, one officer and six enlisted men were given a special course of instruction in radar on the only equipment then existing in the country. They were sent immediately out to the Fleet to supervise the installation of similar equipment on specially selected vessels. The Navy was giving radar its sea-going test.

The results were impressive, and in the summer of 1941 six Warrant Officers



NRL IN 1939—SLOW GROWTH

Ⓐ ***the Highway***

Ⓑ ***Railroad Crossing***

Ⓒ ***the Transmitting Towers***

Ⓓ ***First Radar Antenna on 12***

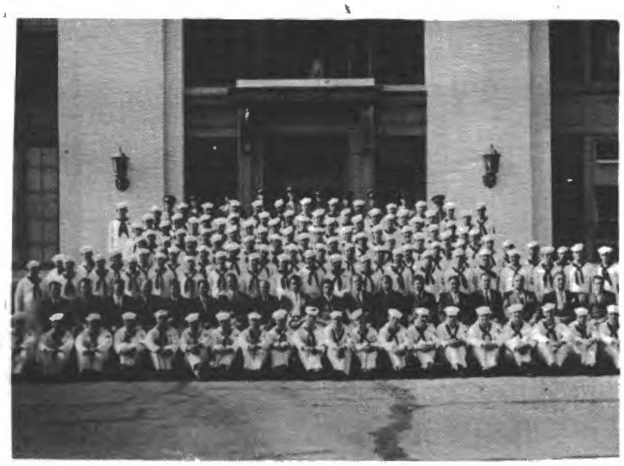
Ⓔ ***RMS was in the basement***

FIRST NAVY RADAR CLASS
Brains plus Brawn

were given another course of instruction in the Navy's secret and still - underestimated electronic device. Five members of that group remained at the Naval Research Laboratory to form a nucleus for the establishment of radar training.

That same summer the school moved from its already cramped quarters in Building 12 to a new building especially designed to train, quarter and mess the trainees whose quota had jumped from the original 20 students in the first classes to the later quota of 60 to 90 and then to the November 1940 assignment of 180 students for the six months' course. Building 28 would now hold the Radio Materiel School, the Warrant Officers Radio Engineering School and the Electrical Interior Communications Schools.

In September of 1941, following the completion of the moving to Building 28 and the declaration of a national emergency which was to end in World War Two, the Radio Materiel School was starting classes of approximately 75 trainees every four weeks. The new overcrowded conditions soon caused the construction of the temporary Building 31 which soon came to be used for barracks, classrooms and laboratory spaces.



PREWAR BELLEVUE
Instructors Wear Civvies

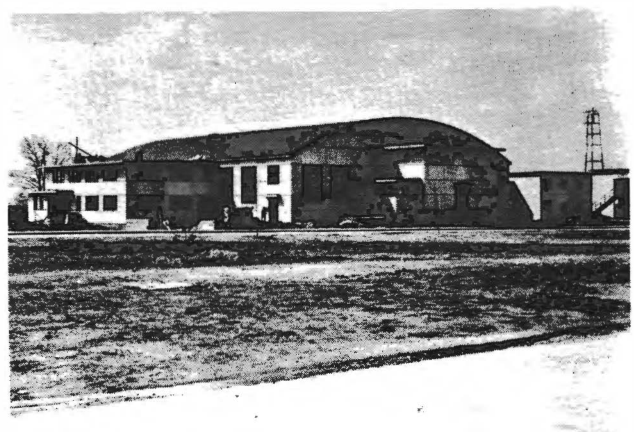
By now plans for the inclusion of radar in the school curriculum were completed and the training program was extended to 36 weeks. With the entrance of this new phase of electronics, The Radio Materiel School started to open its doors to civilian engineers from the Naval Research Laboratory and the Navy Yards, to personnel from the Coast Guard, Marine Corps and the British Royal Navy.

The war had come and with it the urgent need for trained personnel. The Radio Materiel School, Washington, D. C., soon had a companion—the Radio Materiel School, Treasure Island, California.

WAR-TIME BLUES
First class to graduate after Pearl Harbor

Concurrently, the Radio Materiel School started on its own internal expansion program. New buildings were erected and the administrative organization was under constant revision to meet the rapidly expanding training functions. At the start of '43, the input to the school was doubled, classes were started each two weeks, and Barracks 45 was constructed.

The school had now grown so large that it was necessary to place the administration of the school under its own Commanding Officer, Lt. Comdr. Wallace J. Miller, USN (now Captain). Later in 1943, the first few months of the course—the Primary portion—were moved to the College of the Ozarks, Clarksville, Arkansas. This permitted an increase in the number of students under instruction at RMS and the quota was set at 135 trainees per class each two weeks.

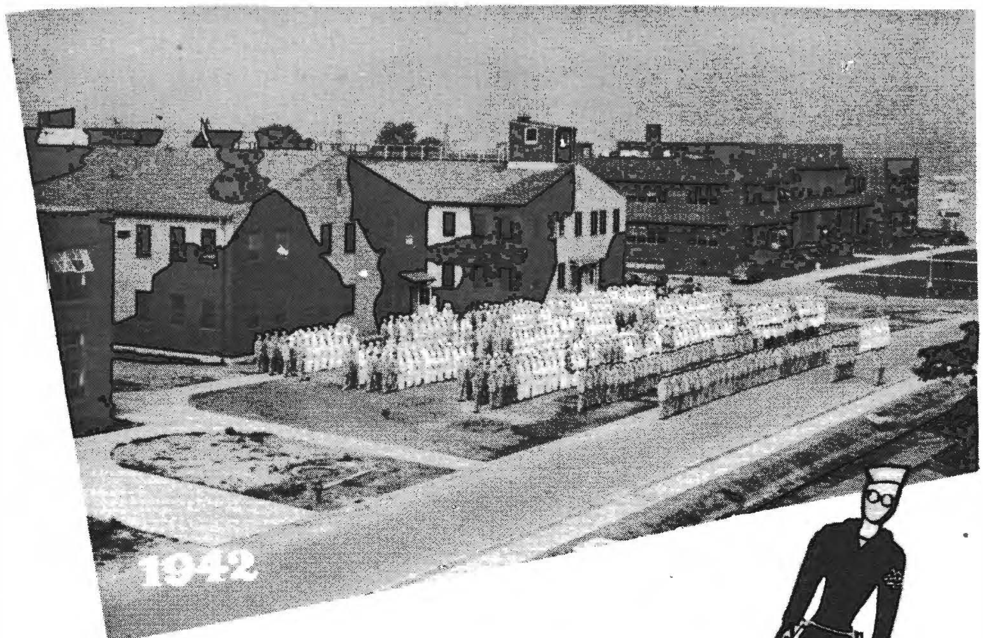


The Rec Building is Erected

Thus it was that during the war the Radio Materiel School was expanded and geared to the technique of training those who would maintain the most modern and complex electronic equipment. It has been said that "A Bellevue graduate can do anything," and the Fleet and industry accept Bellevue men as practical electronic engineers who have the "know how" and the "can do" spirit.

Those twenty students who posed outside on the steps of Building 1 that day in December 1924 were confident in the training they had re-

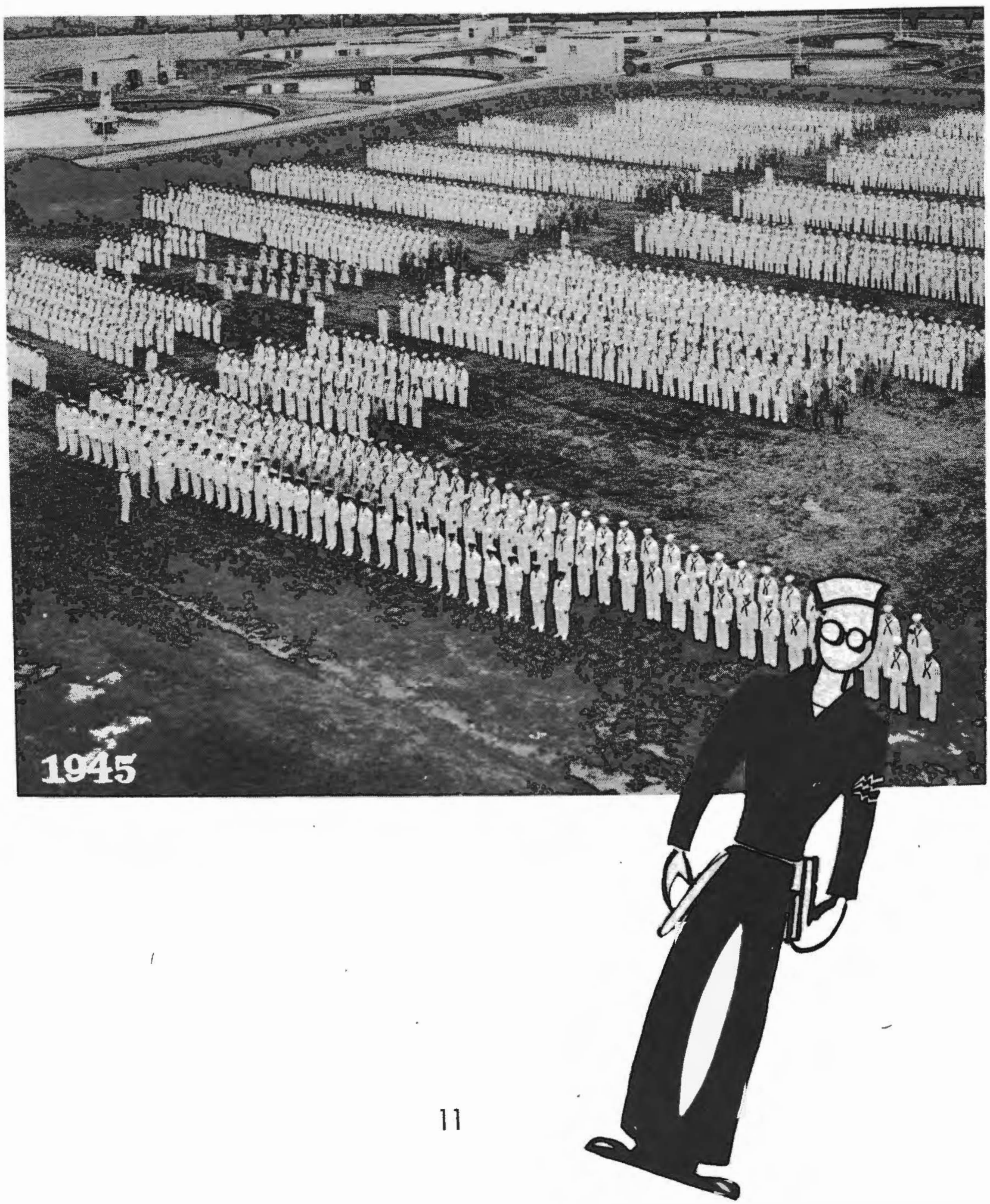
AND IT GREW . AND GREW . . .



ceived at Bellevue—the training which would enable them to service all types of electronic equipment to assure efficient performance. Those who now gather in Building 52 every second Thursday afternoon for their graduation picture are still confident in the training they have received—the "know how", the "can do".

