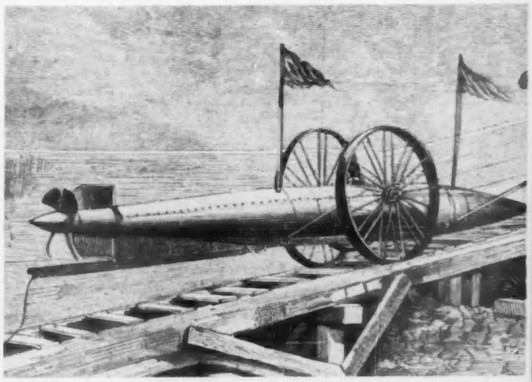
GENERAL ELECTRIC
Review
MARCH 1958

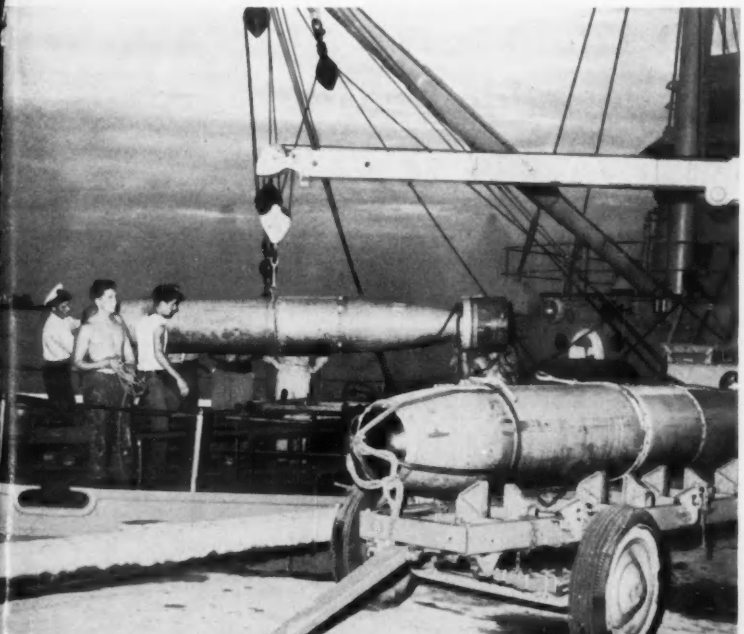
4 Reports On Russian Technology

- Metallurgy
- Electronics
- Power Transmission
- Perspective—1930

Undersea Thunder:



Torpedoes with Brains



The First Complete Story of the Acoustic Homing Torpedo

SPECIAL STAFF REPORT—Page 24

20TH FLUORESCENT ANNIVERSARY ANNOUNCEMENT

His face lighted by the pile of "Bonus Phosphors", General Electric's W. C. Martyny developed the process that gives G-E customers more light from the start . . . more light throughout the long life of the lamps.

This new General Electric Bonus Phosphor gives G-E Fluorescent Lamp users 7 to 9% more light . . . at no added cost!

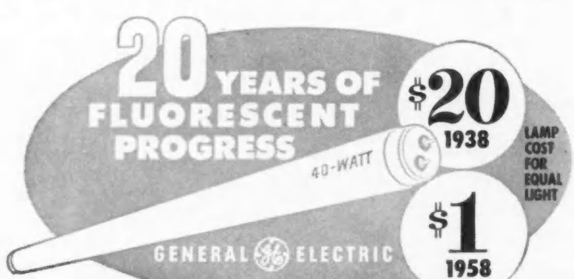
Because G.E. has found a way to throw out the small —and least efficient—phosphor particles and save just the bigger, brighter ones, you now get even more for all your lighting costs when you specify G-E 40-watt fluorescent lamps!

What Does This Mean To You? In factories and offices: added light worth ⅓ to twice your yearly lamp purchases. In stores and schools: 2 to 3 times as much added light as your yearly lamp purchases.

This "Bonus Phosphor" is now available in the 40-watt and new Power-Groove—and will soon be used in all G-E fluorescent lamp types. For the whole "Bonus Phosphor" story, write: General Electric Co., Large Lamp Dept. GER-38, Nela Park, Cleveland 12, O.

Progress Is Our Most Important Product

GENERAL ELECTRIC



GENERAL ELECTRIC
Review

MARCH 1958 VOLUME 61 NUMBER 2

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COVER

The torpedo—the Navy's pioneer guided missile—has come a long way from its early beginnings (photo, right). Today's guardians of our sea lanes, acoustic homing torpedoes (photo, left), are ruthlessly efficient. These cold, unthinking machines will outthink, outguess, and finally annihilate a skilled enemy team operating a complex machine—the submarine and its crew. For Part 1 of the exclusive story of General Electric's contributions in underwater ordnance, turn to page 24.

One of a series*

Interview with General Electric's W. Scott Hill Manager—Engineering Recruiting

Qualities I Look For When Recruiting Engineers

Q. Mr. Hill, what can I do to get the most out of my job interviews?

A. You know, we have the same question. I would recommend that you have some information on what the company does and why you believe you have a contribution to make. Looking over company information in your placement office is helpful. Have in mind some of the things you would like to ask and try to anticipate questions that may refer to your specific interests.

Q. What information do you try to get during your interviews?

A. This is where we must fill in between the lines of the personnel forms. I try to find out why particular study programs have been followed, in order to learn basic motivations. I also try to find particular abilities in fields of science, or mathematics, or alternatively in the more practical courses, since these might not be apparent from personnel records. Throughout the interview we try to judge clarity of thinking since this also gives us some indication of ability and ultimate progress. One good way to judge a person, I find, is to ask myself: Would he be easy to work with and would I like to have him as my close associate?

Q. What part do first impressions play in your evaluation of people?

A. I think we all form a first impression when we meet anyone. Therefore, if a generally neat appearance is presented, I think it helps. It would indicate that you considered this important to yourself and had some pride in the way the interviewer might size you up.

Q. With only academic training as a background, how long will it be before I'll be handling responsible work?

A. Not long at all. If a man joins a training program, or is placed directly on an operating job, he gets assignments which let him work up to more responsible jobs. We are hiring people with definite consideration for their potential in either technical work or the management field, but their initial jobs will be important and responsible.

Q. How will the fact that I've had to work hard in my engineering studies, with no time for a lot of outside activities, affect my employment possibilities?

A. You're concerned, I'd guess, with all the talk of the quest for "well-rounded men." We do look for this characteristic, but being president of the student council isn't the only indication of this trait. Through talking with your professors, for example, we can determine who takes the active role in group projects and gets along well with other students in the class. This can be equally important in our judgment.

Q. How important are high scholastic grades in your decision to hire a man?

A. At G.E. we must have men who are technically competent. Your grades give us a pretty good indication of this and are also a measure of the way you have applied yourself. When we find someone whose grades are lower than might be expected from his other characteristics, we look into it to find out if there are circumstances which may have contributed.

Q. What consideration do you give work experience gained prior to graduation?

A. Often a man with summer work experience in his chosen academic field has a much better idea of what he wants to do. This helps us decide where he would be most likely to succeed or where he should start his career. Many students have had to work hard during college or summers, to support themselves. These men obviously have a motivating desire to become engineers that we find highly desirable.

Q. Do you feel that a man must know exactly what he wants to do when he is being interviewed?

A. No, I don't. It is helpful if he has thought enough about his interests to be able to discuss some general directions he is considering. For example, he might know whether he wants product engineering work, or the marketing of technical products, or the engineering associated with manufacturing. On G-E training programs, rotating assignments are designed to help men find out more about their true interests before they make their final choice.

Q. How do military commitments affect your recruiting?

A. Many young men today have military commitments when they graduate. We feel it is to their advantage and ours to accept employment after graduation and then fulfill their obligations. ***We have a limited number of copies of a Department of Defense booklet describing, in detail, the many ways in which the latter can be done. Just write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.*** 959-8

***LOOK FOR other interviews discussing: • Advancement in Large Companies • Salary • Personal Development.**

GENERAL ELECTRIC

COUPLING WITH WORLD TECHNOLOGY

England contributed radar, sonar, polyethylene, and penicillin to mankind.

Germany first developed the rocket plane, guided missile, and turbojet aircraft.

Russia launched the first earth satellites and now has in operation the largest particle accelerator in the world.

These representative developments—while not covering all the countries of the world nor all their important achievements—bear witness that research and technical advances know no national boundaries. No one nation has a monopoly on brain power.

Vast pools of research and technology throughout the world are often neglected and untapped—possibly because we're unaware they exist or possibly because, as C. L. Rouault says (page 12), we tend to think that ". . . all the good ideas have originated only recently in the United States."

Why is it important that both industry and professional engineers and scientists be alert and well-informed about research and technology throughout the world?

By being well-informed we may use new knowledge and understanding sooner—not only to satisfy the needs of the customer and help our free-enterprise economy forge ahead but also to strengthen our defense programs.

Being well-informed will also increase our efficiency by building on the solid work that others have already done or already know.

Industry now recognizes the distinct advantage of coupling with and tapping the great pools of knowledge and understanding throughout the world. To keep abreast of world technology, companies more and more are . . .

- Reviewing technical publications
- Attending and participating in international technical congresses
- Exchanging visits and information on an informal basis
- Using formal technical exchange agreements.

How can the individual keep aware of what others are doing in his discipline?

- Familiarity with at least one major foreign language is necessary to gain an accurate cross section—through publications—of world-wide technological trends. Liberal translation services are another practical way to help keep up to date.
- Active participation in technical societies, especially those with international scope, are of distinct value.
- Personal contacts, on a continuing basis, with counterparts across the seas improve comprehension and evaluation of world-wide technology. A survey trip may be good once in awhile, but it also pays big dividends for competent people to develop a friendly interchange on a personal basis. Most of the really new ideas are still in the mind and yet to be expressed.

Top-flight engineering managers make it a point to know where they can obtain the competence to accomplish most effectively the work in their operations—whether in their own unit or company or in a research institute, here or abroad. They also know what has been accomplished elsewhere. In this rapidly changing era, we can no longer continue to reinvent the wheel.

Engineers and scientists who wish to move ahead, enhance their profession, and keep their country strong have a twofold challenge in today's exploding technology: to make their own contributions to new understanding and knowledge and to know and use the contributions of others.

Paul R. Heinmiller
EDITOR

Dr. Willis R. Whitney will occupy a unique place in history as the pioneer of American industrial scientific research. His courageous start, in 1900, of the General Electric Research Laboratory had tremendous significance not only for the Company he joined but for the entire electrical industry, which was then in its infancy. It is difficult to imagine a better combination of professional and human qualities for the work that he undertook. His tremendous drive and enthusiasm brought an outstanding group of people to this new industrial activity, and the brilliant success of his laboratory stimulated the growth of research throughout industry. Over the course of his career, and long after his retirement, his active and inquiring mind provided an unfailing source of inspiration to all who were privileged to come in contact with him.

DR. GUY SUITS

Willis R. Whitney

Dr. Willis R. Whitney, often called the dean of industrial research in America, died at Schenectady, NY, on Thursday, January 9, 1958, at the age of 89. Founder of General Electric's Research Laboratory in 1900, Dr. Whitney served as its director until 1932, when he retired. During the last four years of this period, he also served as vice president in charge of research for the Company. After his retirement he continued research in the capacity of honorary vice president and consultant to the Laboratory.

In 1890 he was graduated from Massachusetts Institute of Technology (MIT) with the degree of BS. Six years later he received his PhD in chemistry from the University of Leipzig, Germany.

Following his graduation, Dr. Whitney held several positions at MIT, including assistant professor of theoretical chemistry, nonresident associate professor of theoretical chemistry, and, after 1908, nonresident professor of chemical research—a title he still held at the time of his death. While at MIT, he did important research work on colloids and established the electrochemical theory of corrosion, now universally accepted as the basis for explanation of corrosion reactions. He also contributed to the development of the modern theory of solutions.

While still at MIT, Dr. Whitney, in collaboration with Professor A. A. Noyes, developed a process for recovering and separating alcohol and ether used in the commercial production of photographic paper.

Started in 1900 with a staff of only one assistant, who was shared by Dr. Whitney and Dr. Steinmetz together, the laboratory now employs a staff of 1300, including 400 scientists.

Under Dr. Whitney's inspiring and wise leadership, the laboratory has made important contributions in many fields, including fundamental discoveries in radio tubes and other basic apparatus, harnessing of the cathode ray for radar and television use, the inductotherm (which doctors use for electronically producing fever in the human body), the submarine detector used effectively in World War I, many discoveries vital to jet engines, commercially important improvements in incandescent lighting, development of high-voltage x-ray apparatus, elements in turbine power development, and many others.

Establishing and developing the Company's Research Laboratory was perhaps his greatest achievement. This Laboratory, the first industrial research laboratory in the country devoted to basic research, set the pattern for fundamental scientific research in industry.

For many years Dr. Whitney served as a trustee of the Albany Medical College and the Dudley Observatory in Albany. He was a life member of the Corporation of MIT, and he was also on the U.S. Naval Consulting Board established during World War I. He was a member of the National Academy of Sciences, National Research Council, American Chemical Society (once serving as its president), the American Electrochemical Society (its president in 1912), American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers, American Association for the Advancement of Science, American Academy of Arts and Sciences, American Physical Society, The Franklin Institute, American Philosophical Society, British Institute of Metals, and the French Legion of Honor.

Honorary degrees to Dr. Whitney were awarded by many colleges and universities—University of Pittsburgh, Union College, Syracuse University, University of Michigan, University of Rochester, and Lehigh University.

Other honors include the Willard Gibbs Medal, Chandler Medal, Perkin Medal, Franklin Medal, Edison Medal, decoration of Chevalier of the Legion of Honor (France), gold medal of the National Institute of Social Sciences for having contributed toward the betterment of man, 1943 John Fritz Medal, distinguished service gold key of the American Congress of Physical Therapy, the Marcellus Hartley Gold Medal, and the medal of the Industrial Research Institute.

The contributions Dr. Whitney made attest to his belief: "Inactivity and inappreciation in the presence of infinite, undeveloped truth are the most inexcusable types of error and unfaithfulness. Research is appreciation." Ω

1958 *Alpha*—Tribute and Promise to Science

Cooperation and exchange of information among many organizations put Alpha to work. Now we must find the new facts to expand this success.

By DR. RICHARD W. PORTER

During the early morning hours of Saturday, February 1, 1958, I had the privilege of announcing that the first United States satellite, designated as *1958 Alpha*, had been successfully put in orbit by the Department of Defense—part of this country's planned contribution to the International Geophysical Year. Almost simultaneously, Defense officials began to use the nickname *Explorer* after the name of the project that gave it birth.

Aside from its spectacular success, the launching of *Alpha* is significant in the manner of marshalling the technical and scientific resources of this and other nations—not for war-like purposes but for the peaceful, scientific exploration of the unknown environment of the planet Earth. The cooperation of all of the agencies that will be named here, as well as many others too numerous for individual mention in this space, is something of which we can all be proud.

Only the Beginning

However, let us not be overcome by the feeling of satisfaction that results from such an accomplishment. It is only a first step, and a small one at that. We have a long way to go. If it is our intention as a nation to attain and hold a position in the forefront of scientific research and space exploration, we must take other steps—and soon.

There must be more *Explorers*. The Navy's *Vanguard* program must be made to work as planned. Other and larger scientific satellites must be put in orbit. More must be learned about the effects of space environment on living things and, before long, on man himself. We must learn how to bring a man back into the dense atmosphere of Earth at velocities approaching that of a meteor.

Dr. Porter—Consultant, Communication and Control, Engineering Services, New York Office—began with General Electric on the Test Course in 1937. A national authority on guided missiles and past president of the American Rocket Society, he is now Chairman of the Technical Panel of the U.S. Committee for the International Geophysical Year of the National Academy of Sciences on the Earth Satellite Program.

The rocket vehicle used to launch *Alpha* was an adaptation of a test vehicle developed a little more than a year ago by the Army Ballistic Missile Agency, at Huntsville, Alabama, with the assistance of the Jet Propulsion Laboratory of the California Institute of Technology. The original purpose of this vehicle was to aid in studying the problems associated with re-entry into the atmosphere of the nose-cone section of the *Jupiter* intermediate range ballistic missile, hence its name, the *Jupiter C*. Essentially a Redstone missile of which many test firings have been made, the first stage of the *Jupiter C* has longer tank sections and other modifications that enable it to use a slightly more efficient fuel.

A Cooperative Effort

The launching—made from Cape Canaveral, Florida—utilized the extensive resources of the United States Air Force in that area. Radio tracking and telemetry reception were accomplished by the world-wide network of Minitrack stations established and operated by the Naval Research Laboratory, with assistance from the Army engineers and the governments of Australia and South Africa. This network was augmented by a smaller network of Microlock stations in California, Florida, Singapore, and Nigeria—established and operated by the Jet Propulsion Laboratory with the aid of British government scientists.

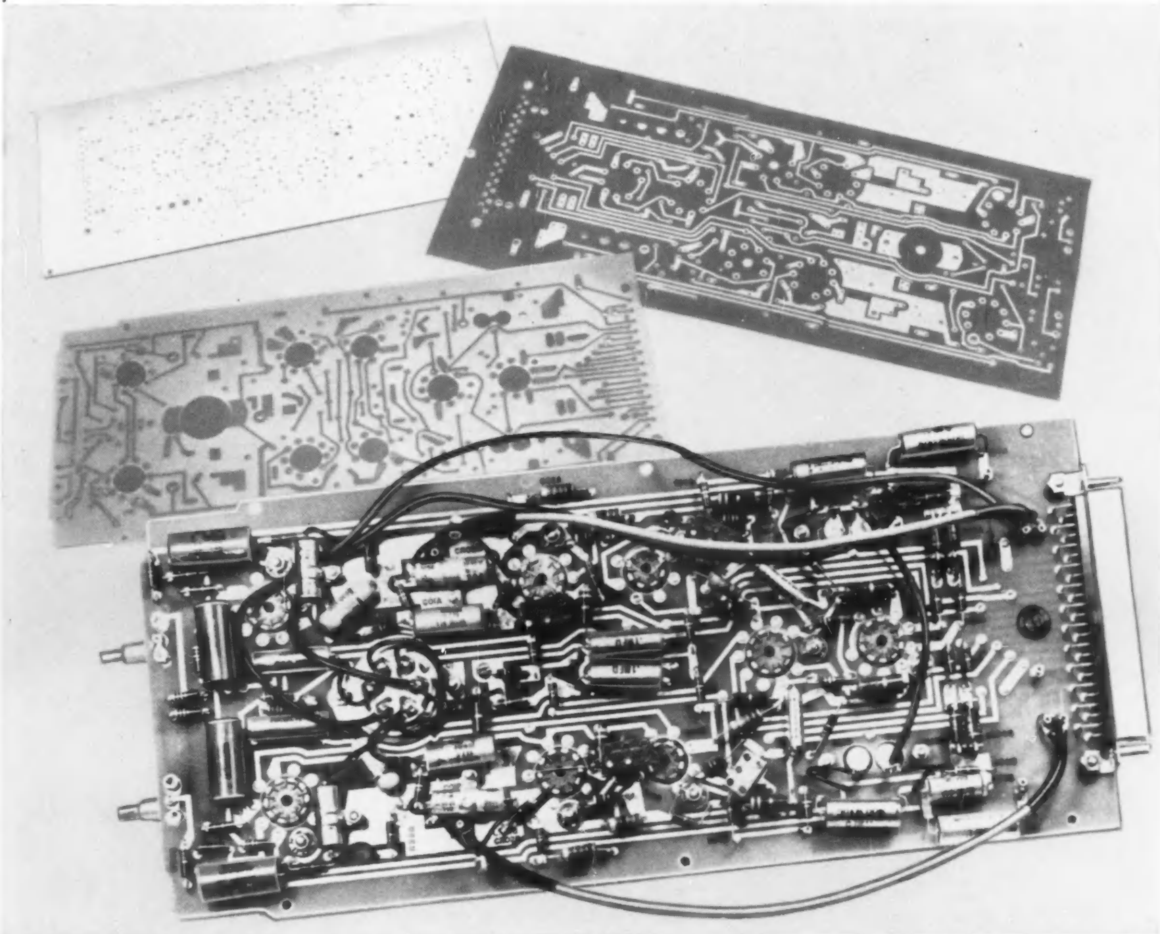
The first visual observations of the new satellite were made by members of the Moonwatch program, sponsored by the Smithsonian Astrophysics Observatory. Their network of phototelescopes, temporarily augmented by equipment loaned from the Army Ordnance Ballistic Research Laboratory and the Air Force, is actively engaged in making precision observations by photographic means. A large number of volunteer radio stations, many of them members of the amateur Radio Relay League, are assisting through the Moonbeam program. Also assisting are many volunteer photographers organized by the National Society of Photographic Engineers under the Phototrack program.

The satellite carries cosmic-ray instruments developed by the Physics Department at the State University of Iowa, instruments for studying meteoric particles developed by the Air Force Cambridge Research Center and the Naval Research Laboratory, and temperature instruments as well as two radio transmitters developed by the Jet Propulsion Laboratory.

NEW AREAS were opened to science with the successful launching of the *1958 Alpha*.

The road ahead will be difficult—and expensive. But with cooperation, determination, and a persistent spirit of urgency and adventure, we need not be second-rate in this or any field. Ω

Industrial Laminates from the company that really knows the electrical and electronics industry—General Electric



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GENERAL ELECTRIC Review MARCH 1958

Four Reports on Russian Technology

METALLURGY: Holloman, Hibbard, Bean

"Outstanding accomplishment can be achieved in Russia even with its lower state of technical development, because of the concentration of power in a few people . . . . Bardin, as the head of the Central Scientific Institute, coordinates all the research of all the metallurgical institutes. . . ." (Page 10)

ELECTRONICS: Rouault

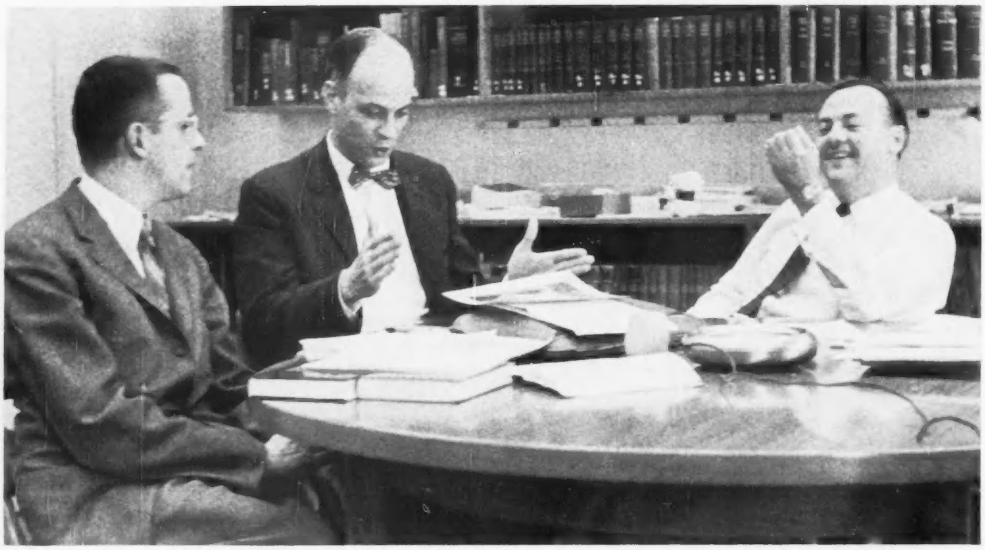
"I was astonished at the depth and breadth of Russian developments. I had been led to expect that we would see examples of a deep penetration in only very narrow areas. Actually, this is not what we found . . . . I didn't get the feeling that they had slighted anything to any extent." (Page 12)

INDUSTRIAL CONTROL: Heumann

"Contributions of Russian designers to magnetic control are practically nil, in my opinion. Rather than evidence of engineering incompetence, it indicates they have accepted our technology as adequate and haven't invested time, money, and talent on novel magnetic-control developments." (Page 15)

PERSPECTIVE—As It Was in the 30's: Roberts, Miller

"The engineers we saw were, in my opinion, rather low-grade. Russia probably realized that an industrial state couldn't be built with that kind of a setup. So the prestige of these people was re-established. They were treated more liberally, and they began to get a little responsibility. . . ." (Page 16)



The recognition of the importance of materials and the science of materials is perfectly clear to the Russians."

