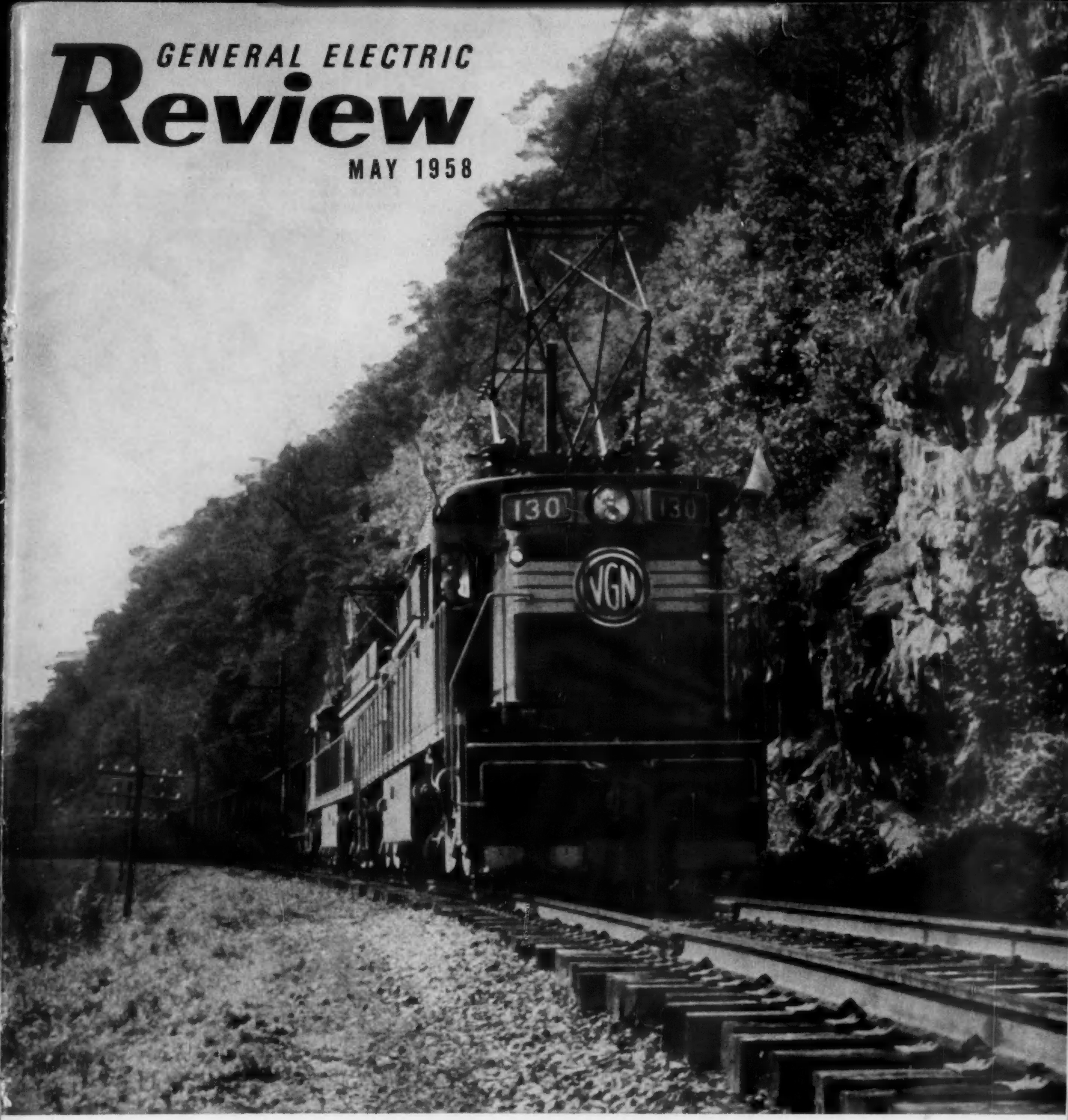
GENERAL ELECTRIC Review

MAY 1958



Answering the Challenge of the Alleghenies

PAGE 34

- High Price of Poor Listening
- Wireless Timekeeping
- Acoustic Homing Torpedoes


Dr. Charles P. Bean, B.A., University of Buffalo (1947), Ph.D. in physics, University of Illinois (1952), joined the General Electric Research Laboratory in 1951. As a member of the *Physical Metallurgy Section,* he has concerned himself primarily with studying the physical aspects of ferromagnetism.

GENERAL ELECTRIC
Review

MAY 1958 VOLUME 61 NUMBER 3

The GENERAL ELECTRIC REVIEW is issued in January, March, May, July, September, and November by the General Electric Company, Schenectady, NY, and is printed in the USA by the Maqua Company. It is distributed to scientists and engineers throughout industrial, consulting, educational, professional society, and government groups, both domestic and foreign. . . . . The GENERAL ELECTRIC REVIEW is copyrighted 1958 by the General Electric Company, and permission for reproduction in any form must be obtained in writing from the Editor. . . . The contents of the GENERAL ELECTRIC REVIEW are analyzed and indexed by the Industrial Arts Index, The Engineering Index, and Science Abstracts and are available on microfilm from University Microfilms, Ann Arbor, Mich. . . . For back copies of the REVIEW—1903 through 1955—contact P. and H. Bliss Co., Middletown, Conn. . . . Six weeks' advance notice and old address as well as new are necessary for change of address. . . . Send communications to Editor, GENERAL ELECTRIC REVIEW, Schenectady 5, NY.

COVER

On the Virginian Railway, rectifier-type electric locomotives haul freight over the mountainous 134 miles between Mullens, W. Va., and Roanoke, Va. These 3300-hp giants, described on page 34, are the modern successors of the steam-powered Mallets of the early '20s. Super Anscochrome by Paul R. Heinmiller.

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

GENERAL ELECTRIC

Guest Editorial

Engineering Comes of Age

Like all compelling events, the successful launchings of the earth satellites promptly produced a crop of popular catch-phrases, which attempt to express the impact of the event on the times. Two familiar ones: "the age of space" and "the dawn of the scientific revolution." Such phrases may have their merits, but I would suggest that events taking place today in the world of science and technology have a deeper significance for engineers. I would say that engineering is coming of age.

As youngsters, we focus upon ourselves and our momentary wishes. Only as we mature do we learn two vital lessons: the importance of relationships with others and the desirability of choosing goals to work toward. Engineers today are learning these same lessons of maturity with regard to science and technology.

Science and technology are exploding. New understanding and knowledge of nature are being generated with astonishing speed, as are new applications of established understanding and knowledge. These generations, of course, are not limited by national boundaries; they occur all over the world. In these circumstances isolationism is as unsound for engineers as it is for statesmen. And we should remember that it is dangerously easy for us to fall into such habits of thought.

You have only to visit abroad—including the USSR—to be impressed with how familiar scientists and engineers in every country are with our achievements. Language is no barrier to them. They closely follow and appraise our work in their fields of interest—regardless of how much the requirements, conditions, and standards of excellence they must meet differ from ours. By comparison, we are inclined to be insular in our relationships with world science and technology.

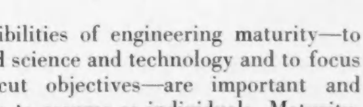
Keeping abreast in their own fields of interest is a more and more important obligation to engineers—and, of course, an increasingly difficult task. If I were to attempt a capsule prescription for success, it would be this: cultivate the scholar's urge to *know*. We all have felt this urge from time to time—whether with hobbies or engineering problems. In whatever areas it occurs, it always shows three characteristics: active, sharply oriented interest; thorough familiarity with the relevant literature; and clearly formulated ideas of what to strive for next.

In contrast, there is the urge to be told. It is a vague, uneasy feeling that "I don't know what is going on." The individual's interest, however, is more passive and generalized. He hopes that someone else will perform the miracle of knowing what is useful to him and will sift the literature to supply it—which is indeed wishful thinking.

Increasing awareness of relationships with others working in the same field of interest plays a necessary part in maturity in engineering. The individual engineer must couple with progress in his field. How and to what degree only he himself can determine, although others can, of course, help once he has stated his problem.

Clear-cut objectives are also of sharply increasing importance to engineering today. As science and technology grow in volume and complexity, research and engineering effort becomes more and more costly in facilities, time, and competence. Keen perception of the optimum balance among all the factors—business as well as technical—related to a given objective is the best guarantee that we shall exploit science and technology most effectively. Engineering must know the over-all objectives of the enterprise of which it is a part; from those objectives a plan of specific technical work to be done must be derived. The technical work plan, in turn, should be the basis for statements of facilities and competence needed. Finally, specific work projects must be chosen with the sharpest possible selectivity; work in progress must then be carefully and continually appraised to weed out activities that develop symptoms of poor return. Multiple approaches to the same end result will often be necessary and desirable, but we must sharpen our ability to pick the winner early and concentrate our effort there.

These responsibilities of engineering maturity—to couple with world science and technology and to focus effort on clear-cut objectives—are important and heavy ones for us to assume as individuals. Maturity, however, not only brings greater responsibilities but also greater rewards and satisfactions.



VICE PRESIDENT—ENGINEERING SERVICES

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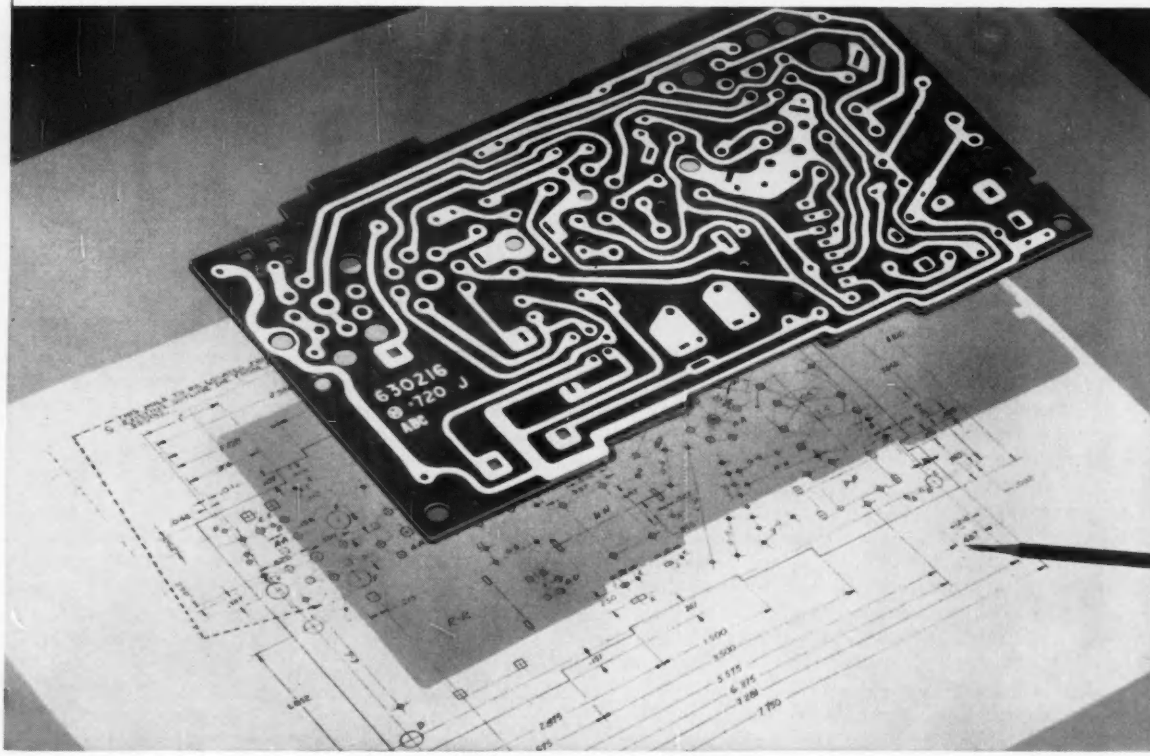

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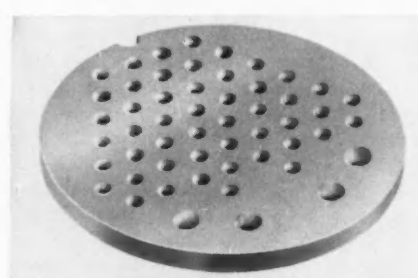

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INDUSTRIAL LAMINATES

GENERAL ELECTRIC

GENERAL ELECTRIC Review MAY 1958

Listening—The Missing Link in Communication

Recent research findings point up the shortcomings in a neglected area of industrial communication. These widespread deficiencies in listening skill carry with them an extremely high and needless price tag in both time and dollars.

By C. J. DOVER

A midwestern plant experienced severe quality problems with a delicate mechanism being mass produced on an assembly line. A swarm of experts—design engineers, quality-control men, and maintenance experts—descended on the scene, but they found no immediate solution to the problem. Worried about the rising rate of rejects and customer complaints, top management finally called in a management consulting firm. And they solved the problem—one of dust control.

About a month later, the personnel director received a jolt when he asked a promising young assembler why he was quitting his job. At first the young man evaded his questions; but the personnel director, sensing something important, probed and listened.