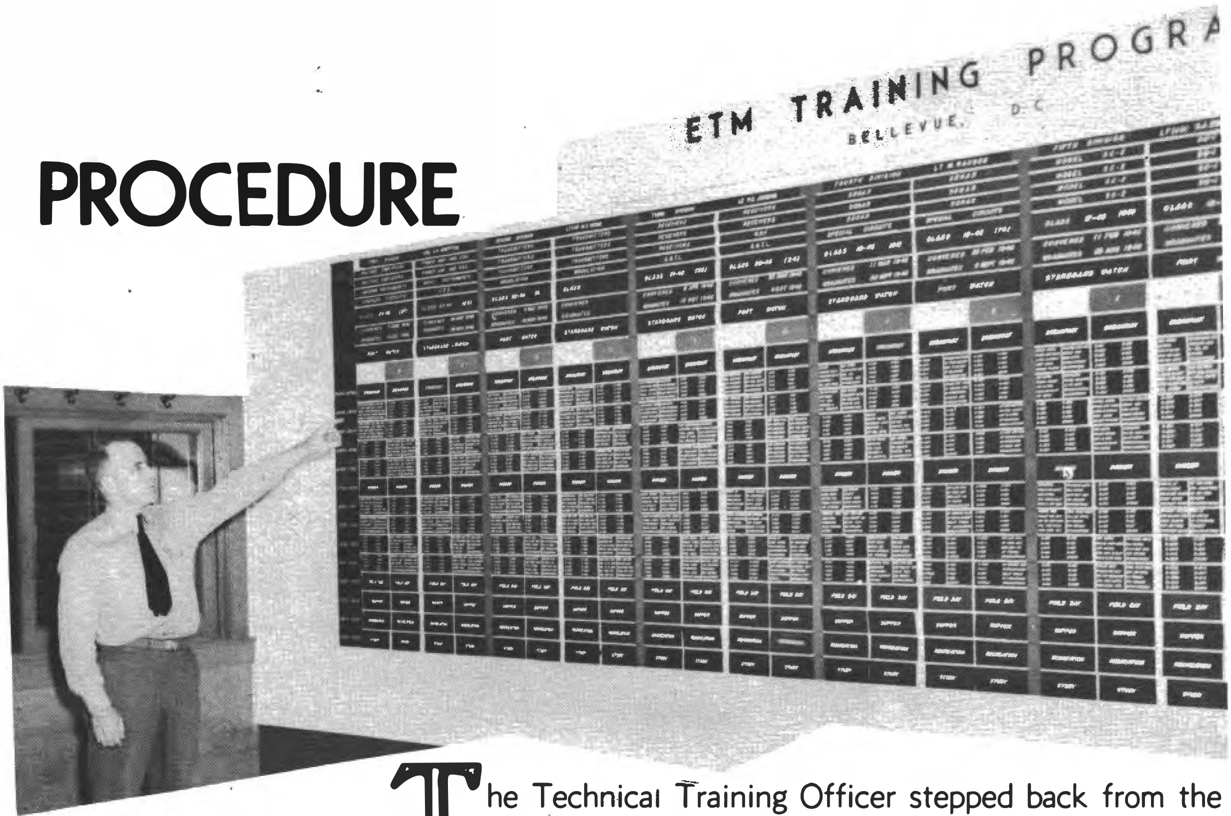
Lt. Comdr. Nelson M. Cooke, USN
Executive Officer.

AND GREW!



NRL

PROCEDURE



The Technical Training Officer stepped back from the chart which covered an entire wall of his office.

"This is the training program developed for the Electronic Technician's Mate here at Bellevue. By a reference to this board we can locate instantly any class in training, tell which division of the course it is in, what equipments it is studying, when the class convened, when it is expected to graduate and even in which room the class is located at any time of the school day."

The Technical Training Officer walked over to his desk and sat down. "Our job called for organization in terms of thousands of men if we were to set up an educational program which would turn out rapidly the men in demand by the Fleet. Methods had to be found and techniques devised to efficiently train these men in theory, operation and maintenance in the shortest possible time. That such a program was establshed, methods found and techniques devised is but a small tribute to those who found it necessary to do, and did."

Here, then, is the report on the procedure, how it was carried out and what it accomplished..

STEP ONE

Ah, sweet mystery . . .

The beginning is the muster. There is one a day and several in between. After a while you develop variations on just plain "Here" and say "Hey" and "Yo" and "Yah". It's an inescapable thing in the Navy, this muster business, like reveilles and field days and inspections. Anyway, someone recognizes your "Yo" or "Yah" or "Hey" and marks you Present. After that, at first, everyone was helpless, but soon someone was herding you vaguely to class. Later on brisk Navy efficiency was the key word and there was no vagueness. But they were still herding you.

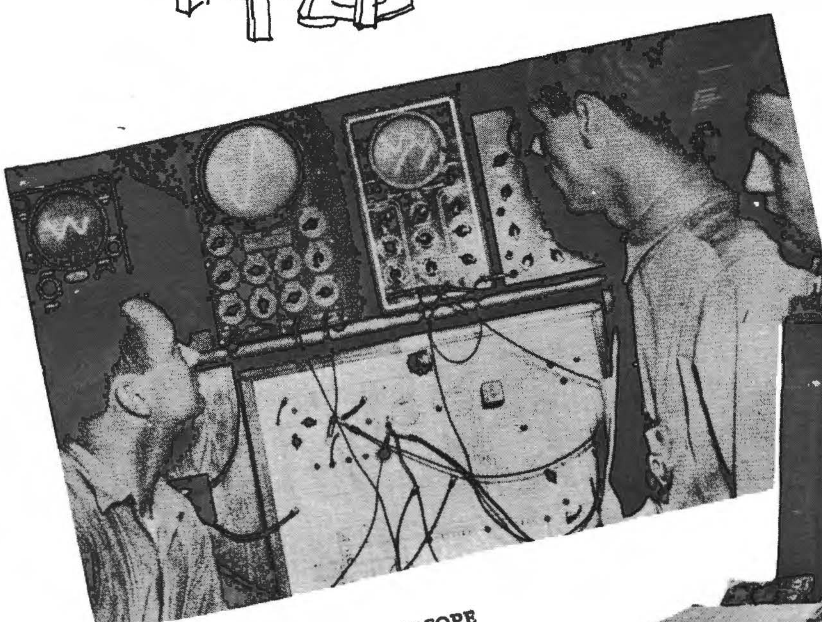
Scholarship begins in class and class begins early. You "Hit the deck," dress sleepily, then head for chow. After that there is a pleasant sort of lethargy as you sit in the classroom waiting for the lecture to begin. The bell rings and the khakied instructor materializes and begins his speech. It's something like . . .

"Gentlemen, this is the First Division. This is the month in which your thoughts will be trained on the subject matter which will be explored in the seven months of your stay here. This is the month to start piecing together the random material and facts you have learned in Primary School. You will recall things, add things, construct a sound foundation in the basic principles of radio design—its mathematics, its test equipment. You will also study the theory of the Cathode Ray Oscilloscope and realize its importance as a piece of primary test gear."

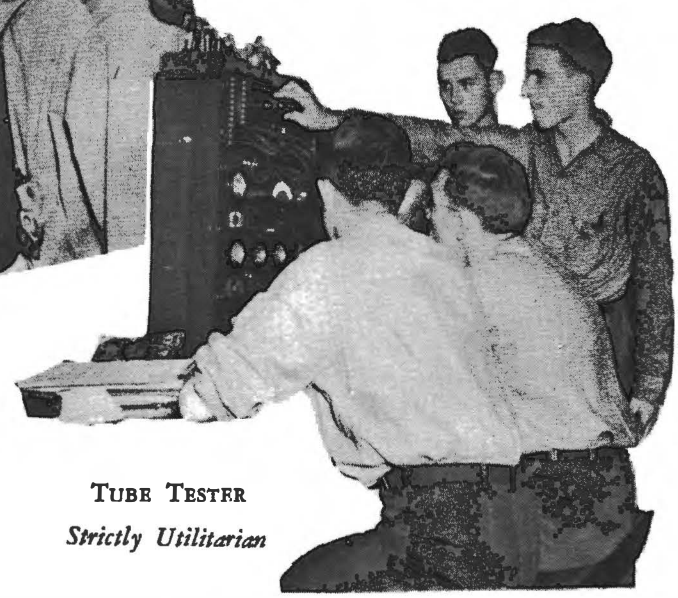
You glance around the room at the others listening intently. The MAA listening more intently than anyone—he was appointed by the Chief. The Chief is your Company Commander who promised he'd be with you for seven months and made a long speech on what you could do, couldn't do and had to do IMMEDIATELY.

"You will spend one half of your laboratory and lecture time in the First Division in the study of Voltage and Power Amplifiers. You will learn the relative merits of the various methods of coupling audio voltage amplifiers and their application to video frequencies—a knowledge useful in the study of radar. You will study the basic circuits for audio and radio frequency amplification and, as an introduction to transmitters, the principles of oscillator design."

The instructor drones on as you begin idly to leaf through the First Division book they have given you. Here it is—that part on the Voltage and Power Amplifiers. Mostly circuits with lettering like Esig, N2Ls, NEout, like what you had in Primary. Of course, Primary School was never quite like this, with the variety of watch bills (plus the Security Watch Booklet) and work parties and barracks field days and chow hall duty days and



Cathode Ray Oscilloscope
Electronic Toy . . .

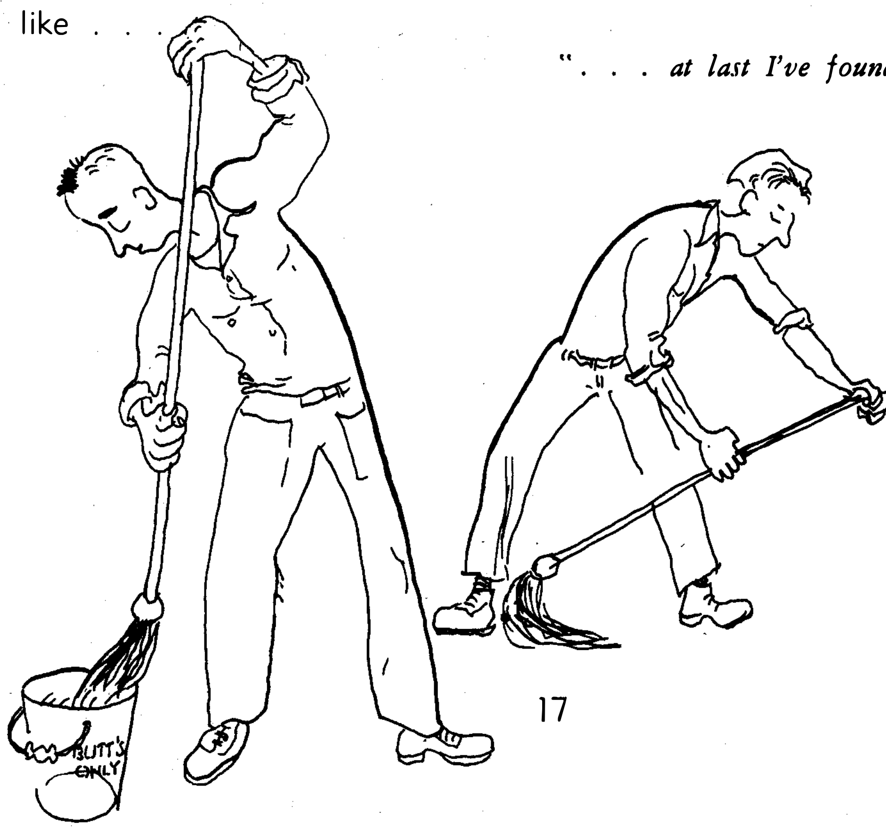


Tube Tester
Strictly Utilitarian

in-the-middle-of-the-day inspections. It was peaceful in Primary, looking way back. Oh, yes, the instructor . . .