REPORT ON RUSSIAN TECHNOLOGY

Metallurgy: Holloman, Hibbard, Bean

HOLLOMAN: What reaction did you get from Russian scientists about Sputnik? You were there when they launched it.

HIBBARD: We had a very interesting experience in this respect. They all brought it up; they were very proud of it. This was an achievement of great importance to world science, and they wanted us to share a toast to it. One toasts everything. But they didn't rub it in. They were just proud of it and made a point of it wherever we went.

HOLLOMON: By the way, I happened to be in Washington the day or two days after; and I had lunch with Bardin, who is one of the leaders in metallurgy in the Academy of Sciences and the IGY. (He is the head of the Russian IGY delegation to the International Geophysical Year program.) I had lunch with Bardin, Bronk of our National Academy, Whitman of the Academy of Sciences, and Dryden of the National Advisory Committee for Aeronautics. We talked to him regarding the Russian accomplishment in launching Sputnik. He made a very, very nice speech, saying that he wanted us to recognize that he now considered the Americans the leaders in science in the world, that they had much to learn from us, they were appreciative of the help that we could give them, and that they were humble before us with respect to science and technology. This speech was not made in a deprecating way at all; it was done thoughtfully and considerately.

HIBBARD: He gave a very similar talk to us the day we were there. He said that the Germans were the science teachers and the Americans were the teachers of technology.

My assignment was to find out the metallurgy course content, texts, examination papers, kinds of specialization, including such things as what sort of liberal education went along with engineering. I spent the first two days at the Moscow Steel Institute, an educational institution.

HOLLOMON: Two thousand students study metallurgy in this institute.

HIBBARD: . . . plus 240 professors and teachers, and they graduate about 400 each year.

HOLLOMON: That's about two-thirds of the total graduated in the United States.

HIBBARD: . . . 30 percent are women. The same holds true in the faculty—a large number of women.

BEAN: What's the specialty of this institute?

HOLLOMON: Steel, steel metallurgy, although it's really general metallurgy.

BEAN: When you compare this to our output, you are comparing this to our *total* metallurgical output—ferrous, nonferrous . . .

HOLLOMON: . . . 400 represents, as far as I could find out when I was there, a fifth of the total output of Russia.

HIBBARD: Somewhere between two and three thousand metallurgists are produced each year. There is a sister institute in Moscow called the Kalinen Institute for Nonferrous Metallurgy and Gold. It is of equal size. This is all nonferrous. Then the Leningrad Polytechnic Institute, larger than either, teaches both ferrous and nonferrous.

HOLLOMON: One of the things that I noticed in talking to the people from the teaching institutes was that a large fraction of the people who are graduated don't go into technical work, but rather go into jobs of supervision and administration in a metallurgical industry. As I understand it, they cannot advance in the factory without a technical education.

HIBBARD: That's correct. In fact, the most striking thing about Russian jobs is that your salary is not only based on

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Dr. J. Herbert Hollomon (photo, right)—Manager, Metallurgy and Ceramics Department of General Electric's Research Laboratory, Schenectady—joined the Company in 1946. *Fortune* in 1954 acclaimed him one of America's 10 leading young scientists. Last August he visited Russia at the invitation of the Russian National Academy of Science. In the same Department, Dr. Walter J. Hibbard (photo, center)—Manager, Alloy Studies Section—joined GE seven years ago. In October 1957 he went to Russia with an exchange delegation of metallurgists, chosen by the State Department. Dr. Charles P. Bean (photo, left), also with the Metals and Ceramics Department as a Research Associate, came with the Company in 1951. Last May he traveled to Siberia to attend an international conference on magnetism held in Sverdlovsk, 800 miles east of Moscow, where he presented a paper on the nature of domain walls in metals.

what you're doing, but how many degrees you have. If a person has a Doctor's degree . . .

HOLLOMON: By the way, a Russian Doctor's degree is not our "Doctor's degree." A Doctor's degree is an age-35 Doctor's degree. It's granted for some extraordinary contribution to science after several years of doing independent research. It's equivalent to many European Doctors' degrees.

HIBBARD: Outstanding accomplishment can be achieved in Russia, because of the concentration of power in a few people. I'd like to talk a little bit about Bardin and his job, to show how this can be done. Bardin, as the head of the Central Scientific Institute, has the function of coordinating all the research of all the metallurgical institutes, including the teaching institute in the area of steel, as head of this group. This does not include the Academy institutes, but he is vice president of the Academy, and head of the Baikov Institute, so at the same time he controls all the funds of the Academy research. Therefore, he is one person who, by controlling the funds, can control the program and pinpoint it in the specific areas that he thinks necessary. And this is the sort of thing that can be done.

BEAN: Did you get an idea of how effective the control was?

HIBBARD: Oh, yes, there's no question about the control.

HOLLOMON: What was your feeling about bright young people, in going around the laboratories? Did you see any evidence of ingenious eager bright young people?

BEAN: Yes, there was one young man, who was unfortunately in a junior position . . . he was a theoretical person who suggested some experiments that are being done at the University of California and in this laboratory right now. He can't get them done in his own place.

HOLLOMON: Is this because of a distrust of "theoretikers," do you think, Charlie?

BEAN: Oh, no, he's just a junior man. But they also have the problem of the theoretical physicist getting in contact with experimental people. They happen to work separately.

HOLLOMON: Well, I kept asking the question when I was there, where were they doing their really high-temperature materials work. And I finally found out that it was at VIAM (the All-Union Institute for Aircraft Materials), and I said, "All right, may I go?" It essentially came down to, "Well, you haven't got time to go." They weren't interested in showing it. I want to make a point, though. That's not particularly unreasonable. We wouldn't let them in KAPL, either, and getting into Los Alamos would be even more difficult.

HIBBARD: You know, the Russians are as familiar with our literature as we are. *Every* American paper of importance is translated into Russian.

We are not equally familiar with their literature?

HOLLOMON: No, not by a long shot. You can get all you want, we just don't work at it.

HIBBARD: In Russia, you can subscribe to America's *Journal of Metals* This is an offset print duplicate, which they send through the mail; and I understand that the number of subscriptions in Russia is larger than the number of subscriptions in the United States.

BEAN: This is like the *Physical Review*; it's not translated, it's just offset in English.

HIBBARD: But, almost every scientist can translate it from English. They teach English for two specific reasons: to translate and to speak.

Do you consider them better teachers than we are?

HIBBARD: No, they *are* more dedicated. They're trying to do a specific thing.

BEAN: I was much impressed by what was reported to me of their teaching methods in English. In a matter of two years they can take a boy and make him speak English English, or American English . . . through separate courses.

HIBBARD: English is required of everyone who takes metallurgy; German, of everyone who takes chemistry. And they must be able to translate a certain number of words a minute.

HOLLOMON: Aren't the kids now required, even in the elementary schools, to study English?

HIBBARD: Yes, starting at age 10.

HOLLOMON: Probably the English is mostly for people who are going on to higher education. The required translation rate is no mean task. It's a very high rate of translation.

HIBBARD: At the Kalinen Institute, they have to translate 3000 letters an hour. That's 600 words an hour.

HOLLOMON: That's 10 words a minute —pretty fast. Ten words a minute is really clipping along.

HIBBARD: This is for a bachelor's degree, a "diploma engineer," and they really teach it.

HIBBARD: The other thing I wanted to bring up: the Central Scientific Institute for Technology and Machine Building. This is where they do turbine development work. And again they were very open about the thing. This is a tremendous institute, with 2500 employees including 17 doctors and 138 candidates and 700 diploma engineers. A large proportion of these are metallurgists, and they are working on problems associated with building turbines and transformers.

BEAN: As I recall, you thought the coupling between science and engineering in practice was much stronger in the USSR than it is here. Is that correct?

HOLLOMON: In the steel-making business the coupling between applied science and practice is better than it is here. The trouble is that new developments are sometimes looked at from too short-term a point of view, in our country, it seems to me.

HIBBARD: As a Corresponding Fellow of the Academy of Science and the holder of several other important jobs, Dr. A. M. Samarin has a lot of influence on the decisions in the steel industry.

BEAN: Well, getting to this question about who makes the decisions—is Samarin a god that he can make the right decisions all the time?

HIBBARD: We asked him this, and apparently you can't make these wrong decisions very often. But he pointed out that in all these cases he had enough evidence. You see, they have an experimental plant at Tula where, if he has something that he has tried on a laboratory basis, he calls up the manager and says, "I'm going to use your blast furnace for the next two weeks;" and he goes and tries it.

NO ENDORSEMENT

More exchange delegations passed between the United States and the USSR last year than in any year since the cold war began. Among these delegations were engineers and scientists from General Electric. To bring you a firsthand account of their impressions of Russian technology, REVIEW editors interviewed General Electric experts from various fields. The publication of these interviews in no way constitutes an endorsement of the Russian political system. They are published as a twofold service to our readers: further your knowledge of Russian technological advances and alert you to their significance.

—EDITORS

"Every place that I went they had people doing . . . basic research."

HOLLOMON: This apparently is run by the Academy of Sciences. It's either run by them or it's available to them. It's an experimental steel mill, so that before having to try out these things on the country as a whole you can try them out in the local steel mill. So, he's in a pretty solid position. And of course he has another advantage: most of them have been tried out in the West.

BEAN: What about the regard for basic or fundamental research? We've had a lot of talk in this country recently about this. Mr. Wilson—the former Secretary of Defense—says that basic research is what you do when you don't know what you're doing.

HIBBARD: Every place that I went they had people doing what they called basic research. (I think we would call it that, too.) I think that Vonsovsky's group of theoretical people and Shoukivitsky, a physical chemist in Moscow, were first class.

BEAN: I was rather impressed to see a translation from Pravda the other day in which Mr. Topchiev read a roll of honor of scientists in the USSR, in connection with the satellite. Well, he didn't talk about anybody building the satellite. He talked about Landau, he talked about Kapitza—great scientists and mathematicians—men doing work very far removed from practice. And he gave them credit. It was rather surprising.

HOLLOMON: Giving this kind of credit is something that we do not do in this country. But, one of the things I noticed in Russia is that the connection between their theoretical people and experimental people is not good. I think Charlie noticed the same thing. That is, their people like our Charles Frank and Mott are not connected with the kind of people we have here in the Laboratory. The connection is very poor . . .

But the education of the people about what's going on in science and technology is absolutely prodigious. The recognition of the importance of materials and the science of materials is perfectly clear to the Russians.

But not to us?

HOLLOMON: Not entirely. The research in the steel industry, for example, and the materials-producing industry, is relatively small in this country, has always been, even though it is growing lately. Steel is one of the industries that supports the least amount of research per dollar production. This is just not so in Russia.

Do they have better steel products because of their different research?

HOLLOMON: I don't know. My guess is that the best *practices* are now used sooner and more broadly in production than in the West.

BEAN: Isn't vacuum melting a case in point here? Their vacuum melting is done on a larger scale than in this country.

HOLLOMON: Let's put it this way: their vacuum processing is done on a larger scale, more broadly, from what I could gather, in Russia than in the West. With one exception, all the techniques they use were developed in the West. Some in Germany, some in the United States, and so on. Yet they're putting them into practice quickly—or at least so they told me.

You have touched upon a couple of "islands of technical competence"—areas where the Russians seem to stand out as unusually good. In addition, to crystallography and steel-making, I wonder if we could list some more of these areas of Russian strength.

HOLLOMON: There's steel, there's crystallography, there's nuclear engineering, there's astrophysics (essentially things that have to do with satellites), crystallography in the classical sense—that is, how atoms are arranged—life sciences, also the chemistry of processing of materials. Anything to do with radioisotopes, that is, use in research of radioisotopes, of all kinds and all varieties. We might be able to think of some more.

REPORT ON RUSSIAN TECHNOLOGY

Electronics: Rouault

I was astonished at the depth and breadth of Russian developments. I had been led to expect that we would see examples of a deep penetration in only very narrow areas. Actually, this is not what we found. The development was along an astonishingly broad front and seemed to cover very adequately the areas of major interest for anyone in the electronics business. I didn't get the feeling that they had slighted anything to any extent.

Charles L. Rouault—Consulting Engineer, Heavy Military Electronic Equipment Dept., Electronics Park, Syracuse, NY—visited Russia for two weeks last summer. Jointly sponsored by the State Department and the IRE, he and three other engineers attended the annual meeting of the Popov Society—dedicated to the early experimenter in wireless communication. While there, Mr. Rouault visited electronic plants and such laboratories as Moscow Physics Institute and Television Research Institute.

In what technological areas do you believe Russia is particularly strong?

Right now they are particularly strong in those areas where pure theory gives them a real advantage—anything to do with applied mathematics, particularly in the field of information theory and transmission of data. I believe they are far ahead of our own understanding in those areas.

Their components, I think, are somewhat slighted. But with them it's a problem of putting the best men to work on the areas where they think it will give the maximum return for a given period of time. Let me explain: Their tendency, I believe, has been to fix on what they thought would be about the best and most applicable component for a wide range of equipment, even though it might mean for ordinary commercial equipment an unduly expensive component. For example, we saw hermetically sealed capacitors used throughout in home television sets. This is definitely not standard in the United States. Most of the techniques we saw were those that would work equally well with what is called professional equipment in Russia, what we would call military equipment here; and what they call civilian goods—the same title applies here.

How does the technical quality of their television compare to ours?

We saw only a few programs and some tests of home receivers as they came off a production line at a Leningrad plant. I would say that the over-all quality compared favorably with what we have.

What was your impression of

Russian production and production techniques?

The Russian factories that we saw would not be in the same league as most American plants. The physical surroundings certainly would not be conducive to the best labor relations in this country. However, I believe they are getting fairly decent results when you consider the limitations under which they currently work. The civilian industry we saw didn't have a very high priority in the use of materials or components. It has sufficient priority to satisfy the needs of the political regime, but relatively little else. Their plants are not well lighted. They are not filled with safeguards for operating personnel such as we use. They are not well finished—sometimes the decor is slightly grim. From my own experience I would guess that their output from a given amount of floor space is substantially less than it is here.

Who determines where the effort shall be in the various technological areas?

I never met the man who did determine it, but I suspect that he is in one of the ministries that apportions their materials in much the same way as we did under the controlled materials plan during the last war.

Is it research and development by fiat and decree?

I am not sure the word fiat applies. I think what probably is done is this: A large number of areas of investigation are suggested—and justified—and then the ministerial groups balance off the available assets with, you might say, the predicted gain. Thus they make a management decision at a level which is quite remote from the actual people who make the suggestion.

What about semiconductor work?

Their semiconductor work in general was substantially behind that of the United States. The problems they have are in highly technical areas. They are not, you might say, overflowing with qualified technical personnel.

What is the situation in regard to computers?

We understand that there are several big computers in the Moscow area. We didn't see any, however. My understanding is that all but one is of the analog type. Apparently there is a big digital computer being built but whether it is operational, I don't know.

Would you consider this is a lag in their technology, particularly since they are so heavy on theoretical mathematics?

I really can't answer that because we didn't get into it far enough to ask intelligent questions.

"The older men had a broad outlook . . . their understanding of human nature was intriguing."

What are the areas of technological weakness?

To me, their greatest areas of weakness at the present time are not in the purely technical but rather in the relationship between the technical group and the manufacturing function. There is a tendency toward separation of function which is artificial. This revealed itself in many cases in some rather interesting gaps. Most of the time, incidentally, they seemed to be aware of these gaps. They know, for example, that their information on manufacturing costs is not good. They know that they do not have a good scale by which to measure overhead and burden of the manufacturing operation. They are quite aware of the fact that their quality-control techniques leave much to be desired. Their over-all concepts of plant safety are rather rough and ready.

Under what conditions does the typical Russian engineer work?

The ones we saw had reasonably good quarters in the plants. Most of them had plenty of good equipment. In some cases, we would be embarrassed by the amount of equipment. Over-all, their working conditions weren't significantly different from those in this country.

We have heard many times that the Russian educational system is turning out highly specialized engineers in narrow fields—to go immediately into industry. Recently I heard that they are attempting to broaden their educational base in engineering and science. What are your observations?

Most of the engineers we met were very well educated in perhaps a somewhat narrow specialty. Don't interpret this as my saying they were overspecialized. They were specialized in one field with perhaps some minimizing of the importance of other fields.

In the older men, however, I did not observe this. They seemed to have a broad outlook and in many cases their understanding of problems of human nature was rather intriguing. A number of them were well educated in the arts. I was particularly impressed by several who had a far more than passing acquaintance with French art of the late 19th century and early 20th century schools.

As far as the broadening of their education is concerned, I think it is almost axiomatic that this must take place as they fulfill their needs for specialists in their industries. They are now getting to the point where they need men who are able to conceive in a rather general fashion the new products which they see coming off American production lines.

Are you saying that they need greater creativity that would be achieved only through a broader type of education?

Yes. One thing impressing them greatly is the capacity of the American economy to turn out consumer goods that, to them, have almost incomprehensible factors involved in the design. For example, the attention to detail in American consumer goods astounds them. They just plain don't understand it. And appearance design, to them, is grossly overdone in the United States.

What do you believe an engineer in this country can learn from his Soviet counterpart?

". . . translations from Russian must be done with extreme care. . . ."

Most of us here, I feel, are too prone to think that fine quarters and the best instruments are necessary for the accomplishment of scientific objectives. The Russians, on the other hand, have had to do in most cases with a bare minimum of such creature comforts, and in many cases with the bare minimum of available equipment. I have never found that a competent man was ever stopped by lack of equipment. Creativity is essentially a state of mind.

Also, we tend to think of a man who works in a climate colder than ours as being less productive. This is not true. After all, most of the ideas we are working on now were developed by men who worked in this country 50 to 100 years ago—under the same conditions that the Russians are currently working.

I think a big problem of American engineers is their feeling that all of the good ideas have originated only recently in the United States. If American engineers were to start reading foreign technical literature they would soon find out what they have been missing.

Do you believe that American engineers and scientists should have more of an international outlook?

I think the American economy—to continue at its present pace—must find greater and greater export markets for its goods and services. Engineering at the present time is quite incapable of handling the requirements of this foreign business because we don't understand the psychology and interests of people abroad. We tend to think that everything is defined in terms of Anglo-Saxon words and/or American slang derivatives from them. On the other hand, the ideas that may be involved in a piece of equipment when expressed in a different language might lead to an entirely different over-all design for that piece of equipment. But you must understand the psychology of the people who made the remarks.

Are American engineers incapable of doing this?

To a very large degree I think that is true.

Do you recommend any course of action that a United States engineer could take to help increase his facility and awareness and outlook concerning world-wide engineering and scientific trends and developments?

First of all, I believe the American engineer must recognize that there is significant technical material—in practically every subject in which we are currently interested—written in French, German, Russian, Dutch, Italian, and a little bit of Spanish, some Swedish, and perhaps Japanese. I am not advocating that we all learn to speak and read and write all of these languages. But I do think it is necessary—to gain an accurate cross section of the technical progress of the world—that an American engineer be familiar with at least one foreign language. At the present time I would recommend German. If he has the talent and inclination, then he should be familiar with three: French, German, and Russian. With these he would certainly bracket all the remainder.

The reason for suggesting so strongly the need for language capability is this: it is very difficult when reading a translation of an article to know whether the translation is accurate unless you can go back to the original source and check the translation as it applies to the particular art in which you are involved. I have several times been of value to our own patent people by being able to translate technical French within the framework of specific electronic techniques.

The second reason for suggesting a familiarity with a foreign language lies in the fact that we are sometimes prone to bias our methods of thinking by the civilization with which we are surrounded; but it may lead us to solutions of problems which are unnecessarily complicated and almost willfully at variance with the fundamentals of the particular problem we are trying to solve. Sometimes an excess amount of equipment allows us to obtain an answer at an otherwise unreasonable cost.

The third reason, and perhaps the most difficult to explain, is that we continuously misunderstand people, particularly those abroad, by our inability to understand the language with which they express themselves. We place ourselves at the mercy of those people who translate these remarks for us, and we are thereby subject to bias which may or may not be adverse. For example, translations from Russian, as I have had cause to remark, must be done with extreme care because of the fact that the Russian pays great attention to grammatical detail, and the change of even so much as the sense of a single word can alter completely the sense of the whole sentence or paragraph. Therefore, you must be able when questioning a particular statement to go back to the source. But even more than that you must be able to understand the language of the people, to understand those factors that may influence them at some time in the future to take an action that is either positive or negative with respect to that which we wish to pursue.

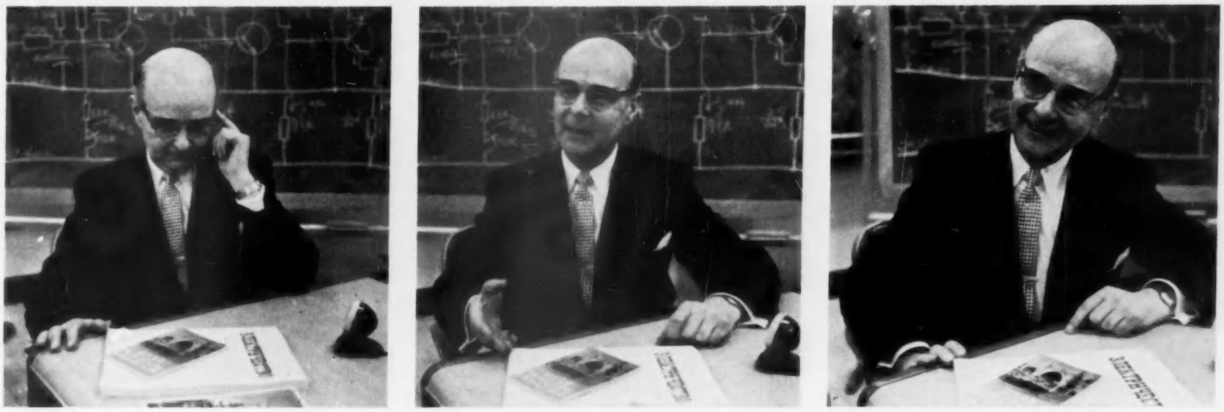
I think the average American engineer is overeducated in what I call picture-book courses, and undereducated in the fundamentals of an engineering education: mathematics, physics, chemistry, and certain essential language skills, among which should be the reading and writing and speaking of intelligible English and at least the mastery on similar terms of a minimum of one other foreign language, such as the ones I've mentioned already.

So far you have talked about Russia's accomplishments today. What is her goal for tomorrow?

Russia appears to have had one objective in mind for the last 25 or 30 years: equal or surpass the United States in those areas which they considered sufficiently important to devote the required effort. In most of these areas I think they are in a position where they feel they have obtained their goal—that they have equaled or surpassed us. They are, therefore, in a position of leading from strength. The impetus which has been observed the last couple of years is not something that will be slowed down easily.