Eventually the story unfolded: The assembler wasn't absolutely sure, but at the time he thought he knew the answer to the quality problem that the experts had so desperately sought a short time earlier. And it developed, his hunch had been right.

"If you thought you knew the answer," the puzzled personnel man asked, "why didn't you tell us?"

"I tried to tell the foreman. I tried to tell the design engineer. But I stopped trying because they made me feel like a jerk. They wouldn't listen."

Can you imagine a more devastating indictment of management's performance in a crucial area of communication than those three words "they wouldn't listen"? And yet the evidence suggests this as no isolated incident. For among the employee-attitude surveys conducted by Opinion Research Corporation and other research firms, similar complaints frequently appear.

Father Theodore V. Purcell of Loyola University conducted an 18-month study of employee attitudes at Swift & Co. He reported that in interview after interview Swift's hourly employees equated good foremanship with good listening: "He listens . . . ." or "I can talk to him . . . ." And in summarizing his survey results, he said: "Of all the sources of information a foreman has by which he can come to know and accurately 'size up' the personalities of the people in his department, *listening* to the individual employee is the most important."

Shortcomings in Listening Skill

Listening broadly defined is more than mere hearing. It involves aural perception of a sound stimulus plus an interpretation of the stimuli received. Reasonably then, the act of listening can include the assimilation and interpretation of visual stimuli received in context with sound stimuli. For example, a project engineer, listening to his project supervisor comment on a proposal he has made, will not only be alert to what the supervisor says but will also watch closely for visual stimuli—the boss's facial expressions and mannerisms.

A recent research test incident suggests the abundant indications of poor listening in the ranks of management itself. The foremen and supervisors in 24 industrial plants were asked to rate 10 morale factors as they thought the factors would be rated by the employees; the hourly employees in the same plants were then asked to rate the same 10 factors in order of actual importance to them. The morale factors rated by employees as first, second, and third were placed as the last three on the list of the supervisory "guesstimate"! These three factors—full appreciation of work done, feeling "in" on things, and sympathetic help on personal problems—so grossly underrated by the supervisors and placed in top-ranking positions by the employees significantly indicated of themselves the value of effective listening by management.

High Price Tag on Poor Listening

Are listening habits in business and industry really so bad? Though probably no worse than in any other segment of society, they do suggest an inescapable conclusion: Efficient listening is a vital missing link in the evolutionary growth of communication—particularly industrial communication, at the point now where business and industry spend an estimated $500 million annually on employee communication alone.

It may be hard to prove but easy to postulate that business and industry literally lose millions of dollars annually through deficiencies in listening skill. For thousands of costly and vexing problems surely remain unsolved for long periods of time as a result of listening failures. And just as surely, thousands of money-making ideas go unrecognized because of the common

Mr. Dover—Consultant, Employee Communication and Group Relations, Public and Employee Relations Services, New York—provides advice, counsel, and appraisal functions for General Electric's production departments. Before joining the Company in 1948, he was Director of Public Relations for UNRRA. Author and speaker, he has recently completed *Effective Employee Publications*, a book soon to be published by the Bureau of National Affairs. Twice awarded the George Washington Honor Medal by Freedoms Foundation for Americanism activities, he also received a citation from the American Public Relations Association for outstanding public relations achievement.

"A few companies have taken positive steps toward upgrading the listen

failure of managers to really listen to their subordinates. Of equal certainty, thousands of brilliant proposals for engineering changes—springing from the fertile minds of bottom-of-the-ladder engineers—get killed off by an intermediary's sloppy listening habits, never to be reviewed by any decision-making authority.

But signs increasingly indicate that top management is becoming more aware of how costly and inefficient poor listening can be. Even though the data may be sketchy in terms of scientific research, abundant and convincing pragmatic evidence points to real and widespread listening deficiencies.

And simple arthmetic shows that managers, engineers, and other members of the management team receive a significant portion of their salaries for time spent in listening. For example, consider the cost to a company when a $10,000-a-year man attends one two-week course to improve his on-the-job skills: Moderate travel and living expenses added to his salary for a two-week period result in nearly a $1000 investment by the company. And while attending such a course, he will likely spend about 90 percent of his time listening. You can see that listening inefficiency carries a high price tag indeed.

Reasons for Listening Deficiency

Why is listening efficiency a missing link in human communication generally and industrial communication particularly? Although a deceptively complex question, it has at least one answer suggested by what appears to be a basic deficiency in the educational process. Four skills commonly are considered as component parts of communication: reading and listening—the assimilative skills; and speaking and writing—the receptive skills.

Reading and writing have traditionally been stressed in the teaching process at practically all levels in educational institutions. Speaking receives ever-increasing emphasis in curricula, particularly at the high school and college levels. But listening, until only recently, has practically been ignored during the entire history of mankind's formal effort to educate itself! And yet, we devote a large portion of our communication time to listening.

As long ago as 1929, Dr. Paul T. Rankin, formerly Supervising Director of the Detroit public schools, studied the activities of adults in various occupations. He concluded that people on the average spent 70 percent of their working hours on communication of one form or another; he further broke down this total time to 9 percent in writing, 16 percent in reading, 30 percent in talking, 45 percent in listening.

One may quarrel with these percentages. But almost any manager, engineer, or technician who studies his own job content will probably also conclude that he actually does spend a significant portion of his time on the job in listening. The exceptions will likely be the kind of a person George Bernard Shaw meant when he said: "I dislike him because he listens only when *he* is talking."

Steps Toward Better Listening

Fortunately, attempts are being made to close the listening-instruction gap in our educational institutions. In recent years the subject of listening has prominently appeared on the agenda of conventions held by such organizations as the National Society for the Study of Communication, the Speech Association of America, and the Conference on College Composition and Communication. More than 20 colleges and universities now offer courses in listening, and a few secondary schools also include listening in the curriculum.

But improvements in the basic educational process will be slow. And it will make little immediate or near-future contribution to improving listening skill in business and industry. So what about management's current problem?

Here again, the developments are encouraging. A few companies have already taken positive steps toward upgrading the listening skill of management, including the American Telephone and Telegraph Company and the General Electric Company. AT&T's company-wide training program carries special sessions on "The Importance of Listening to People" for all levels of management between line supervision and division and district managers. Various segments of AT&T are attacking the problem with listening instruction tailored to local needs. Some of AT&T's 21 operating phone companies crank listening instruction into their regular training courses on interviewing and counseling techniques. Other components of AT&T also stress listening in their training programs.

At General Electric the Communication Training Course for communication managers and specialists from operating components stresses the subject of listening comprehension on its agendum and devotes a full day to upward communication. Dr. Ralph Nichols of the University of Minnesota—an outstanding authority on listening comprehension—has lectured frequently before General Electric management groups at both the Communication Training Courses and the Advanced Course for Employee and Community Relations Managers. He has done much to awaken educators and businessmen to the need for better listening habits. His most recent book, *Are You Listening?* co-authored with Leonard Stevens and published by McGraw-Hill (1957), provides instructive reading for individuals who desire to improve their listening skills.

Measuring Listening Skill

In conducting some preliminary research on General Electric management's listening skill during the past two years, the author has used three methods: 1) measuring actual listening skill by administration of the Brown-Carlson Listening Comprehension Test, 2) administering follow-up tests at periodic intervals to measure retention and recall, and 3) observing variations of listening skill by conducting a series of group experiments called Chain Loss in Oral Communication.

The Brown-Carlson test, originally developed for use in schools and colleges, measures what the researchers concluded are the five most important facets of listening skill: immediate recall, following directions, recognizing transitions, recognizing word meanings, and lecture comprehension. Before-and-after tests permit measurement of the improvement, if any, by an individual exposed to listening instruction. Although a number of General Electric managers and individual contributors have now taken the test, the sample is still too small to draw any definite conclusions. Preliminary data leave no doubt, however, of the wide range of listening skills among a typical cross section of management personnel. For example, the test profile for one fairly

ing skill of management."

homogeneous group of engineers in a General Electric operating department revealed that the best scorers listened with almost twice the efficiency of the poorest scorers!

Still an imperfect tool, the Brown-Carlson Test has nevertheless made it possible to establish much-needed bench marks of actual listening skill and has made a valuable contribution to the general field of inquiry.

The author hopes that further testing will enable him to develop some generalized answers to such questions as . . .

- What is the actual *range* of listening skill among General Electric management?
- Is there a correlation between listening skill and occupation? (For example, are technically trained men better listeners generally? And, for a really intriguing question, are managers generally better listeners than their subordinates?)
- Is there a correlation between listening skill and age? (Sketchy research done elsewhere suggests that younger men are the best listeners.)
- Is there a correlation between listening skill and education? (For example, in spite of the general absence of formal listening training in our educational system, is there a built-in factor that tends to make highly educated men better listeners?)
- What is the extent of the loss in retention and recall of verbal communication among good listeners and poor listeners?
- Do test results suggest any direction for the development of training procedures that could be utilized usefully and economically by operating departments in an effort to improve listening skills, and thus upgrade on-the-job efficiency?

TO IMPROVE YOUR LISTENING SKILL . . .

. . . DON'T let the details of what you hear obscure the speaker's central theme.

. . . DON'T let your mind wander to other matters while listening to someone talk.

. . . DON'T let your built-in emotional filter distort the listening process.

. . . DON'T let the listening environment interfere with listening efficiency.

. . . DON'T let excessive note-taking diminish your listening efficiency.

. . . DON'T overlook opportunities to improve your listening through practice.

. . . DON'T reject what you hear because it appears to be trivial, completely familiar, or completely unfamiliar.

The Chain Loss in Oral Communication group experiment has been conducted by the author with about 30 groups of 25 to 50 persons, each consisting mostly of management people but also having some engineers and technicians. The results—often hilarious to the audience—were invariably depressing by what they revealed about deficiencies in listening skill and the shortcomings of the oral communication process in general.

Used extensively as a research tool by the late Dr. Irving Lee of Northwestern University, this demonstration is a variation of an old parlor game. Six participants are selected, and five are sent from the room. The remaining person is shown a slide depicting a scene on a subway car. The scene's central theme: Two persons, a well-dressed Negro and a white man in working clothes, stand in the middle of the car apparently engaged in some kind of an altercation. The white man holds an open razor in his hand. In addition, the viewer can observe a mass of details: a number of odd-appearing but passive characters seated in the car, a clock, some advertising display cards, and many other insignificant details.

The first participant studies the slide for two minutes to prepare himself for verbally reporting the scene to the No. 2 man when he returns to the room. He is then called in and asked to listen carefully to what the No. 1 man has to say, so that later he can pass the information on to the No. 3 man—a process repeated until the chain of reporting is completed.

Although the results of this experiment varied somewhat depending on the makeup of the different groups, certain distinct patterns emerged over and over again. Three of these patterns seem to have special significance to the study of listening deficiencies . . .

. . . *The central theme itself is often lost in the process.* The No. 1 man in this experiment, fresh from a *visual* study of the slide's contents, almost invariably gives the No. 2 man a fairly accurate report about the two central figures having some kind of an altercation in the subway car. Along with this, the No. 1 man invariably gives a mass of details: ". . . and there's a clock in the car showing the time as 20 minutes to seven; seated in the car is a blonde lady, wearing a big hat, with a baby on her lap; there are seven other people, including a Chinese man and a rabbi . . ." As the story is relayed from man to man, the quantity of information passed on is sharply reduced. But, more significantly, by the time the No. 6 man gets the report often no mention is made of the two central figures. In other words, what may be termed as "listening loss" obliterated the only significant item in the report.

. . . *Even when the central theme survives the chain, it usually is distorted during the process.* In the actual scene the Negro gentleman is well dressed, and the white man is dressed in working clothes and holding an open razor. But even when these two figures survive the reporting chain, the final report sometimes has the razor in the Negro's hand, or the white man becomes the well-dressed individual, or some similar distortion. This illustrates another weakness in listening habits—the tendency to filter what we hear through the complex matrix of our own individual emotions, experiences, and beliefs.

This emotional filter can bring strange results: Two seemingly insignificant details of the subway car scene—the blonde lady's big hat and the baby—were all that survived the chain when this demonstration was staged with a New York City audience, consisting primarily of unmarried fashion-conscious career women!

. . . *There is a distinct attrition in the amount of information passed along from person to person.* The more perceptive individuals playing the role of the No. 1 man have passed along to the No. 2 man as many as 50 details from the scene. Invariably there is quantitative attrition as the chain progresses. Rare has been the occasion when the No. 6 man received more than 10 details. These results are consistent with research done on listener retention of

"Wandering mind . . . possibly biggest single barrier to good listening."

verbal communication. Experiments conducted at three universities—Michigan State, Florida State, and Minnesota—indicate that for people with average listening skill immediate recall of oral communication is usually limited to about 50 percent—and the figure drops off to 25 percent after a two-month interval.

Although much remains to be learned about listening skill and its improvement, this preliminary research among General Electric management points to three conclusions, substantially supported by research results obtained by academicians working with students in high schools and colleges. . .

- Listening skill among General Electric management people differs substantially.
- People can improve their listening skill through proper guidance, practice, and the application of greater concentration and self-control.
- Certain common pitfalls to good listening are identifiable and should be avoided.