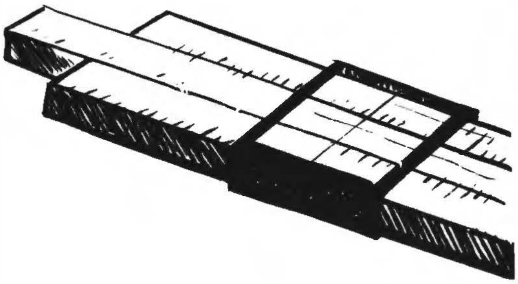
". . . spend one quarter of your time studying the theory and operation of some of the Navy's test equipment. You will study the LM and LR frequency meters and use them to measure frequencies and check oscillators for stability. With the tube-checking equipments, OD and OQ, you will find which tube in a set is impairing its operation. You will learn how a Vacuum Tube Voltmeter works, why it is more sensitive than a magnetic meter and how easily it can be damaged. In laboratory experiments all your classwork will be illustrated by procedures especially prepared to enable you to actually use the equipment. You will also learn about the LP signal generator and about frequency-controlling crystals. The remainder of the time will be divided equally between Coupled Circuits, dealing in mathematics pertinent to amplification and filter circuit design, and Cathode Ray Oscilloscopes, utilizing electrostatic and electromagnetic deflection. There will also be a demonstration of the use of a Wobbulator circuit."

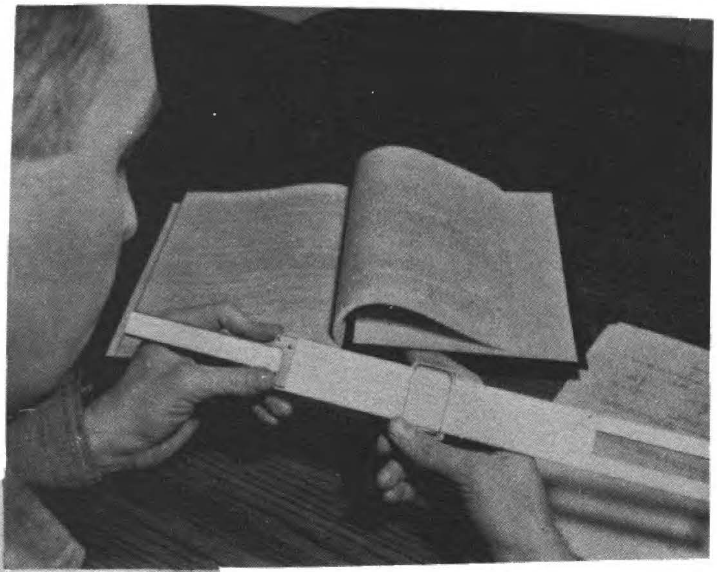
The bell rings and you start to get up. The Chief comes into the room with another list of names. It's the Galley detail; you're lucky to have watch tonight instead. Everybody gets up to take a smoke outside and you follow them. Wonder what a Wobbulator circuit is like . . .



". . . at last I've found you."

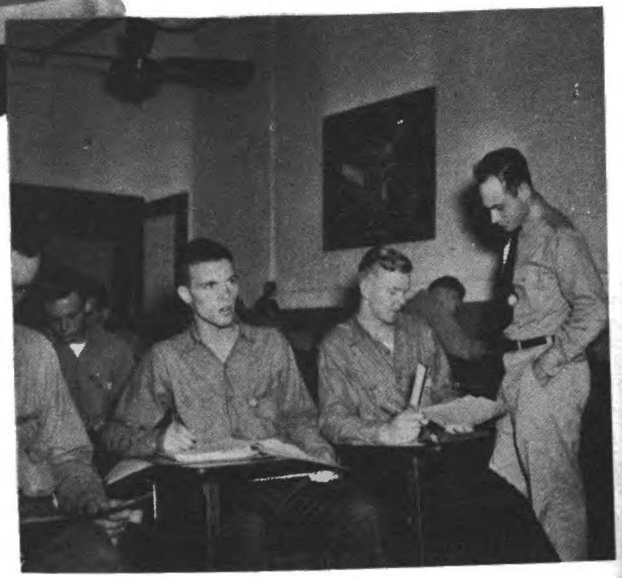
THE SLIPSTICK IS A VALUABLE WEAPON





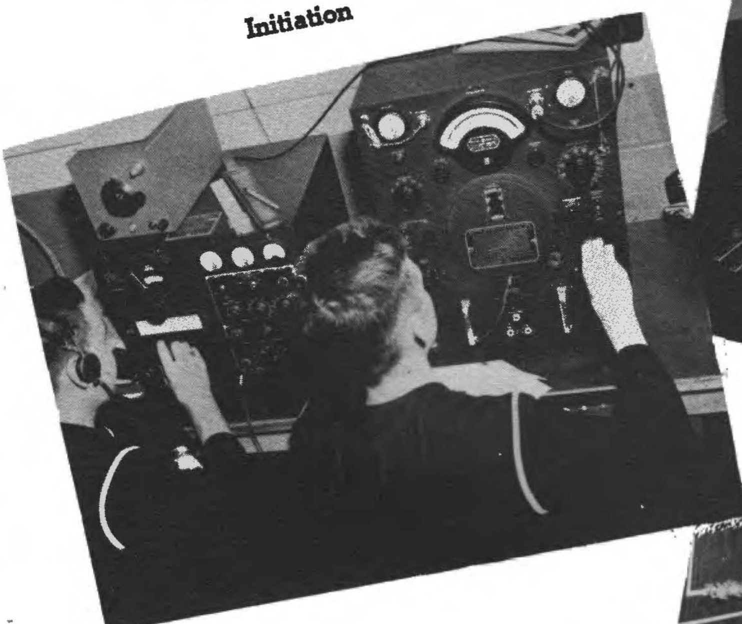
for home work

Experiment



and class work

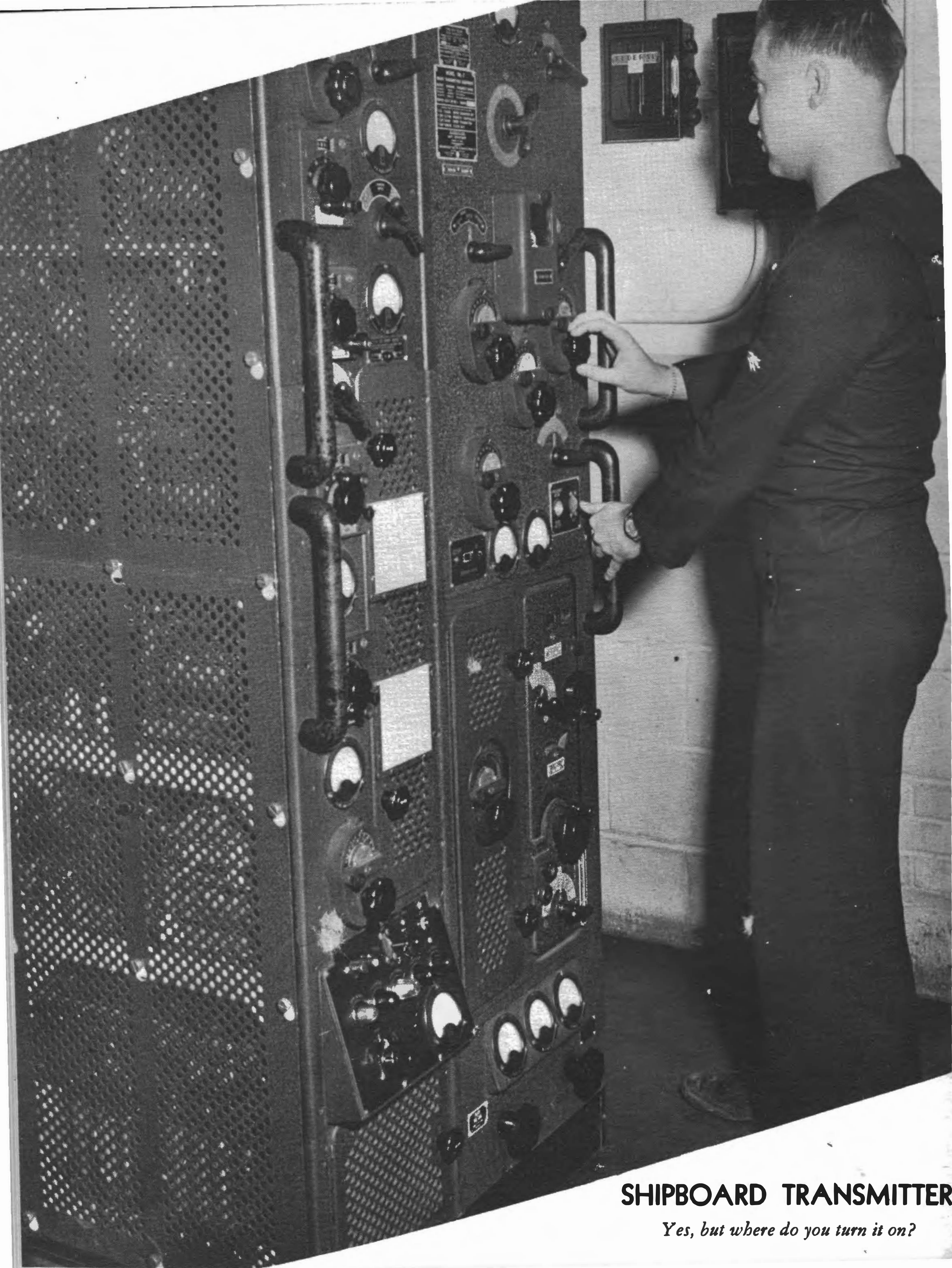
Initiation



Oscillation

Mensuration

Concentration



SHIPBOARD TRANSMITTER

Yes, but where do you turn it on?

STEP TWO

There is no noise quite like that of a crowded classroom five minutes before an exam. Everyone is shouting out the few things he remembers, trying to impress them on his mind while there is still time. The less brilliant say the same thing over and over in a sort of dazed way as if the secret of the universe was that "Switch S-107 is for Standby Operation." The eager beavers who win, place or show in the Second Division Examination Report argue a technical point which "naturally won't be on the test, but you should know it anyway."

The noise cuts off as the instructor enters. First he passes out the diagrams drawn up to "simplify the course," pages of schematics and across-the-lines and control circuits. Then he passes the exams as quickly as he can to the grabbing hands—everyone wants to see what he's up against.

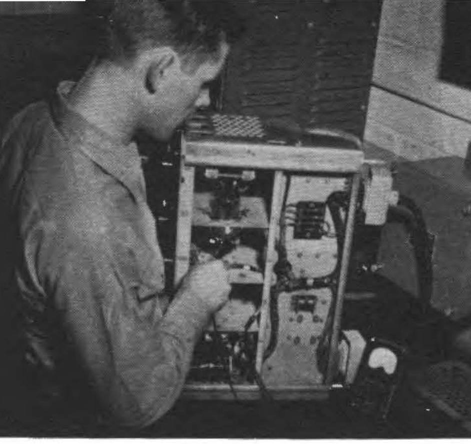
QUESTION 1. *Draw a block diagram of the TAJ-11.*

That's one of the big transmitters in black cabinets with "Danger—High Voltage" signs on them and grilled steel panels to keep fingers off the 3000 volts. It puts out a lot of power and takes a lot more, with a five horsepower motor to run its generator. Everything about the TAJ is oversized: a four-foot coil and a three-foot tube and tuning dials the size of a fist, because it handles 500 watts and because it's for a below-broadcast band frequency, down to 175 Kilocycles. As for a block diagram, that's just a picture that doesn't specify what any of it is. The bright students draw one, the rest just call themselves blockheads and groan.

QUESTION 15. *What is the purpose of Relay K-101 in the TBS?*

The Second Division offers a thorough treatment of Relay K-101, which is a small coil of wire with magnetic contacts. "Energized by current from the bias generator," the book maintains, "it closes contacts A, B and C, applies plate voltage

Surrounded by DANGER



He works

And listens

to the audio oscillator, cuts off the modulation limiting tube and energizes Relay K-104 which applies low voltage to all stages and energizes Relay K-103 whose contacts shift the antenna from the receiver to the transmitter and apply high voltage to all stages, *lighting the Carrier On lamp on the front panel.*" Such is the way of all knowledge in the Second Division—step after step followed through by instructors going down the right hand wire of the diagram, three inches to the left, and up two and a half to prove that the lamp actually lights. On the exam, the students hastily follow the same old wire, and end up in the opposite corner of the transmitter.