There are, however, some factors that may alter this. First of all, now that they are trying to maintain their position of leadership, they will find it a little bit troublesome to keep their eye on the ball. Contrariwise, we must not fall into the trap of thinking that our objective is to equal or surpass the Russians. Rather we must continue to play the game in which we have been involved all the time: to satisfy the needs of the people at minimum cost.

If we can do this and do a better job than the Russians, then eventually we will come out all right. Here's a story: A noted newspaperman was asked if he could explain why Willie Hoppe kept winning billiard championships. He replied, "I think Willie Hoppe wins billiard championships because he plays billiards; the others keep playing Willie Hoppe."



"Equipment in older factories was not modern . . . . noted absence of electronic control . . . . Russia relied heavily on copying the West."

REPORT ON RUSSIAN TECHNOLOGY

Industrial Control: Heumann

To me, it appeared that motor control is not high on the Russians' priority list with regard to engineering and development effort. The manufacturing equipment that I saw is old; much of it was taken out of Germany after World War II. Industries in Russia still use quite a lot of manual control. Keeping it in good repair, they make no effort to replace it with more modern control. In the Moscabel Cable Works, I noticed some General Electric motors and control in the rod mill and on some wire drawing machines, apparently dating back to the 30's. Much of the postwar machinery in that plant bears East-German nameplates; the only new equipment claimed to be Russian-built is wire enameling ovens, which looked neat and well-built.

From these casual observations and from conversations with Russian engineers, my impression was that in the power utilization area their industry relies to a large extent on foreign-built machinery.

Russian designers have nothing to contribute to motor control then?

Contributions of Russian designers to the magnetic-control art are practically nil, in my opinion. But this should not be interpreted as evidence of Russian engineering incompetence. Rather, it indicates to me that the Russian have accepted our technology as adequate, and they have refrained from investing time, money, and talent in novel magnetic-control developments. The control products exhibited look neat, workmanlike, and well-finished. From all indications I believe the Russians are capable of using and applying the control tools they have copied from the West. And they seem to have mastered the skills of the West in that area.

Can you please give us a little more information about what you mean by products being exhibited?

I refer to a portion of the All-Russian Agricultural and Industrial Exhibition located in the outskirts of Moscow. A permanent fair, it consists of a number of pavillions located in a large park landscaped with flowerbeds, trees, shrubbery, and water fountains—for which the Russians have a particular fondness.

One section of the Exhibition consists of pavillions of the various federated republics that comprise the USSR. The pavillions contain exhibits to show the geographic and ethnic character of the republics and their products. And special emphasis is laid on the claim that the federated republics enjoy great autonomy in governing their local affairs.

Pavillions in other sections exhibit industrial goods. Each pavillion concentrates on a particular industry and displays machinery, components, and products of Soviet industrial enterprises—over-all an excellent collection of source material from which the state of the art can be judged. Naturally, the bulk of the exhibit contains producer goods; consumer goods fill only a comparatively small pavillion. The government utilizes the Exhibition to impress its own citizens, satellites, and foreigners with Soviet industrial accomplishments.

And, as a specialist in motor control, you were impressed with their exhibits in that field?

From a visit to the Exhibition, in which an entire hall was devoted to motors and their control, I gained a better impression of motor control than I did from trips through some of the older factories. For one thing, the equipment in the factories was not very modern. One of the guide books stated that the Exhibition showed the latest and most modern tools of automation.

My impressions at the Exhibition were later confirmed by a visit to the laboratories of the Moscow Energetic Institute, a technical university. Comprehensive facilities are available there for testing motors and controls by students. The control components for testing as well as inspecting samples are the same as the designs shown in the Exhibition. And similar control components could also be observed at the Electrotechnical Institute, a testing and development laboratory.

Although I did not have occasion to inspect an up-to-date recently built manufacturing plant, I believe that the sources mentioned represent the present status of Russian control art.

Gerhardt W. Heumann, Senior Engineer, Power Utilization Engineering, User Industries Sales Dept., Schenectady, joined the Company in 1931. A native of Germany, he received his Master's degree from the Technical University of Dresden. Last summer he visited Moscow and Leningrad to attend the meeting of the International Electrotechnical Commission (IEC) as Chief U.S. Delegate to the Subcommittee on Controlgear. Trips to Russian manufacturing plants, exhibitions, and laboratories helped him form an impression of their technology as related to his field—motor control.

"Russians are proud of what they have done in the power line. . . ."

How about advanced development work? Did you get an impression of it?

The engineers I met were either not sufficiently familiar with advanced development work or they were unwilling to talk about it.

From the exhibits on the peaceful use of nuclear energy, I gained an indication of one phase of it—the utilization of radioactive isotopes for measurement and control.

One exhibit shows equipment for counting soda bottles on a conveyor. A radiation beam is directed across the conveyor to a receiver. When a bottle intercepts the beam, the receiver responds and generates a control signal. On this application the radiation beam is used in the same manner that we use the interception of a beam of light for photoelectric counting.

Did you notice any other examples of unusual development?

Two other exhibits demonstrated the gaging of the thickness of materials. One machine intended for thin materials uses a roll of cotton tape as an example. On the other machine, intended for thick materials, a strip of linoleum serves as an example. Both machines were enclosed and sealed, so I couldn't see the working parts. Our guide explained that both machines measure thickness by measuring the absorption of the radiation beam. The resulting signal can be used for indication and inspection or to control the process machinery.

Another application concerns marking. Here the problem is grading steel with an indelible mark to permit later identification and sorting. A spot of irradiated material is welded to the steel, the characteristic of its radiation being coded to the grade of steel. When this steel is placed in a reader, the indication identifies the grade of steel.

Did you observe similar advance development work being done in your own area of motor control?

Based on the assumption that control components and equipments exhibited in the permanent fair I described are representative of the present state of Russian control art, I must answer that Russia has relied heavily on copying the West. And the lion's share in designs copied, incidentally, consists of General Electric ones.

Were you allowed to inspect the exhibits freely?

I didn't have an opportunity to inspect the control for the working exhibits. The operators refused to open the control cabinets, claiming they are instructed to keep them locked for reasons of safety.

Could you describe some specific examples of equipment you observed?

I brought home some photographs of a control panel that show a collection of a-c and d-c control devices. In general appearance the board resembles a General Electric steel-mill panel. It contains slate bases, and the devices are supported by live studs. Many devices are copies from General Electric drawings that the Russians received in the 1930's when International General Electric dealt with Amtorg. While the basic features of the General Electric designs are clearly recognizable, the Russians have made modifications. Some of the devices are now unit-assembled so they can be mounted on the panel in one piece. Auxiliary contacts are also unit-assembled and so modified that one assembly fits several types of devices.

And here's something I *didn't* see that's worthy of mention—the complete absence of electronic control. Neither in any of the laboratories nor in the industrial exhibits did I see any motor controls employing electronic tubes. And I saw photoelectric controls only on one occasion: the device was employed with an instrument for grading pelts according to sheen, utilizing the degree of reflection of light by the pelt.

How about general observations of the electrical field?

In this field the top priority seems to have been assigned to the creation of a system of generating, transmitting, and distributing electric power throughout the country. By far the major portion of engineering graduates enter this field. Inspection trips to schools and laboratories showed that power problems occupied far greater space than utilization problems.

At the exhibition, the space devoted to electric power apparatus also greatly exceeded the space allotted to utilization apparatus. And the program of IEC inspection trips included a much greater number of power-generating and -distributing plants than manufacturing facilities. Apparently the Russians are proud of what they have done in the power line rather than in the industrial line.

How about the atomic energy field?

The Russians emphasize and take great pride in their work in the nuclear energy field. One pavillion in the Exhibition is devoted to "the peaceful use of the atom." This exhibit contains a working model of a 150-kw reactor unit installed in a deep well filled with water. Rod movement and control mechanism can be observed through mirrors. Indicating instruments register the power generated. Small-scale models are shown of 200,000-kw power stations with nuclear reactors, several of which are claimed to be under construction. And I understand the first one is intended to be in operation in 1958.

REPORT ON RUSSIAN TECHNOLOGY

Perspective—As it Was in the 30's: Roberts, Miller

ROBERTS: I was actually in Russia from the first weeks of May 1930 for a period of six months; I went over to superintend the installation and starting up of a paper mill at a place called Kursa on the Volga River, northeast of Moscow.

MILLER: I was there from September '31 to the end of '33 at Dneprostroy on the hydroelectric project that was part of the first five-year plan. Approximately 15 other G-E men were also on the job.

ROBERTS: I lived in a log house—the "foreign hotel"—with English, Canadian, and a few other American engineers. We were all called "Americanskis." We had separate bedrooms, common bathrooms, and lots of bedbugs. At dinner the Germans sat at the opposite end of the table from the Americans with visiting Russian "commissars" in the

"... Russian machines were the largest ... they had the bigness complex even then."

neutral zone between. There were a great many German operators in Russia in those days. The technicians who ran the machinery—production machinery—were German, and I think that's generally true of Russia at that time.

MILLER: Two houses were made available for our living quarters. We shipped in a lot of American food; otherwise we would have had very slim eating. I had charge of the food supply for awhile, and we kept it under lock and key so the Russians couldn't make off with it.

ROBERTS: Actually you couldn't get enough food—you couldn't get enough of a balanced diet in Russia in those days to live anywhere near the standard of living to which we are accustomed without importing food.

What was your impression of the competence of Russian engineers?

MILLER: They seemed highly theoretical, not very practical. Of course, there were only a very few engineers there. A Russian engineer was in charge of the over-all project, and he had perhaps three or four men on his staff. The rest of them were laborers and so-called mechanics who had been brought in mostly from the surrounding farms.

Wasn't that a pretty important job for farmers?

MILLER: It was, but at that time Russia had very little heavy industry and her supply of experienced men was very limited. Of course, we had American armature winders over there and erectors. In my own case, I was supervising the erection of the generators, and GE engineers (Ollie Bemis, Renny Maine, and I) did all the line-up work, so the important things were not left to the Russians. They provided the labor.

ROBERTS: I think you've got to recognize that an enormous change has taken place. When the Communists took over in Russia, the opposition was among the intelligentsia. And the intelligentsia includes, of course, the engineers and that sort of people. Most of those were liquidated; probably because they would not conform.

While we were in the country, I think people were just terrified—scared of their lives. If they made a mistake they were hanged, shot, or sent to Siberia.

Technical mistake?

ROBERTS: Any kind of mistake. American engineers would go over there and take responsibilities. We were given as much as we'd take, because they didn't want responsibility. When we wanted things done and they made excuses, we had a technique: you write a letter—5 or 6 copies to all the commissars or people you could think of—telling them that "If this isn't done, we assume no responsibility." It would be done next day.

Now, there *were* engineers there, and I think you could see a pattern. Engineering was going to be important pretty soon, but it certainly wasn't important then. The ones we saw were, in my opinion, rather low-grade engineers. Finally, they probably realized that an industrial state couldn't be built with that kind of a setup. So the prestige of these people was re-established. They were treated more liberally, and they began to get a little responsibility; they took it and developed it. Probably the war accelerated this program.

A paper machine is a continuous process—24 hours a day, 7 days a week, if you can keep it running that long. In America, if you see something going wrong—and a little adjustment to be made—you'd shut down the machine and fix it before serious damage resulted. But the Russians would take bailing wire or the equivalent and keep going. When it finally broke down, *everybody* would fix everything; each person was afraid to assume the responsibility for the shutdown. Finally, someone had it forced upon him.

Was it your impression that they had good theoretical background but that it was emotionally blocked?

ROBERTS: Well, an old-time paper maker, the superintendent, was pretty good. He was, I would judge, a man who weathered the revolution. Probably in the business all his life, he had professional competence. Still I think he was very worried for fear of his job.

It's quite a pathetic picture to see a bunch of highly intelligent people who starved for intellectual discussion. The business of sitting down and talking, chatting, or mixing with the Americans—that kind of stuff—was out. Much too dangerous.

MILLER: And they had no concept whatsoever of the outside world. When we would talk about each family owning their own home and practically everybody driving a car, it was beyond their comprehension.

ROBERTS: It's interesting to me to read these stories about the present Russian libraries that include all the technical magazines and all the technical publications from the entire world—very, very complete, good libraries, available for everybody to read. Now, maybe this isn't a true comparison, but I took over certain books with me: *Shakespeare*, *Vanity Fair*, and Wells' *Outline of History*. The first day that I got in, a knock came at my door and a little fellow came in and introduced himself as Mr. Kruschev. He said, in one of the best Oxford accents I've ever heard, that he was going to be our interpreter. In our conversation it came out that he was an Oxford-educated lawyer—a member of the intelligentsia—on his way to being liquidated. In the meantime he was making a living for his wife and his boy and himself by interpreting in this mill. While chatting, I noticed his eyes straying away from me. They were looking on the bed where I had started to unpack and had put these books. He sat

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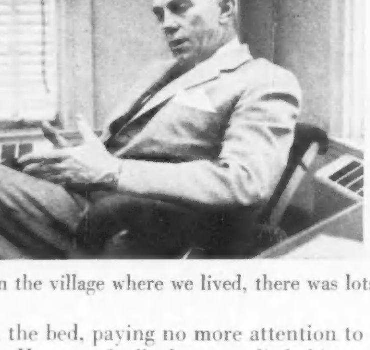
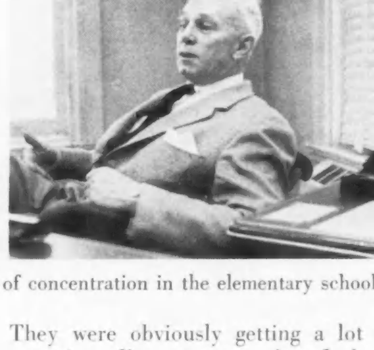
F. Morley Roberts (photo, right)—Manager, Industrial Engineering Section, User Industries Sales Department, Schenectady—began his career with General Electric 34 years ago. William E. Miller (photo, left) joined the Company 28 years ago and is presently Manager—General Mill Engineering Unit, Industrial Engineering Section.

"In the village where we lived, there was lots of concentration in the elementary schools"

on the bed, paying no more attention to me. He sort of talked to me a little bit on the side while leafing through the *Outline of History* and was just, so help me, was just like a starving dog with a piece of red meat. Literature was something that interested him, and the idea of being able to sit down and read a history book freely—something that had been written without restraint—was out of his world.

Did their technical people appear equally limited as far as looking outside their country?

ROBERTS: In a place like the one I was in, you wouldn't expect to find libraries. But L. A. Umansky—General Electric engineer noted for the contributions he made in electrification for industry (see "Electrification of Industry," May 1955 REVIEW, pages 26-31)—told us that long before the revolution, they used to get all the copies of the AIEE journals and translate them word for word. It was their "bible" in the pre-Revolution days. I would judge that for awhile nearly every Western magazine of any sort was suspect. This gradual freedom to reach technical journals has developed pretty much in the last 15 years, maybe since the war.

Could you occasionally see the beginnings of independent engineering thought developing?

ROBERTS: There is no question in my mind that the two or three technical or electrical engineers that we had in our area were beginning to have some standing. They were just beginning to see some evidence that they were considered to be pretty important and that engineering was an important thing.

Did you notice anything about their educational system?

ROBERTS: In the village where we lived there was lots of evidence of concentration in the elementary school areas. They seemed to do a good job. The children looked well fed and happy. They were obviously getting a lot of attention. I'm not sure, but I don't think they had anything like a high-school system comparable with ours. I got the impression that they were carrying the children at that time up through the elementary grades and dropping them pretty fast. Of course, none of the technical schools that you read about today were even started.

As you look at today's reports about Russian engineering and scientific work, if you can separate that from the social and political conditions, what changes strike you as most significant?

ROBERTS: To me the most significant thing is that I honestly believe that the Russian engineer today has a high social standing and that he is allowed to think. There's lots of evidence that they are highly intelligent and essentially very decent people. I believe they've found it necessary to reinstitute the intelligentsia and give them social standing.

What was your over-all impression about such things as their electric power facilities and distribution?

MILLER: They were very limited by our standards. Dneprostroy was one of their first big hydroelectric projects.

What would have been the capacity and the voltage of that project?

MILLER: . . . that was 110-kv transmission voltage. General Electric installed five 77,500-kva 13.8-kv generators, power transformers, switchgear, and outdoor switching yard—in other words, all the electric equipment. After we left, the Russians expected to add another three or four generators. The powerhouse was laid out for these generators, and they were under way on the first one when we left.

Were they designing their own generators?

MILLER: No, they took our designs and bought the critical parts—such as the magnetic steels, the stator iron, and the shaft and bearings—from the General Electric Company. The rest of it was fabricated at Leningrad.

This 110 kv, was that the highest transmission line voltage in Russia at the time?

MILLER: Yes, I imagine it was—at that time.

How would that have compared with this country?

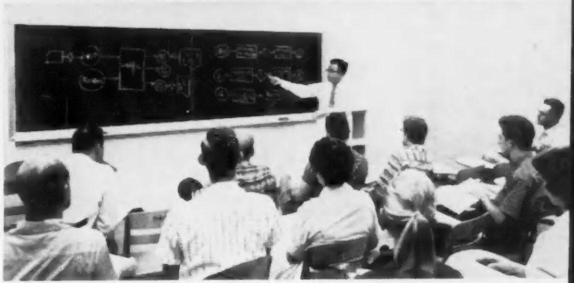
MILLER: Well, that was about tops here, too, at that time. You see the Russians were striving to do everything bigger and better than the rest of the world, and when Russian machines were built, they were the largest.

ROBERTS: They had that bigness complex even then.

We didn't have very much Russian-built equipment in our paper mill. Nearly all the equipment that wasn't American was German, but the Russian-built equipment that we did have—was poor quality by our standards. Actually we had an accident there due to failure of a connection of a 6000-volt terminal on a knife switch. It failed and blew up because the clip was poorly anchored into

CONCLUDED ON PAGE 45


". . . the important things were not left to the Russians. They provided the labor."



ARIZONA STATE CAMPUS possesses today's closest link between an industrial organization and a university—Arizona State Computer Center, operated by General Electric. The purpose: To attract and develop people who can contribute to our nation's technological progress.

Industry Goes to the Campus

By D. D. McCRACKEN

Long before Russia's first *Sputnik* triggered Americans to an awakening interest in their educational system, a unique experiment in higher education was taking place on a college campus in the Southwest (photos).

Last spring, representatives of industry and Arizona State dedicated a large computer facility at the school. It represented the confluence of two related streams of development—one in industry, the other in education. Both were based on the fantastic growth in complexity of modern technology.

Natural Alliance

Dependent on the quality of education, industry has tried—especially recently—to assist educators in their work. Of the many possible examples, three will show you the steady development of industry's closer cooperation with educational institutions.

The pattern began in 1951. Then General Electric established its Advanced Electronics Center on property owned by Cornell University in Ithaca, NY. In 1954, cooperation became even more apparent when the Company's Microwave Laboratory opened near Stanford University, Palo Alto, Calif.

Early 1957 saw the closest link to date between an industrial organization and a university: establishment of the Arizona State Computer Center, operated by General Electric on the campus of Arizona State at Tempe, 10 miles east of Phoenix.

True, many specific motivations do lie behind this progressively closer alliance. But the *basic* reason is a desire to attract and develop *people* who can contribute to our nation's efforts by improving products, services, and technological know-how.

Adapting to the Nation's Needs

Nor have educators been unresponsive to the needs of our growing technology. Dr. Grady Gammage, President of Arizona State, points out that you can clearly trace education's adaptation to the needs of our nation back at least to the Civil War.

In 1862, with support of educational leaders, Congress passed the Morrill Land Grant Act to "donate public lands to several states and territories which may provide colleges for the benefit of agriculture and the mechanic arts . . . without excluding other scientific and classical studies, and including military tactics." The grant amounted to 17,430,000 acres and realized a sum of more than \$7½ million.

Subsequently came the introduction of engineering subjects into the higher-education curriculum. Still later came business administration courses: accounting, personnel administration, industrial management, and others. In each instance, American education broke further away from the European tradition of classical education: philosophy, law, medicine, and theology. In each instance, American education took the bold—and not unopposed—step of recognizing the social, economic, and

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A previous contributor to the REVIEW, Mr. McCracken—who joined General Electric in 1951—is the author of *Digital Computer Programming*, published by John Wiley and Sons. Formerly Manager, Training, Computer Department, Phoenix, Arizona, he is now Specialist, Manufacturing Control Systems Research and Education, Manufacturing Services, New York Office.

HOW THE COMPUTER CENTER BENEFITS STUDENTS

By July 1957, two classes in digital computer programming had been taught in Arizona State's mathematics department. This was a rather small beginning because it didn't reach the areas of business administration or computer engineering. Still, a pattern of benefits to the students appears.

The biggest gainers are naturally the mathematics and electrical engineering students who hope to go into the computer profession or who are already on the edge of it in industry. To them the course is almost a vocational one, although their math and science subjects are still much more important to their eventual success. The course of digital computer programming isn't so narrow, though, that it is valuable only as applied to a particular computer. Fortunately, many of the basic principles of computer operation apply equally to all machines.

Another group of students derives benefits that are less obvious but perhaps more significant in the long run.

These students come from mechanical engineering, or physics, or chemistry—or maybe one day, from history and psychology, too. They probably won't be professional programmers, but they'll have occasion in their work to take advantage of a computer's powers. That is, they'll use computers *if* they know what a computer can do. In such courses, these students are at least introduced to the capabilities of a computer, and they see it solve problems in their own fields.

As an important part of the programming course the student chooses a problem to be solved on the computer. One man, for instance, analyzed the results of a spectroscopy experiment. Another prepared a program to tie in with his studies of high-temperature physics. Two students worked together on a study of rocket-sled propulsion, growing out of their interest in work at a nearby government test center during the summer.

Involved with elementary numerical analysis, several students prepared programs comparing two methods of numerical integration automatically until they obtained a specified accuracy. Attending evening classes, three employed students ran a program of value to them in their work on microwave propagation.

For all, there was at least one fascinating sidelight. A mechanical engineering student chose for his computer project a small part of a bridge design calculation. To check his accuracy, he worked basically from a previous calculation carried out by a consulting firm on an actual bridge. The student ran into difficulty in checking out his results, however. Carried out by graphical methods, the older calculation wasn't nearly so accurate as the computer's!

technological needs of the country by providing training in new fields as well as in liberal arts.

Dr. Gammage and others at Arizona State, not itself a land-grant college, feel that the introduction of courses in computer technology is simply another logical step in this pattern of education.

But how does a school with more vision than money implement its dreams? Only the nation's largest institutions can afford to buy or build a large computer for instruction and research. And though some members of industry subsidize educational computers, in our free society they can't be expected to supply enough financing to do the whole job.

Practical Approach

After General Electric chose Phoenix as the headquarters location for its Computer Department, Arizona State officials immediately recognized the opportunity to achieve—at reasonable cost—something they couldn't accomplish for many years by tax support alone.

And so, with the establishment of the Arizona State Computer Center, two streams of development converged.

In its new Technology and Industry Building, the University prepared space for the computer. This entailed installing a false floor in the machine room, air conditioning, and power equipment, besides finishing part of the wing for office space to house personnel of the Computer Department's Scientific Applications Section. Approximately 80 people comprise this group—largely computer programmers and analysts who prepare problems for machine solution.

Additional to initial costs of installation, Arizona State pays for electricity, air conditioning, maintenance, and janitor service. In return, General Electric bears all expenses for the computer and allows adequate time on the machine for academic instruction and research. Instructions of computer-oriented courses are supplied by the Computer Department as the school requests.