Pitfalls of Listening Comprehension

If you wish to make a serious effort to improve your listening comprehensions, try to avoid the known pitfalls. These cover many of the major listening faults identified both by research in General Electric and by experts elsewhere. . .

. . . *Don't let the details of what you hear obscure the speaker's central theme.* As the results of the Chain-Loss experiments emphasized, too many listeners are so intent on registering minor details or supporting facts that they fail to hear or remember the speaker's main idea or ideas.

. . . *Don't let your mind wander to other matters while listening to someone talk.* Herein lies possibly the biggest single barrier to good listening. Understanding the reason for it is, in itself, a step in the direction of listening improvement. Research indicates that the brain can think or receive verbal communication at a rate four times faster than the average speaking speed of 125 words per minute. How we utilize this "spare time" is probably the greatest single factor in determining whether we are good or poor listeners! Poor listeners fake concentration on the speaker with such devices as the glazed stare while thinking about what they are going to say next, how they can rebut something the speaker has said, or some totally different situation such as a problem at home or at the office.

The fable of the hare and the tortoise applies to this problem. If the relatively speedy mind gets diverted too often from the relatively slow flow of verbal communication, the mind will snap back to attention too late to catch up. It isn't easy to utilize the spare time properly, but the best listeners will put it to work by reviewing what the speaker has said, structuring his message, anticipating what he'll say next, and watching for meaningful nonverbal communications such as facial expressions and gestures.

. . . *Don't let your built-in emotional filter distort the listening process.* Poor listeners can't concentrate on what a person says if they dislike him personally or resent some aspect of his speech, appearance, or bearing. Then, too, if the subject being discussed arouses deep-set emotional reactions, the poor listener will often literally fail to hear anything the speaker says. This pitfall is especially obvious with a controversial subject when the speaker takes a position antithetical to the listener's. The poor listener will immediately adopt a defensive position mentally, and the complicated process of rejection that ensues usually includes an effective tuning-out of anything else the speaker says. The good listener, on the other hand, will withhold evaluation until after the speaker has finished.

Psychologist Carl R. Rogers of the University of Chicago suggests a way to overcome this problem whenever a discussion or argument becomes heated: An individual may express his position on the subject under discussion only after first stating the opposing position to the full satisfaction of the previous speaker! This procedure has intriguing possibilities. It not only would guarantee more effective listening but also would likely eliminate many arguments entirely—or at least reduce them to a well-defined area of disagreement which could then be discussed in a calm, unemotional atmosphere of mutual understanding.

. . . *Don't let the listening environment interfere with listening efficiency.* Few frustrations equal in impact those experienced by a subordinate when his boss grudgingly grants 10 minutes to hear his new proposal all the while allowing phone calls to be put through, people to stick their heads in the door, or similar interruptions. Another occupational hazard is the boss who says, "Go right ahead and talk, I'm listening," and then proves he isn't by shuffling papers on his desk, reading correspondence, or doing other irritating chores.

The built-in psychological barriers to good listening alone are enough to make effective listening a difficult task, and it doesn't make sense to compound the problem with environmental pitfalls that can be easily avoided. A good listener will shut the door, shut out noises, phone calls and other distractions, take a seat directly facing the speaker, sit in an erect and attentive position, establish direct eye contact with the speaker—in short, make his whole self a delicate, empathic, finely tuned, receiving mechanism.

. . . *Don't let excessive note-taking diminish your listening efficiency.* The right method and amount of note-taking is a difficult matter to determine. Research indicates that people can't listen with maximum efficiency while simultaneously writing. On the other hand, the Michigan State and Florida State research, abundantly confirmed by our experience with the Chain-Loss experiments, clearly proves the substantial loss in both immediate (50 percent) and post-exposure (75 percent) recall. Effective retention thus seems to demand the taking of notes.

The best answer at the moment appears to be that note-taking should be a flexible arrangement adapted intelligently to a given communication situation. For instance, the listener might limit himself to quickly jotted notes on the speaker's main themes and fill in supporting details after the speech or discussion. Or, if the speaker uses a slow-delivery style, the pauses in his speech may provide an opportunity for brief notes. But the important thing to avoid is any attempt *during* his delivery to capture in note-taking a comprehensive account of the speaker's message, complete with supporting facts and details.

. . . *Don't overlook opportunities to improve your listening through practice.* Even without formal training procedures, everyone has myriad opportunities to improve listening skill through

CONCLUDED ON PAGE 43

Electronic Clock Ushers in Wireless Timekeeping

Stray fields from electric and magnetic fields provided clue to development of latest innovation in timepieces.

POWER CORD no longer restricts clock location; its absence enhances room decor.

By READE WILLIAMS

Every so often a milestone in some facet of technology appears on the scene. The wireless electronic clock (photos), an outgrowth of persistent research and development, represents such a milestone. Less dramatic than earth satellites and ballistic missiles, it nevertheless promises to revolutionize timekeeping technology.

Today, accurate timekeeping is so common that we take it for granted. But bear in mind that the rise of our technological civilization closely parallels development and refinement of modern timekeeping methods. And a moment's reflection will indicate how the smooth functioning of society the world over relies on accurately synchronized clocks and watches.

Perspective

For accurate operation, every clock or watch depends on some kind of time standard.

A pendulum, a vibrating string, a quartz crystal—all are examples of time standards that have been used to control the motion of clock hands. Accuracy of a time standard depends on this: you must keep its rate of motion or vibration as much as possible independent of all external influences such as temperature, humidity, and barometric pressure.

Time standards are necessarily intricate and costly devices. And so, as early as 1841, someone proposed that two or more clocks be run from a single time standard. Information was to be transmitted between the time standard and remotely located "slave" clocks, their hands to exactly follow the standard. But as you can imagine, transmission of such information from the time standard, or master, to the slave clocks by purely mechanical means proved awkward. Thus the first *workable* systems of this type were interconnected electrically.

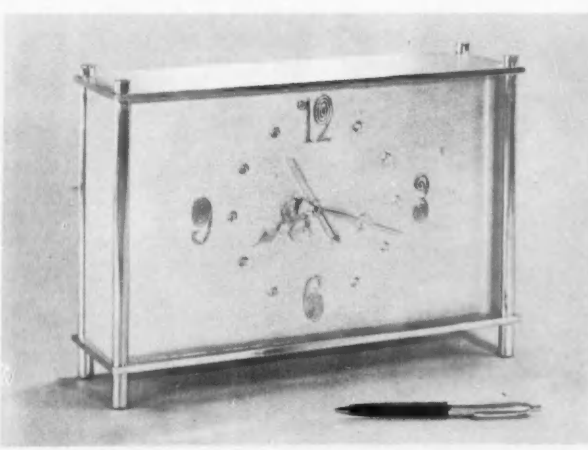
In a typical system, an electric switch mounted on the master clock's pendulum sent one electric impulse to the slave clock for each swing, causing the latter's hands to advance.

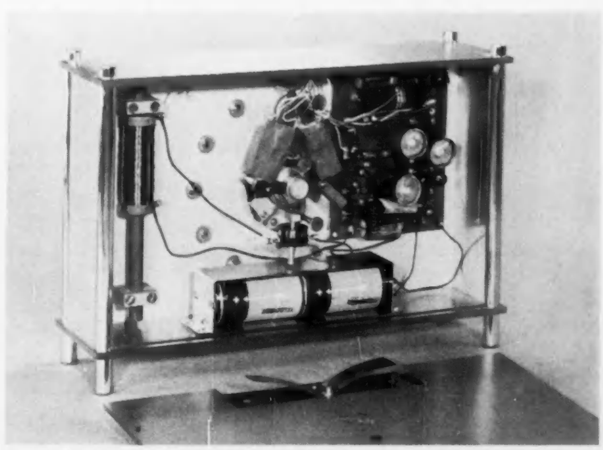
Henry Warren's Idea

Up to 1915, master-slave-clock systems were largely confined to office buildings, institutions, and schools because of their complexity. Mass application, as we know it today, was made possible by the late Henry E. Warren, who manufactured accurate battery-operated clocks in Ashland, Massachusetts, during the early part of this century.

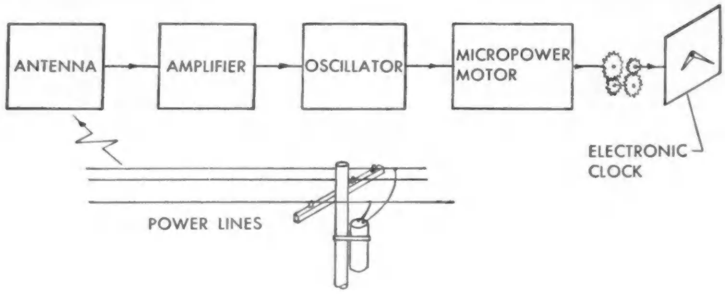
Warren proposed using electric power-distribution lines to interconnect innumerable slave clocks to a single, highly accurate master clock. Where would the master clock be located? In the power station, of course. Its function there would be to maintain the

Mr. Williams, an advance and development engineer in General Electric's Clock and Timer Department, Ashland, Mass., joined the Company in 1954. His work involves the application of electronics and semi-conductor devices to new products in the clock and timer field.





MERCURY CELLS power clock's miniature micropower motor for 18 months; ferrite antenna picks up the synchronizing signal.



HOW THE ELECTRONIC CLOCK WORKS

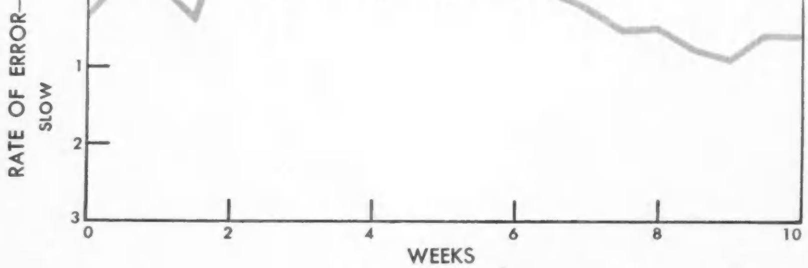
A coil of fine wire wound around a ferrite rod comprises the electronic clock's antenna. Small a-c voltages are induced in the coil when 60-cycle magnetic fields are attracted to the ferrite rod (illustration).

This induced voltage—in a typical situation, a few thousandths of a volt—is increased by the transistor amplifier to a few tenths of a volt. Two-stage RC-coupled, the transistor amplifier utilizes n-p-n transistors.

Next, the amplified 60-cycle voltage is injected into the transistor oscillator. In the absence of any output from the amplifier, the oscillator has a stable frequency of oscillation as close as possible to 60 cps. When the clock is placed in the 60-cycle field and a voltage appears at the amplifier's output, the oscillator ties in with the frequency of this voltage. Thus the oscillator becomes synchronized with the power line's frequency.

The electronic clock's micromotor represents a genuine breakthrough in motor technology. Basically it's a two-pole single-phase permanent-magnet synchronous motor with remarkably low losses. It can run at synchronous speed, driving a 1000-to-1 gear train on as little as 25 microwatts of input power. Low loss is the result of a specially developed, patented, magnetic and physical configuration.

Two mercury cells, with a rated capacity of 14,000 milliampere-hours, serve as power supply for the clock's motor. This amount of battery energy is sufficient to operate the clock for 18 months. Because these cells develop constant voltage throughout their life, design of a stable constant-supply frequency oscillator was greatly simplified.



TIMEKEEPING ACCURACY during power failure is kept to within one tenth of a cycle by signal from clock's oscillator. Resetting is not needed even if power fails for several hours.

average frequency of electric generators at exactly 60 cycles.

Accordingly, on October 23, 1916, the Boston Edison Company began to govern the frequency of its generators by a Warren Master Clock. Now virtually every power company in America has master-clock frequency control.

In this system, as you know, hands of the slave clock are driven—through gears—by a synchronous motor revolving exactly in step with the power company's line frequency. Once this system was introduced, anyone whose home was wired for electricity could buy an inexpensive electric clock, plug it in, and confidently expect it to keep time as accurately as the expensive precision-made master clock in the power station.

Push of Progress

The great popularity of the electric clock, with its convenience and dependability, came about by making use of already existing electric power-distribution networks.

But engineers have known for a long time that information can be transmitted without the need for direct connection to the source by wire or cable. Our great electronics industries are built upon this principle of wireless communication. Therefore, if a practical system for transmitting information to a slave clock without direct connection could be developed, the master-slave-clock system would achieve *universal* application.

Every clock and watch in the world could theoretically run in synchronism with one superaccurate master clock—just as every point on earth is now within range of some radio transmitter.

Stray Fields Give Clue

As is common in engineering, a clue to a successful wireless clock system had been under our noses for many years.

Every electronics engineer or technician is, at some time in his professional life, annoyed by the persistence with which 60-cycle hum is induced in circuits by magnetic and electric fields originating in surrounding power lines. These stray fields are frequency-controlled at the power station—a fact never appreciated by people trying to shield stray fields out of wiring and transformers!