QUESTION 22. *What is the output power of the TBL on Voice, MCW and CW?*

There certainly are enough possible choices, for the Second Division teaches "flea" power, low power, medium power and upwards of 500 watt transmitters. The TBL is a particularly choice specimen, with two transmitters using the same vacuum tube for different ranges. Its place in the power spectrum no one quite remembers. They pick a likely number and go on to the next one.

QUESTION 30. *What is the frequency range of the TBY?*

The TBY is one of the little walkie-talkie transmitters, small enough for one man to carry around if he is stranded on shore. It runs off a vibrator and battery, like an automobile radio, instead of the elaborate rectifiers, motors and engine-generators used in other equipments. The TBY belongs to the line-of-sight group, a very high frequency range where radio waves travel in straight lines and don't curve with the horizon. Exact figures for the TBY are 20 to 80 Megacycles (million vibrations a second).

QUESTION 39. *What is wrong if the TBK timetactor fails to operate?*

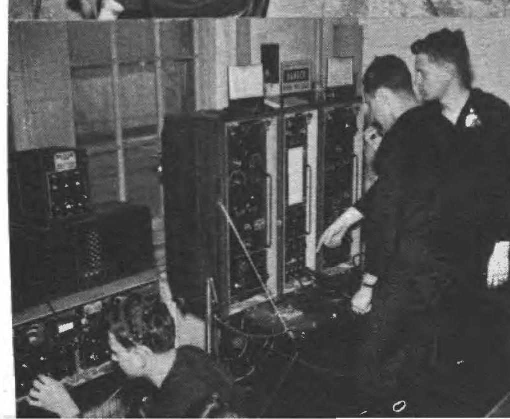
Shades of lab and of the hours of servicing—"to prepare the student for problems he will encounter in the Fleet" by making him search for the troubles ("bugs") put in by the instructors. And what their imagination leads to are resistors just a little too large, timetactors fixed so they sound like pinball machines and yards of invisible scotch tape. To locate the "bugs" you crawl around listening to the various relays clicking, open the panel and gingerly poke inside with a discharge probe and then just sit back with a schematic and wait for inspiration to strike. Usually lab "bugs" turn up as problems on the test. This timetactor, for example—a little scotch tape would do it. But this is a test—it is dirt instead.

QUESTION 46. *What type of modulation is used in the TDE?*

Modulation was the one theoretical course, about the process of superimposing hearable tones on radio waves. A vacuum tube can have up to six wire grids in it, and the voltage on any of them can be varied for modulating. Course 2-2 simply explained the methods and how they were used in different equipments. It was the most interesting but certainly the most difficult course and no one is quite sure whether the TDE modulates the screen grid or the plate or the tip of the antenna Time is just about up, and a lot of hopeful guesses are made.

The instructor collects the papers from lingering hands, and the storm bursts—"What did you put for Question 27?" "Did you say K-107 was stuck?," "Is it 3.5 Megacycles?" There is no noise quite like that of a crowded classroom five minutes after an exam.

. . . his own power supply



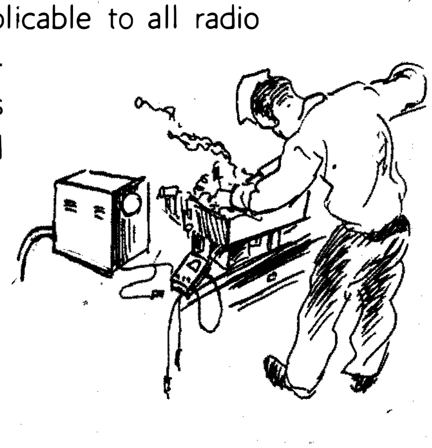
. . his own operator

Every man his own mechanic

STEP THREE

The month had started on a note of optimism based more on a familiarity with the subject than on the subject material. Those who attended that first lecture in the Third Division felt that they had better than a fifty-fifty chance of staying the first round with a course in radio receivers. In one subject, at least, they would have some pre-war familiarity. The farm boys, the shoe clerks, the high school students—all had radios in their homes and perhaps had even put an apprehensive soldering iron to them on occasion when their sketchy knowledge of radio told them a part needed changing. Their familiarity with both the soldering iron and the part-changing grew with their Pre-Radio and Primary School experience of building a superhet. Their familiarity with radio itself grew with the courses in Voltage and Power Amplifiers, Coupled Circuits and Modulation of the first two months. And their optimism grew when the instructor announced that the first two weeks of the month would be spent in Antennas and Transmission Lines, Receiver Theory and Receiver Servicing. Even the diehard pessimists who bemoaned the days they would have to spend studying circuits that wouldn't help a lawyer win more cases nor a grocer sell more boxes of breakfast food were converted to the post-service practicability of the program—for that one month at least.

The Navy had all kinds of receivers for them to study and service—one of each type over a continuous frequency range from 15 Kilocycles to 1000 Megacycles. And the instruction was of the type they preferred—first the general circuit theory as applied to all types of radio receivers and, then, as applied to the specific Navy receiver under study. At the same time the student was shown, in the Receiver Servicing portion of the course, a methodology which is applicable to all radio receiver trouble-shooting. Since most of the emphasis today is on high and ultra-high frequencies, it was only natural that a greater part of the course should



Receiver Lab

The waves stood still

Bearing 0090

Surgery

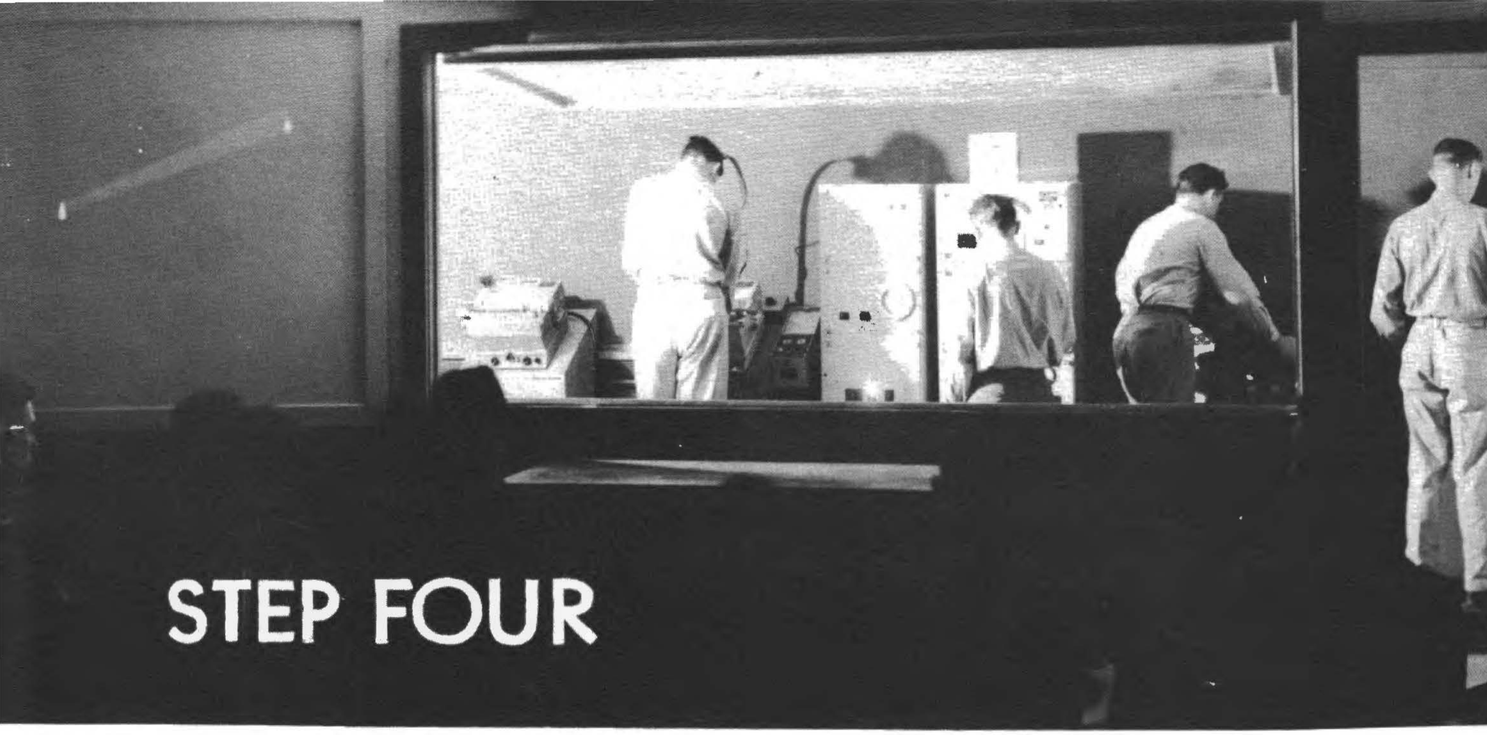
deal with them—a winning point with the radio amateurs who plan to have their own radio station some day and who eye speculatively the top frequencies just released to the amateur stations by the Federal Communications Commission.

The course in Antennas and Transmission Lines wasn't quite as disarming as the name. It involved mathematics and considerable theory, and it meant real study to be able to stay with the instructor as he plunged through the transmission lines, wave guides and coaxial cables used for the transmission of energy and later on as he discussed the various types of antennas used for radio transmission and reception.

The interesting sidelights were given in Radio Direction Finders, a late-coming course in the Third Divison. Its practicability was unquestioned—most commercial vessels depend on the United States shoreline Radio Direction Finder Stations for their bearing and fixes. This method is now largely being replaced in the United States Navy by the new system of Long Range Navigation (Loran), but there are many other uses and much to learn about Radio Direction Finders in their applications as homing beacons and as a means of locating illegal or enemy radio transmissions.

The month did not always end as optimistically as it began, for sometimes there was too much math to remember for the Antennas and Transmission Lines course and sometimes those radio circuits would pull a surprise blow. But most went away feeling refreshed and totally confident that they could make the family radio tick like new if something happened. That was reason enough for a long note of optimism.

Electronic Plumbers



STEP FOUR

Contact. Range approximately three thousand yards. Bearing two seven five."

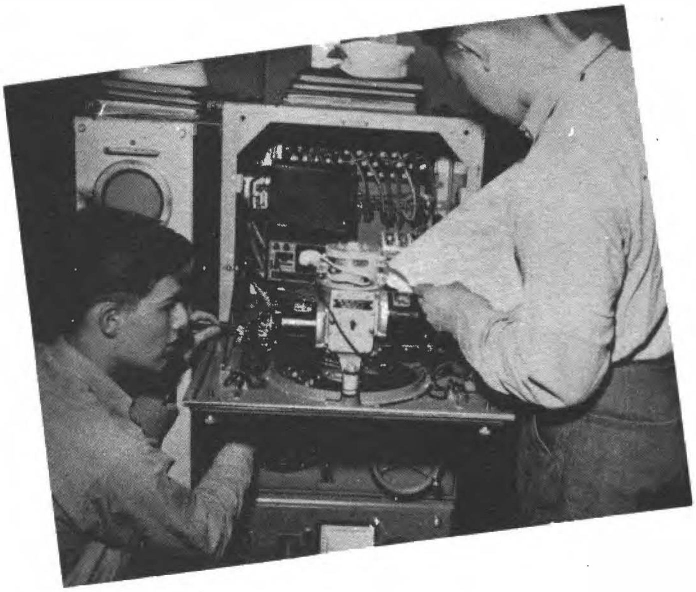
The men in the darkened room watched the attack team at work. They could see the Sound Operator as he read the range and bearing dials. They could see the Conning Officer as he ordered the ship swung around to make the attack. They could see the other members of the team, each ready.

"Range twenty six hundred yards. Bearing three zero zero."