Of course, the computer is far too large for use by the University alone. It's one of the most powerful mass-produced scientific digital computers presently available. A stored-program machine, it accumulates in its memory instructions defining a problem along with data to be operated on. Depending on needs, you can supply the computer with memories storing between 4096 and 32,768 numbers or instructions. It carries out most instructions at a rate of more than 40,000 per second.

Actually, the computer is used as a design and accounting tool and as a service-bureau computer—sold to any group wanting to buy the service, both inside and outside of General Electric.

The Computer Department's Engineering Section uses the machine to design new computers now under development. It also handles some of the Department's accounting work. And a committee with members from all Sections is actively considering other paperwork areas that can be effectively set up for electronic data processing.

Everyone's Gain

What are the advantages of a Computer Center on campus?

Two courses in computer programming were taught at Arizona State during the 1957 spring semester. In fact, the courses began even before the machine was in place. Had the University waited for tax support, it couldn't have started for several years—and then on less up-to-date or smaller equipment.

What's more, even if Arizona State obtained a computer of its own—through a grant, let's say—they wouldn't have had the staff to operate the machine and teach courses. Now on campus, however, are many qualified General Electric instructors—most of whom have previous teaching experience. A total of nine courses were taught during the 1957 academic year: one by a regular Arizona State faculty member, one by an employee of another computer manufacturer, and seven by General Electric personnel.

Several members of the Computer Department teach mathematics courses, principally because they like to teach. They receive no compensation from Arizona State, unless the course is taught on their personal time.

Arizona State benefits primarily because it can offer a better-rounded curriculum, taking into account the growing importance of computer technology to the nation. True, the presence of a facility and staff attracting some students who specifically want computer courses —or attracting new faculty members who want to teach such courses with the proper equipment—may well increase the school's prestige and enrollment. But at Arizona State they focus chiefly on the *education* of students (Box).

Aside from this long-range philosophy of providing the best instruction in a new and growing field, the college can better serve Arizona business and industry in the here and now. Employees of many local industries attend night courses, a few traveling from outside the Phoenix area.

A direct benefit comes through services provided to the School's administrators by the Center. A computer program eliminates much of the drudgery of the student-registration process. And applications are under consideration in such areas as payroll accounting and maintenance inventory control. Some areas have spectacular potential value and influence. Others, less ostentatious, help facilitate the task of administering a school with 8000 students enrolled.

Blending Intellects

The computer and staff of the Center draw many visitors to Arizona State's campus. Some casual visitors simply want to see the "giant brain." And the school welcomes them. More important to the school, however, are the speakers who come at the joint invitation of Arizona State and General Electric.

Already Arizona State has welcomed many distinguished visitors—men from other computer installations who give informed lectures on computer education, numerical analysis, and foreign developments. These men spend busy days in informal discussions with staff and faculty, speaking at colloquies, and generally sharing their knowledge and stimulating their listeners.

You cannot overestimate the importance of such visitors to campus intellectual life. To the extent that the Center attracts such visitors, to that extent it enriches the school's program.

Another effect of industry on the campus, though less direct and immediate, suggests great long-range importance. It is symbolized by luncheon meetings at which faculty and members of the Computer Center staff meet to discuss common problems and interests. Arizona State's faculty members say this interchange of viewpoints stimulates them in investigating computers' potential and in initiating research projects—even to the extent of including some of the pertinent information in their courses, whether mechanical engineering, music, or sociology.

Perhaps the most important part of this conversational interchange lies in its potential for triggering the imagination—an important part of education, as you know. These informal exchanges between educators and industry may become one of the primary ultimate benefits if the discussions provide some new insight, shake loose some conservatism, and direct vision toward the future—and if these things are passed on to the students.

But the advantages do not all accrue to education. Industry shares in the practical benefits, too.

Many highly qualified technical people enjoy a university atmosphere. Some like it simply because the cultural events surrounding a university stimulate them; some like the athletic events; some like the informal interchange with professional educators. Others enjoy their close proximity to a school where they can continue studying — particularly when they're close enough to take daytime classes. Still other people like the occasional opportunity to teach, or they enjoy browsing in a library. Whatever their special reasons, many technical men do prefer being close to a campus.

But most important of all is the opportunity for industry to convey to students the fascination of computers.

Close Ties, the Key

The Computer Center at Arizona State represents the first major instance of a facility supplied and operated by industry and located on a university campus and in university buildings.

In many instances, industrial relations are on the fringe of this situation. Private groups donate equipment and even lend personnel on a part-time basis, but they do not retain operating control. In this category, for example, are several companies—including General Electric—that donated apparatus to Arizona State: Westinghouse Electric Corporation, AiResearch Manufacturing Company, and Kennecott Copper Corporation. A few times a private group has entered into a cooperative arrangement, but the facility was not located on campus.

With the Computer Center, the situation was clear from the start; if the cooperation was to be successful, it had to be close cooperation. Students couldn't be expected to drive 10 miles twice a week to a computer laboratory located off campus. And at that time, Arizona State couldn't have financed or staffed such a center on campus.

Response to the first night course offered in computer programming well illustrates the interest in—and need for—the courses offered. With less than a week's notice, having placed only one newspaper announcement plus a few calls to local companies, 30 people came out for the first night session. Computer time subsequently used by this one class for their laboratory sessions, if bought at commercial rates, would have cost about $7000.

Education for New Age

Most of the people concerned with the Computer Center see no end in sight for cooperation between education and industry. If anything, the motivations that led to it—the growing complexity of technology, the desirability of campus life, and the importance of good students—will grow stronger.

Today, millions of Americans openly question the effectiveness of this nation's educational system, in view of noteworthy accomplishments abroad—by other people, with other systems. And rightly so. No nation has a monopoly on brain power or talent.

But when all is said and done, Americans will find that their system of education—nurtured by free men over many years—is flexible and fundamentally sound. Rather, the need calls for improvements, refinements, and intellectual disciplines, with some fresh approaches typified—in higher technical education, at least—by the Computer Center at Arizona State College.

The mutuality of benefits of industry's cooperation with education is apparent. During interviews conducted in preparing this article, leaders of *both* groups said essentially the same thing: "We can't help but like it, for we seem to have the better part of the bargain!" Ω

CREDITS

Page	Source
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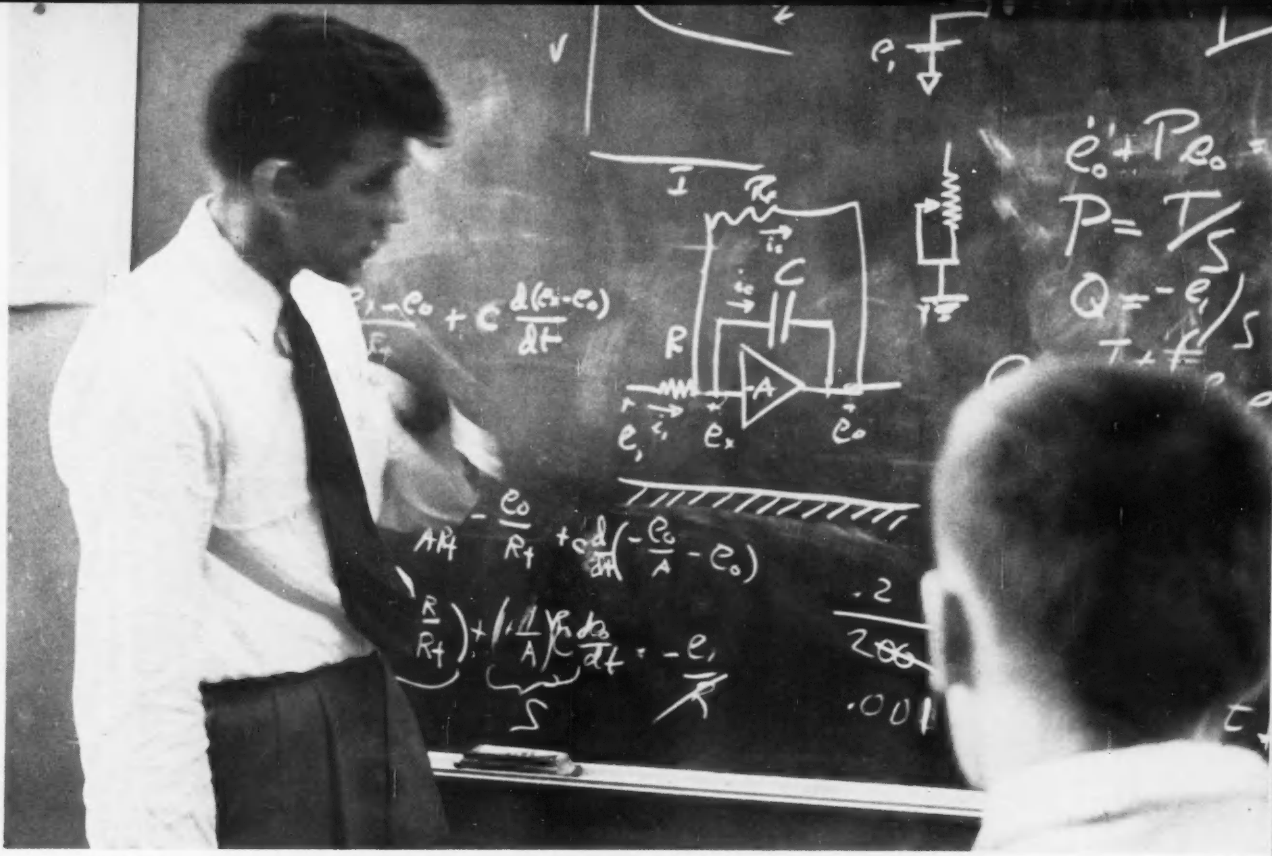


... circuit design of analog computers

... photoconductivity in storage tubes

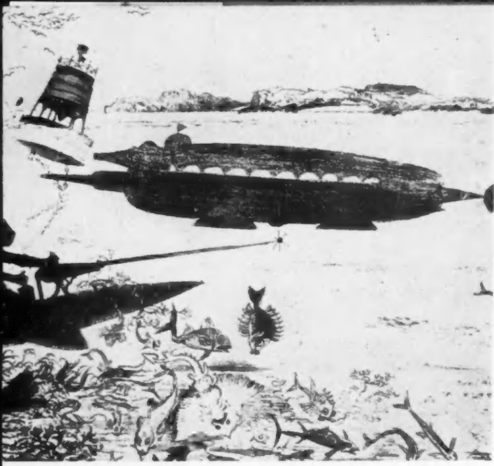
. . . very high resistivity silicon

Thought

"Thought is the property of him who can entertain it," wrote Emerson. Among scientists and engineers, you'll find such cerebral entertaining sometimes solitary, sometimes social—as likely to be going on around a luncheon table as in a laboratory or conference room. You often see technical work pictured as straight-line logical progress toward a goal. It is seldom so simple. Here are glimpses of men engaged in the kind of thought—sometimes circuitous, sometimes tentative—that makes science one of man's adventures.

. . . performance of semiconductors

. . . electron ballistics by analog methods



Even though the torpedo had a hazy, fanciful (lithograph, left, dated 1882), and erratic history, it sank 5-million tons of enemy shipping during World War II, damaged 2½-million tons more during the conflict.

During 1942, General Electric Research Laboratory scientists began development work on acoustic homing devices at Lake George, NY. This work led to a series of acoustic target-seeking torpedoes for our Navy.

Tests at Key West, Fla., of Mark 35 acoustic homing torpedo helped engineers develop it into a deadly underwater missile—designed to seek out enemy submarines, follow their maneuvers, and home in on the target.

DEADLY FISH— Mark 35 acoustic homing

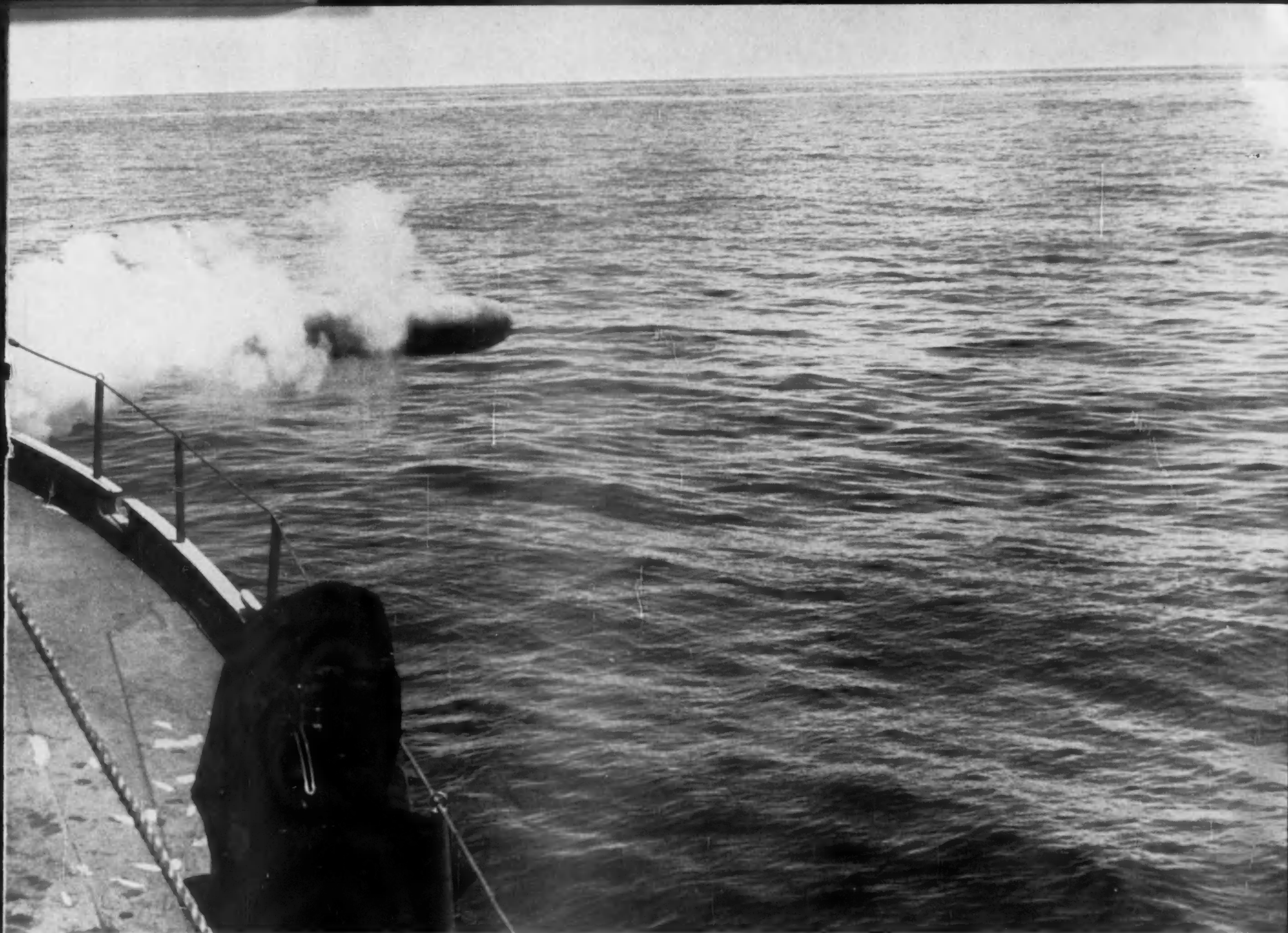
Undersea

***Review* STAFF REPORT**

Sea lines are life lines. In the event of a national emergency, our nation must maintain control of the seas. True, cargo aircraft have made enormous strides in transporting goods at high speed and long distances; but the fact remains that the load of one aircraft would be lost in the hold of a World War II Liberty ship.

One worrisome threat to the merchant ships and the troop transports that use the sea lanes: submarines. To maintain control of the seas, enemy submarines must be eliminated. And to eliminate a submarine, you must find it; then kill it.

Highly sensitive search radar on aircraft and surface ships can detect an object as small as a snorkel on the water's surface. Sonar—sound navigation and ranging—equipment, mounted



torpedo leaves deck launching tube of test ship to seek out target submarine. The torpedo is recognized as the Navy's pioneer guided missile.

Defenders: Story of Acoustic Homing Torpedoes

on ships and submarines and dragged through the water from blimps and helicopters, can give the bearings and distances of enemy submarines under power or hovering.

The kill is more troublesome. You can shoot rockets and depth charges from a destroyer and lay down a pattern that, mathematically, should do the job. Or you can drop charges from a blimp or helicopter. Either way leaves something to be desired.

A device is needed that can be launched from a jet aircraft, a blimp or helicopter, a surface vessel, or a submerged submarine—a device that will then relentlessly search for the target, locate it, attack it, and destroy it.

For more than a decade, General Electric has been working on the development of a family of such devices—acoustic homing torpedoes.

"They are purely an antisubmarine weapon," a General Electric spokesman has carefully stated, "and aren't designed for use against cargo ships and transports. This is a weapon we need to keep the sea lanes open and to keep our nation free."

These torpedoes are ruthlessly efficient. With them a skilled enemy team operating a complex machine—the submarine and its crew—will be outthought and outguessed and finally annihilated by a cold, unthinking mechanism. The lot of the enemy submariner in the next war will be most unhappy.

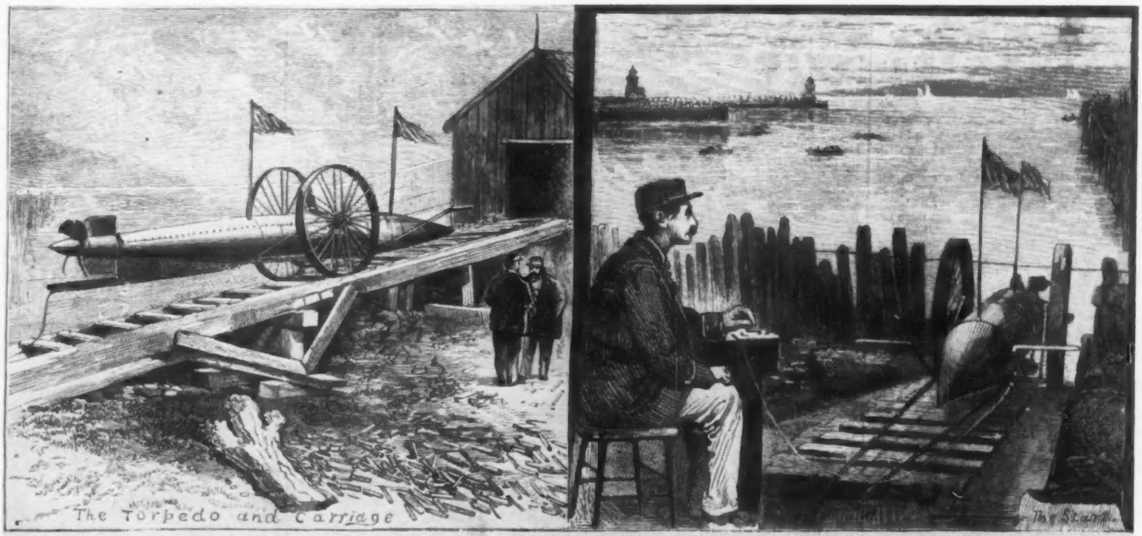
1—A MURKY HISTORY

The early history of the torpedo is, at best, murky. Considering that it has sunk more tonnage than any other weapon, the situation is indeed incongruous. Commander Peter Bethell, RN, neatly sums it up in his entertaining article "Development of the Torpedo" in *Engineering* when he says, ". . . the inquiring person who turns to encyclopedias finds no more than a dim and turgid summary, which leads him to class the weapon with Aldous Huxley's old man of East Anglia—whose loins (it will be recalled) were a tangle of ganglia."

The most recent American book on torpedoes was published in 1889; British, 1880; and French, 1924.

Robert Fulton, associated with the early steamboat, was also involved with torpedoes. But not until 1864 during the Civil War was the first ship destroyed by a moving torpedo when a Confederate vessel sank the Union sloop *Housatonic* off Charleston. The South proved surprisingly aggressive in this particular branch of warfare, far overshadowing the Yankee's engineering and manufacturing potential.

The giant of modern torpedo inven-



THE LAY TORPEDO—THE PUBLIC TRIAL AT CLEVELAND, OHIO.—From Photographs by Thomas T. Sweeny.—[See Page 590.]

TORPEDO EXPERIMENTS

. . . we give several sketches illustrating the experiments recently made at Cleveland, Ohio, with what is known as the "Lay Torpedo," an invention of Mr. Lay, of Buffalo. This torpedo, as may be seen in our engraving, is cylindrical, with conical ends. The forward cone is calculated to contain one hundred pounds of dynamite or some other explosive substance. The forward section of the main cylinder is charged with a liquid capable of powerful expansion into gas, which is used as the motive power, and is connected with the machinery by a valve operated by electricity, and a pipe. The boat is steered by a double rudder, controlled by means of electricity. Beneath the keel is an exhaust-pipe and under this a second pipe through which the electrical cable, which lies coiled like a harpoon line in a whale-boat, is paid out as the boat pursues its way. This cable may be of any length desired, and connected with the shore or a vessel.

When launched, the torpedo is entirely under the control of the operator, who may be stationed on shore or aboard ship. He has a compact battery, and key-board, on which are small switches with which he guides, controls, and explodes the craft by means of electricity.

The secrecy with which the preliminary experiments have been made had aroused general curiosity, and on the afternoon of July 10 a large crowd of spectators gathered on the dock at Cleveland to witness the public trial. It was a splendid success in every particular. There were present a number of distinguished men, conspicuous among whom were the Assistant Chinese minister, Yung Yuen Poo, and his secretary; a number of naval officers and visitors from other cities. A stakeboat was stationed half a mile from the shore, and when the battery was applied, the torpedo started off at a rapid rate, going to the stake-boat in three minutes and twenty seconds, and, gracefully rounding the boat, started on her return, which was made in the same time. It is claimed by the owners that this craft will travel twelve miles per hour. The rapidity and precision with which the machine obeyed the operator, clearly demonstrated that it is one of the most formidable weapons of naval warfare ever invented. It will be shipped directly to some European power, for which it was built. The owners decline to state which one, but say they have orders for a large number from the same power.

—Harper's, 1877

tion and development—Robert Whitehead, a name still to be reckoned with—began his experiments in 1864. "Essentially, it's still Mr. Whitehead's torpedo," an engineer who currently works in the field remarked recently.

Whitehead, an English engineer, was managing the iron works at Fiume, Austria, when he built his first model. Six years later he was engaged in full—and private—production of a unit 14 inches in diameter and 11 feet in length. It weighed 300 pounds, compressed air drove the propeller, and it had a speed of 6 knots and a range of 200 yards.

Whitehead, promoter as well as a top-ranking inventor and engineer, freely peddled manufacturing rights to the navies of the world, who at that time could afford a rather luxuriously priced weapon. By 1872 the manufacturing rights of the new automobile torpedo, as it was sometimes called, had been sold to most of the European powers.

Over the years the Whitehead units increased in size, weight, range, speed, and complexity. Contrarotating propellers were one of the early innovations to improve control. (The spent air was exhausted through the hollow propeller shaft to give added jet thrust.) Launching was informal; one of the first attempts involved sliding a unit off a mess table through a port in the side of the ship, and thus into the sea.

The United States can claim the first torpedo station, founded in 1869 at Newport, RI—and this station still exists. Two years later a unit quite frankly a copy of Whitehead's torpedo was built and tested; but the majority of effort until the late 1800's was concentrated on some rather novel homegrown products.

John J. Lay designed a cable-controlled one (Box) that the Peruvians used against Chile in 1879 with no success. Lay sold manufacturing rights to Russia and Turkey and two units to the U.S. Navy.