Late in 1952, we realized that these stray fields—until then of only nuisance value—could be put to work. For several reasons, the idea looked attractive. The master clock and wireless signals were already present. We merely had to pick up the signals with a simple induction coil or length of wire, amplify the induced 60-cycle voltage, and apply it to an ordinary synchronous electric clock.

Now came the question, would it work? Our manager of engineering called the General Electric Research Laboratory in Schenectady and explained the idea. Though at first a bit skeptical of the results, the Laboratory agreed to throw together a "bread-board" model to try out the idea.

Their efforts looked more like a haywire hi-fi rig than a clock. Comprising a 25-pound battery pack and a 5-tube amplifier, it could supply 2.5 watts of 60-cycle power to a synchronous electric clock. Its antenna or field pickup was a paper clip protruding from the amplifier chassis.

But the most amazing of all—it worked! In fact, this "electronic clock" even kept time on the airplane as it was flown to New York City for a demonstration.

From Development to Product

Encouraged by this success, we began serious development of a practical wireless clock.

From the very beginning, three characteristics of the electronic clock were deemed necessary . . .

- The clock must be sensitive enough to synchronize itself with the 60-cycle fields found in ordinary houses and buildings under a variety of conditions.
- It must run for at least a year on one set of batteries as power supply for the amplifier.
- In the absence of synchronizing fields, the clock must still operate with a fair degree of accuracy.

To satisfy the first condition, we surveyed electric and magnetic fields in various locations within a large variety of houses. The next question: how much 60-cycle electric power could be obtained from field pickups or antennae situated in fields of these magnitudes?

It turned out that the typical magnetic field would deliver many times more power to an antenna of restricted size than would an electric field. Accordingly, we designed the clock to be highly sensitive to 60-cycle magnetic fields and relatively insensitive to electric fields.

Although 60-cycle magnetic fields normally present in your house are sufficient to synchronize the electronic clock, it's conceivable that under special conditions they may not be satisfactory. The most common circumstances encountered that result in low field strengths are 1) cancellation or interference between two field sources and 2) less commonly, field sources too weak or too remote from the clock.

Because of the many field sources in and around the average home, you can probably find certain spots where cancellation does occur. Should you place an electronic clock at one of these places, it might not synchronize properly. Weak fields, on the other hand, are sometimes found in houses remote from power-distribution lines. Here the magnetic field necessary to synchronize the clock arises solely from house wiring and service-entrance cable. And under these conditions the field inside the house will be small when no loads are switched on.

A problem, then, was to insure proper synchronization of the clock under all conditions. To solve it, a separate field source or transmitter is supplied to the purchaser (photo), boosting the natural 60-cycle field where necessary.

So that the clock would run at least a year on one set of batteries—and to keep that battery pack as small as possible—transistors were essential because of their low power requirements and small size. Also, we needed a synchronous motor of extremely low friction. Transistors existed, but the motor didn't. One of our engineers with vast experience in the field of electromechanical devices evolved an entirely new approach in the design of small permanent-magnet synchronous motors.

Despite transistors and a specially developed micropower motor, however, the clock's battery pack would have been impractically large if we used ordinary zinc-carbon cells. Instead, by utilizing a new-type cell, we reduced battery space to reasonable size. Composed of two mercury cells, the battery has a large energy-to-bulk ratio and takes no more space than two flashlight cells.

What do you do for synchronization when power failures occur, as they sometimes may in certain parts of the country? To meet this condition, we incorporated in the clock a transistor oscillator (Box) that operates with or without a synchronizing field. With no synchronization, the oscillator's frequency remains accurate within one-tenth of a cycle, on the basis of 60 cps. With a synchronizing frequency present, the oscillator is firmly tied to the power line's frequency.

SEPARATE TRANSMITTER insures proper synchronization of electronic clock where normal 60-cycle field is insufficient.

Accordingly, the electronic clock runs unsynchronized so that you shouldn't have to reset it after power failures of several hours or more (illustration, lower).

Outlook

You can consider the electronic clock in its present form the preliminary step of a revolutionary development in timekeeping technology. Instead of millions of clocks and watches beating time at their own individual rates, those of the future will synchronize with each other and with a super-accurate time standard.

Surely this is an ambitious goal. And universal fulfillment is a long way off. But the electronic clock definitely is a step in this direction, because it proves conclusively that you can build practical, wireless synchronous clocks.

Developments within General Electric already promise to make deep inroads into the clock's current price of $195, the manufacturer's suggested retail price plus applicable taxes. Miniaturization of the clock's electronic and mechanical components has progressed to the point where we can now make an electronic clock to suit almost any appearance requirements.

It's all a question of economics. The continuing goal of business enterprise is to bring more and better products to more people at a lower cost, while assuring share owners a reasonable profit on their investment. Accordingly, any decision to move ahead with production of a smaller, less expensive electronic clock for the mass market will be an economic and not a technical one. Ω

Today

With a new constant pressure system, high-altitude and high-temperature locations can handle even the most volatile gasolines.

Yesterday

The station attendant had to contend with few dispensing problems. Fewer cars and lower octane ratings made his job easier.

Enterprising Designers Turn Leaking Gas into

To ease the strain on old-style gasoline pumping installations, engineers developed cept. The pump and motor operate submerged, using the gasoline as both coolant

By L. E. STAAK and M. J. CARROCCIO

"Fill'er up" is an Americanism that has been with us ever since Henry Ford introduced the Model T. That our gas tanks are filled and we are on our way in minutes is taken for granted—much the same as the instantaneous light we get by merely flicking a switch.

Motorists on the great turnpikes of the nation, rolling into a high-volume gasoline filling station in eastern mountains or a western desert for quick refueling, hardly dream of the problems underlying today's "service with a smile." The American motorist's demands for increased performance have led auto manufacturers to increasingly higher engine compression ratios, and fuel octane ratings and volatilities have risen correspondingly.

The most common engine compression ratio—an index of the power race and the increasing difficulty of gasoline pumping—has shot from 7 to 1 to nearly 9 to 1 in only seven years. By 1966, estimates indicate average production auto engines will be running at 10.4 to 1.

The increase in engine compression ratios and corresponding increases in fuel octane ratings and volatilities are assuming dramatic proportions. Volatility has risen about one third since World War II, as measured by Reid Vapor Pressure (RVP). Sixty-octane gas ran the Model T; today's cars are using premium fuels around the 100-octane mark. Men in the field even talk of devising a new way to measure gasoline power—the old "octane rating" may be obsolescent.

These innovations have strained the capacities of old-style gasoline pumping installations and demanded new engineering concepts of supporting equipment.

As suppliers of pump motors to builders of gasoline dispensers, General Electric engineers worked with a gasoline pump manufacturer, the Tokheim Corporation, in tackling the matter of a radically new design well in advance of need. Back in 1951, they developed methods of operating an electric motor submerged in gasoline. One innovation was to let the gasoline "leak" into the motor and then use it as a lubricant for the spinning shaft. A few years earlier, this would have been considered a suicide machine. Today, such pumps are used by country filling stations and turnpike giants alike. Submersible pump installations have increased so rapidly around the nation that one conservative estimate indicates they will reach one third of all 1960 pedestal installations.

The development of this pump benefited both large and small stations.

But the large superservice stations, where numerous pedestals and long supply lines to remotely located tanks multiply fuel-pumping problems, realize the most benefits (Box, page 17).

The Suction System

Installations employing the suction-type system, which locates the motor and pump in the pedestal, are particularly susceptible to these fuel-pumping problems. Average prewar installations are barely able to handle today's fuels and sometimes may develop flow-stopping vapor lock. At 10 pounds RVP, gasoline cannot be pumped in areas where temperatures of 120 F are encountered. Pump efficiency is also adversely affected at reduced temperatures.

Other disadvantages somewhat less tangible are inherent in the system. Usually large and heavy, the pump has numerous moving parts subject to wear.

With General Electric since 1950, Mr. Staak was a development engineer in Advanced Engineering while working on the submersible pump project. Recipient of four patents, he is presently Manager, 30-Frame Engineering, General Purpose Component Motor Department, Fort Wayne. Mr. Carroccio—Market Specialist and Application Engineer, also with the General Purpose Component Motor Department—began his career with the Company in 1947. And his experience in the pump field dates back to 1953.

Lubricant

an entirely new con-
and lubricant.

Leaking gasoline from the seal required on the pump shaft may cause hazardous conditions. Noise, an annoyance people are becoming increasingly aware of, may be considerable. Furthermore, the station owner has invested in a pump and motor for each pedestal and does not realize their full value unless all pedestals are dispensing gas.

Vapor Lock

Vapor-lock conditions occur when a volatile liquid, such as gasoline, changes from a liquid to a gaseous state in sufficient proportions to make the system inoperative. The probability of this condition occurring is increased by the presence of one or a combination of the following: 1) higher-volatility fuels, 2) high ambient temperatures, and 3) high altitudes. Perhaps the area most seriously affected is the southwest where high ambient temperatures increase the possibility of vaporization in the suction line.

In northern areas the problem occurs during the warm summer-like days of early spring that sometimes catch dealers with large quantities of the more volatile winter-grade gasolines. Also plagued with vapor lock are mountainous regions, where high altitudes become the prime factor contributing to the situation.

The higher vacuum that high altitudes require to pump the product increases the likelihood that the gasoline will "pull apart." One cubic inch of gasoline will increase to approximately 300 cubic inches in its vapor state. The pump, incapable of handling this expanded volume, practically ceases to function.

Able to pump little or no gasoline, the station owner then suffers a loss of revenue. Occasionally, sprinkling or placing wet burlap sacks on the driveway over the buried piping can gain some relief. The evaporating water may provide sufficient cooling to the pipes, reducing the tendency of the gasoline to vaporize in the supply lines. In addition, ice can be packed around the pumps, but these practices are makeshift solutions at best.

Remote Suction and Turbine Pumps

Attempts to reduce long suction lines are found in the remote suction and turbine pumps.

The remote suction system simply removes the pump and motor from the pedestal and places it over the storage tank. Suction time is reduced, but the system still retains the old pump unit and requires the additional installation costs inherent in pit or "dog house" construction.

The turbine unit is also mounted at the storage tank. A motor above the tank drives impellers, located in the tank, through a long shaft. This arrangement eliminates all suction lines but introduces problems of shaft alignment and lubrication. And like the remote suction unit, it requires a pit or dog house for protection of the motor.

Because pits are subject to flooding and dog houses require valuable land space, neither of these approaches provided the final answer.

The Submerged Unit

Early systems involved considerable loss in the transmission of energy to the gasoline. The solution to the problem appeared to be in a submerged unit, which would place both motor and pump in the gasoline. Resulting in a high efficiency pumping unit, it would keep the supply lines under positive pressure at all times. High ambient temperatures or high altitude problems would not be encountered. Removing the pump and motor from the pedestal would eliminate the source of noise, making the climate at the point of sale more desirable. Smaller pedestal design would also be possible. The number of moving parts would be reduced, resulting in lower maintenance cost.

The First Attempt

A customer who took his cue from the aircraft industry did some work on this problem. As most existing stations had storage tanks with 3½-inch openings, a small ¾-hp 400-cycle motor driving a single-stage pump was devised. This system required a 60–400-cycle motor-generator converter set and control for its operation. The frequent stops and starts required in service-station operation resulted in difficulty with the drive motor and high-frequency noise of the set, which proved objectionable to the station operator. With its many components, it also proved expensive in both initial cost and maintenance.

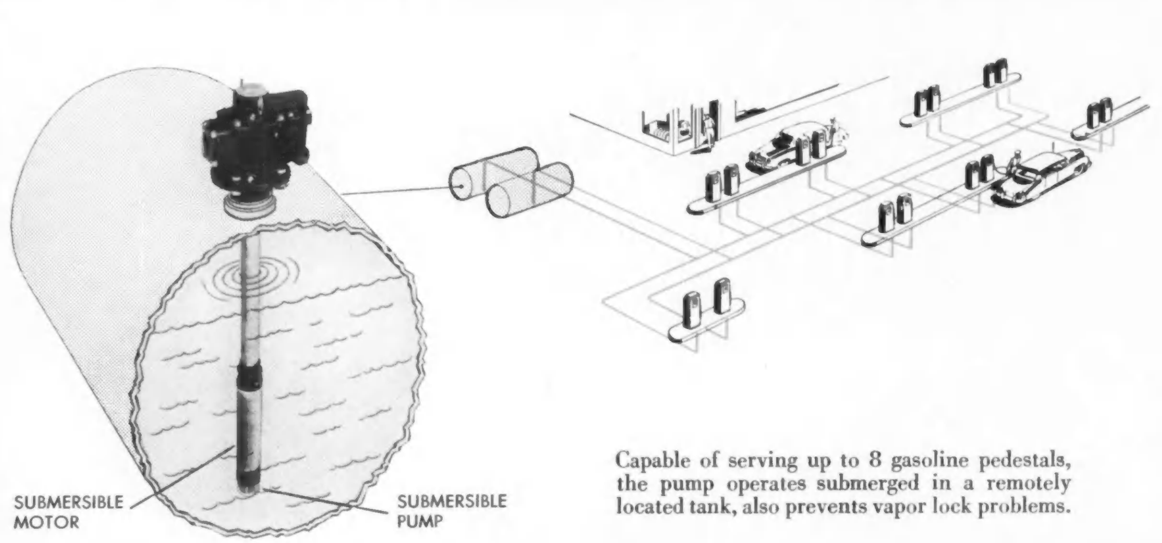
Striving to eliminate these disadvantages, we proposed to build a small-diameter 3600-rpm 60-cycle motor for the application. A three-stage pump, necessary to obtain desired pressures with the lower 60-cycle speed, was also designed. This eliminated two pieces of rotating equipment, but it also increased problems of motor design.