Off to the left, the men could watch on a screen an actual picture of their problem—the submarine, their own ship. They could see the sound equipment in operation. Each pulse of sound energy sent out, each "electronic" feeler, could be seen as a line of light going out from the ship. The principle of Sonar—the use of a sort of electronic spotlight to search out an object—became clear to them.

"Range twenty three hundred yards. Bearing three one zero."

This was a clear definite picture of the purpose of the Fourth Division. Ever since men have gone down to the sea in ships, others have sought to go under the sea in submarines. The submarine menace of the First World War spurred on a search for a means of underwater



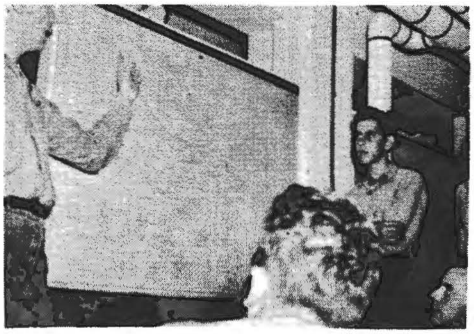
SONAR troubles topside

. . . and below →

craft detection. It was then that the first steps in the program of Underwater Sound—the science of sending a pulse of sound energy through the water and timing its travel to and its return from an object to determine the distance and bearing of the object—were taken. The advent of the Second World War and another submarine menace was the additional spurt needed to advance Underwater Sound—the name then changed to Sonar—to a point of practical usefulness. By this time, the latter part of 1943, Sonar was being taught to the Radio Materiel School students by a staff of four overworked instructors who strove to turn over to the Fleet as rapidly as possible men capable of servicing the equipment which later won the Battle of the Atlantic.

"Range two thousand yards. Bearing three two zero. Switch to Tactical Range Recorder."

Another member of the team was called into operation, determining accurately the range of the target as the ship moved closer to the submarine. Those who watched were impressed with the need for accuracy and correct operation of the equipment they would have to learn to maintain. This was their job—it was also a job for the Fourth Division. They would be taught to use all of the basic theories they had learned in the months before. They would learn to apply all their knowledge of transmitters, receivers, motor generators, measuring instruments to this one task of maintaining units of equipment which sought to search in the sea's depths.



Schematic Headache

"Range one thousand yards. Bearing three three five."

Those who sat in this new class could only feel the importance of this new task. They were yet to learn all the equipment that was to make possible this attack on the submerged craft. They were yet to learn what made the range indicator indicate the distance to the object and

the bearing deviation indicator establish the direction of the target and the attack plotter show the attack problem, complete with representations of the attacking ship and the target. They would learn of the types of transmitters which sent out this super-sonic pulse of energy and of the types of receivers which would receive this energy reflected back and transfer it into a "ping" in the loudspeaker, a "pip" on the scope, a "spot" on the attack plotter. They would learn of training mechanisms which would rotate this "beam" of energy to search out new areas.

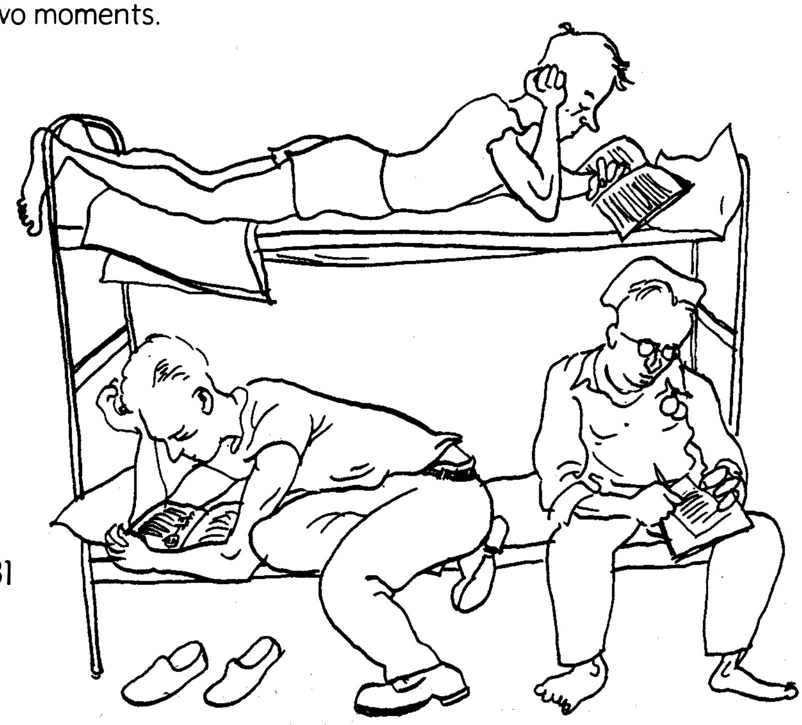
"Range five hundred yards. Bearing three five zero."

200 students a month had watched this demonstration to emerge at the end of the month after guidance by some 20 instructors somewhat the wiser in this matter of "pings" which told of enemies and friends. Ever since March of 1945 when the Fourth Division moved to Building 59, a building especially built to house and operate the new and rapidly modified sound equipment under conditions much like that used aboard ship, this section of the school held many in fear and dread of its lectures and labs, its flopping capacitors, its delta-connected resistors, its mountain-moving amplidynes, its miroscopic diagrams. Those who emerged would do so better equipped to go on to further study in this game of electronics.

"Lost contact. Range one hundred fifty yards. Bearing three five eight. Fire by Tactical Range Recorder."

The group leaned forward. The officer at the Tactical Range Recorder moved his hand towards the firing lever which would release the depth charges. A moment. Two moments.

"Fire."



STEP FIVE

For some time now, advancing to the upper Divisions of the school—the Fifth, Sixth and Seventh—was symbolized by a little red button with RMS and a number on it, the one pass that could get the student by the guards who stood at the gate to the Radar spaces. For that was what the upper Divisions taught—RADAR and its many electronic applications in the field of ultra-high frequencies.

The student had by now been well introduced to the design problems of the low, radio, high and very high frequency circuits. At First, he had learned to apply the random electron theory of a Primary and Pre-Radio schooling to actual circuits. In the Second, he had learned to apply this knowledge to the construction of message-sending transmitters and, in the Third, receivers which would hear the message. In the Fourth, he had learned something new—the timing of the travel of a sound wave in water to search out objects in the sea's depths. Now he would be taught to time the travel of a radio wave in air to search out objects on the ground and in the air. This was the RADAR he had waited for.

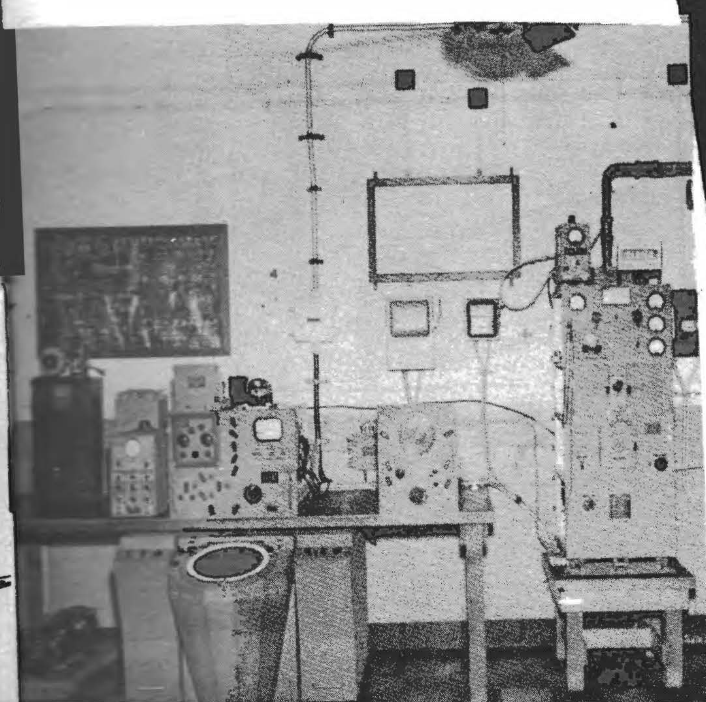
He sat in the little room listening to the stories of the early days of radar when such studies were referred to as "Special Electronic Circuits," when all was "Confidential" (to be discussed only in the classroom) or even "Secret." He heard also of the future in Television and Electronics—the applications of ultra-high frequency equipment in medicine, industry, communications, transportation. He was told of the

course of study in the Fifth Division: the basic principles of elementary search radar, the equipment used simply to give indication of whether or not a target or object exists in the area being scanned.

He visioned this apparatus which could search a 20, 40, 80 mile radius to warn of approaching aircraft or ships. But he could not vision the thousands of circuits and individual components which would make this "sight at night" equipment possible, the hours of study over a single section of SC or SG (the two pieces of search equipment studied in the Fifth Division), the many lectures on the various means of connecting those basic radio parts—resistors and capacitors—to produce circuits that would give the results that were claimed for search radar equipments. He could not vision the many hours he would sit and watch an instructor prove that by turning a small knob down in the radar room, he could control the movement of a 500 pound antenna mounted on the mast of the ship. Then, too, there would be the arguing over the theory of what made the heart of radar—the magnetron—produce the high power necessary to search the wide areas essential to early warning of an approaching enemy.

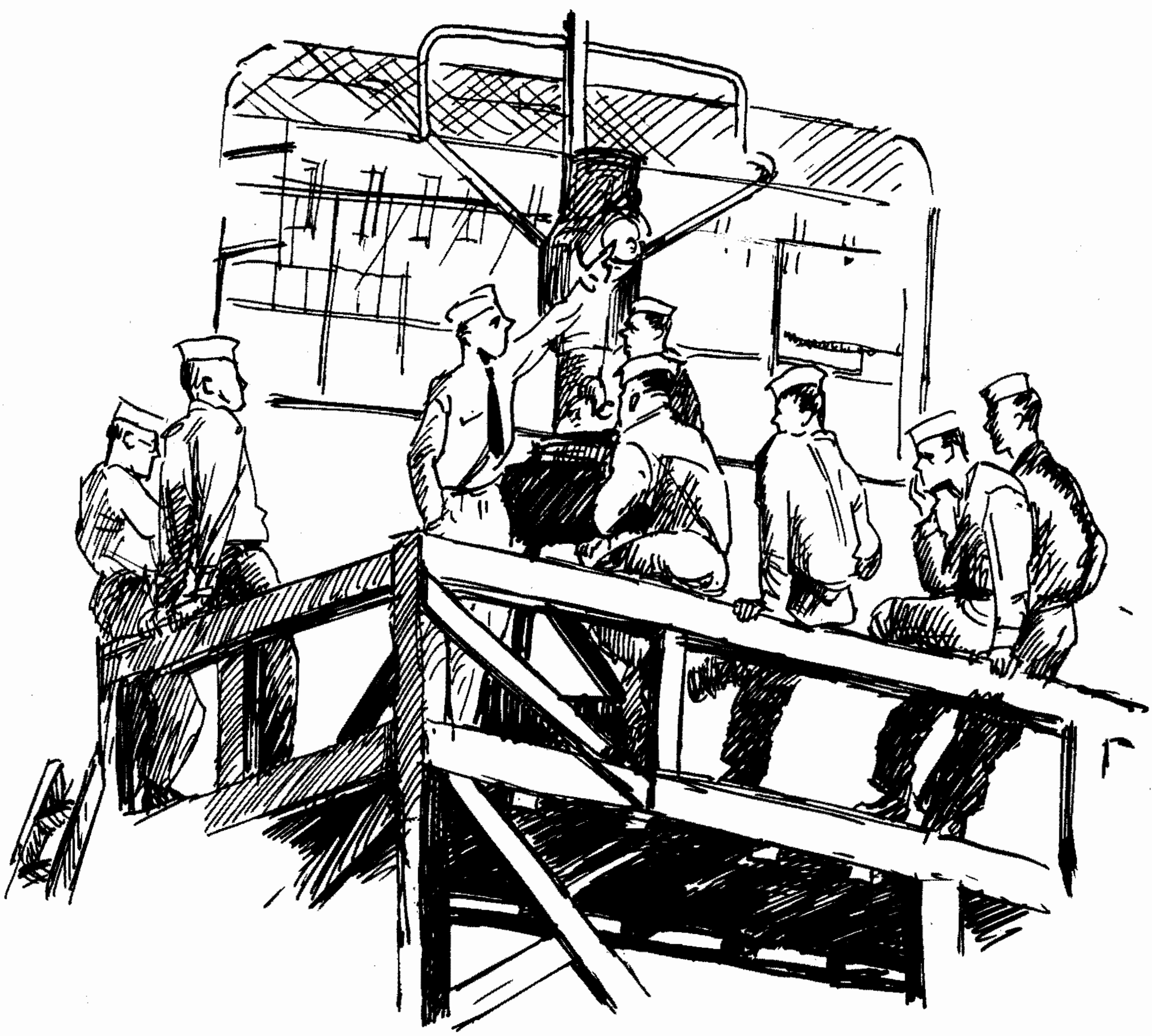
None of these could the student vision as he sat there listening to the indoctrination lecture on radar and the purposes of the Fifth

Before . . . Operation . . . and After



Sixth and Seventh Divisions. He could only vision those bright spots on the scope that would translate into *"Bogey. Range twenty miles. Bearing two one five."*

The lecture was over and the student filed out with the rest of the class. There would be a demonstration of the equipment in the lab. As the student walked up the stairs, the guard looked at him. He showed his button and the guard nodded. The student passed on.