John Ericsson, designer of the famed *Monitor*, devised a submerged gun projectile 16 inches in diameter and 25 feet in length that fired from a gun mounted below a ship's waterline. The Navy's Bureau of Ordnance firmly rejected the unit; its range of 310 feet was entirely inadequate.

The Sims-Edison electric fish torpedo design appeared in the early 1880's (Box, page 28).

One American product—a torpedo invented in 1884 by Commander John Adams Howell, USN—did show much promise. Guidance troubles had always plagued the Whitehead; by careful adjustment of the rudders and just as careful launching, it could be made to run straight for about 800 yards. In a most forthright manner, Howell licked the guidance problem with a flywheel that weighed 112 pounds and was spun to 10,000 rpm before launching. The unwinding flywheel drove two propellers. By 1898, Howell was getting a range of 800 yards at 30 knots. One of the runs describes the tracking as "absolute." This torpedo was used on some Navy battleships.

Howell's glory was short-lived. A gyroscope incorporated in the Whitehead gave it satisfactory accuracy.

In 1891, American manufacturing rights to the Whitehead were purchased, not by the government but by the Brooklyn firm of Bliss & Williams, makers of heavy industrial machinery. The firm—later changed to the E. W. Bliss Company—in turn sold them to the Navy.

One of Bliss's engineers, Frank McDowell Leavitt, wasn't overfond of the Whitehead device nor was he pleased with the reciprocating compressed-air engine designed and developed by the British. He proposed to drive the torpedo with a Curtis turbine; his first experimental unit hit the water in 1903. Named the Bliss-Leavitt torpedo, 300 were ordered by the U.S. Navy in 1905. (After World War I, Bliss gave up torpedoes and concentrated on building mechanical and hydraulic presses, canning machinery, dies, and rolling-mill equipment. During World War II the company built British torpedoes on a contract basis.)

During the Spanish-American war (1898) torpedoes were used with little effect.

The early Whiteheads used compressed-air driven motors; later, steam replaced compressed air. In the period preceding World War I, the Whitehead was further refined and grew in bulk to a diameter of 21 inches and a length of 21 feet. But even with these advances, its role as a primary naval weapon was diminishing because of the increased range and efficiency of the big guns mounted on battleships and cruisers.

Various other schemes were devised to propel torpedoes. Units with electric drives first appeared in 1872. They had the advantage of constant weight, no telltale trail of air bubbles, and their construction made them cheaper and easier to build. Although forerunners of today's units, they failed to dislodge the firmly entrenched Whitehead. The Germans had an electric torpedo under development in 1917.

Torpedoes with gas turbines, rockets, and water jets were all developed and tried before 1900. Their main characteristics were short range at high speed (40 knots); long range at slow speed; a generous amount of inaccuracy; and, more often than not, a discouraging combination of all.

During World War I the torpedo played a minor role in fleet engagements but gained the headlines by its effectiveness against merchant shipping. The prewar courtship of the torpedo and submarine was consummated in a potent and happy marriage.

2—WARTIME PRESSURE

In retrospect, American efforts between wars to develop a highly efficient weapon were undistinguished. This led to a bit of soul-searching and self-incrimination. Vice Admiral George F. Hussey, Jr.—Chief, Bureau of Ordnance, December 1943 to September 1947—incisively commented that the nation used its "native potentialities to less advantage in peacetime in ordnance research than in almost any other field of activity."

Pitifully small budgets were another factor. Vice Admiral R. W. Christie, who has a long record of work with torpedoes and submarines during and between both wars, offered a spirited defense when he wrote . . .

> The Naval Torpedo Station at Newport was working between wars on a research budget of $70,000 a year. We had to stand on the doorstep of General Electric and Massachusetts Institute of Technology (MIT) hat in hand for help. And we were never turned away empty-handed. Dr. Moss—General Electric's engineer of supercharger fame—helped us attain a torpedo turbine speed of 25,000 rpm. Dr. Hull of General Electric, Schenectady, NY, loaned us the first magnetron built to measure the magnetic field under ships in various parts of the world in 1928. He also loaned us a laboratory plaything that later became the thyratron and which caused us to junk the magnetic exploder and redesign. Dr. Keyes and Dr. Gill of MIT gave thousands of dollars of research consultation free.
>
> Not until after World War II was well upon us did millions become available for research and development. In general, we fought the war with what we had on Pearl Harbor Day.

The official government document *U.S. Navy Bureau of Ordnance in World War II* candidly states . . .

> During the interwar period when time was available for research, the Bureau's approach to the torpedo problem was not properly scientific. Evaluation was almost invariably inadequate and tests were unrealistic. Economy was properly a goal, but improperly applied. Security, a necessary concern of the armed forces, became such a fetish that measures designed to protect a device from enemy eyes actually hid its defects from those who made regulations. Ironically, some of those defects were already known to the foreign powers who later became our allies or enemies.
>
> Production planning in the prewar years was also faulty. Torpedoes were designed for meticulous small-scale manufacture. When military requirements demanded that they be supplied in large numbers, a series of new problems were exposed. Realistic plans simply were unavailable for providing the weapons in adequate quantity.

Pearl Harbor found America with five types of torpedoes in stock or in production. They caused an unparalleled amount of grief both for the men who used them and for the enemy.

The Mark 8 and Mark 15 were used from surface ships; the latter proved to be a dependable performer by the end of 1944.

Mark 13 was an aircraft torpedo. After three years of continual alteration, it became "the best aircraft torpedo owned by any nation."

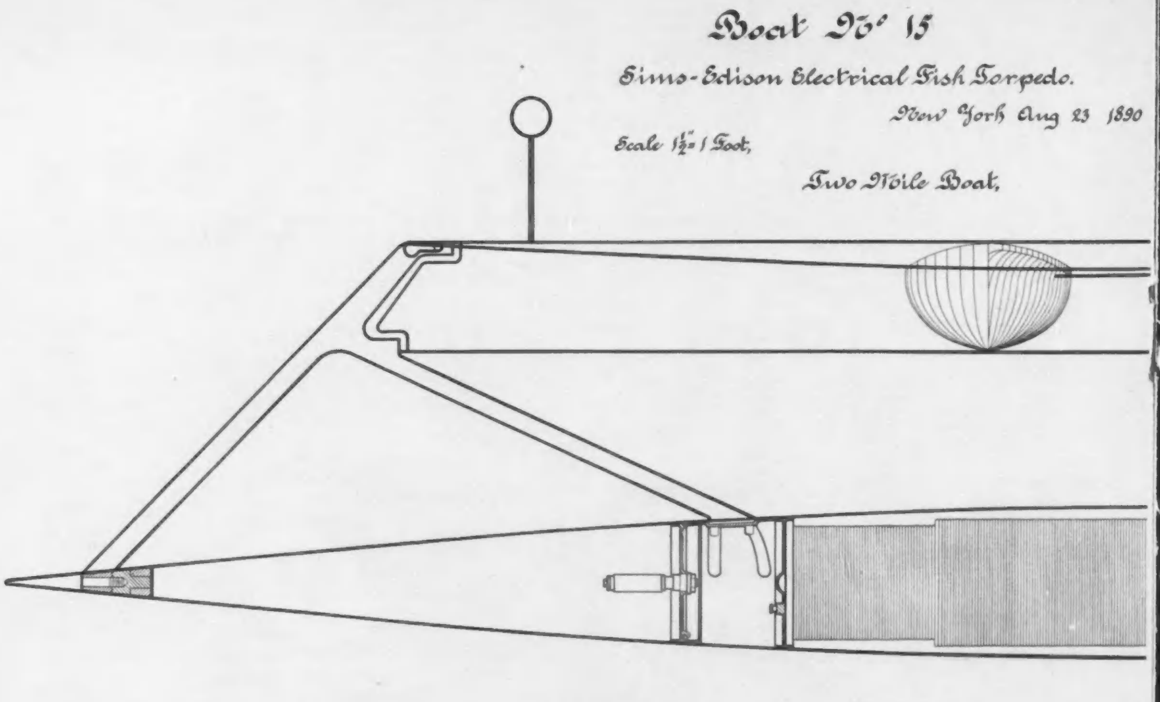
The Marks 10, 14, and later 18 were used exclusively by submarines. The Mark 10—nearly 30 years old—tended to run deep; production was stopped shortly after hostilities began.

But on the Mark 14, the most recent type, the abuse was heaped. It ran consistently 10 to 15 feet deeper than set. When allowance was made for *that* error, it was discovered that the detonator and exploder were faulty. Possibly the only bright outlook: the British and Germans were obtaining even worse results with their weapons—small comfort to our submariners.

Two years after the war began, the Mark 14 had been modified into a reliable weapon.

The two-year hassle also had stimulated the development of other types of torpedoes, primarily chemical (gas-evolving exothermic reactions) and electric.

The electric torpedo received the most attention. Certain features made it popular for submarine use, and it was easier to mass-produce. Although work on an electric torpedo was begun by the Bureau in 1915, progress was sporadic. One of the biggest drawbacks, besides the chronic shortage of funds, was the lack of a successful storage battery. By 1928 a model was tested. It sank and remained on the bottom for



SIMS-EDISON—A UNIQUE APPROACH TO TORPEDO DESIGN

The Sims-Edison electric fish torpedo, developed during the 1880's, probably represents General Electric's initial entry in the field of underwater ordnance.

Early documents describe it as an "indestructible" copper float about 20 feet long, supporting a copper torpedo that varied in length from 28 to 31 feet and in diameter from 18 to 25 inches. On the float's deck, two vertical rods topped by balls, flags, or lights showed the operator the path of the torpedo.

A sharp, steel blade that caused the unit to dive under cables or friendly vessels protected both the hull and float.

The bow section of the torpedo concealed a dynamite charge of 200 pounds. The next section contained the coil of cable; then came the motor. The steering gear was in the stern compartment. Including charge, the total unit weighed from 3000 to 4000 pounds.

After launching, an electric motor powered the torpedo. A generator either on shore or on ship fed power through the cable to the torpedo. As the torpedo traveled toward its target, the cable ran out of the tube fixed under the propeller astern. Cable length varied from 6000 feet to 4500 yards.

A battery operated the steering apparatus that was controlled by an operator from a small keyboard. Positions were START, STOP, RIGHT, LEFT. The charge could be exploded by the operator or by contact.

Although later units reportedly traveled at 20 knots, the speed of early models was 10 to 11 miles per hour.

The unit shown above was probably the successor to the one developed by the Sims Electrical Fish Torpedo Company, Evening Post Building, 206 Broadway, New York City. Sixty tests were made on a unit in September-October, 1880, by the Official Board of Engineers of the U.S. Army, Torpedo School, Willet's Point, New York Harbor.

In *Edison—His Life and Inventions*, (Harper–1929)—Dyer, Martin, and Meadowcroft hint at how Sims and Edison got together . . .

> Edison has never paid much attention to warfare and has in general disdained to develop inventions for the destruction of life and property. Some years ago, however, he became the joint inventor of the Edison-Sims torpedo with Mr. W. Scott Sims, who sought his cooperation.

"A Day with Edison at Schenectady" in *The Electrical World*, August 25, 1888, has an interesting description of the Sims-Edison torpedo . . .

> The work being done in one of the aisles of this shop exemplifies, remarkably too, the ease with which the electric motor can be adapted to difficult tasks—namely, its use in the Sims-Edison electric torpedo, the construction of which is being actively carried on to fill contracts for the American and foreign governments. . . . Some extraordinarily successful results have been obtained with these craft, the only ones of the kind, and it will be observed that the apparatus is unsurpassed for handiness

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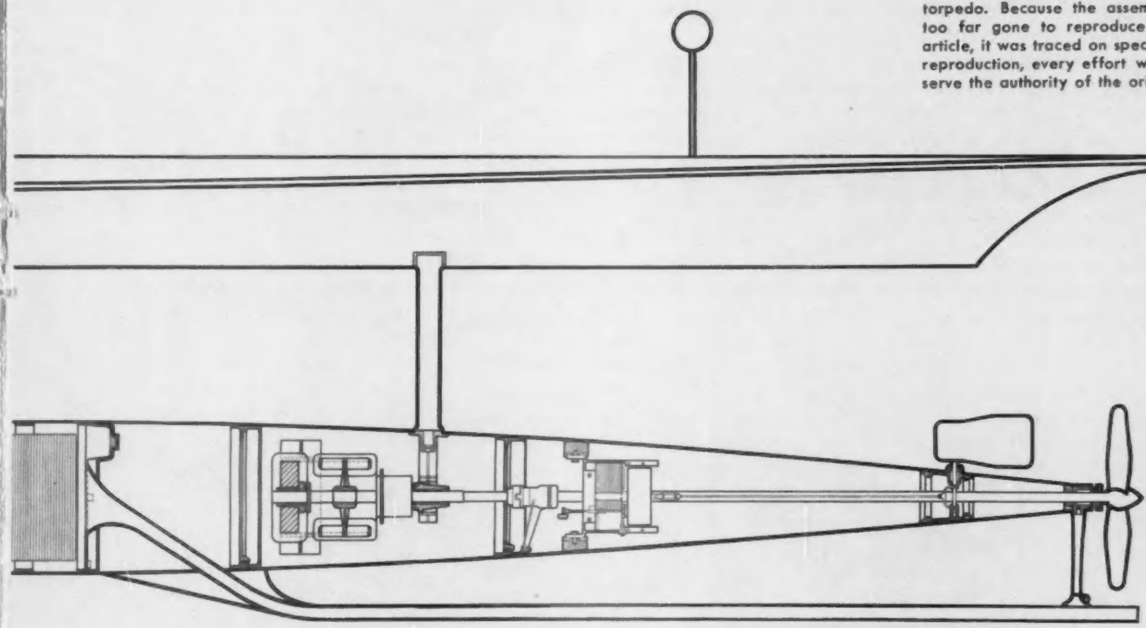
two years until accidentally recovered. Batteries were also the stumbling blocks on later models. Finally in 1931 the Bureau abandoned the electric torpedo.

Ten years later, with a war on the horizon and overwhelming reports of German success with an electric torpedo, the project was reactivated. According to the official record . . .

> The Bureau would have preferred that the entire project be handled by the General Electric Company, but that corporation was too busy with other contracts to accept the responsibility. A compromise solution was found, whereby Newport was assigned the development of control mechanisms, General Electric was contracted for the propulsion motors, and the Electric

When cleaning out some files in General Electric's Schenectady Plant some years ago, a stack of battered blueprints was uncovered. It contained detailed drawings of the Sims-Edison torpedo. Because the assembly drawing was too far gone to reproduce for a magazine article, it was traced on special paper. In this reproduction, every effort was made to preserve the authority of the original drawing.



in having an unlimited supply of power for propelling it, and in being governable at every minute of its trip out or home again. The cylindrical shape of the torpedo and the limitations of weight have necessitated the construction of a motor of special design, with field magnets completely encircling the armature. Speaking of this torpedo, after some of its first experiments, General McClellan, in an official letter, described it as "the best of the movable torpedoes yet invented." It is some satisfaction to know that, when the Haytian navy invades our coasts and France ceases the Isthmus, we shall, though without a fleet, still have a defensive line of Sims torpedoes within which to assert the authority of the Monroe Doctrine and our determination to enforce it against all comers.

In 1892, trials of the Sims-Edison unit were made in England. Lt. G. E. Armstrong in his book, *Torpedoes and Torpedo Warfare* (G. Bell & Sons, London, 1896) writes . . .

An interesting trial was made with it in Stokes Bay on February 15, 1892, before a large number of experts and foreign attachés, and judging by the results this torpedo constitutes a very formidable weapon for harbour defense . . . The torpedo on being launched generally remains almost stationary in the water for about 10 seconds and then gradually develops a speed of about 20 knots. On the occasion of the trial referred to, an attempt was made to demonstrate the suitability of the torpedo for ship work. To accomplish this, a large unwieldy crane was fitted up on board the steamer *Drudge*, and the torpedo was hoisted out and launched when the vessel was crawling along at the rate of about 3 knots. No decision of any value could, therefore, be come to regarding the merits of the torpedo when worked from a ship. In any case, the same objections must weigh against the Sims-Edison as with the Brennan. Connecting cable would be most unwieldy at sea, and in a general action between two fleets, it would be sheer madness to attempt to use locomotive-controllable torpedoes of such a pattern. Besides, the apparatus required for hoisting out a Sims-Edison torpedo is top-heavy enough to capsize any torpedo boat yet built. There is one important particular, however, in which the Sims-Edison shows an improvement over the Brennan. It can twist and turn about in *any* direction, and can, if necessary, return to its point of departure. If a vessel entering a harbour possessed extreme handiness, she might manage to escape from a Brennan by turning on to a course which that weapon could not follow. With the Sims-Edison, however, no such evasion would be possible. On the other hand, the Brennan is completely submerged during its run, whereas the Sims-Edison has its supporting float exposed; and if that should be hit or torn by shot the torpedo it supported would stand little chance of remaining effective much longer. In short, a great question as to whether the Brennan or the Sims-Edison is the more effective weapon can only be finally decided by the carrying out of exhaustive comparative trials—an unlikely event to happen.

During the revolutionary war of 1893, the Brazilian Government had one Sims-Edison torpedo aboard the auxiliary cruiser *Androda*. But, because no one understood how it worked it never saw action.

Storage Battery Company (Exide) was given the job of producing a satisfactory battery . . .

The 90-hp motors were built at General Electric's Erie Works. Ten experimental torpedoes, designated Mark 2, were to be built. Divided responsibility led to delays. And when a German electric torpedo was recovered intact, the Bureau shunted the Mark 2 project back to Newport and contracted with Westinghouse to produce a torpedo copied after the German model except for the gyro, depth mechanism, and exploder. This was known as the Mark 18.

The Mark 2 was later redesignated Mark 20, and 20 of them were built by General Electric's Home Laundry Department in Bridgeport. It was a high-speed unit (40 knots) with an 8000-yard range, 1000-pound payload, and powered by a 180-hp motor. After the war the project was turned over to General Electric's Aeronautics and Ordnance Systems Division (A&OS) in Schenectady and redesignated Mark 36. A few samples were made, and then the project was abandoned.

The Mark 18 venture unraveled the battery problem enough to get the performance up to Bureau standards, and during the middle of 1943 it was turned over to the fleet, where it was accepted gradually. The electrics finally overtook the steam torpedoes in fleet use; and during the last six months of the war, at least 65 percent of all torpedoes fired by submarines were Mark 18s.

For a comparison, the record shows that steam torpedoes sank 133 Japanese merchantmen in 1942; whereas in 1944 the electrics sank more than this in three months.

Troubles or not, submarines' principal weapon sank 5-million tons of enemy shipping and damaged another 2½-million tons. In the words of the two authors who wrote the history of the Bureau of Ordnance in World War II, ". . . the Bureau of Ordnance, while batting many a fungo, supplied the world's mightiest fleet with the fire-power that is nearly synonymous with sea power."

3—THE SUBMARINE MENACE

Late in the summer of 1943, newspapers reported the Germans using an "intelligent" torpedo—the *Gnat*—that automatically guided itself to a noise source, such as that created by a ship's propeller (cavitation).

United States intelligence was well aware of the situation. And in 1940 the recently created National Defense Research Committee (NDRC), under the leadership of Dr. Vannevar Bush, sponsored work on underwater listening devices to combat the submarine menace. One project for an acoustic torpedo was headed by Western Electric, and work on the homing system was centered at the Bell Telephone Laboratories and the Harvard Underwater Sound Laboratory. In April 1942, Western Electric approached General Electric for the "hardware" to complete the torpedo: body sections, propulsion unit, steering and control gear, depth control, and other items. The Company's War Projects Committee turned the job over to the Consulting Engineering Laboratory in Schenectady. This was done because the A&OS Division, normally the recipient of such orders, was tied up with gunfire control systems for the Navy and the fire-control system for Air Force bombers.

The new work was known merely as Project F within General Electric, and to the Bureau of Ordnance as Mark 24 Mine—the last word added as a decoy for security reasons. Actually, it was a small, airborne target-seeking missile. It carried a payload of 100 pounds (compared to the 500 pounds of conventional torpedoes) and was powered by a 5-hp electric motor that drove it at a speed of 12 knots for five minutes.

Six samples were built at the Laboratory, and the results proved so good that the Bureau of Ordnance placed an order for 200 production units in early 1942. Because the Company's refrigerator production line at the Erie Works was shut down for the duration, manufacturing centered there. But before completing this order, General Electric late that year received an additional order for 5000 units. Too much for Erie's facilities to handle, the Company made space available at the Philadelphia Works, normally used to produce switchgear.

But before *this* order was under way, the Company received still another for 4500. The top-engineering and -manufacturing skill that went into the development and production of the torpedo soon paid off. For the torpedo proved more effective than anticipated, and thus the second order for 5000 was cut back. "This weapon," an official Company report states, "is commonly credited with being the development that stopped the German submarine campaign during 1943 and was referred to by Hitler in a speech of that year."

On December 1, 1943, the late Gerard Swope, who came out of retirement to be President of General Electric while Charles E. Wilson headed the War Production Board, wrote the following letter to Harry A. Winne, now retired but then the Company's Vice President in charge of Engineering . . .

> In last week's Progress Report on production, I note that 3500 units on Project F have been cancelled, the reason being that experience has shown a much larger proportion of these devices has proved effective than was anticipated in the beginning.
>
> I do not know whether our organization or that of the Western Electric Company is responsible for the fine performance of this device, but I want you to know it is recognized.

Project F was the forerunner of General Electric's successful attempts in the following years to completely design, develop, and manufacture a highly efficient antisubmarine torpedo for the Nation's defense.

In September 1943 the Bureau of Ordnance again requested the Laboratory for engineering services and products to be applied to a new mine, the Mark 33. The over-all mine (actually a torpedo) was designed by the Bureau and incorporated many General Electric features for steering, depth control, and the drive motor. The Laboratory built and tested a sample, and 30 units were built at the Philadelphia Works.

By the early part of 1945, the total volume of torpedo business for General Electric was about $18,000,000.

In February of 1945, Dr. Vannevar Bush wrote the following letter to Dr. W. D. Coolidge, who was then director of the General Electric Research Laboratory . . .

> I assume that you know of the letter from the Bureau of Ordnance to Dr. Conant in which Admiral Hussey states that the device developed as a result of Projects NO-61 and NO-94 [Mark 24] has functioned satisfactorily and has proved its value as an effective weapon of the Navy, and in which appreciation is expressed for this important contribution to the development of naval ordnance and the personnel concerned is commended for the success attained in this project.
>
> There is, of course, always a feeling of satisfaction to be obtained through a job well done, but this is heightened by the knowledge that the effort has been crowned with success in use and that the accomplishment is recognized and appreciated as in this instance. Accordingly, I take great pleasure in adding my own word of congratulation that the work has been carried out in such fashion as to merit this commendation from the Navy, and I will be glad to have you convey this message to the personnel of the General Electric Company concerned.

4—TORPEDO MARK 32

It should be noted that all the acoustic weapons described previously were "passive;" they listened for a source of sound and then attacked the

1944 the electric torpedoes sank more than this in three months."

source. This technique, while far more effective than any preceding it, had limitations against a slowly circling submarine, a submarine running deep where propeller cavitation is practically nonexistent, or a submarine sitting on the bottom. It could also be fooled by countermeasures: a stream of bubbles expelled from the submarine, noisemakers or random-frequency generators shot from or towed by the submarine, explosive cartridges detonated overboard, or chemicals expelled by the submarine that cause the water to foam furiously.

A crash-diving submarine is an elusive target because of the large swirls and bubbles it generates; a high-speed wake is another countermeasure. To counteract the German's acoustic homing torpedo, the British used the *Foxer*. Merely a piece of pipe with holes, it was towed behind a ship. The water rushing through the holes set up a resonance that baffled the torpedoes, and the pitch could be altered by shortening or lengthening the pipe. "With $5 worth of junk we had one of the best decoys ever built," said a man once associated with the project.