The original motor was a ¾-hp 230-volt 60-cycle single-phase capacitor-start capacitor-run motor. Its explosion-proof construction prevented any unexpected explosion in the motor from propagating to an explosive mixture on the outside of the motor. Flames from an explosion in the motor would be quenched by long close-fitting rabbets at all external joints and a very long metal path with close-running clearance to the shaft where the shaft extension came out of the motor. Determined by the volume enclosed by the end shields and motor shell, these flame paths are of set length. They must be free of any flaws or tool marks that would pass open flame to the outside of the motor.

The motor operated in a vertical position, with a three-stage centrifugal pump attached to the bottom. To provide an annular space around the motor for gasoline flow, a shell was mounted on lugs extending from the motor end shields and extending from the pump to the top of the motor. At the top of this shell, a casting was attached to the pump discharge pipe, which also served as a means to support the motor in the gasoline tank.

The flow of gasoline over the motor provided the necessary cooling. In the event the tank was pumped dry, with no fluid to cool the motor, a conventional bimetallic disc-type thermostat was

SUBMERSIBLE PUMP PERMITS SAFE, EFFICIENT STATION LAYOUT



Capable of serving up to 8 gasoline pedestals, the pump operates submerged in a remotely located tank, also prevents vapor lock problems.

placed in the motor to prevent motor damage due to overheating. This first design proved that a 60-cycle powered system was practical: The motor and pump unit could be made in a diameter small enough to go through the 3½-inch diameter openings found in most of the existing filling-station storage tanks and still meet all the customers' pump-delivery requirements.

Test Requirements

The unit was submitted to Underwriters' Laboratories (UL) for testing. Because of the hazardous conditions involved, extreme care was taken to insure that the motor would successfully contain an internal explosion. One end shield was drilled and tapped for a spark plug and pressure gage. Filled with a predetermined mixture of gasoline and air and designed for an explosion creating maximum pressure, the motor was then placed in a fireproof chamber. Additional explosive vapor was pumped into the chamber. Energizing the spark plug created an explosion that was successfully contained within the motor. To assure maximum pressures were generated, several trials were made. These pressures were then checked against known strength of component parts to insure adequate safety margins.

The motor also successfully passed a burn-out test. Here, the motor is connected to a power source and made to burn out. Case temperatures are measured to insure that the outside of the motor does not reach temperatures high enough to ignite surrounding vapors.

Difficulties arose, however. UL required that the motor and pump unit, with its 10 to 12 feet of discharge pipe and flanges, be shipped as an assembled unit. This insured that the completely assembled pump would not be tampered with in the field after inspection by the UL representative prior to leaving the manufacturer. The entire assembly, when packed for shipment, looked like nothing more than a crated piece of pipe; shippers and installation men handled the crate with little care in spite of the special handling labels. On new installations, the unit was occasionally used to empty tanks of ballast water. It was then permitted to stand unused until the station was completed and opened, causing corrosion that resulted in premature motor difficulties.

As shown by field tests, this rough handling caused seal leakage on some units; gasoline seeped into the motors and diluted the lubricating oil. Operation of the motors was still safe, however, because of the strong explosion-proof construction. But dilution of the lubricating oil caused serious bearing wear. Designed for operation in oil, the bearings could not carry the required loads on low-viscosity gasoline. The field tests also indicated that, even with the best of handling, to consistently seal oil in and gasoline out of the motor would be very difficult if not impossible.

New Design—The Answer

Results of the trials pointed to a redesign of the motor to overcome the difficulties encountered. Considering the almost insurmountable problems involved in keeping gasoline out of the motor, we decided that the motor should be redesigned to allow the gasoline to enter!

The motor was therefore opened to the gasoline, which served both as a lubricant and coolant. Both the sleeve and thrust bearings were redesigned for operation in gasoline. We discovered that by increasing both the diameter and length of the sleeve bearings and by changing the journal finish, the required radial loads could be carried on a hydrodynamic film of gasoline.

Although tests indicated that most gasolines did not affect the insulation on the magnet wire, the stator winding was encapsulated in an epoxy resin to protect it from the more severe gasoline additives and the small amount of water that might be encountered. (A pressure-vacuum process forces the epoxy material into all crevices or air spaces normally in slots and between windings.)

The motor shell is effectively and economically protected by cadmium plating. Zinc, another widely used protective material, oxidizes rapidly in gasolines, providing good sacrificial protection but for too short a period to be acceptable for the application.

Allowing the gasoline to enter the motor presented another problem in addition to bearing-load capacities and winding insulation. The disc-type thermostat used in the original motor was open and would therefore not be safe to operate submerged in gasoline. Still desirable, even though not required by UL, a thermostat would prevent unnecessary bearing wear by shutting off the motor within a reasonable length of time, should the storage tank be pumped dry. To overcome this problem, we used a hermetically sealed thermostat. Epoxy resin, similar to that used to encapsulate the windings, was added to protect the thermostat terminals and lead connections.

Operational Performance

Because a motor-pump unit is capable of supplying up to eight pedestals at one time (illustration), it is relatively easy to obtain operating information. The first redesigned motors were installed in test tanks in April 1954. To determine the effects of this foreign material on the motor, tests were deliberately conducted in "dirty" gasoline contaminated with water and tank scale. After approximately 300 hours of running under various cycling conditions, the motor was torn down for a close inspection of bearings and other components likely to be affected. No appreciable wear was evidenced, and the motors were immediately installed in a large station that could be kept under surveillance. These original motors have been operating for approximately 3½ years, each having pumped approximately 1,250,000 gallons of gasoline without any maintenance.

Concurrent with these tests, the redesigned motor was submitted to UL for approval. This was the first time UL had been called upon to examine a motor whose design permitted such free entrance of an inflammable fluid. Extensive tests were run and the design approved for UL label service.

The break-even point, when considering the over-all first cost of a submersible-versus-conventional pump-pedestal system, is at three dispensers per pump. Savings accrue rapidly as additional dispensers are added. However, the decision to use submersibles is usually not based on cost as much as the technical factors involved, such as length of supply lines and climate.

Under certain altitude, temperature, and gasoline volatility combinations, you simply can't move the gas with an old-style pump. You'd have to use a submersible. As stations become larger and storage tanks increase in size, supply lines are getting longer. This means added pipe friction and greater "lift," or "head," requirements; again, a submersible pump may be the only answer.

Additional benefit accrues at the time of station modernization. Estimates show that only approximately five percent of the dispensers ever wear out on their original installations, the remainder being removed to other locations with lower pumping requirements. At a first-class station, such a change could occur every three to five years. The remote pedestal can be replaced over its suction pump counterpart with a savings of 10 percent.

Other Applications

Benefits of the new motor-pump design have even spread to businessmen outside the gasoline-dispensing field. In one installation, acetone, alcohol, and toluene are pumped from a basement storage tank to spigots located on the various floors of a printing plant, eliminating the use of hazardous storage drums formerly located at the point of usage. An automobile manufacturer uses a submerged unit in a centrally located storage area to pump oil to the production line for filling automatic transmissions. Other installations employ this unit to pump such materials as paint thinners and cutting fluids. Again, we find great potentials in those applications where remote storage tanks, for reasons of safety or pumping of highly volatile products, make the characteristics and features of submersible pumping desirable.

While they make up less than one percent of the total, perhaps the most widely publicized submersible installations are those of the Ohio, Indiana, Florida, Massachusetts, and Oklahoma turnpikes. Here, the remoteness of the storage tanks and the large numbers of pedestals are ideal for the submersible.

Since the development of submersible gasoline pumps for service-station use, the automotive industry has successfully applied the principle to its field. Some 1958 model trucks will employ positive-pressure fuel systems. It is conceivable that these systems will appear in passenger cars within a few years.

Meanwhile, its application in service stations certainly has assured its future by providing the answer to many irritating problems plus fast, convenient dispensing of gas to customers. Ω

SUBMERSIBLE PUMP OFFERS MANY BENEFITS

The motoring public of America may never lay eyes on one of these pumps, whirring away in its underground cavern; but they will certainly benefit from its operation. The submersible pump points the way to reduced distribution costs — which help offset increases in gasoline, taxes, and rising production costs.

Also, certain high-altitude and high-temperature geographic locations in the United States are now able to offer uninterrupted gasoline-station service for the first time.

The gasoline-service-station operator — a typical American small businessman — will benefit from pioneering design in several ways . . .

- Lower service and routine maintenance costs
- More freedom in arranging the traffic pattern around the station, because the new pump requires no room above ground
- Elimination of the chances of lost business because of "vapor lock"
- Significant improvement in safety
- Improvement of outdated systems by the use of submerged unit as a "booster"
- Suitability of large-size versions of the new motor and pump for bulk plant use
- Faster service—One operator of a large truck stop found his business had increased 15 percent after installation of one of these units, because of the speed with which he was able to service his customers.

The activity prior to launching the acoustic homing torpedo begins the last and probably most critical phase of its development—tests in the sea.

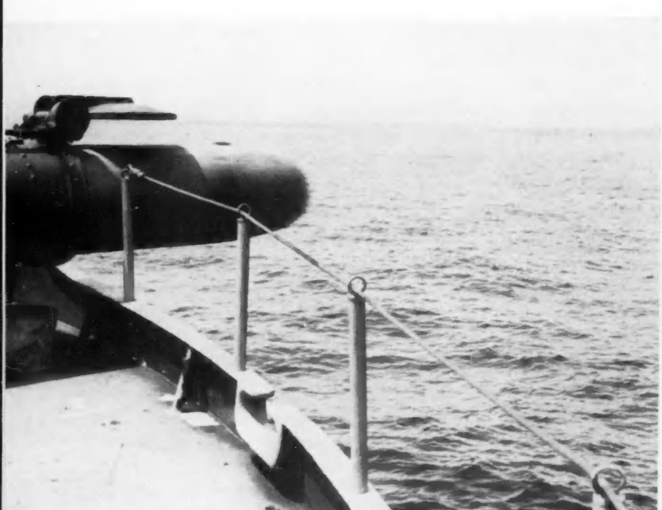
SEA TRIALS AT THE

PART 2

Undersea

***Review* STAFF REPORT**

This concluding installment reveals the testing sequence at sea, where the actual operating conditions necessary for final and accurate appraisal of the torpedo's performance will uncover any defects in its design, construction, or control.



"At Brown's command of 'execute,' I heard . . .

. . . a sharp hiss and saw a surge of fog. . . .

NAVAL ORDNANCE UNIT, Key West, Florida, begin at dawn. A slow ship, the YF requires a head start to arrive at the test area on time.

Defenders: Story of Acoustic Homing Torpedoes

(Story continues on page 20)

The torpedo emerged in a graceful arc with both props spinning...

... making a mighty splash in the ocean. That was all."

YF A converted yard freighter, it is equipped to launch torpedoes both from the deck and underwater. The deck launching tube, in the bow, is under wraps.

TARGET The submarine *Manta* has additional steel plate and a false hull

Early in 1948 the Bureau became concerned over the tardiness of the Mark 35 program. Units No. 4, 5, and 6 were performing in an encouraging manner; but the depth control, long known as a bad actor, was up to its usual pranks. The Bureau took action, calling for a showdown meeting late in June.

During this period G. A. Hoyt, who headed the project for the Laboratory, labored long hours over the depth-control problem. Early in June he hit on a solution, initiated a crash program to get a sample built, and within three weeks had it shipped to Key West for tests.

The June meeting, held in Washington, is still known among those engaged in torpedo engineering as the "vindication meeting." Hoyt, on his feet for more than two hours, gave a detailed appraisal of the project. During his summary, a telegram was delivered to him. He stopped, glanced at it, then read it aloud. It came from Key West: tests on the new depth control were successful!

This incident was the turning point of the meeting; the crisis had passed. (Today, Hoyt with a grin denies that the arrival of the telegram was anything more than a coincidence. Some of his associates think differently: "Jerry is not only one of the best engineers in General Electric, but he's also a showman," one said recently.)

At the meeting's conclusion, the Bureau asked for a proposal based on 100 units that would incorporate all improvements to date.

What had started out to be a complaint turned into an order.

A short time later John L. Sullivan, Secretary of the Navy, gave the program a high-level shove. In a letter to Charles E. Wilson, then president of General Electric, he wrote. . .

> The early completion of this task, which has been undertaken by your Company, is essential to the national security of the United States. I earnestly request that your Company give all practicable priority to the rapid solution of the design problems involving this torpedo, to the end that necessary production drawings may be made available at the earliest practicable moment.