STEP SIX

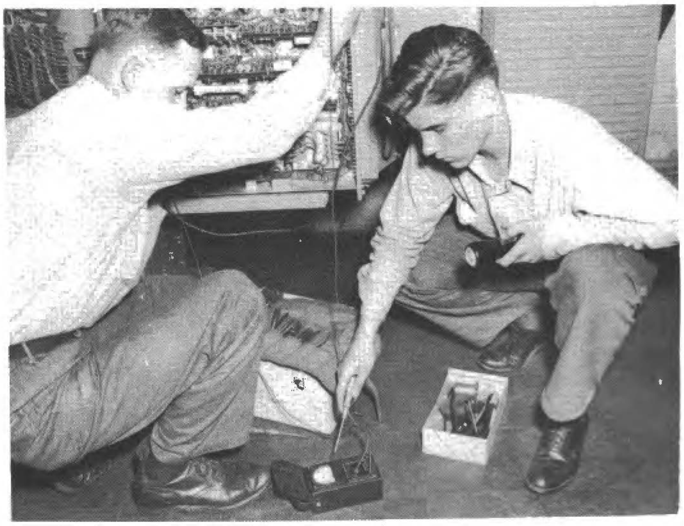
It was one of those moonless nights in the South Pacific. A night which turned out to be as black as the Ace of Spades. An officer groped toward the side of the ship, feeling for the rail. He looked out into the blackness and saw nothing. He spat into the night and returned to the hatchway. He opened the hatch, came into a dimly lit wardroom and spoke to the men sitting around the table. It would be a good night for the run all right, with this dark cover—they and the other three cruisers would certainly get supplies to the Japanese troops by morning. 25 knots was a good speed for a night like this.

They sped on, those four Jap cruisers, confident in such protection.

Suddenly the night lit up and with an infernal roar the Jap ship disappeared from the face of the earth.

Observers on the other three cruisers were confused in their reports. The ship just seemed to lift itself from the water and explode into a million pieces. The Japanese observers might have been confused, but observers on the American Task Force which had stolen in to fire point blank at the Jap cruiser were clear in their report. This had been the first test in the aiming of a ship's guns by radar and every ship in the American force had its guns trained on that one Jap cruiser.

The search equipment had located the ships. The Americans had moved in and then the accurate fire control radar had taken over, sending information to the fire control room on the distance, bearing and speed of the target. This was all the information necessary for the solution of the tactical problem. The guns were trained on a target which was still invisible to the human eye. Right up to the actual firing of the guns, the fire control equipment had continued to send information to the fire control room on changes in the bearing, distance or speed, continuously correcting the aim of the guns.



Some things he finds out

The deadly accuracy of this fire control equipment which accounted for the total destruction of this Jap cruiser was also responsible for the victories of the almost hopelessly outnumbered American ships in the early and crucial engagements of the war.

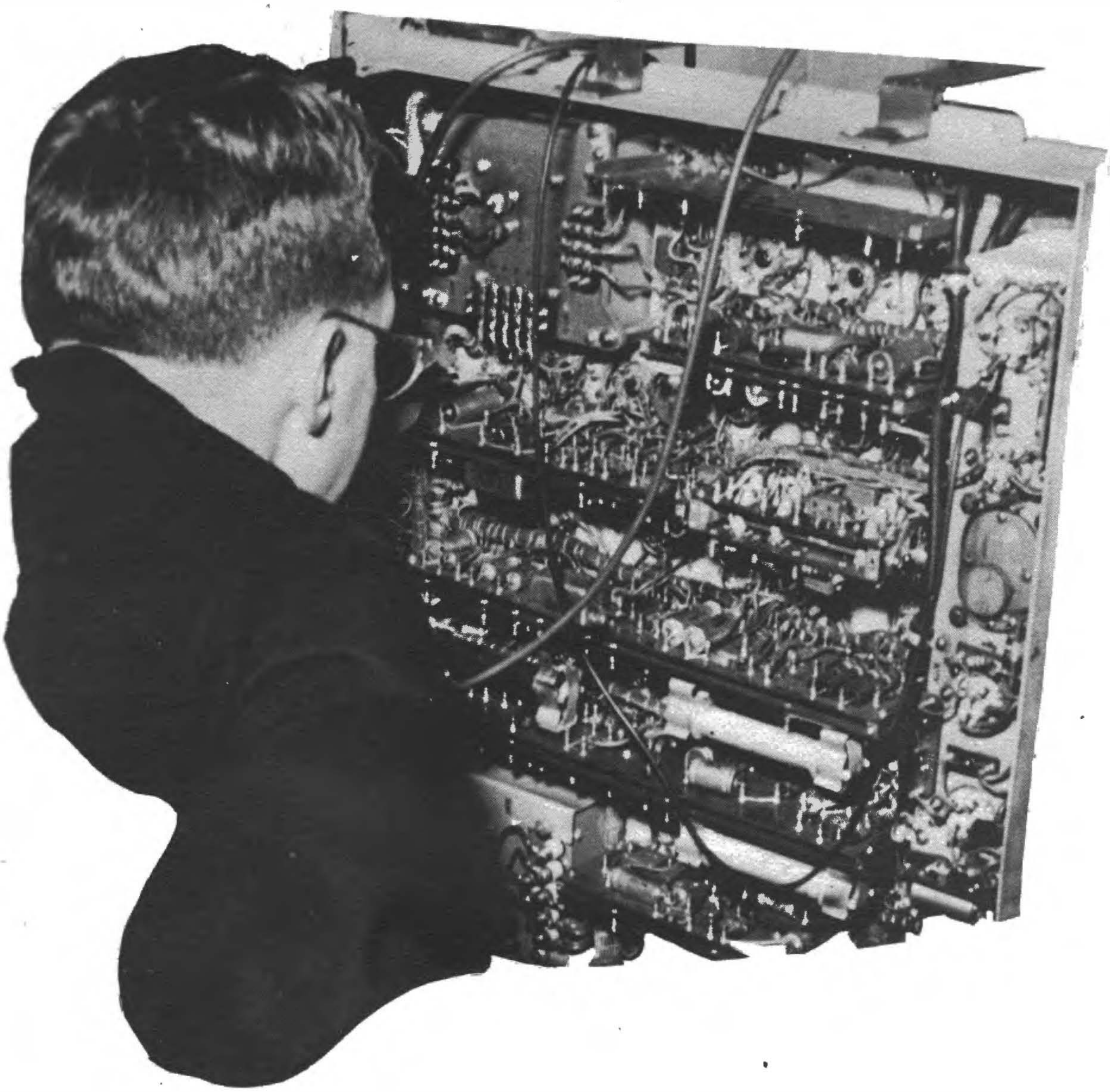
And it was during this early part of the war that fire control radar was first taught at the Radio Materiel School. It was a revolutionary application of the radar principle, then, and the modifications were coming in fast. With the introduction of the newer equipment, fire control radar was assigned to the Sixth Division and has remained there.

But fire control radar alone would never have discovered and sunk this Jap cruiser. Spotting and tracking required the specialized advantages of search equipment, which can point out the existence of the target and follow it while the fire control equipment is placed in operation. In connection with this approach to an ordnance problem, an improvement was made in the search equipment. A new device was introduced to permit the transmission of the radar scope presentation to remote battle stations throughout the ship. The Conning Officer could get on it enlarged pictures of the whole area being searched, and in case of a failure of the fire control radar equipment could even direct the guns with it. This equipment is listed as remote radar indicating equipment and its theory, operation and maintenance occupy the remaining hours of lecture and lab in the Sixth Division.

The student can now realize the amazing applications of radar in fire control problems where

Other things are pointed out

accuracy of a few yards in a mile is essential and in remote indicating equipments where clear definition is important. Without that accuracy and definition, the Jap cruiser would have had an even battle against guns alone. With them, it never had a chance.



SCANNING THE RADAR

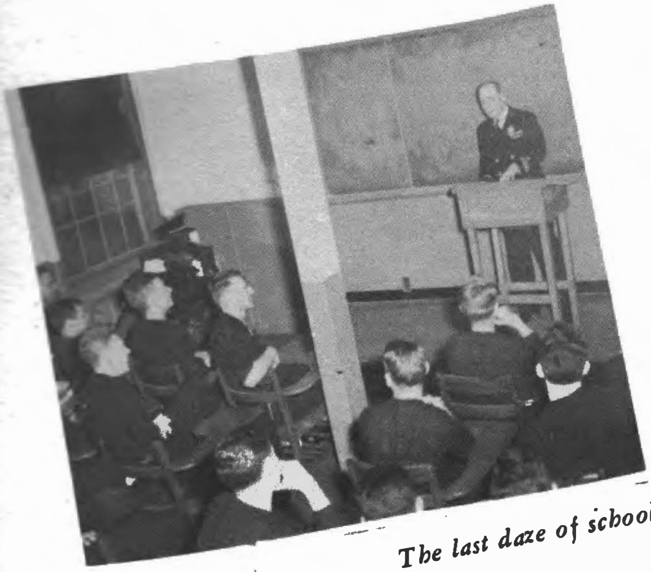
STEP SEVEN

The Chief looked at the list he held in his hand.

The class was being scattered all over—seven to Brooklyn Navy Yard to pick up destroyers, three to Philly to catch a cruiser, five more to Boston for ships not yet commissioned. The usual sizeable chunk was going to Norfolk for further assignment and a few were staying on to take a special course in the SP—a long range, high power air search equipment.

The Chief glanced down the muster list, reading now-familiar names. In a few days these men would graduate and move on and he, as Company Commander, would have to recommend men for these assignments now. He had followed them through seven months and he knew them all, liked some, knew one or two as friends. There was one who got along well and had good marks—he might make a good instructor. Recommend him. Another's marks were good in the theoretical work. Give him the advanced course. And, oh yes, the fellow who spoke to you about duty on a small ship; give him the destroyer. Going to sea—the Chief remembered how apprehensive he had been, after his several months schooling, about getting out and getting going. But school had been different, then, without the Radar Divisions—the confusion in the Fifth, the memorizing in the Sixth and the relaxation in the Seventh. These men had something to look forward to . . . but his problem was to make out the assignments, and for the moment their's was to finish up another Division to add to the other six.