The chronology must now revert to 1940—the beginning of one of the most exciting developments in the field of underwater ordnance.

From the NDRC's founding in June 1940, it had been actively involved in the problem of underwater listening devices to detect submarines.

In 1941, with funds supplied by

EYES AND EARS OF THE TORPEDO—THE TRANSDUCER

Transducer is just a fancy name for a simple device like the loudspeaker in your radio, a telephone handset, or the pickup in your hi-fi record playing setup. A loudspeaker and a telephone receiver take electric energy and transform it into sound energy; a pickup transforms mechanical energy into electric energy.

The transducer in an acoustic homing torpedo—or sonar—does the same thing. It takes electric energy and transforms it into sound energy and takes sound energy and transforms it into electric energy.

Both sonar and an acoustic torpedo work in essentially the same manner: A short burst of supersonic sound (a "ping" about 0.1 second in duration and 25 kc in frequency for sonar) is transmitted into the water. Immediately the system switches to receiving, and the transducer acts as a microphone (or hydrophone, to be exact) to pick up any supersonic signals in the water. What it wants to pick up in particular is an echo (reflection) of the outgoing signal. The information received is amplified and can be used to give visual and audio indications of the bearing and range of the object (echo-ranging) for sonar. Or it can be resolved into steering information for the torpedo. This is, of course, essentially the process by which radar operates. A torpedo that sends out its own signal, or ping, and then listens for the echo is referred to as the active type.

Synthetic crystals, such as Rochelle salts, are often used as transducers. They operate under the piezoelectric effect, efficiently converting electric energy into supersonic sound energy, and vice versa.

Another effect commonly used in transducers is that of magnetostriction. When certain magnetic materials are subjected to a magnetic field, internal stresses are set up that change the dimensions of the material. The result: a vibrating piston. Transducers of this type, first developed by the Harvard Underwater Sound Laboratory, are used in acoustic homing torpedoes for two important reasons: Unlike crystals, they're not affected by temperature changes, and they can take the abuse encountered when launched from the deck of a destroyer moving at 20 knots or dropped from an airplane at 250 knots.

Mounted in the nose of the torpedo behind an acoustic window—a rubber diaphragm of special composition—the transducer operates in a bath of electrical grade castor oil. Losses through these two media are insignificant.

The engineer designing a torpedo transducer must compromise. For best guidance and control, he would like a narrow beam. But this takes a high-frequency signal, and the higher you go in frequency the faster your troubles multiply—especially in the areas of losses and distortions. Lowering the frequency cuts the losses, but it also means a wider beam and more difficult guidance techniques.

In developing the transducer, General Electric engineers applied many radar techniques to the problem for the first time and also operated the units at higher power than had ever been achieved before. "With the higher power, we not only had to be careful that we didn't saturate the transducer," says F. G. Patterson of the General Engineering Laboratory, who was one of the pioneers in this field, "but we also had trouble getting the power from the transmitter to the transducer. More than once we burned up relay contacts because of the high voltages we were using. Anyway, you soon reach a point of diminishing returns, because the maximum range versus power curve flattens off pretty fast."

Early workers had many headaches. If the torpedo pointed its nose up more than two degrees, chances were good that it would receive echoes from waves on the surface, masking the target echoes. In a dive it would get "bottom return" from the sea floor or echoes from the stratified layers of water at various temperatures (thermoclines). Sometimes there would be a double echo—from target to bottom to torpedo. This is similar to a "ghost" on your TV set and just as annoying.

Circuit noise, mechanical vibration inside the torpedo, and noise caused by bumps or irregularities on the shell's exterior all caused spurious signals that oftentimes were comparable to the echo received from a weak target.

Propeller cavitation was one of the biggest problems, often assuming such proportions that the torpedo would literally "chase its own tail." Noise from the propeller would race ahead of the unit, bounce off a wave on the surface, and be reflected into the transducer. Clumps of seaweed were regularly "seen" by torpedoes that thought they were legitimate targets.

Experiments at Lake George

Working on underwater listening devices to detect submarines, scientists spent the summer of 1942 at Lake George, NY. Their experiments were responsible for the conception of radically new guidance techniques. A transducer was mounted 20 feet under

NDRC, work on the problem began in General Electric's Research Laboratory at Schenectady. Clifford Mannal and Elmer J. Wade, two of the young scientists involved in this work, experimented with projecting blinding flashes of light by means of capacitor discharge, catching the reflections to determine the position and range of objects. Their tests showed it was effective in air for thousands of feet; but when tried underwater, it was practically useless.

Next, they turned to the listening gear used on destroyers to detect submarines (Box, page 31). Their efforts in that field caused them to ask themselves, "Why can't we guide a torpedo by means of echo-ranging equipment?" This turned out to be an extremely significant question. "I don't think the idea was particularly new," Mannal has said since, "It was like flying or getting to the moon. The trick was to *do* it. Destroyer sonar gear occupied a space equivalent to three chests of drawers. Our problem: putting that much stuff in one or two cubic feet and then using its intelligence to steer in such a way that the torpedo really 'homed'."

In May of 1942 they presented their ideas to the NDRC, and the decision was made to go ahead. Less than a month later they received the official NDRC contract for what became known as Torpedo Mark 32—an airborne, antisubmarine weapon. "There was always plenty of money available in those days to play a long shot," Wade recently commented.

The closest body of water of any size to Schenectady was Lake George, 50 miles to the north. The war had severely limited interference by tourists, and a certain area of the lake was fairly secluded.

The scientists spent the summer on the Lake in an 18-foot motor boat purchased for $240. The boat seemed always about to sink, riding nose down in the water. Electronic gear was piled in the stern to keep it level.

Twenty feet underneath the boat the transducer (Box, page 31) was mounted on an *A* frame, giving rise to much discussion. Did the boat support the *A* frame or the frame hold up the boat?

Their target was simple: a pipe ring 10 feet in diameter suspended underwater from a buoy. To the ring was attached a rubber hose in which holes had been punched with a big needle. Air was pumped into the nose, and the cloud of ascending bubbles acted as an effective reflector for the sound waves sent from the transducer.

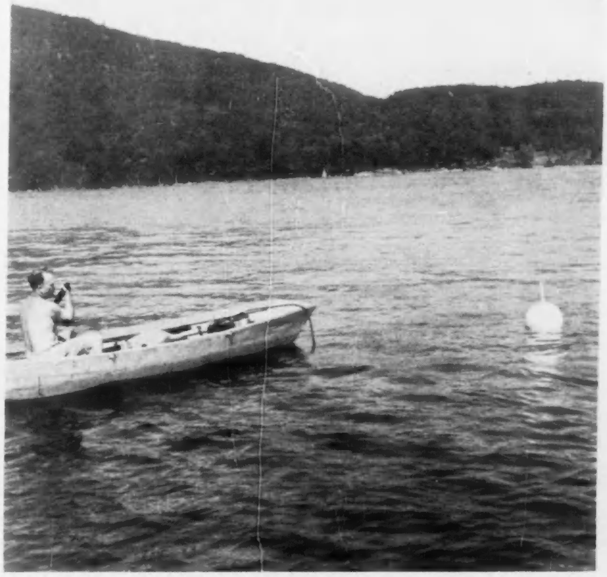
The Lake George experiments saw the conception of a radical guidance technique—and the electronic circuits to go with it—used on present-day torpedoes, making them immune to countermeasures for all tactical purposes.

By August the scientists had made successful homing runs with the motorboat on the bubble target at distances greater than 700 feet. They were jubilant. "We can sink any submarine in Lake George!" was their favorite cry.

But would it work in the ocean? To find out, the crew split. One group went to Boothbay Harbor, Maine, late in September, while the other continued the work at Lake George with a single Mark 24 body.

Knowing just what a torpedo was doing during a run, even in the shallow waters of Lake George, was difficult. A cathode-ray recorder was devised to fit inside the shell and record such information as roll, rate of turn, pitch, and depth. Later on, a compact multichannel oscillograph, developed by the Consulting Engineering Laboratory, was used. Probably these were the first instances where recording instruments were actually put in a moving torpedo, and they gave valuable data that aided in the development of future weapons as well as the ones currently being worked on.

The northern contingent at Boothbay Harbor utilized a 45-foot fishing boat and swung the transducer over the stern. One of their early reports states: ". . . the results were very different from those experienced at Lake George." Essentially, too many reflections came from the waves on the surface, baffling



the water on an A-shaped frame that was supported by an 18-foot motor boat. The target: a pipe ring 10 feet in diameter suspended underwater from a buoy. Air pumped into a rubber hose peppered with holes that surrounded the ring sent up a cloud of bubbles that made an effective reflector for the sound waves sent from the transducer. By August the cry was, "We can sink any submarine in Lake George."

the transducer by giving it too many echoes. By the end of October the group solved this problem.

Meanwhile, work at Lake George diminished and finally halted when the camp's plumbing fixtures froze up and exploded.

With the efforts in Maine concluded, the group split into three sections. One worked in Schenectady to convert two Mark 24 torpedo bodies to handle the acoustic equipment. "Space and weight limitations were always a brake on blue-sky ideas," Mannal has said since. "We had only about 7 pounds of positive buoyancy in 700 pounds total. Our equipment could weigh only 50 pounds. If it weighed 57½ pounds, the torpedo never came back. Any bright idea had to be bright—and light."

The second group built the electronic gear at General Electric's Works Laboratory, Pittsfield, Mass., while the third made a survey to find suitable quarters where deep water (600 feet or more) was close to shore with suitable weather for year-round operations. They finally found it near Ft. Lauderdale, Florida, on the end of a man-made pier on the Inland Waterway, one-half mile from Port Everglades. The only habitation on the pier was a gas station, its pumps dry because of wartime rationing; the inhabitants of the mangrove swamps nearby were primarily rattlesnakes. The land, taken over by the Navy in December of 1942, was popularly called the "15th Street Station."

Working quarters was a tent; the first machine shop was in a large trailer; and the men lived at one of the resort hotels, pedaling 15 miles to and from the base every day on their bicycles. Later, three other outfits with competitive devices set up operations on the pier: Bell Telephone Laboratories, Brush Development Laboratories, and the Harvard Underwater Sound Laboratory. "We were all on friendly terms with each other," John H. Payne, one of the scientists associated with the project recently related, "and even though we were all competitors in a sense, we exchanged considerable technical information—because winning the war always came first. But each group did have the burning conviction that its system was the best and was going to work."

Sea operations at Ft. Lauderdale were primitive. The weapon was usually towed to the firing area, and a hardy soul in a dinghy approached the unit with a long pole, on the end of which was a magnet. His job: touch the magnet to a magnetic switch located on the body of the torpedo. This started a time-delay mechanism that gave the man in the dinghy some 30 seconds to get out of the way before the torpedo took off.

Work progressed and steady advances were made. The number of tubes in the electronic panel, for instance, was reduced from 36 to 18, later to 8. Within the General Electric group, which numbered about 18 at peak strength, two entirely distinct electronic guidance systems were developed; that both systems did the job equally well shows how scientists can effectively operate—even under wartime strain—in a democracy. One system was chosen, primarily because it was slightly easier to mass-produce. (The other system was used on another weapon developed a few years later.)

The transducers were altered. From the first ones that used crystals (piezoelectric effect), the scientists switched to one developed by Harvard that operated on the principle of magnetostriction. Immune to temperature changes, it could also take abuse—especially important because the Mark 32 was to be air-launched.

On June 1, 1943, a test torpedo made the first successful run in azimuth against a bubble target. (It was set to run at constant depth; the scientists first wanted to lick the problem of azimuth control before they worried about depth control.)

Encouraging reports were sent back to Schenectady, while a general air of confidence prevailed at Ft. Lauderdale. But the next runs were unsuccessful, and they kept getting worse. The troubles turned out to be minor—and easily corrected. However, the many small

"The ocean is an in

THE SEAWATER BATTERY SOLVES A TORPEDO PROBLEM

Building batteries that could operate a torpedo at the speeds and range required has been a problem ever since the efforts of 40 years ago.

The Mark 18 of World War II used a lead-acid storage battery as do present-day torpedoes that are tested and recovered. But they have their shortcomings: They don't pack enough power; and hydrogen is given off, which has led to some near-fatal explosions during development tests. During rough launching, battery acid is liable to be sprayed around inside, fouling up the homing system.

The sea-water battery, as it's commonly called, is the answer. It has approximately five times the power and one tenth the weight of a lead-acid battery for the same application. In storage and during handling, this battery is harmless because it's perfectly dry; during test runs, 85 percent of the material used can be recovered. The device is absurdly simple. When the torpedo enters the water, sea water is scooped through the plates of the battery, and power is generated. But temperature and salinity affect the operation, and the price is high—between $6000 and $8000 per unit.

Bell Telephone Laboratories worked on the early phases of development; it was brought to its present state of refinement by General Electric. Progress was slow and painful because no one had much experience in designing or building such a battery. Shells were porous, and the inspection techniques weren't satisfactory. Internal and external shorts occurred leading to incidents like one taken from a progress report: "The SWB burned up at approximately one to two minutes after fire. The unit was observed from the firing vessel to come to the surface and was spouting flames and debris from the battery section. The unit sank and was not recovered."

With a further refinement in manufacturing techniques, the sea-water battery became one of the most reliable performers of the torpedo's system.

problems, combined and often interrelated, were frustrating to solve.

Such things as small craft in the area created wakes that befuddled the torpedo; the targets themselves tended to be temperamental by either getting out of position or by having water currents trail the bubbles around. The torpedo rolled and pitched, and temperature gradients (thermoclines) in the water caused the sound waves to bend similar to the way light bends when it enters water—a fact understood but underestimated.

"The ocean is an incredibly difficult laboratory and a humbling place to work. It's never the same on two days," Mannal said recently.

During this trying period, Dr. Kenneth H. Kingdon, one of General Electric's top scientists who succeeded in isolating minute quantities of U-235 in 1939, joined the operations at Ft. Lauderdale.

The problems were finally solved, and by September the percentage of good runs again approached a reasonable figure. On February 1, 1944, a sound-controlled (active) torpedo made the first completely successful three-dimensional attack on a target.

The next step: how well would they perform against submarines in fleet operations? At a conference in Washington on May 10, 1944, the decision was made to start tests at the Key West Naval Station on July 1.

During the preceding period the General Electric scientists reported directly to the NDRC and were encouraged to develop new and different ideas. With such free rein, they had designed a weapon lacking in gadgets—and it worked. The Key West tests against submarines early in August bore this out.

For the first time runs were made on a submarine by an echo-ranging torpedo, which made many hits.

After the success of the Key West trials, the days of the Research Laboratory in torpedo work were numbered.

They had developed workable samples; now it was up to a manufacturing component of General Electric or to an outside concern to produce the unit in quantities the Navy wanted.

Preliminary conferences in the spring of 1944 indicated that General Electric had no manufacturing facilities available for a production contract; Leeds & Northrup of Philadelphia was tentatively agreed upon as the supplier. Later the Navy and NDRC confirmed this.

General Electric cooperated with the new supplier until July 31, 1945 to get production under way. That date finished the Research Laboratory's activities in the field of homing torpedoes—an activity that contributed many significant advances to the field of underwater ordnance.

With the end of the war, General Electric completed its contracts for current production models; its factories converted to the output of peacetime goods.

Leeds & Northrup delivered hardware for 50 Mark 32s, but only 10 were ever assembled and tested. The project was cancelled at the war's end; it was reactivated in 1951 when yet another contractor did some redesign work and built a quantity of units.

5—TORPEDO MARK 35

Early in 1945, parallel with the Mark 32 development in Ft. Lauderdale and Key West, the Bureau of Ordnance expressed the need for ". . . a universal type weapon not to exceed 123 inches long and to carry a payload of 400 pounds at a speed of 20 knots for 20 minutes. This unit is to be airborne, deck launched, or submarine carried. It must be able to use any of several target-seeking systems as well as to navigate under its own control for mine use or associated work." This statement appears in the official General Electric report authorized by M. A. Edwards of the General Engineering and Consulting Laboratory (the postwar name of the Consulting Engineering Laboratory). His engineers soon became thoroughly involved in this activity.

The Bureau knew what it wanted. Using modern marketing techniques, it had taken a "consumer survey" of submarine skippers, destroyer officers, and anyone else involved with the operating end of torpedoes to find out what was desired most in the weapon. The comments were strong and straightforward.

Roughly, the over-all plan called for ideas generated by the Laboratory and the Bureau's survey. Add the best mechanical features of the Mark 33, and combine them with the homing system of the Mark 32. End result: the "universal" torpedo.

Planned as a program of continuing development, the Laboratory would "advance the state of the art" by building,

credibly difficult laboratory . . . . It's never the same on two days."

testing, and evaluating two or three units, and then incorporate any design changes into the next two or three units. This would continue until a satisfactory design evolved or until 50 torpedoes were built. The contract with General Electric totaled $2 million.

Initial efforts on what became known as Torpedo Mark 35 were confined to studies and conferences. New ideas evolved. Some showed shrewd foresight; others increased the weight, cost, and unreliability. "You never have trouble with the things you leave out" was the dogged appeal of some engineers.

Practically all the work was applied research; it took the all-out effort of many engineering teams to develop the new ideas and conceptions and circuitry, much of which had never been done before. All this took time, but by the middle of 1946 units No. 1 and 2 were in the water at Ft. Lauderdale.

Early in 1947 the Bureau became increasingly anxious about progress and how the taxpayers' money was being spent. At a full-dress review held in June 1947, the Company contended, as expressed by an observer, that torpedo research and development was a "rough, tough, nasty business."

Three important conclusions were reached at the meeting. General Electric was authorized to begin development of the sea-water battery (Box), and to buy $600,000 worth of silver for use in the batteries with funds that still remained in the original $2-million contract. (A chilling thought to Company lawyers who feared repercussions in the world silver market. As a result, the Bureau ordered the silver from the Government, which was disinterred at Ft. Knox.)

The universal torpedo ceased to exist. Like the Philosopher's Stone, it proved to be highly elusive. The weight of the Mark 35 had increased beyond the limits acceptable for aircraft, and it was also too long—no fault of the torpedo. But aircraft had become increasingly complex, and the addition of more equipment had caused designers to shrink the torpedo bay. Junking of the airborne Mark 35 paved the way for later development of an air-launched weapon that was smaller, lighter, and sturdier.

The final result of the meeting was a two-year contract for $1½ million to continue development of the Mark 35 and start work on the sea-water battery.

By the fall of 1947, units No. 4, 5, and 6 (No. 3 was never built) were in the water, and the outlook was cheering. That particular series of weapons looked good, and their performance hastened some highly significant developments.

6—TRIALS AT KEY WEST

When the Research Laboratory wound up its work at Ft. Lauderdale in July 1945, the General Electric operations were taken over by the General Engineering and Consulting Laboratory because of the impending tests of the new Mark 35.

But with increased pressure on this and other programs, it became apparent by the middle of 1946 that operations at Ft. Lauderdale were outgrowing the facilities. The decision was made to transfer to Key West, with its high availability of surface ships, submarines, aircraft, and good weather. The 15th Street Station was closed out, and the land returned to its private owner.

On November 1, 1946, the Naval Ordnance Unit (NOU) and the various contractors set up operations at Key West. Their new home was the Flagler Terminal—the pier and buildings of the ill-fated railroad that once operated between Miami and Key West. Tracks were removed, and the buildings were modified for development laboratories. Power was brought in, offices partitioned off, cranes installed, and the old vault turned into a drafting room. Later, additional buildings were added to the east end of the pier.

In those early days, equipment was sketchy or nonexistent. Tanks to pressure test the torpedoes or to check trim had to be built. High humidity and salt-water corrosion were a constant nuisance. To launch a unit, it was slid off a ramp at the rear of a boat. "We had only two samples to play with in those days," said R. W. Hodgers who was in charge of the facilities for a period, "and if we launched three or four shots a week, it was a good week. With only seven men, we couldn't have done much more anyway."

Even with excellent cooperation from the Navy, the Mark 35 program experienced the usual number of sorrows and snarls, as do all developments of this nature. It also enjoyed many achievements.

During most of 1947, emphasis was on torpedo dynamics; by the end of the year attention was centered on the electronic equipment. Battery trouble once again cropped up to plague the engineers, just as it had other torpedo pioneers since 1915. Antique lead-acid batteries from the Mark 18 of World War II were the only ones available; but because of their bulk, the length of the torpedo had to be increased five feet. This was bad enough by itself because it made dynamic studies doubly difficult; but the headaches were compounded when the batteries only drove the torpedoes at half speed. Extrapolated data are not reliable.

Propeller cavitation posed another problem. In a fit of inspiration, one of the engineers cut two blades off the standard four-blade propeller used on fleet torpedoes. It worked and was used until a new design became available.

Failure of components was one of the most abrasive aspects of the entire program. To get all the electronic gear into the confines of the torpedo shell, it was necessary to use standard devices that would fit. They weren't always JAN (Joint Army Navy) approved; "We'll get that tomorrow," was the not unreasonable rationalization. Use of "off-the-shelf" items was commonplace. "Anything to keep the fish in the water" was the byword.

Monthly reports of the late 1940's from Key West give a mild indication of the trials that were being endured by engineers on the project. Under a heading "Reason for Unsuccessful Run" appeared such frustrating items as: rust on propeller, main battery plug came out on launching, high noise level, launching range too great, main contactor welded shut (as a result of contactor bouncing from water-entry shock, which usually meant the battery burned up), unit never saw the target, unsatisfactory run . . . for unknown reasons, and main battery blew a cell.

Later, items like those become less and less frequent; the reports assume a more spirited tone . . .

> The unit hit the target submarine on the first pass and was lost.
>
> The unit made seven passes on screw noise from the target submarine. On two of these passes, the unit came very close and was rolled almost completely over by the wake. The unit finally got out on the side and attacked on echoes and hit the submarine. The only damage to the unit was [to the transducer].

TO BE CONCLUDED

ASSOCIATION OF IRON AND STEEL ENGINEERS

By T. J. ESS

In 1907 the steel industry of the United States—a husky adolescent—was flexing its muscles, foreshadowing the giant it was to become. Production that year totaled 25,781,361 gross tons of pig iron and 23,362,594 gross tons of steel. The open-hearth process had just caught up to the Bessemer process as a steel producer.

Electricity, a new phenomenon in the industry, had been applied to cranes, lighting, and a few auxiliaries. In the United States, the first application of direct-current motors to mill tables took place in 1893 at the Homestead Steel Works; drive motors were first placed on main mill rolls at the Edgar Thomson Steel Works in 1905; and the first reversing drive powered a universal plate mill at the South Works of the Illinois Steel Co. in 1907.

Electric equipment then available, largely of general-purpose design, did not adapt well to the rigorous service of the steel industry. Also, the application of electricity posed many problems—problems unique to the industry and formidable to the men in the relatively new field of steel-plant electrical work.

Early Organization

Thus it is not surprising that these men felt the need of banding together. It started in April 1907 at an informal meeting of 28 electrical engineers from the steel industry. They had met to inspect a special exhibit of electric equipment for use in iron and steel plants. One of the group, James Farrington, suggested the formation of a national organization of the men in charge of the electrical departments of the iron and steel industries. Its purpose: to increase co-operation between the makers and users of electric apparatus and to improve this equipment. The minutes of this preliminary meeting indicate approval of the idea by showing that each of the 28 men chipped in one dollar.