The proposal was made to the Bureau in September 1948, on the basis of 100 units to be known as Torpedo Mark 35 Mod 1. They were to be built in Pittsfield, in a Navy facility known as the East Plant. Under A&OS supervision in Schenectady it produced gunfire control for the Navy.

At this point, the design allegedly had been "frozen for production." What actually happened is a twice-told tale that can be heard in any company when a project goes from development to manufacturing. The development engineer cries: "They didn't do right by our Nell;" the manufacturing engineer asks: "What do those guys know about production techniques?"

Both Laboratory and A&OS engineers were constantly on the alert for new and better ways of doing things and were aggressively funneling ideas into the supposedly static design. "How can you do without *this?*" was heard on all sides. Some ideas were good, others not properly evaluated. Understandably enough the customer had his own thoughts on the matter and cranked 55 ordalts (Ordnance Alterations) into the 100 units—not an unreasonable number considering the importance of the project.

(You'll find some torpedo design problems in the Box on page 23.)

To further aggravate the troubles, development work was carried out while production was under way.

Personnel was another factor: The Underwater Ordnance Section formed in A&OS to handle the torpedo project was shaking down with new people. Reorganization changes occurred in the Laboratory, and in the Bureau a new officer took charge of torpedo development every two years.

Regardless, the first unit of Mark 35 Mod 1 was shipped on schedule. Nearly all 100 were used for Bureau and Fleet evaluation purposes, with favorable results.

With the Mark 35 in production, the General Engineering Laboratory (formerly the General Engineering and Consulting Laboratory) completed the remaining portion of its original contract for 50. Research, development, and field-test of the new weapon had cost between $14- and $15-million.

In October 1952, A&OS took over operation of the Key West Test Station.

7—TORPEDO MARK 41

In May 1948 the General Engineering and Consulting Laboratory began development of an air-launched version of the Mark 35, known as Torpedo Mark 41. The Bureau contract was in two parts: develop the complete torpedo except the propulsion system and develop a turbine-drive propulsion system. At the same time another firm received a contract to develop a reciprocating engine for the same torpedo, in competition with the turbine-drive. Hoyt and his co-workers soon realized

for protection against the repeated impact of 1000 pounds of steel moving at 20 knots.

AVR Designated aviation-rescue, the ship is slightly smaller than the PT boats of World War II fame. They have been modified to retrieve spent torpedoes.

that a successful turbine-drive was a long way off and not much more could be expected from the reciprocating engine. On this basis, they designed a battery-motor package. Later events proved them right—neither the turbine nor reciprocating engine was satisfactory. The new electric drive was not only superior but also available, and it was used on production units built by General Electric.

8—TORPEDO MARK 43

"Early in 1950 it became apparent that there was need for another torpedo weapon to be used in antisubmarine warfare. The requirements for this weapon stem from the fact that one of the most serious problems in any war is the problem of overseas transport..."

This statement began a memorandum by Hoyt—a memorandum that disclosed a most eventful advance in this nation's efforts against the submarine menace.

Hoyt's supposition was that if aircraft, used to protect our convoys, "could locate the presence of enemy submarines, [they] should be so armed that [they] could engage action with the submarines immediately without calling for additional help from the convoy. This . . . called for a lightweight, small target-seeking torpedo that could be carried by aircraft and would be cheap enough to be used in considerable quantities."

Hoyt was fairly certain that the Bureau of Ordnance was thinking along these lines, too. In May 1950 he outlined the design of a torpedo that would meet this tactical requirement, wrote a set of tentative specifications, and obtained an appropriation of $2000 from the Ordnance Committee of A&OS to cover the cost of preparing a proposal for the Bureau of Ordnance. Hoyt's prescience paid off: One week before his proposal was presented to the Bureau, General Electric and four other concerns were asked to submit a proposal on just such a weapon, the Mark 43.

Even with such forward planning, Hoyt and others were dubious about receiving a contract. They gave two reasons: The Company already had the Mark 35 and Mark 41 projects; and the Bureau had often stated, "we don't want to put all our eggs in one basket." But the General Electric proposal was so concise and in tune with Bureau thinking that competitive development contracts were issued—one to the Brush Development Co., the other to General Electric.

(On the hunch that a development contract *might* be forthcoming, Hoyt obtained an additional $30,000 of Company money to progress the development and construction of a prototype torpedo. The unit was in the water and running *before* the signing of the development contract.)

In 1952 after that program was well under way, a task force of Laboratory engineers came to the conclusion that private industry, as a good national citizen, should do some further thinking and development in underwater weapons of considerably advanced design to complement efforts of the government. For this purpose the Company appropriated slightly less than $1 million. A series of torpedoes was developed to meet various tactical situations.

The Bureau of Ordnance—constantly on the lookout for fresh thinking and ideas on how to better protect our nation against aggression—appreciates such efforts.

Rear Admiral M. F. Schoeffel, Chief, Bureau of Ordnance, (1951-1954) in writing to a General Electric official said . . .

This is a very informal note just to let you know how favorably impressed we are here in the Bureau with the forward thinking that has recently been evidenced by the personnel of General Electric who are connected with torpedo work . . .

He added a longhand postscript . . .

"These ideas raised Cain with our pretty plans . . . but we like to get socked this way."

The magnitude of an article of this nature involves the handling of many necessary details that cause an inevitable lag between the time of writing and the actual publication. Some of the personnel mentioned in the following sections have since been assigned to other work. The nation's defense planning has altered other aspects of the situation. Even so, we believe you will find the following account of interest.—EDITORS

9—HOME OF TORPEDO TESTS

Tourists visiting Key West know it's a fullblown Navy town. Even if they shun the honky-tonks and remain close to their expensive motels and beaches, they can't help but see the silhouettes of destroyers, DE's, and the thin profiles of submarines strung out in a long, grim line, proceeding seaward every morning and returning every night.

Early risers, perhaps waiting at the Greyhound Station for the first bus to Miami, also receive hints about the nature of some of the Navy's activities. For rumbling through the streets at this early hour are strange gasoline-propelled vehicles carrying torpedoes, painted a gaudy yellow or green, slung on their haunches. If one of the curious onlookers is an ex-Navy man who has had experience with torpedoes, he'll immediately note that the warheads are different: these are smooth with no projections that would indicate a trigger mechanism; instead, the circular piece of shiny black material forming the nose is one indication of the torpedo's odd parentage.

These strange weapons abide at a closely guarded Navy pier—home of the Naval Ordnance Unit, under the command of Commander Joseph C. Wheeler. About 400 people are involved in this work, split almost evenly between Navy personnel under Wheeler, and contractor employees. Of the latter, General Electric has the largest number and occupies the most space.

Within General Electric, few people know that the Company has an installation at Key West; its official title is Field Test Station, and its official address is a Post Office box number.

The subsequent chapters give a first-hand account of a REVIEW *editor's observations while covering General Electric's torpedo project at the Key West Field Test Station.*

10—TIME AND TALENT

Some time ago I visited the Field Test Station and met Bob Haviland, in charge of operations. Well-equipped to handle the job, he has had a good number of years' experience with guided missile work for General Electric at White Sands. Haviland, in his 40's, has a quiet manner, a good tan, and thinning hair. He had no illusions about the task they were doing at Key West, although he considered it simpler than rocket work. "There's one fish we've already launched more than 200 times. You can't do that with a rocket," he told me by way of bringing out his point as we talked in his office.

Haviland said the job of the Test Station was twofold: to test and evaluate what had been designed; and to modify equipment—when necessary—to make it work. This entailed the talents of about 75 engineers, technicians, and office help and involved the launching of many torpedoes each year. As an example, Haviland told me that "during 1953 well over 1000 torpedoes were launched by all the contractors. Of that total, we put 45 percent into the water. That's a lot of fish."

Haviland took me on a tour of the General Electric facilities that were housed in a one-story building at the end of the pier. Engineers carried on their paper work at desks in the crowded outer office. Various projects were located in a series of rooms. Work benches and apparatus circled each room. The supervising engineer and his staff shared a small office along one side. Torpedoes in various stages of assembly occupied the center of many of the rooms. Some rooms were devoted to testing equipment—electronic devices, depth gages, and batteries—common to all types of torpedoes. The facilities also included a small machine shop, photographic laboratory, a teletypewriter, and a Coke machine.

After we returned to Haviland's office, he made arrangements for me to view the next day's operations aboard the YF-411—a converted yard freighter equipped to launch torpedoes both from the deck and underwater. "You can see firsthand how these things operate, and you'll get some idea of the conditions under which we work," he said.

11—ACTION AT THE AREA

At 6:45 the next morning I arrived at the dock outside the General Electric section of the pier where the YF was being loaded. Alongside the ship two "cherry pickers"—mobile cranes that are used to transport and handle torpedoes in the area—were swinging the Mark 35 units aboard the YF. I climbed to the boat deck and watched the loading operations. As the torpedoes were swung aboard, they were placed side by side on cradles mounted on tracks on the port side of the deck. Crewmen lashed them firmly in place. Even though a YF is a steady, lumbering vessel, three quarters of a ton of torpedo thrashing about the deck could create havoc. Near the bow on the starboard side was the draped form of a torpedo tube with its long snout projecting over the side of the ship.

At 7:30 loading was completed. We cast off and were soon following the buoys that marked the main channel to the Key West area. I talked for awhile with Chief Warrant Officer Joseph Brown who was in command of the YF. He said we were heading for a designated area in the Florida Straits about 15 miles out. The area south of Key West was divided into large grids, each with a letter and number symbol such as B6, with appropriate channels marked off for merchant traffic. Each day the various projects received an area designation in which to conduct their operations. The grids were many miles square, the instructions straightforward; but even so a stray ship or two will drift into an adjacent area.

"We'll rendezvous at 9 o'clock with the target boat, the two retrievers, and the search plane," Brown told me. "We're always first out because we're the slowest. We can do only 7 knots."

Torpedo development work in Key West is under the jurisdiction of the Naval Ordnance Unit. It also coordinates operations that involve submarine squadrons, air detachments, airship (blimp) detachments, helicopter squadrons, destroyer squadrons, and a few others from time to time. The YF and the retrievers are permanently attached to the NOU.

Scheduling is prompt. By 4 pm every afternoon, the activities for the following day are posted on a large chalkboard near the NOU operations office. Each contractor knows how many of his torpedoes are to be on each ship, and when they must be available. Departure and rendezvous times, operational area, and other facts are listed. Haviland, I recalled, had said that the operational efficiency of the General Electric programs was about 70 percent

ECHO-REPEATER TARGET

An echo-repeater target is merely two transducers swung to the proper depth over the side of the target boat. One transducer receives the ping (impulse) from the torpedo; the signal is then properly strengthened and sent out via the other transducer. The torpedo receives this echo and is fooled into believing it is attacking a target the size of a submarine. A torpedo making a successful attack on an echo-repeater target usually passes within a few feet of the target, at times smashes right into it. Even when targets are wrecked, it's still less a burden on the nation's taxpayers than using a submarine all the time for a target, and it's a comforting thought that the accuracy is so high.

In 1951 General Electric engineers developed a powerful "universal" target—it is used solely as a noise source, or as an echo-repeater. It also gives a complete recording of its operation, which in turn furnishes information about the torpedo's run.

UNIQUE PROBLEMS CHARACTERIZE TORPEDO DESIGN

Torpedoes were the original guided missiles, although today the latter term usually is applied to rockets with warheads.

They both have the same objectives; consequently it's interesting to compare their mutual problems and to see how the environment in which they operate governs their development.

The range of temperatures and pressures is much less severe for torpedoes than for rockets. For torpedoes the temperature may vary between −30 and 135 F, but the heat barrier is nonexistent. In torpedoes, pressures go up rather than down, as with rockets. Because submarines have been known to operate at depths greater than 500 feet, the torpedo must be able to function at even greater depths.

The speed ratio between rockets and torpedoes is in the neighborhood of 100 to 1. Forty-five knots (about 52 mph) is really fast for a torpedo; to an aircraft or guided-missile engineer it's slow-motion stuff.

Gathering data on torpedo performance is relatively simple: Fewer items need recording, and there's always the hedge that the unit can be recovered and run again the next day. With a rocket there's no second chance.

Combination of Systems

Torpedo work challenges engineers because so many different fields of endeavor are concentrated in such a small space. As one engineer told the *Review*: "The modern torpedo is a complex mechanism. In few other equipments will you find systems so completely integrated involving ultrasonics, mechanics, electronics, thermodynamics, hydrodynamics, hydraulics, and pneumatics. Thus the torpedo is a combination of systems and, in addition to this, is a part of a complex weapons system involving detection and identification of targets and fire control; so we have systems of systems. Then, too, the requirements for reliability are phenomenal. The submarine skipper, who has carried a handful of weapons hundreds of miles into enemy territory, may have his torpedoes in racks for weeks before using them; however, he expects every torpedo to function perfectly on its only warshot run."

The dynamics of the torpedo was one of the first things that had to be solved by General Electric pioneer. Prior to their technique of mounting recording equipment inside the torpedo, the precise story of just what it was doing during a run was, at best, hazy.

Commonly, a series of nets were strung along the path of the torpedo. By measuring the depth of the holes in the nets, it was possible to tell how deep and how straight the torpedo was traveling. But nets had a tendency to sag and to be warped by errant currents, so the results weren't too accurate.