The Seventh Division had always been a terminal division for the finshing touches. In the old days it had taught the "jamming" of the enemy's radar to confuse his readings so that he could not detect our ships. That was a two-week course called Countermeasures. At the end of the war it was replaced by Long Range Navigation (Loran), a wartime and peacetime application of electronics used to give ships

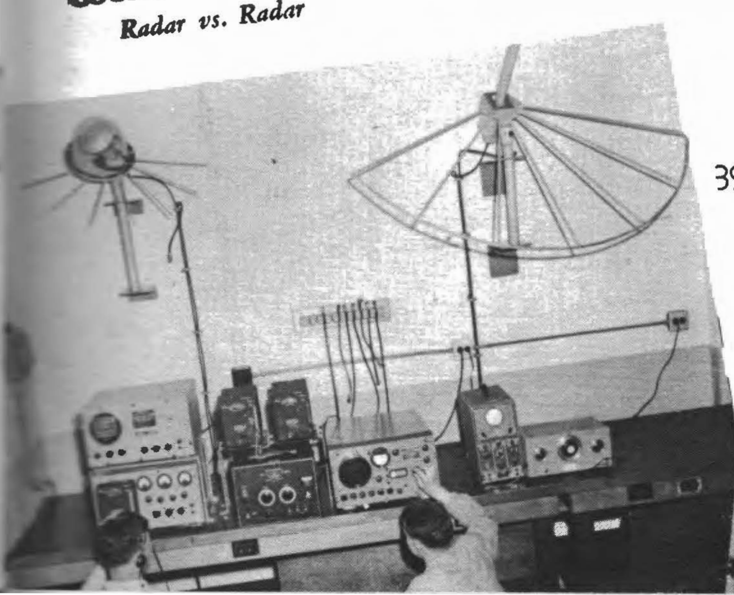


The last daze of school

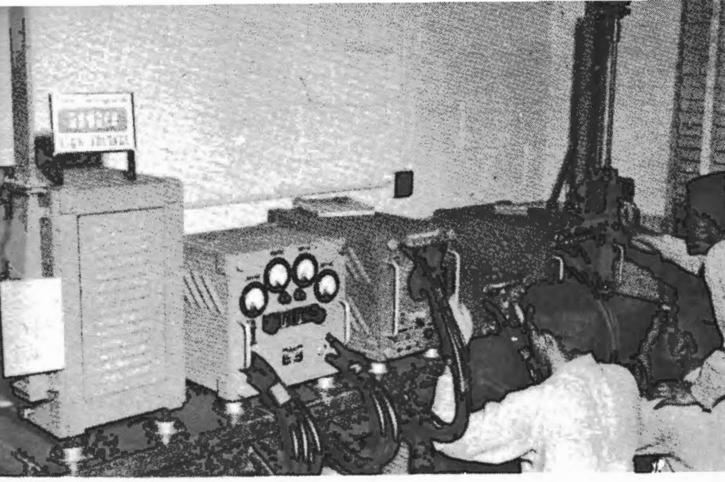
their accurate position at any time and in any part of the world. There was also a course in Identification, Friend or Foe, a holdover from the war days when identification of an object as friendly or enemy was of the utmost importance. IFF was a device for making an airplane broadcast whether it wanted to or not by stimulating a little receiver and transmitter it carried. If no response was received, the plane was presumed to be enemy. These were not essentials; they were refinements, sidelights to the main purpose of the course, but they were interesting and offered a glimpse of the open vistas of electronics. The down-to-earth part of the month was the two weeks in the shop, where the student had a taste of practical work and the Navy found out how well he could apply his experiences of the preceding six and a half months.

That was what the men were doing now, some of them installing new equipment or modifying the old, others doing odd jobs in the RMS Shop. At the end of these last few days there would be a class party and the nine days leave, the packing and the shipping out, the goodbyes.

COUNTERMEASURES
Radar vs. Radar



LORAN LINEUP
Calibrations, Approximations



New acquaintances

The Division Officer is interested

And ahead, what? the Chief asked himself. He picked out a few more names. To Boston. Might even get a couple of weeks leave myself, he thought. Been a long time, these seven months. Let's see, for the Norfolk draft . . .

The Chief looked again at the list he held in his hand.

* * *

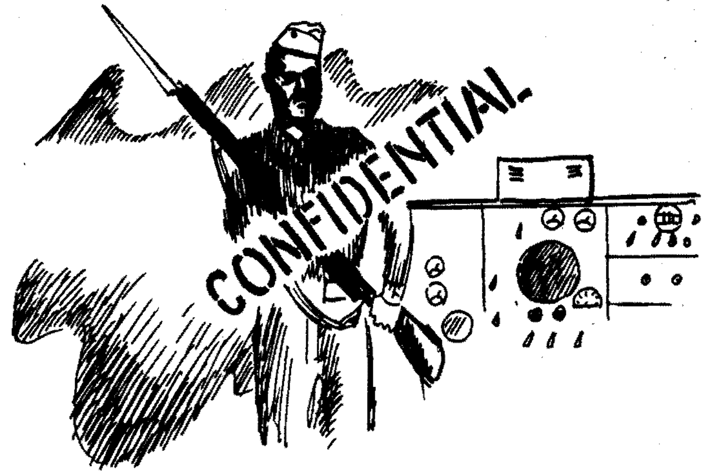
For the subject, the project is over; for the project, one more subject has passed through the experimental laboratory.

The procedure is complete.

Stand the ETM'S assembled—

—with their glasses raised on high

STEP "X"

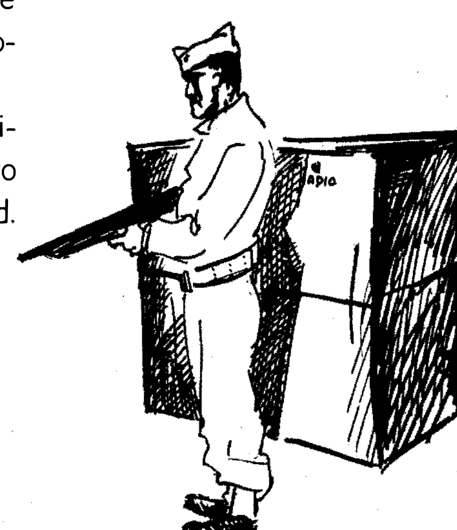


THE tall, grim-looking Marine adjusted his pistol so that it was within easy reach. The truck drove up and without a word he helped the driver load the small crate with "radio" and a small green dot stenciled on the side. At the railroad terminal the box was loaded on a train under the Marine's watchful eye and the door to the car was sealed. On arrival, there was another Marine waiting, just as grim-looking, who broke the seal, helped unload the box and saw it safely in the truck which sped them to Bellevue. Once there, the box was quickly and unostentatiously unloaded and taken to the second deck of Building 53. Here the Marine received a signed receipt for the box—his duty was done.

Now that the war is over, all of this secrecy seems rather needless, but in that box and in hundreds like it were the newest pieces of radar and electronic equipment, all destined to become part of the curriculum of the "X" Division.

The reason for the "X" Division was obvious for, as the war progressed, there was a tremendous advancement in electronic research and design, with many new and improved radar sets appearing and being installed aboard naval vessels. These new equipments were often very bulky and complicated, sometimes being based on entirely new and revolutionary techniques and concepts. Even a technician familiar with electronic principles found it difficult and in some cases impossible to use and service this new equipment.

Thus it was in December 1944 that a new division was formed and named the "X" Division, to denote that no rigid curriculum was to be followed.



The students had a variety of origins and purposes. Some came for a refresher course, and they were instructed in the use and maintenance of all the equipment which had come out since their graduation. Others were ordered to Bellevue from a ship in an Atlantic port, assigned for from one day to one month—for as long as their ship could spare them. They were sent to learn all the new pieces of equipment which were aboard or were expected aboard their ship. Sometimes when a student graduated from the regular training program, he was trained in the "X" Division in order that he might learn all the new equipment which was aboard the ship to which he was assigned. This led to the establishment of two specialized courses for graduates of the regular school—one in high power, long range air search radar and another in the maintenance of Loran navigation equipment.

Today there are no more grim-looking Marines or "hand to hand signature" shipments, but the "X" Division must continue to make room for the new equipments, changes and modifications which are still shipped in those inconspicuous crates with "radio" and a small green dot stenciled on the side.

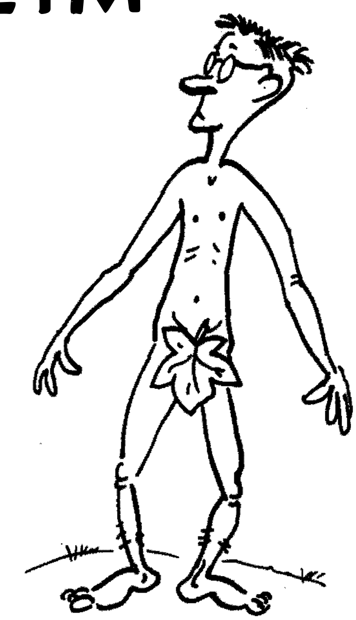
AIR SEARCH RADAR

variety of shape . . .

SUBMARINE RADAR

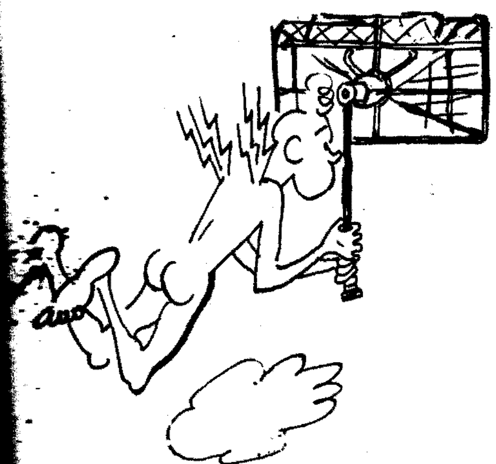
. . . and size

THE CREATION OF AN ETM



IN the beginning God created Heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep.

So it was in the beginning at Bellevue. And the classes were without form, and void; and darkness was upon the minds of all.



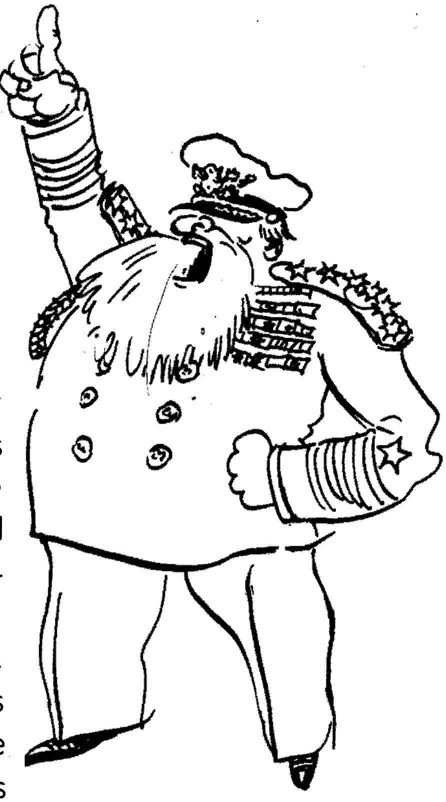
And the Powers said, Let them be taught; and they were taught. And what was taught, they called the Course; and what was not taught, they called much-too - complicated - theory. And there were Cathode Ray Oscilloscopes, Coupled Circuits, and Amplifiers of Voltage and Power; yet in them there was darkness more than light.

And the evening and the morning were the first day.

At the creation there was a division between the waters which were under the firmament and the waters which were above the firmament. And it was so. And RMS made a Second Division, and Modulation was under the waters and Transmitters was above the waters, but only a little. And the laboratory brought forth confusion and scanty were the seeds of learning; yet the rates flowed like wine. For it was so.

And the evening and the morning were the second day.