The following October brought the first Annual Meeting at Pittsburgh, with 15 members and 8 guests. The group adopted the name Association of Iron and Steel Electrical Engineers and elected James Farrington its first president. Dues were set at $10 a year, which still prevails, although the minutes indicate some sentiment that "a membership fee of $10 would keep out a number of men who would not want to go in that deeply until they see what they are going to get."

Within the next few years, the membership of the Association became fairly representative of its section of the industry. In 1910, revised bylaws permitted associate memberships, with representation from equipment suppliers.

As the value of Association activities became apparent, district sections were established: Pittsburgh in 1914; Chicago in 1915; Cleveland and Philadelphia in 1916; Birmingham in 1919; Detroit in 1938; Buffalo in 1944; Youngstown in 1953; San Francisco, Los Angeles, and St. Louis in 1954; and Utah in 1956.

For the first 10 years of the Association's existence, the members themselves entirely planned and carried out the activities, but growth made this work burdensome. In 1917, finances permitted the organization to employ a full-time manager—the beginning of a permanent staff.

Membership

As membership grew, interest developed in fields other than electrical. A combustion division was formed in 1921, a lubrication division in 1930, a mechanical division in 1932, an operating practice division in 1938, and a rolling-mill division in 1943. The growth of these divisions rendered the original name of the Association obsolete; in 1936 the name was changed to Association of Iron and Steel Engineers (AISE).

Today AISE membership includes representatives from practically all levels in the steel and allied industries—from presidents through all branches of engineering, operating, and maintenance.

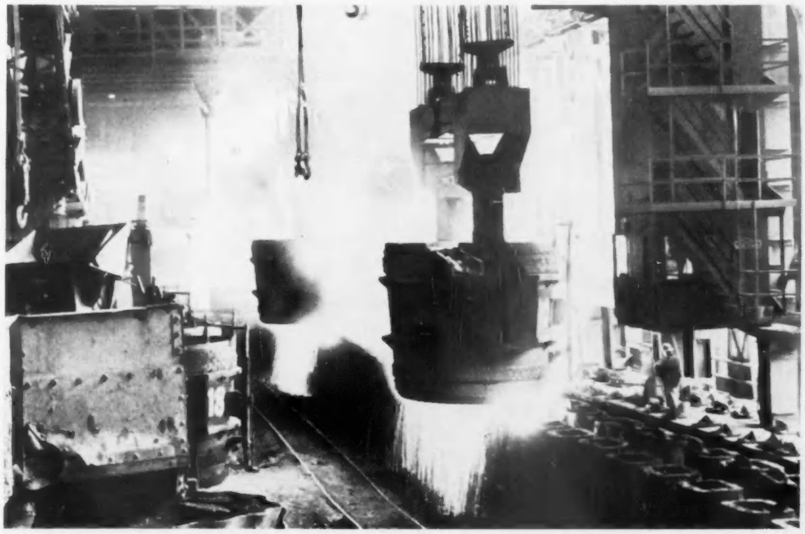
Because the Association embraces all branches of engineering but only within the relatively narrow confines of the iron and steel and allied industries, it has—unlike many other engineering societies—no student membership. This handicaps membership volume but results in a compact group of specialized interests.

Believing that its principal function consists of helping the industry it serves, AISE keeps less stringent membership requirements than some engineering societies. It feels that any help given the iron and steel industry's personnel constitutes a service to the industry. The Association opens its meetings to personnel of the iron and steel industry,

STEEL PLANTS that sprawl for miles along navigable waterways, forming a panorama of light against a dark sky, substantiate the fact that steel is a large and still growing industry.

Mr. Ess—Managing Director of the Association of Iron and Steel Engineers, Pittsburgh, Pa.—has written numerous articles about the industry.

ELECTRIC ARC FURNACES are rapidly gaining acceptance in American steel plants. AISE members take a keen interest in watching developments progress in this field.



OPEN-HEARTH FURNACES, along with the Bessemer process, continue to handle the bulk of today's smelting for the steel industry because of their economic advantage.

whether Association members or not, and charges no attendance or registration fees.

Activities

Dedicated to its purpose of "advancing the technical and engineering phases of the production and processing of iron and steel," AISE schedules a broad program designed to disseminate information that will help the iron and steel industry and Association membership. These activities appraise and emphasize the value of new developments as demonstrated by practical experience.

The steel industry is big business—really big. It represents a capital investment of about $12 billion and an annual expenditure of $14 billion. Spending this kind of money requires careful planning, necessitating knowledge, ideas, experience, and a broad perspective. AISE tries to help in these areas.

Association activities include an annual convention, a spring conference, and a western meeting—each with programs consisting of technical papers covering wide fields of steel-plant interests. In addition, each of the 12 district sections holds monthly evening meetings through fall, winter, and spring.

The Iron and Steel Exposition, started in 1919, constitutes an important AISE activity. Now held biennially, the Exposition has grown into a major industrial exhibit visited by 13,000 to 15,000 men. It offers the advantage of visual inspection of the newest developments in steel-plant equipment and supplies produced by manufacturers serving the industry. This Exposition affords an opportunity for valuable contact with manufacturers' representatives regarding technical features of their products.

Publications

Following the first Annual Meeting, AISE began publishing its *Proceedings*, which contain the papers and discussions presented at the meetings. Published regularly until 1924, *Proceedings* was then changed into the monthly magazine *Iron and Steel Engineer*, now in its 34th year. In 1936 the format of the *Iron and Steel Engineer* was revamped, using the plastic binding that has become so much a trademark.

Technical papers presented at national and district meetings still form the principal content of the magazine. These papers—originally selected by committees in the various areas of interest in the industry—are original, complete, and practical and are designed for the men in the steel plants.

From the start, the *Iron and Steel Engineer* devoted itself exclusively to the design, construction, operation, and maintenance of iron and steel producing plants. It is editorially unique in that the readers themselves contribute or at least suggest its content to a great extent.

Each year the Association permanently binds its proceedings for the members. This book, a fine addition to every engineering library, provides a valuable, permanent reference covering a wide range of steel plant subjects—a fund of data available in no other place.

AISE has also published a number of special books in fields lacking but needing published material. In 1941 *The Modern Strip Mill* provided a comprehensive analysis of these new mills that revolutionized the production of sheet and tinplate products. Now out of print but still in demand, the book—though used—has been known to sell at $50 or more a copy.

Between 1943 and 1948, the Association published a series of monographs, including *The Modern Coke Plant*, *The Modern Blast Furnace*, *The Modern Open Hearth*, *The Modern Arc Furnace*, and *The Modern Blooming Mill*. Thousands of these booklets were distributed throughout the industry, and many company training programs still use them.

In 1953 *Tube Mill Practice*—made up of 23 articles on various phases of tube mills and tube production—was published. *Roll Design and Mill Layout*, put out in 1956, formed a major addition to the sparse published information in this important field. At present, work progresses on several other books in various fields of steel plant interest.

Awards

AISE has established only one award —the Kelly award in memory of John Fredrick Kelly, the first managing director. It is given annually for the best paper written by a steel-plant man and published in the *Iron and Steel Engineer*. It carries certificates and cash awards for first, second, and third places.

Services: Safety . . .

Perhaps the Association's greatest achievement—lying beyond the area of engineering—reaches into the private lives of everyone. Only one year after its formation, the new organization set up a safety committee, and safety work became a prominent feature of its programs. It was soon recognized, however, that the safety movement must be spread throughout all industries.

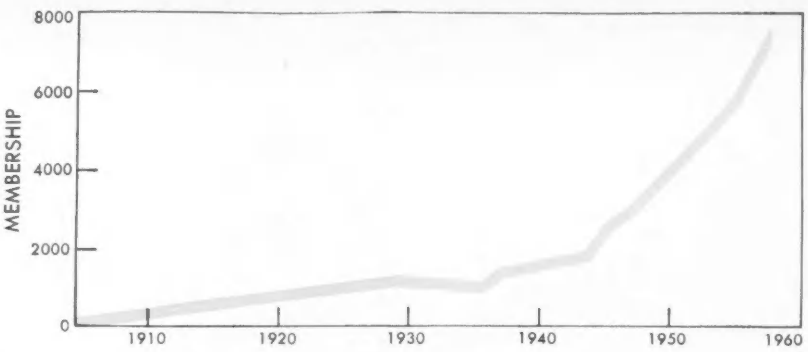
Accordingly, in September 1912 the Association's Safety Committee—under the chairmanship of L. R. Palmer—sent invitations to all industries concerning a Cooperative Safety Congress to be held in Milwaukee in September-October 1912 in connection with the Association's annual convention. Representatives from the mining, manufacturing, and transportation industries and from state and federal governments attended this meeting.

AISE President Barton Shover appointed a committee, which elected officers. This was the first step in the organization now known as the National Safety Council—a lusty foster child of the Association.

. . . and Other Programs

Other AISE achievements include maintenance of a program of activities that have developed the original organization of 28 men into one of international character. The Association now claims 7600 members in 31 countries, but all in a specialized field—steel. This program has purposely been held to a practical level for maximum benefits to the men of the industry. It has broadened the ability and viewpoint of AISE members and fostered close cooperation not only with their counterparts in the various steel plants but also with the manufacturers of equipment and supplies.

The Association promoted the application of electric motors to rolling-mill drives and the broad electrification of auxiliary machines. It furthered the development and application of combustion control and instrumentation in steel-plant processes. And moreover, it influenced improvements in the design of the equipment used in the iron and steel industry and helped in the application of modern bearings and lubrication devices.



AISE MEMBERSHIP includes all branches of engineering within the iron and steel and allied industries. This results in a compact group having specialized interests.

With the advent of the continuous hot-strip mill, Association programs dealt extensively with the equipment and methods of the new process. Of all the developments in the steel industry no other was so freely discussed nor proceeded so rapidly and successfully to its maturity. Subsequently, the Association broadened into other areas of the rolling-mill field that sorely needed investigation and a greater interchange of ideas.

Research and Standardization

Research programs sponsored by AISE—under way almost constantly—include work on the design of electric overhead traveling cranes, design of hot-metal ladles, design of ladle hooks, thermal distribution in blast furnace hearths, and the causes of strip-metal-roll breakage. Out of these projects have come several standard specifications and design standards, particularly for steel plant cranes, ladle hooks, and hot-metal ladles.

Committee work contributed toward setting up of other AISE standards. The first of these, started at the Association's 1908 meeting, sets certain specifications for the d-c mill motors so widely used in the steel industry. Other standards cover machined surface finishes, slings and crane chains, wiring diagrams, crane wiring, carbon brushes, mill motor brakes, and plain bearings.

Educational Projects

Over the years the Association has sponsored many educational projects such as lecture series on steel-plant topics presented in the AISE sections. Undergraduate scholarships and post-graduate fellowships have been maintained at different times. And last year the Association began a program of four-year engineering scholarships—named AISE Merit Scholarships—administered by the National Merit Scholarship Corporation.

In addition, the AISE-Farrington fund —maintained at Rose Polytechnic Institute in honor of the founder of the Association—is used partially for scholarship work, partially for the purchase of needed equipment. AISE also maintains a fund at Carnegie Library in Pittsburgh for the purchase of special reference material of interest to the iron and steel industry.

The latest project in this field consists of AISE sponsorship of a comprehensive economic history of the iron and steel industry of the United States to be prepared under the direction of William T. Hogan, S.J., of the economics department of Fordham University. This work will require three years and will fill a definite void in the literature of the industry.

The Future

AISE, like other engineering societies, will doubtless continue to grow. Equipment and controls in industry continually become more and more complicated and, at the same time, more automatic! This means more problems for engineers and, consequently, more demands on their societies. It follows, then, that programs must be broadened to cover these needs as they arise.

AISE will continue to serve its members and the steel industry as in the past. Ω

High-key lighting, with all four systems turned on, illuminates the room with an average of more than 70 lumens per square foot, the minimum installed light density that assures a pleasantly warm atmosphere.

How to Light Your Family Room More Effectively

With one room in the home becoming the focal point of family activity, space is important. Planned lighting can make it five rooms in one.

By CARL J. ALLEN

Planned lighting makes good sense, no matter what the application. But when the application is the increasingly popular family-type room, it can make work easier, relaxation more beneficial, and hobbies more fun. With a different lighting treatment for each activity—family parties, dances, hi-fi sessions, teenage projects, hobbies, movies, and slide projection—a family room can become the center of a pleasant, comfortable, versatile home life.

Should you be planning such a family room, it is preferable to arrange early for a flexible lighting system that will give you a variety of combinations. For instance, if your entire family is using the room, you might choose to have these activities carried out under full light (photo). But on another occasion, say, a dance or party given by your teenage daughter or son, a dimmer control could create the desired atmosphere in the room.

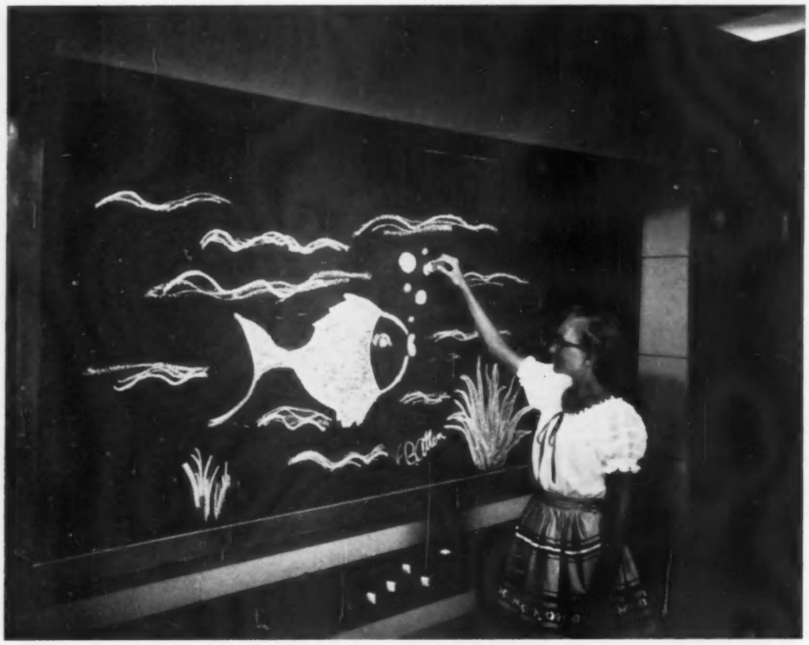
Importance of Color

Another important aspect of your planning is the choice of finishes for the ceiling, walls, and floor. The success of the lighting effect depends as much on them as your choice of lighting fixtures and their arrangement. In the room described here, this proved especially true.

For instance, a light floor contributed essentially to the success of the lighting treatment. Because the general lighting was recessed in the ceiling and directed downward, it required a high-reflectance surface on the floor to bounce the light back to the ceiling. The highest-reflectance floor covering suitable for the moisture conditions of below-grade basement use, and readily available, was a vinyl asbestos tile. Its off-white background, decorated with a colorful confetti pattern, offered a reflectance of about 50 percent. But despite the tile's light color, it presents no maintenance problem.

For the cement-block walls—requiring a pleasant appearing light-toned surface—the choice was a light blue-green paint with a silver ink jackstraw pattern, which added an interesting effect to the surface. This color also complements skin tones, making a flattering background for the human complexion. To fill in the normal cement-block crevices, we used a moisture-proof cement-base paint. Over this a rubber-base paint in blue-green was applied.

School lighting specialist for General Electric's Lamp Division, Nela Park, Cleveland, Mr. Allen is nationally recognized as an authority on lighting in schools and colleges. With school and industrial lighting comprising his first two articles for the REVIEW, he focuses his technical knowledge on the lighting requirements for a room in his home.



FLUORESCENT LIGHT through a black-light filter activates colored fluorescent chalks. Glowing brilliantly against a dark blue background, the drawing appears to be suspended in space.

The pattern in the slipcovers and draperies picks up the blue-green color and introduces a touch of coral. Applied to the brick foundation of a chimney that forms a side wall of the room, the coral color, in a glossy enamel, topped several coats of cement paint. This vibrant hue gives the room both a visual flamboyancy and a feeling of cheerfulness.

Systems and Sources . . .

The lighting in the room utilizes four types of lighting systems: overhead center luminous panel, recessed perimeter downlights, lighted wall bracket, and illuminated chalkboard. These four systems employ three different light sources (Table). With all four systems turned on, the room glows with an abundance of pleasing luminosity. Yet, because of the good louvering, the lighting creates no sensation of glare or annoyance from any of the equipment.

While you may not normally think in terms of engineering the lighting for a family-type room, engineering concepts formed the basis for deciding many of this room's fixtures. Experience has shown that, when the average installed density of light exceeds 70 lumens per square foot, rooms in a home assume an air of pleasantness and warm liveability. Seventy lumens per square foot, then, became our goal and was the determining factor in the number of fixtures needed. (A list of the lumen output of all common lamps can be obtained by writing to the Lamp Division, Nela Park, Cleveland, Ohio.)

. . . Luminous Center Panel . . .

The center of the room—location for the card table, ping-pong table, or a small-size folding billiard table—boasts the highest concentration of light. Louvered fluorescent troughs are located between the joists with single 40-watt fluorescent lamps in each of the five troffers.

Two developments of recent years make the fluorescent lamp most acceptable for home lighting. One, the rapid-start principle of operating a fluorescent lamp, eliminates the starter as well as the initial fluttering action once characteristic of earlier preheat type lamps. These rapid-start lamps light in a smooth, gradual manner. The other development—the deluxe version of the warm-white lamp (now the Home-line lamp)—gives a flattering light to the complexion and renders colors in their most appealing hues. Although the deluxe cool-white lamp can be used, the Home-line lamp is the principal home light because its color closely approximates that of incandescent lamps; these two light sources blend harmoniously.

. . . Perimeter Downlights . . .

The square-louvered incandescent downlights located around the rim of the room serve two purposes: They supplement the lighting by filling in the perimeter of the room not covered by the center panel. And, when used alone and dimmed by means of a variable autotransformer, they provide low-key lighting for dances or showing motion pictures or slides.

These small-size wall-box autotransformers, available for home use, will fit into a 6-inch-deep wall partition and control up to 750 watts, say, ten 75-watt R30 reflector lamps—the number and size used in the room under discussion. You can also use this autotransformer to dim rapid-start fluorescent lamps, if dimmer-type ballasts are used instead of the regular rapid-start ballasts. The dimmer operation of the lamps in this particular family room continues to fascinate all who see it.

. . . Illuminated Chalkboard . . .

Striking and unusual is the effect of the black light that illuminates the autograph board where visitors can sign their names in fluorescent chalk. The characters appear to glow in the darkened room, and the brilliant colors float

FAMILY ROOM LIGHTING PLAN

System	Source
Overhead luminous panel Lighted wall bracket	40-watt Home-line (formerly warm-white deluxe) fluorescent rapid-start lamp
Recessed perimeter downlights	75-watt R30 reflector incandescent lamp
Illuminated chalkboard	Black-light fluorescent lamp (BLB)

(The black-light fluorescent lamp gives an abundance of near ultraviolet energy but little visible light.)

against the dark-blue background of the chalkboard (photo).

These fluorescent lamps have an integral black-light filter that emits practically no visible light. Located at the ceiling behind a valance board, they are about 18 inches from the board—a spacing that assures uniformity of black-light energy over the entire board (illustration, top). And under the activating effect of the black light, colored fluorescent chalks glow brilliantly.

The chalkboard, a 4×8-foot panel of composition wallboard, has one coat of dark-blue rubber-base flat paint. This panel, hinged to the wall at the bottom, serves another purpose: when lowered to a horizontal position, it forms the base for a miniature railroad layout.

The children are permitted to operate the downlights for their parties, but we specify the minimum voltage to be maintained—55 volts is the limit for our 13-year-old daughter, but our 16-year-old son can dim the lights down to 45 volts.

. . . And Lighted Wall Bracket

One part of the lighting system functions from morning until night, even though the room remains unoccupied: the fluorescent wall bracket, located above an array of potted African violets. Under 300 footcandles of fluorescent light for 16 hours per day, these plants grow from slips to healthy maturity without ever seeing daylight. Home-line lamps, used in this instance, give an over-all decorative effect. When the principal concern is plant growth, cool-white lamps are generally recommended for the installation.

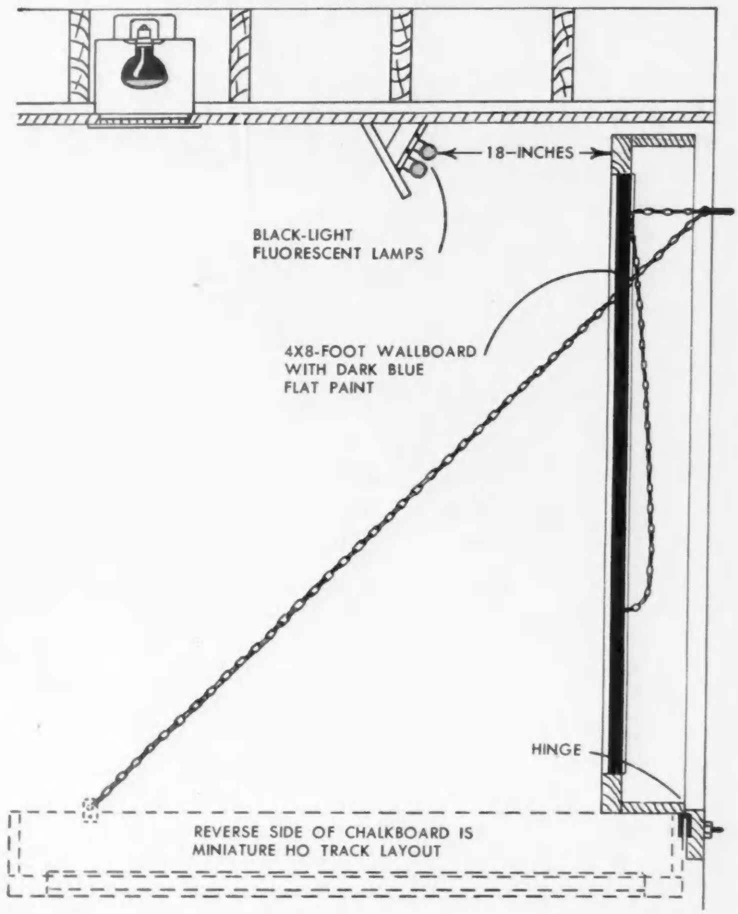
The top of the wall bracket is slightly above eye level, bringing the lamps about 18 inches from the 7-foot ceiling. The tilted face board of the bracket allows a good upward sweep of light across the ceiling and also conceals the lamps (illustration, lower).

Utilitarian and Decorative

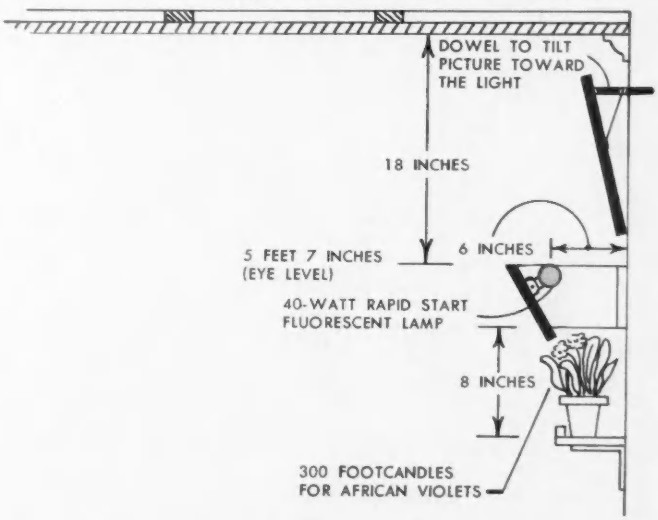
A family room can have an amazing number of uses—both for the children and the parents. Effectively and efficiently planned lighting, besides being utilitarian, can be a versatile decorating medium, as well. People are immediately put at ease because they enjoy the feeling of being surrounded by an abundance of light.