Today, engineers know just what a torpedo does from the time it enters the water until it completes its run. Such fundamental knowledge will hasten the time when computers can be used to test new systems.

Torpedo Construction

A modern torpedo is usually built of cast aluminum, in four sections. The nose contains the transducer and electronic panels; the next section is the warhead. The battery section follows; and the afterbody—containing control and propulsion equipment—completes the unit. The sections are bolted together, and the weapon must be strong enough to withstand pressures at depths greater than 500 feet, plus the shock of launching from the deck of a fast-moving destroyer. Units dropped by fixed-wing aircraft take an even worse beating. If the shell is stressed, water will enter and upset the trim and buoyancy of the unit, and chances are that it will sink before it can be recovered. Slow leaks mean that the salt water has a chance to do some subtle damage before it can be detected.

Requirements of modern warfare dictate that the torpedo must operate satisfactorily at limits far more critical than in the past. For instance, it must of necessity be able to overtake any submerged submarine—even an atomic-powered submarine should offer no problem. At higher speeds, control systems must be able to react faster. Another problem that confronted engineers was the specifications for the depth control: It had to guide the torpedo within far narrower limits over a much greater range than ever before.

And the solution to all these and many more problems had to be crammed into a shell that would fit existing torpedo tubes and weigh less than before; be able to locate, attack, and kill its target; and do it at least 8 times out of 10.

Searching Blindfolded

Another problem the scientists and engineers had to solve: after the enemy submarine is detected, how does the torpedo "find" the target?

Here's what they were up against: Picture yourself trying to locate a black cat (small, fairly mobile, and with the unfeline aptitude of being able to move, and remain suspended, in mid-air) in a pitch-black room. The floor and ceiling are covered with small mirrors set at crazy angles, and the walls aren't particularly well defined. Your only equipment: a flashlight, with a battery on its last legs.

How would you find the cat? (There's a good possibility the cat may not even be there.)

One method would be to stand in what you thought was one corner of the room and swing the flashlight beam in a 90-degree arc, raising it slowly from the floor to the ceiling as you swing it.

Or you could walk slowly around the room in a good-sized circle and swing the flashlight beam up and down in a vertical plane and a 90-degree arc. (The reflections from the mirrors on the ceiling and the floor might confuse you, but if you had real sensitive eyesight, you could possibly determine the real cat from the reflection.)

Or you could stand in what you figured was the middle of the room and hold the flashlight down by your feet, pointing it straight out from you. Then you could slowly revolve, raising the flashlight gradually at the same time. But don't overlook the odds-on chance that your battery would fail before you ever got the flashlight chest-high, which wouldn't do you much good if the cat were above you.

Or you could try the same technique, starting with the flashlight at eye level and slowly working down. But the cat may have decided that the floor was a pretty cozy resting place, and down around your knees the battery would probably give out.

How else would you solve the problem?

(There's also the cheerful thought that you might try to attack yourself, which is equivalent to the torpedo turning on the craft that launched it. And there's the discouraging possibility that the cat may be equipped with a "flashlight," too.)

1 The test torpedo surfaces when spent and must be retrieved for the information recorded during its run.

2 Low buoyancy makes the torpedo (arrow) difficult to locate, but a vivid green dye helps by marking its position in the water.

—a high figure, especially when you factor in the weather, mechanical troubles with ships, aircraft, and torpedoes, and personnel error. It's a definite tribute to the planning skill of the Navy and the contractors. "We're physically close to the Navy," a General Electric official once remarked, "and you can bet we have the Navy's point of view."

The trip to the operational area was pleasant but slow. I had a chance to talk with Horace Hudlow, one of General Electric's sea technicians assigned to the YF for the day's program. He and the other two sea technicians employed by General Electric were retired Navy veterans. "There's close to 100 years of Navy experience in the three of us," Hudlow said. "This may not seem like much until you know that there's about the same amount of experience in all the rest of the General Electric employees at Key West." I learned that the Company hired these men for three important reasons: They knew Navy procedure, they could stand up under the grind, and they liked it.

Shortly after 9 o'clock, two retrievers—AVRs (aviation-rescue)—roared past. Slightly smaller than the PT boats of World War II fame, they were modified to retrieve spent torpedoes. The ship carrying the echo-repeater target was already in the area (Box, page 22).

Because torpedoes of another contractor were first on the schedule, the General Electric units weren't cleared for action until nearly 12:30. The tarpaulin had been removed from the torpedo tube, and the nose cover opened. The first torpedo was pushed in its cradle to a position in line with the tube, and deck hands laboriously shoved the unit into position.

I watched the operations from the boat deck. Dead ahead was the target ship; off to the left were the two AVRs. Behind me on the bridge I heard Brown speak over the command radio that linked all units: "This is Rutgers One-One. All units stand by for Test Baker." The checks came in except for Two-zero Eyesight—the Navy plane assigned to cover our operations. It was temporarily switched to another project, so we maintained our position for 15 minutes until it returned.

"This is Rutgers One-One. All units: Two-minute standby," Brown said behind me.

Hudlow turned a valve on the torpedo tube, and I heard the hiss as air under 1200 psi rushed into the tube.

"This is Rutgers One-One. All units: One-minute standby."

On the deck near the torpedo tube, Hudlow crouched over a small black box about the size of an office wastebasket. At the proper time he would press the firing button.

At 30 seconds Brown gave an "All units stand by" and kept his microphone open.

"Execute!"

I heard a sharp hiss and saw a surge of fog at the front of the tube. The torpedo emerged in a graceful arc with both props spinning, making a mighty splash in the ocean. That was all.

Torpedoes with electric drive leave no telltale trail of bubbles—an advantage during war but a definite disadvantage during test operations. To make the units easy to spot, fluorescent green dye was ejected during the run; and when the unit surfaced, the dye made an ever-widening blotch on the water. Green may seem an unlikely color, but this violent Kelly green was far more effective than, say, a bright yellow. I later saw some color movies taken from a blimp, and the wake contrasted brilliantly against the deeper blue-green of the ocean.

Trying to spot a surfaced torpedo from the relatively low vantage points of the YF or an AVR is a difficult task. It is generally known that the unit—during a successful run—will surface somewhere near the target ship. With all these intangibles at hand and with an expensive piece of equipment at stake, naturally a blimp or airplane must be present to help spot the units.

After one of the AVRs had retrieved the first Mark 35, the other shots of Test Baker were run off.

Test Charley involved a single torpedo of a different design, the Mark 43. Small and inexpensive, it lacks some of the niceties of its big brothers.

I went aft with Hudlow to the fantail of the YF where the 43 lay on its launching rack—a simple trough of lumber hinged at the front to a fixed stand slightly higher than the rail. Two canvas straps held the unit to the rack. Hudlow removed the straps and attached a wire lanyard to a pin in the afterbody. When the signal to fire came over the command system, two crewmen lifted the rear of the launching rack by handles, Hudlow pulled the lanyard, the prop started spinning, and the unit slid into the ocean. It was an inglorious way of launching such a handsome object, but it effectively simulated an air drop, besides eliminating the complexity and cost of a launching tube.

About 2 o'clock, with all missions completed, we plodded back to the base, arriving at 4 pm. I went ashore and passed the two AVRs that had docked earlier. They had been unloaded, and the torpedoes were already in the General Electric shops where the technicians were removing the oscillograph films.

3 Attaching the nose cage, a heavy steel towing device resembling a bottomless bird cage, is an exasperating, cold, wet job.

4 Not without a struggle, the unit is finally winched aboard, using a steel cable attached to the nose ring of the cage.

They would be developed during the night and analyzed the next morning. Not until the films are developed can anyone know if a unit made a successful attack on the echo-repeater target. Technicians aboard the target ship can determine in a general way if the run was successful, but it's not until the oscillographs are studied that the final answer is determined.

Hudlow was pessimistic about the results; he claimed the torpedoes were swinging wide. ". . . going way out into left field," as he expressed it.

12—A ROUGH, TOUGH JOB

A boldly painted "Rocket 88" on the side of AVR-88 gives you some idea of the uninhibited nature of the craft and of the men who run it. It's a rough, tough, raucous job. I made this discovery the following morning, soon after we left the pier at 7:28 o'clock and headed for the day's operations. The sky was overcast, but the ocean was smoother than the day before.

Over the incessant rattle of engine static on the command radio, Harry R. Smith, a navy enlisted man in charge of the AVR, told me about operations. They'll do 22 knots, but when they get in a moderate sea, you soon discover that a 63-foot boat, even when operating at cruising speed, is like riding in a washing machine. The engines, Smith said, had more than 700 hours on them so he cruised at 16 to 18 knots. "We work 'em every day," he said. "They get no rest."

At 8:25 we arrived at the area and met the YF. The target ship was just arriving; overhead a Navy torpedo plane of World War II vintage circled, acting as air search.

Fifteen minutes later the problem was set up, and we circled slowly the proper distance from the target ship. In the rear of the AVR on the ramp leading down to the water, the crewmen were removing the tarpaulins from the winches and inflating a two-man rubber boat. Two of the four crewmen went below and soon reappeared in swimming trunks and life jackets.

"All units, this is Rutgers One-One. Three-minute standby," came over the speaker. It was 8:52.

Smith throttled back on the engines and kept his bow toward the YF.

The two- and one-minute standby calls came over the speaker.

"This is Rutgers One-One . . . Standby . . . Execute . . . Execute . . . Over."

Smith killed the engines, so their noise wouldn't interfere with the torpedo's run on the target, and at the same moment we saw the unit leave the launching tube on the YF.

We waited, and after a time the announcement came over the speaker that the unit was at the end of its run.

Smith pressed the starter button. The two engines roared into life and the search began. He made a slow turn away from the target boat, and we all started looking for the splotch of green dye or the yellow nose of the torpedo bobbing on the surface. The search plane circled overhead.

Five minutes later we received word from the YF that "Eyesight has spotted the unit . . . ." He gave the location. Smith pushed the throttles forward and racked 88 into a tight turn. We heard a roar, and the search plane swept in low over our port quarter. I saw a small object drop from the plane, strike the water, and a cloud of heavy smoke billowed from the flare. Smith corrected his course, and soon after we spotted the torpedo's yellow nose in a pool of green. The AVR was brought around to within 50 feet of the unit; the two crewmen were ready at the water's edge at the rear of the ramp. One threw the rubber boat into the water, and both leaped in. Another crewman played out the line attached to the boat.

In the boat, one man used the oars while the other rode in the bow and held the nose cage—a heavy steel affair that looks something like a bird cage without a bottom.

The man paddled furiously, spurred by the chilly wind and the shouts of his shipmates. Smith kept the AVR idling with its stern pointed toward the unit.

The small boat came up to the torpedo, and then began a grotesque wrestling match between the crewman with the cage and the slippery, restless piece of mechanism that seemed to be perversely animated. Even with a fairly calm sea, it was still an ungainly task. A torpedo hasn't any nose rings or handles on its nose. You can't hold it in place, and you can't push down on it because it obligingly ducks under water.

Finally, half in the boat, half out, and thoroughly drenched, the crewman got the cage over the nose of the torpedo and clamped it in place.

No serious injuries have occurred during these operations, but fingers are sometimes badly bruised when they get caught between the cage and the lurching nose of the torpedo. Occasionally, the boat gets too close to the AVR and it spills. Another unpleasant factor near the AVR is the large volume of foul smoke from the engine exhaust.

With the unit safely caged, it was towed to the rear of the AVR where a steel cable was attached to the nose ring of the cage. Two men worked the hand-operated winch and dragged the unit, glistening and formidable, up the ramp of the AVR. They locked the winch and let the unit lay.

Smith radioed to the YF that the unit was secure, and soon we were in position near the target ship for the next event—a launching from the underwater tube of the YF.

The usual "standbys" came over the radio and we heard the execute, followed shortly by the terse, "All Units. This is Rutgers One-One. Unit did not run." Smith shrugged. There's no way of knowing what went wrong, explanations aren't given over the command radio.

"Rutgers One-One to Kingsbury Three-One. Request you come near our port bow. We will proceed to blow out the unit." On the way to the YF, Smith said crewmen aboard the YF would eject the defective unit from the tube with compressed air. It would pop to the surface a few feet from the bow. It did and soon after was retrieved and lay on the ramp of the AVR.

The other events on the day's schedule were run off, and late in the afternoon we headed home.

POLARIS . . .

Because its tactical application involves being fired from a moving, submerged submarine towards a target 1500 miles distant, the Navy's IRBM Polaris represents one of the most complex missile systems yet conceived. Now considerably ahead of scheduled development, the Polaris will serve as a hidden, highly mobile line of defense. General Electric holds the prime contract for the submarine's fire control system.

Launching the Polaris is not an instantaneous operation—it is a continuous affair. A geo-ballistic computer in the submarine works constantly, plotting the vessel's position. With extreme accuracy, it considers distances traveled, motions of the submarine, and other navigational information. This information is passed on to fire-control computers, where the data are converted from analog to digital form.

Just prior to launching, the fire control feeds its data to the digital computer in the Polaris guidance system, maintaining a constant position until the missile is launched. At this point the inertial guidance system in the weapon takes complete control.