And the Powers decreed, Let them learn receivers; and it was so. For they learned Regenerative and TRF and Superhet and Inverted Superhet receivers; and from many receivers they cast out troubles so that they were without fault. And indeed they found that Antennas and Transmission Lines were



up in the air; for these things were over all heads. But verily the waves stood still and did not move.

And the evening and the morning were the third day.

Then the day was no longer divided from the night; for Sonar was made, and darkness enveloped the deep. And miracles were performed and devils cast out, but many were they that were not raised. And weird noises emanated from the lab as tormented souls slowly became demented; but even as the good, the evil passed; and meditations on the quietness of the Attack Plotter restored the soundness of minds.

And the evening and the morning were the fourth day.

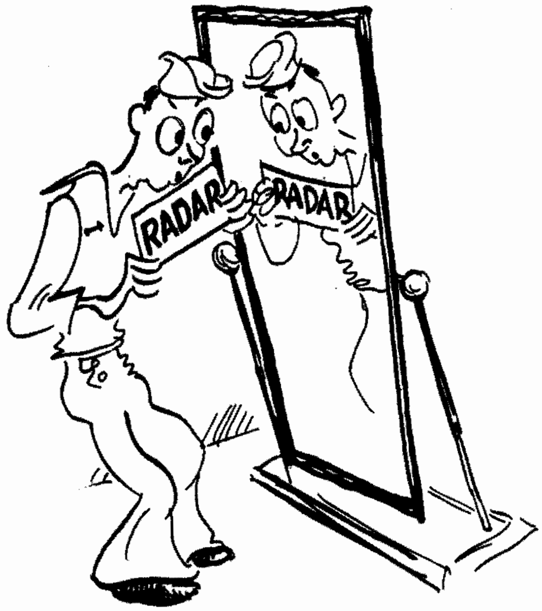
In the creation man was made and the word was made flesh and the word was God. So the pip was made and the word was made confidential and the word was radar. And verily I say unto you, that radar backwards spells radar. And they stood in the presence of Gear and it spoke to them. It spoke in microseconds and ranges and directional velocity; and they stood amazed and in awe.

And the evening and the morning were the fifth day.

And the Radio Materiel School Staff said, Let us make Little Miss Video in the image of woman. And they created Little Miss Video and told of her in the Course. And they blessed her and radar, and caused them to be fruitful and multiply in pips. And the circuits were enumerated and the capacitors discharged. And there were search radar and fire control, and, behold, they worked. But the examination came and discovered that liberty had tempted and led astray. Yet many were they that were pushed past the tree of knowledge.

And the evening and the morning were the sixth day.

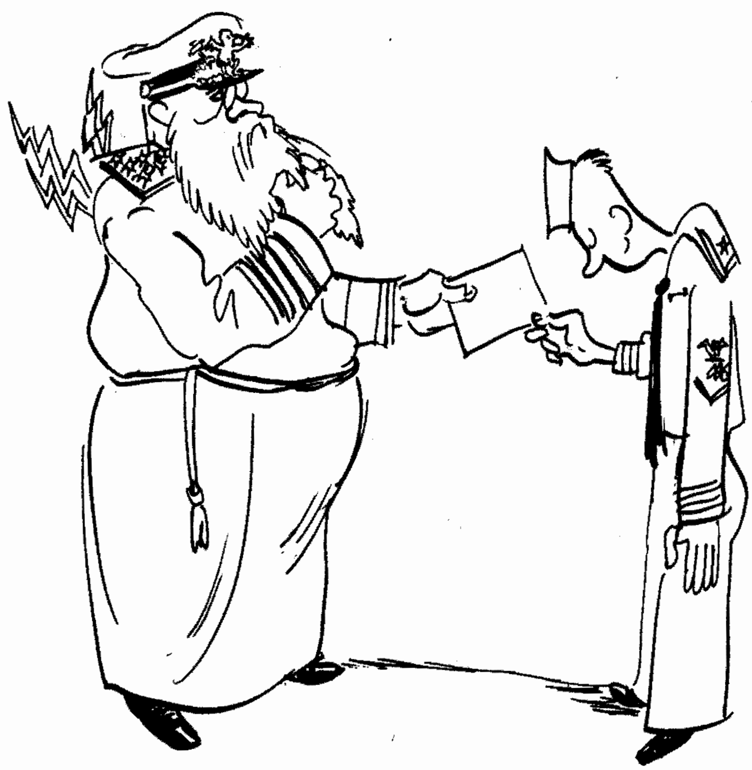
On the seventh day of the creation, God rested. But for the Wicked there is no rest. And in the seventh month, RMS continued



its creation. For they taught with the speed of wind and IFF was the breeze. But the labors were not ended, for they toiled with their hands and learned of installation, modification, and sundry works of electrons.

And the evening and the morning were the seventh day.

For thus in seven months did the Radio Materiel School create the Electronic Technician's Mate. And they viewed their work and tested it. And it was good.



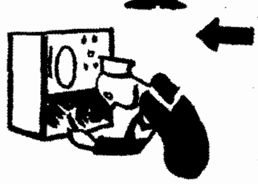
RESULTS

The student body grew from 60 to 3000.

The staff of the school increased from 8 to 480.

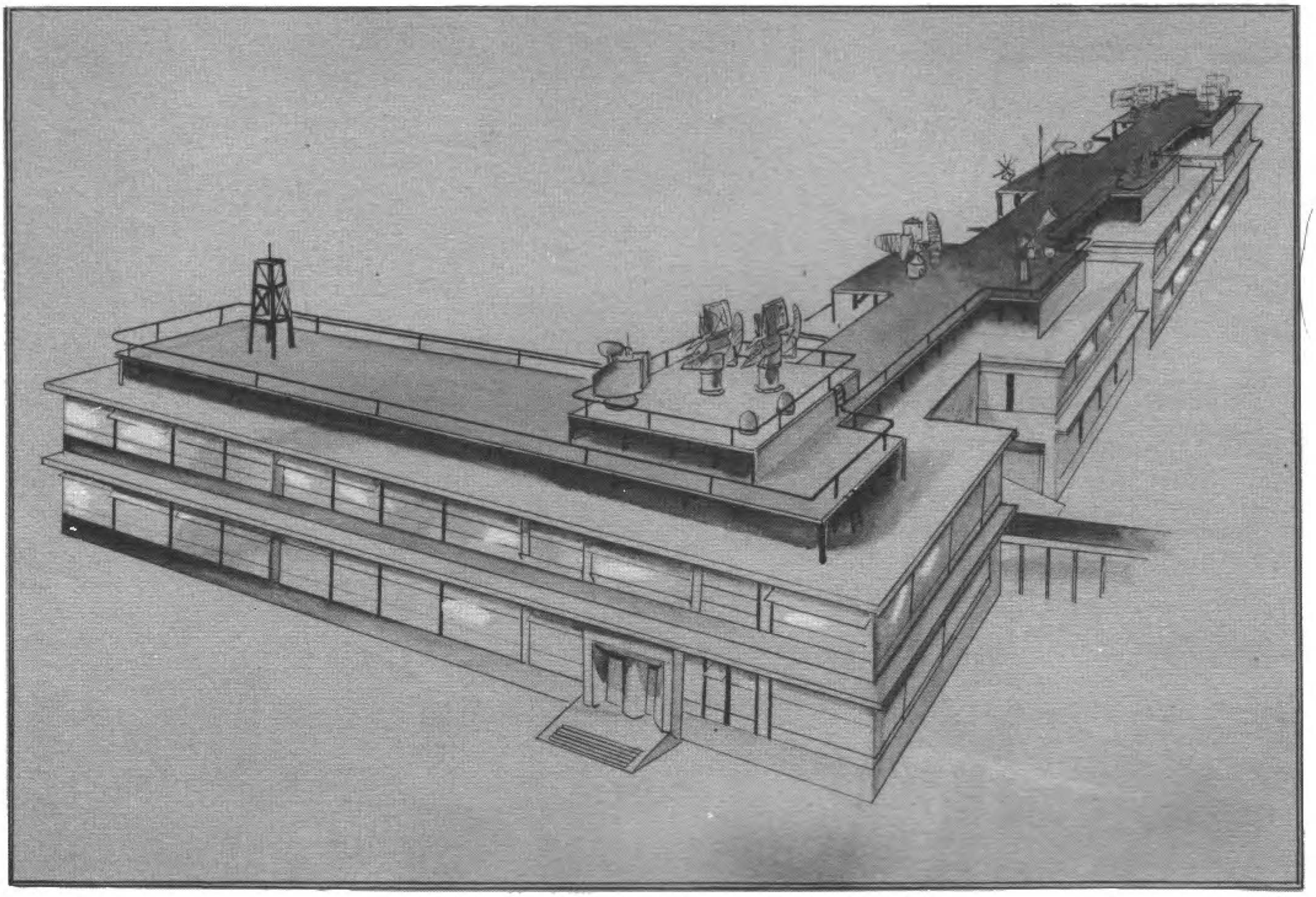
Construction increased the original 2 school buildings to 25.

From the original 120 annually, the rate of graduation accelerated to 250 monthly.



The total number of graduates has been 8142.

The total expense of developing the school has been approximately seven million dollars.



SKETCH OF PROPOSED LAB BUILDING FOR RMS, GREAT LAKES

CONCLUSIONS

Electronics has a future. It is a field barely opened, fertile to new ideas and endeavors. In science it is an infant; and it has many years of development ahead before reaching maturity.

Nor is the future any more barren for a school of electronics. Radio Materiel School, Bellevue, has terminated its wartime phase of rapid expansion, but it has not ceased to exist. Washington, D. C., may be replaced by Great Lakes, Ill., on the letterhead, but the school is going on as before. Already the elaborate equipment installed here is being prepared for the move. By July, the first of it will be on its way. All of it will have been shipped, the staff will have been transferred and the new school under way by mid-summer, 1947.

The modern building shown here will house the administrative offices and the laboratory spaces. Equipment will be the best obtainable and the working conditions optimum. The designs have been completed and the construction will start shortly at an estimated cost of one and one half million dollars.

Adjacent to the lab will be the classroom building, already completed. It is on a par with the projected laboratory in design and comfort. Directly across the street will be the barracks for the quartering and feeding of the trainees.

The future, it is anticipated, will attach a Primary School directly to each advanced one, with a saving of delay in transfer and a simplification in organization. Thus the curriculum can be more completely integrated and the program a more connected unit of a projected 52 weeks' length.

Today those who look at the past to see what was done, at the present to see what is done, at the future to see what will be done, agree on one point. There is a future for electronics.

And a future for RMS.

* * *

END

The last decision has been made, the last action has been taken, the last entry has been made in the files of of the Navy Department.

The experiment is over. The plan adopted five years ago was carried out, its steps followed through and its results compiled. For electronic training there is a future; for Operation Electron there is only a past.

RADIO MATÉRIEL SCHOOL
BELLEVUE

ACKNOWLEDGMENTS

• • • To our Skipper, Commander Raymond Cole, for his encouragement and constant support.

• • • To the Executive Officer, Lt. Comdr. N. M. Cooke, and his Administrative Aide, Lt. D.W. Stout, for their assistance in obtaining materials and personnel and for the many helpful suggestions.

• • • To Lt. Comdr. F. C. Atnip, Lts. Turnham, Shockley, Leary and the Officers and Instructors of the school divisions for their aid in the compilation of technical materials.

• • • To Mr. J. A. Rice, of Fraternity Press, for the pains taken in meeting a difficult printing schedule.

• • • To C. Thompson and J. Robinson and the staff of the Photographic Lab of NRL for long and exacting work on the production.

• • • To Robert Lickel, Kenneth MacDonald and the staff of the BELL TECH for the valuable contributions to the writing and preparation.

• • • To Frances Hoover for pulling the strings together.

William Gudaitis, Editor
Wolf Kahn, Art and Layout
Clinton Heiner, Literary