One properly lighted well-planned room can take the place of five, be more comfortable, attractive, and in effect larger. Ω

HOW TO MOUNT CHALKBOARD AND BLACK-LIGHT LAMPS

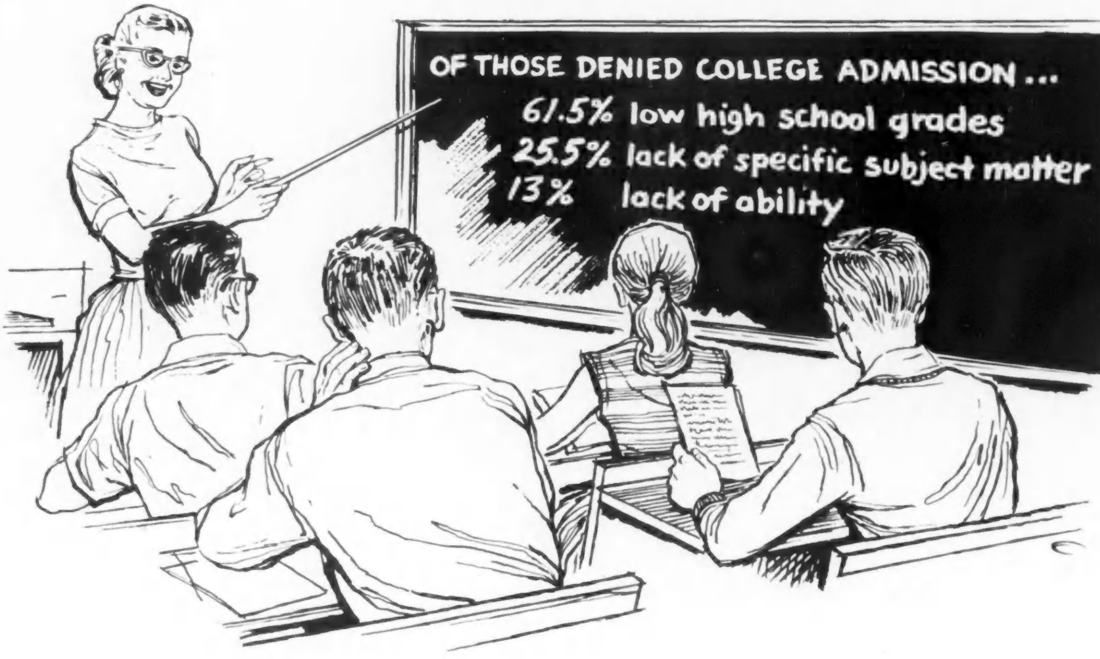


HOW TO INSTALL THREE-PURPOSE FLUORESCENT WALL BRACKET



78 COLLEGE ADMISSIONS OFFICERS ASK . .

Are you SURE you can go to college?



"Sure, I can go to college because my dad has the money to send me."

Are you *sure* that's all you need to get into the college of your choice today? If you are really interested, you had better take another look, for things have changed quite a bit since your dad went to college.

As the *New York Times* recently noted, "The time is long since past when dad's ability to pay the frat bills and the upkeep of a flivver was the main requirement for getting a not-too-bright son out of his hair and onto the campus. It's grades that count now. Without good scholarship and the proper choice of subject material while in secondary school, the high school graduate is finding it increasingly difficult to get into the college of his choice."

What has caused the terrific squeeze in college enrollment today? It's pretty simple—more people want to go—and more important, are financially able to go—to college in these degree-conscious days than ever before. Expansion of higher institutions of learning has not kept pace.

Plan Early

How do you stand in this scramble for a berth in a good college or university? Oh sure, we know you are only in junior or senior high school. Why should you worry about going to college now, when it will be several years before you must cross that bridge? Because if you don't start early to plan your college career you might find yourself out in left field when the rest of the team is in the dugout. In other words, you had better start thinking and planning now for a spot in the rapidly overflowing colleges and universities, or you might find yourself in a tough spot at entrance time.

The United States today, virtually "splitting at the seams" both economically and scientifically in its tremendous growth and expansion, has a growing need for college-trained young men and women to fill positions of responsibility continually being opened by the phenomenal enlargement of industry. Unfortunately, many of the would-be leaders of America never have the opportunity

to realize their full potential. By failing to prepare themselves adequately for college work while in high school, an increasing number of students are refused admission to colleges or universities of their choice.

Take Work Seriously

We here at General Electric are becoming increasingly interested in the young people of America—not only as possible employees of industries like General Electric—but as citizens in a scientific world. With this thought in mind, we asked college admissions officers why so many of the young people who apply for college admission today are turned down. They answered our questions without if's and but's. Let's see what they had to say.

Looking at the rejection rate on a purely statistical basis, these educators told us that an alarming 61.5% of all denials are made because the applicant ranked low in his high school graduating class. *More disheartening than this, most of those rejected could have placed in the upper part of their class had they taken their high school work more seriously.*

However, even if you have pretty good grades in high school, you can't always be sure that the collegiate doors will automatically open as you appear. For unless you've taken certain good, solid subjects before you apply for admission to college, you may find yourself in the same boat as the other 25.5% who are turned down for lack of specific subject matter. Surprisingly enough, only 13% of the applicants were actually lacking in ability, as shown by test scores on the pre-entrance exams!

But listen to what the admissions officers themselves say about the subject. Henry C. J. Evans, the Assistant Director of Admissions at Rutgers, sums up the situation like this: "We have found that the chances for an individual to succeed in college are almost directly proportional to the quality of work he has done in high school. The four-year high school period represents a record of the student's attitude toward his work, the effectiveness and efficiency with which he can perform, and the study habits which he has acquired. We place a great deal of weight upon this secondary school record and do not like to consider an applicant unless he is at least in the upper-half of his class in high school and preferably the upper-third . . ."

Admissions officials also find a significant lack of proper subject matter being taken by high school students today. One official goes as far as to say that "more than 90% of the rejections are attributable to lack of preparation in specific subject matter areas. The subject matter areas most frequently lacking are mathematics, English, and science." In other words, the algebra course you fail to elect, or possibly the elective course in English composition which you may feel is uninteresting, conceivably may be the course which could get you into the university which you plan to attend.

Top educators across the nation tell the same story. "The chief reasons for denial," says the admissions officer, Illinois Institute of Technology, "rests on the applicants' inadequate preparation in mathematics and science. Many of these rejected students are also ill-prepared in English, including the lack of ability to read with ease and proficiency . . . Approximately 75% of the denied applicants involve relatively poor background in mathematics. About 30% of the denials are related to inadequate preparation in physics and chemistry . . ."

Why do so many students on the high school level fail to do the quality and quantity of work required to gain admission into our leading colleges? Possibly it is because high school students today feel that to be a good student is to be unpopular with the crowd. This, of course, is far from the truth. John F. Morse, Director of Admissions of Rensselaer Polytechnic Institute in Troy, New York, has this to say about the subject, ". . . they are afraid their classmates will think them 'grinds' or 'bookworms,' or any of the other dozen

slang terms now in current use . . . I would try to convince them that being on the honor roll is as significant as being known as a 'good guy' or being a varsity letter winner. We look for the student who can combine any two or all three of these honors."

The ideal student, then, is the one who is admired by both faculty and students alike. He has the talent and initiative to combine both good grades and an active extra-curricular life. This is the type of person who equips himself at an early age to accept responsibility and get things done. Prospective employers as well as college admissions officers look for these traits in high school students.

It all boils down to this—it takes more than your dad's check to get you into a good college these days. Acceptance officials are forced to be more strict than ever before as to whom they allow to attend their institution. They are looking for the student who has proved by his high school record that he is prepared to do well in college. Primarily, good grades are important. Secondly, study in the basic subjects—math, English, science—is a growing necessity for a good background for college work.

Educational Crop

So you had better recognize the fact that you may have trouble reaping the educational crop unless you sow a good seed in the beginning. If you really want to go to college you had best think about what these officials—the men you must face when you apply for admission—have said concerning why you may be refused admission. Their advice about preparation for acceptance into college will be condensed for your benefit and published in a forthcoming issue of the REVIEW.

INDUSTRY PROMOTES THE STUDY OF THE THREE R's (PART 8)

You may want reprints of this article "Are You Sure You Can Go to College?" to help guide the young people with whom you come in contact. They can be obtained free by writing to the GENERAL ELECTRIC REVIEW, Bldg. 2-107, General Electric Company, Schenectady 5, NY. In your request, please ask for publication PRD-110.

New trends and developments in designing electrical products . . .

General Electric thermistors and Thyrite* varistors have unique properties that apparently contradict normal electrical laws. Here's how they can be harnessed to improve your product.

General Electric thermistors and Thyrite varistors are ceramic-like semiconductor resistance materials. Each has unique properties – apparently disobedient to normal physical laws – that enable it to perform tasks in electrical and electronic circuits which otherwise would require costly, complex components.

The distinguishing feature of thermistors is their *thermal* sensitivity. Thermistors have large *negative* temperature coefficients of resistance (i.e., their resistance decreases tremendously when heated, instead of increasing slightly like other materials).

Thyrite varistors, on the other hand, are *voltage*-sensitive. Contrary to Ohm's law, a current through a Thyrite varistor varies as a *power* of the applied voltage (i.e., doubling the voltage through a Thyrite varistor can increase the current from 15 to 25 times, instead of the normal 2 times).

The applications based on the unique properties of these materials are almost limitless. In general terms, thermistors are used in the detection, measurement, and control of minute energy changes; Thyrite varistors are used to protect, stabilize, and control circuits.

To give a clearer understanding of the ways thermistors and Thyrite varistors can be applied, here's how they have solved two of the electrical engineer's most vexing problems – temperature compensation and surge suppression.

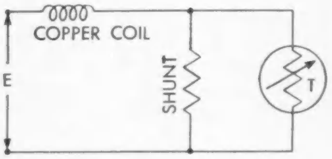


FIGURE 1 — Typical thermistor temperature-compensation circuit

The resistance of a conventional conductor is so affected by ambient temperatures that steady current flow cannot be maintained. For example, as the temperature of copper swings from −60° C to +80° C, the resistance increases 53%.

However, when the copper is compensated with a properly selected thermistor, the maximum deviation from the total average resistance at 25° C is only 3½% – despite the 140° swing in temperature.

In the circuit in Fig. 1, the thermistor's negative temperature coefficient of resistance offsets the positive temperature coefficient of the copper to stabilize current flow. In other circuits, thermistors can be utilized for signal and warning devices, sequence switching, and other time delay applications, because of the inherent thermal inertia involved.

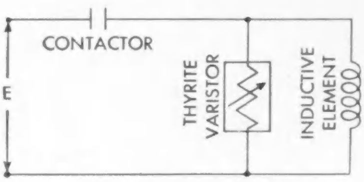


FIGURE 2 — Thyrite varistor surge voltage suppression circuit

Sudden interruptions of inductive circuits cause surge over-voltage, arcing, and high-frequency oscillations – all of which can cause trouble. The circuit in Figure 2 shows how a Thyrite varistor can be connected to hold these effects within safe limits.

With the Thyrite varistor out of the circuit, the surge voltage caused by interruptions of the current may rise to 9 times applied peak voltage (Oscillogram, Figure 3).

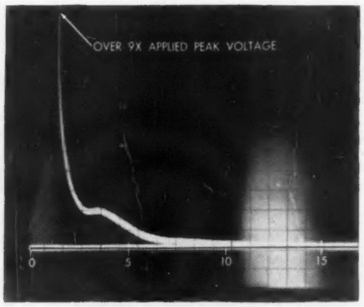


FIGURE 3

But with the Thyrite varistor in the circuit, (Figure 4), the surge voltage is limited to less than 3 times the normal applied peak voltage.

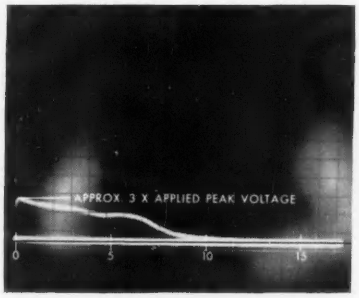


FIGURE 4

The Thyrite varistor draws negligible current at rated voltage, yet offers sufficiently low resistance at the peak current to limit the surge voltage to a safe value and to reduce arcing. Also, the Thyrite varistor quickly discharges circuit energy by providing increasingly higher resistance as the inductive current decays.

If a linear resistor were used to provide the same voltage suppression level, it would have to draw a current equal to more than 30% of the inductive element current.

In addition to surge suppression, a Thyrite varistor can be used as a nonlinear resistance parameter, a potentiometer, and a frequency multiplier. It can also be used as a bypass resistor to protect personnel and equipment from circuit faults.

Technical literature giving complete data on properties, applications, sizes, and shapes of G-E thermistors and Thyrite varistors is available. And, for the experimenter, there are two engineering test kits on each.

To obtain kits, literature, or the assistance of a General Electric Engineer on your problem, write: *Metallurgical Products Department of General Electric Company, 7802 E. 8 Mile Road, Detroit 32, Michigan.*

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Abstracts

For your convenience: brief summaries of the articles appearing in this issue.

1958 *Alpha*—Tribute and Promise to Science *Classification:*
PORTER, RICHARD W.

This statement describes the *Jupiter C*, credits agencies and facilities contributing to its success, and points out science's attendant responsibilities.

GENERAL ELECTRIC REVIEW March 1958 p 7

Four Reports on Russian Technology *Classification:*
HOLLOMAN, J. H.; HIBBARD, W. R.; BEAN, C. P.
ROUAULT, C. L.
HEUMANN, G. W.
ROBERTS, F. M.; MILLER, W. E.

Three of these four interviews concern specific areas of Russian technology—metallurgy, electronics, and industrial control; the fourth deals in retrospect with Russian technology of 1930. Each a specialist in his field, these men derived their opinions through personal contact with their Russian counterparts and inspection of factories and laboratories.

GENERAL ELECTRIC REVIEW March 1958 pp 9–18

Industry Goes to the Campus *Classification:*
MCCRACKEN, D. D.

Industry has become more actively concerned with the quality of education; the author describes the closest link to date between an industrial organization and a university—establishment of Arizona State Computer Center, operated by GE on the campus of Arizona State University, Tempe, Ariz. Text covers computer installation, programming personnel, and the many advantages for educators, students, and industry.

GENERAL ELECTRIC REVIEW March 1958 pp 19–21

Thought *Classification:*
REVIEW PICTURE REPORT

This depicts climates for thought processes that lie behind research.

GENERAL ELECTRIC REVIEW March 1958 pp 22–23

Undersea Defenders: Story of Acoustic Homing Torpedoes *Classification:*
REVIEW STAFF REPORT

Part I of two parts, this article reveals for the first time the complete story of GE's achievements in the torpedo field—the acoustic homing torpedo. This first segment traces torpedo history from early conception to the beginning of experiments on models that were to become accurate and deadly undersea weapons.

GENERAL ELECTRIC REVIEW March 1958 pp 24–35

Association of Iron and Steel Engineers *Classification:*
ESS, T. J.

This article, 24th in the series "Engineering Societies of America", covers AISE history, activities, services, education, and research projects.

GENERAL ELECTRIC REVIEW March 1958 pp 36–38

How to Light Your Family Room More Effectively *Classification:*
ALLEN, CARL J.

A lighting expert reports on the requirements of a typical family room and how to obtain versatility through planned lighting. Proper application and location of four types of lighting systems and three different light sources are discussed; two diagrams are included.

GENERAL ELECTRIC REVIEW March 1958 pp 39–41

Industry Promotes Study of the Three R's *Classification:*
Why Study Series: Are You Sure You Can Go to College?

Addressed to high school students, this article points up pitfalls young people encounter in seeking college admission and urges adequate preparation in high school mathematics, science, and English as a basic requirement. (Reprints are available.)

GENERAL ELECTRIC REVIEW March 1958 pp 42–44

Russian Technology

(Continued from page 18)

the insulator. And they had a few d-c motors, which I thought were also of very poor quality.

But how were the Russians in production—in the paper mill, for instance?

ROBERTS: Very, very, very low. At that time, in this country, we were using about say 15 percent sulfite mixed with 85 percent ground wood to make newsprint and running it about 1000 feet per minute. When I left the Russian mill, the best they could do—on a brand-new machine, with a brand-new General Electric drive on it, with all the equipment in good shape, and with an American operator as supervisor—was 770 feet per minute at 40 percent sulfite, which would never make money in this country at that time.

What would you have attributed that disparity to?

ROBERTS: Well, to tell you the truth I attributed the lack of efficiency and a lot of the things that went on in that mill to *hunger*. The people just didn't have enough food to keep them efficient.

Did you form any impression of the transportation system within Russia?

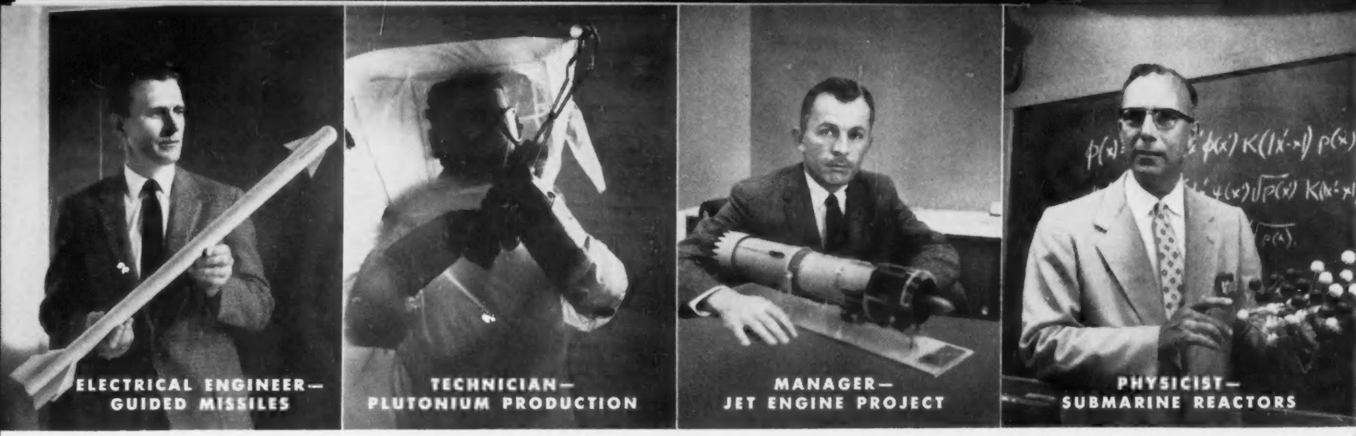
MILLER: Well, they had practically no highways—there were just cobble stones or usually just dirt roads taking off across the prairie.

How about railways?

ROBERTS: Very third-rate. The only good cars they had were some of the old Wagon-Lits cars that were left over from or before the revolution.

MILLER: All of their rail stations seemed to be cluttered up with people who had been waiting there maybe for days, trying to get a train out.

ROBERTS: I'd like to close on this note: I believe we fell into a horrible mistake when we underestimated Russia. We ought to have enough sense to see that the Sikorskys and Severskys, and the Umanskys in our own place here—who came from Russia and have this unique ability to be creative—were representative of one group of Russian engineers. There are many such people. And I think the hope for the future lies in the fact that these people—the intelligentsia—are being re-established. To me, they have the ability to think and to mix with the Western World a lot more than ever before. Ω



Devoting the talents of outstanding people. Staying ahead of potential aggressors requires quality of people as well as equipment.

How General Electric is trying to help meet the increasing challenges of defense

Today Americans are being forced to think in a totally new way about national defense. The United States can no longer expect to build military strength after an attack, but must be ready at all times to discourage aggression and maintain peace.

Yet, at the same time that a sizable portion of research, development, and production is constantly devoted to defense, we as a nation are striving to continue to advance our living levels.

Security with solvency

The resources of the nation are not limitless. Maintaining security with solvency presents a challenge to business and government to make sure that every citizen is getting the most for his defense dollar.

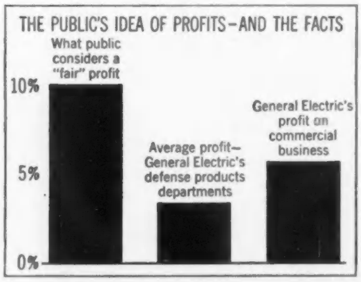
In helping meet this challenge, General Electric is:

- Devoting the talents of nearly half of the company's scientists, engineers, and technicians to defense activity.
- Bringing to bear its large-scale resources to pioneer vast and complicated defense projects . . . and then breaking down the big jobs into tasks to which thousands of other businesses contribute their specialized skills.
- Trying to conduct defense work as a business instead of an interruption of business.

Toward greater defense values

Meeting defense requirements is a continuing duty of responsible business. General Electric believes, however, that even fuller value from industry participation can be gained by infusing into defense work the same free-enterprise incentives that keep the civilian economy vigorous and able to supply good values to customers.

One way is to encourage maximum incentives for cost reduction in which both the taxpayer and the producer share in savings; another is to stimulate risk taking by making possible returns on defense accomplishments that warrant greater private investment.



As General Electric sees it, fully utilizing the incentives of a free society will deliver to every citizen greater defense value for his tax dollars . . . and at the same time continue to provide Americans with the highest living levels anywhere in the world.

Progress Is Our Most Important Product

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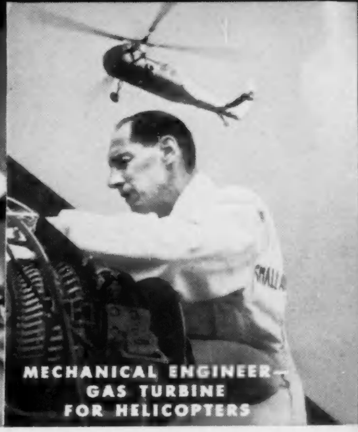
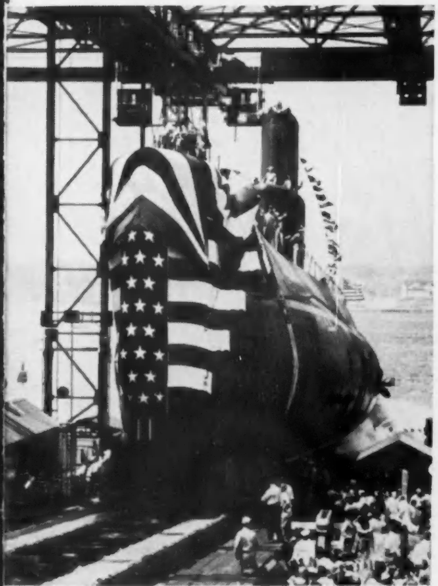
If you would like more information about General Electric's views and activities concerning national defense, please write us at Department A2-119, Schenectady, N. Y.



Nearly half of G.E.'s technical personnel is assigned to defense work, even though it is only about 20% of the company's total business.



Bringing to bear large-scale resources. Typical of complex jobs undertaken by General Electric is development of atomic reactors for submarines (like the *Seawolf*, above).

Mobilizing the skills of businesses of all sizes. In taking responsibility for complicated defense projects, and breaking them down into jobs smaller firms can handle, General Electric brings together the specialized talents of many businesses. Here are a few representatives of more than 800 firms which help General Electric produce large radar units.

The revolutionary J79 jet engines powering the new B-58 supersonic bomber and F-104A fighter-interceptor were developed by General Electric. The J79 is the most powerful jet engine for its weight yet built.