The guidance system consists basically of a digital computer for "remembering" directions given it by the fire-control system and a stable reference platform against which the "remembered" information is checked. If the two components do not agree, corrections in the Polaris's flight must be made until they do. When this happens, the missile is on a correct trajectory to its target.

. . . RAT

The rocket-assisted torpedo (RAT) increases the distance at which a surface vessel can wage submarine warfare. Without leaving its assigned area—in a convoy, for instance—a destroyer launches the RAT from a standard 5-inch antiaircraft gun mount. Boosted by a rocket engine using a solid-propellant fuel, the missile flies to the target area, where the airframe is dropped by a preset timing device. Parachutes brake the torpedo's descent into the water to a speed that won't damage the sensitive homing mechanism. It then begins to home in on the selected target.

Utilizing the ship's sonar data, an interlocking fire-control system employs an analog computer to program the missile's flight.

When the RAT concept came into being, the Navy approached General Electric with the request that one of our then current torpedoes be modified to serve as an evaluation vehicle for the system tests. Our engineers studied the RAT application and calculated the design changes necessary to beef up the torpedo, then in production. It met the Navy's demands for the system. The Company is still working closely with the Navy on similar developments.

13—"STAND BY FOR HIT!"

Firing an acoustic homing torpedo against an echo-repeater target will give you a good idea of what the weapon will do in combat, but it's not quite the real thing. To make it as close as possible to the real thing—without using a warhead—a series of events known as hit shots are run off. They're conducted just as any other event except the target is a moving, submerged submarine.

Two days after my trip on the AVR, Haviland obtained the proper clearances for me to be aboard a target submarine during a series of hit shots.

One morning shortly after 8 o'clock, I reported to the deck officer of AG (SS)-299, the *Manta*, berthed at the U.S. Naval Station. We cast off at 8:30, and on our way to the rendezvous I talked for a while with Lt. Commander W. H. McCaughey (pronounced McCoy), captain of the *Manta*. In the Navy 17 years, he has been involved with underwater exploits except when he skippered PT boats during the war.

The *Manta*, he told me, was a standard fleet-type submarine, commissioned in November 1943, but saw no action. It was then decommissioned and later recommissioned in 1949 as a target submarine. I asked him what that meant. "It had some beefing-up here and there," he said. "First, all the armament was removed and also two of the four engines. That cut our surface speed to about 12 knots.

"The next thing was to put ⅜-inch steel plate over the decks plus a ⅜-inch false hull around the forward and after torpedo rooms' pressure hull. The midship areas already have extra protection because the water and fuel tanks are located there.

"Also, we have no snorkel, and our conning tower hasn't been prettied up," he pointed to another submarine following us through the channel, "like some of the remodeled ones. Even with all this protection," he continued, "we have some nasty dents. More than 1000 pounds of steel coming toward you at more than 20 knots can do a lot of damage."

The *Manta's* first trial as a target found the crew in a skeptical mood, but not because the men were leery of the protective plates. It was just that the torpedoes had missed other targets so many times and they doubted if they ever would be hit. The trial was run in 150 feet of water. The submarine went down to 60 feet and, as an extra safety measure, headed for shore while a submarine rescue ship stood by. The torpedo was fired; it missed.

When the *Manta* is unavailable, other submarines can be used. Then the torpedoes are set to pass over the submarine at a specified distance rather than to hit it.

McCaughey went below soon after, while I stayed on the bridge. It was another overcast day, and a fresh breeze occasionally blew spray over the conning tower. The *Manta* took the seas well, and at 9:50 we met the YF and the two AVRs. A search plane was already overhead.

By 10 o'clock we had maneuvered into position for the first event—8N1 Charley—that would take us across the

CONCLUDED ON PAGE 43

In the evolution of the spray iron many concepts were tried. One had the spray coming out of the bottom (above). But home economists finally chose a version with the spray coming from the top. The story behind the development of this product shows . . .

How Creative Engineering Cut Ironing Drudgery

By THEODORE R. FLOWERS

The evolution of the hand iron to the stage where it solves practically every ironing problem illustrates the creative engineering skill found in the appliance field.

The steam iron, introduced before World War II, provided a definite improvement over the conventional hand iron. But it still wasn't the cure-all for every household ironing problem.

Prior to introduction of the steam iron, certain aspects of the ironing ritual were of a primitive nature. For example, predampening was necessary. This consisted of sprinkling water on the pile of laundry, rolling it, and wrapping it inside a towel for two or more hours. If wrinkles were inadvertently ironed into the fabric, the whole process had to be repeated. And if interrupted while ironing, your wife had two choices: leave the laundry in the towel and hope it wouldn't mildew; or dry it out and later go through the entire dampening process again.

Housewives were pleased that with the introduction of the steam iron they could iron many fabrics without special treatment. But an iron that would answer all the housewife's needs was yet to come. For heavy linens and starched cottons still had to be dampened before being ironed.

Recognizing a Need

Marketing research people were tuned to the housewife's comments and her yearning for a "universal" iron. One of the primary reasons for the existence of a business is to serve people through products and services that contribute to better living for all. And to satisfy this need, Advance Engineering began work on the development of an iron that would iron *all* the laundry.

Their first question: "If the present amount of steam allows some fabrics to be ironed, why not increase the steam rate and do all the fabrics?"

At first, engineers tried a system that pumped water onto the soleplate at a constant, controllable rate. The heat of the soleplate turned the water into steam, producing the desired amount of steam. But the complexity and cost of a pump-motor system made this idea impractical.

The next approach involved taking a tank with a heater inside and "building up" an iron. By varying the power input into the tank, the expulsion rate of the steam from the iron could be regulated. It took some juggling to measure steam rate and correlate it with the power input, but this adjustable-steam-rate iron gave our home economists a chance to iron with any amount of steam they wanted. They tried it with these results: No improvement in ironing and a very wet ironing board.

More steam wasn't the answer to ironing all fabrics. But why? What properties in steam prevented ironing of clothes—or what was in the clothes that prevented the steaming process from working?

Analyzing the Problem

You've heard the phrase, "limp as a dishrag." But how wet is a limp dishrag? To find out, a controlled amount of moisture was put in various fabrics and attempts were made to iron them. After many tests, we found the minimum amount of water required to iron each fabric.

The next step: find out how much steam can be condensed on the fabric—fairly simple because steam will only condense if the fabric can absorb its heat. If the fabric is too hot, say above

Joining General Electric on the Test Course in 1951, Mr. Flowers is presently Project Engineer, Advanced Engineering, Portable Appliance Dept., Bridgeport, Conn. His responsibilities involve the creation of new products and the development of new concepts into products. Among his achievements—besides the spray iron, for which he received a management award—are a clock wiring system, a coffeemaker thermostat, and the toaster oven.

HOW THE SPRAY IRON OPERATES . . .

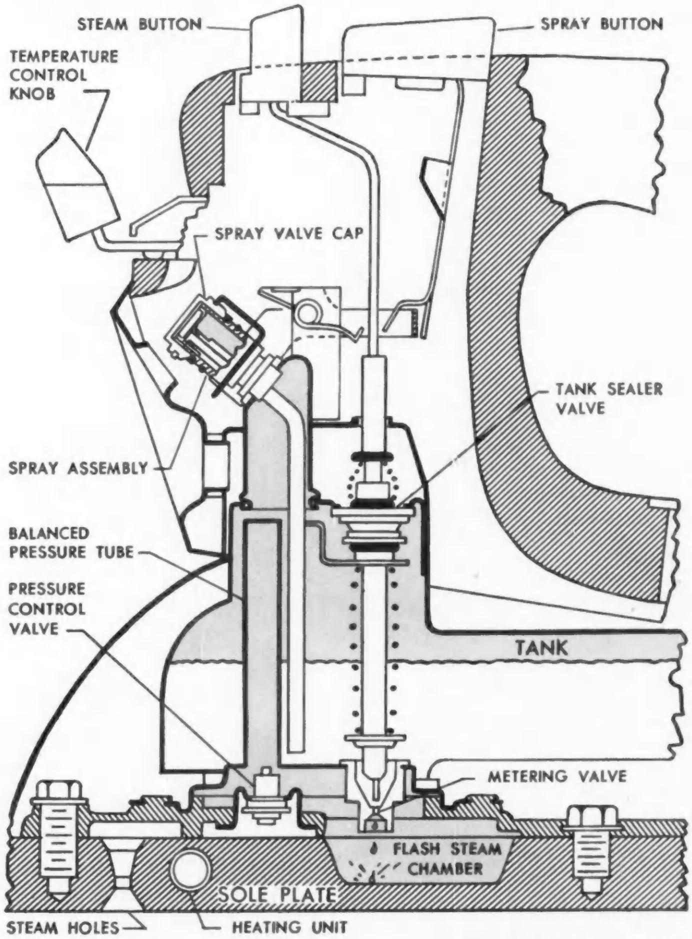
. . . lift the spring-loaded steam button by releasing it from its catch. This upward motion closes the tank sealer valve, which seals the tank and allows steam pressure to be built up. As the tank sealer valve closes, the metering valve simultaneously opens. Dripping through the metering hole—drop by drop at a governed rate—into the flash steam chamber the water flashes into steam.

The steam builds up sufficient pressure to overcome the pressure control valve. When this valve opens, steam flows through it and out through the soleplate steam holes.

Steam also travels up the balanced pressure tube into the top of the tank. By this method, the balanced pressure tube keeps the vapor pressure above the water at boiler pressure so that the drip into the flash steam chamber continues at a constant rate.

Steam also rises up into the spray assembly. When you push the spray button, the spray valve cap is lifted from the atomizing sprayer. This allows steam to flow from the tank out through the spray nozzle while water is being drawn up from the tank to be atomized. The careful arrangement of the steam and water nozzles gives an atomized spray of very fine, warm water particles.

Release of the spray button stops the spray. When you depress the steam button to turn off the steam, the metering valve closes. Pressure in the tank holds the tank sealer valve closed. This pressure bleeds out slowly through the soleplate until the pressure goes back to atmospheric. At this point water can be added through the fill opening.



STEAM AREA IS SHOWN IN COLOR

212 F, steam certainly won't condense on it; if the fabric is cold, however, condensation will take place. Somewhere in the middle, you will find that very little more steam is condensed because the fabric is too hot. In other words, the heat in the steam transfers to the fabric as the steam condenses. When the fabric becomes too hot the steam stops condensing; that's all the water you can get into the fabric from the steam.

A comparison of how much water can be condensed with how much water is needed for ironing introduced some interesting facts. Whether a fabric can be steam ironed depends on two factors: the fabric's specific heat and the amount of water required for its ironing. Only a fabric that remains cool enough to permit the formation of water can be steam ironed. Fabrics that get hot too quickly to allow sufficient condensation to take place can't be satisfactorily steam ironed. Two additional hurdles: both the hot soleplate of the iron and the process of condensation itself contribute to the higher temperatures that prevent condensation.

The amount of water that actually did condense would depend upon the temperature of the fabric before the steam was present and also on a quantity known as the "dryness" of the steam. Pure steam would be water vapor; however, this water vapor might carry small drops of liquid water with it. This is known as the "quality" of the steam. One-hundred-percent quality steam is all steam; 50-percent quality steam means half steam and half plain water. The 50-percent steam and water would deposit more water before the fabric temperature was raised too high for condensation, because steam has more heat than water. Calculations showed that a 5-percent quality steam would be necessary to iron all fabrics. Look at this another way: 5 percent-by-weight actual steam; 95 percent, fine-water mist. To make steam that is mostly water would be a difficult job.

Even if you did get this low quality steam, you would find your calculations in error. When this steam hits the fabric, it raises the fabric temperature by the condensation process. According to the calculations, the maximum water is obtained when the fabric is up to temperature; the fabric should then allow the steam to pass through without further condensation. There will be no more condensation, but this stream of 95-percent water will be filtered by the cloth. All you have really done is spray the cloth with a fine mist. Instead of the almost impossible feat of 5-percent quality steam, why not make a practical atomizer sprayer?

It was obvious that steam could not get the fabrics wet enough because of the physical limitations. The steam iron actually steamed enough moisture to allow ironing, but only one fourth of it could be condensed on linen. Perhaps some other liquid in the steam iron would condense on the fabric at a high enough rate to permit the ironing of the fabrics. Before developing this proposal further, more knowledge of the ironing process was necessary.

Evaluating the Ironing Process

Ironing itself is a fairly simple three-step process: 1) get the fabrics limp, 2) smooth them, and 3) dry the fabrics in the smooth condition.

Water or some other liquid softens the inherent stiffness of fabrics. When fabrics are limp, you can stretch, push, or pull them to give them a new shape and let them dry. They will then be stiff in their new position—ironing is unnecessary. Of course, you may not like to do it this way, but it can be done. Suppose you take a handkerchief and put it in water—it would then be very limp. You can then place the wet handkerchief on a piece of glass, smooth it, and let it dry overnight. In the morning you would have a smooth handkerchief—nicely "ironed." But you would have to wait overnight for the ironing to dry, and you would also need a large amount of space for sheets and other articles.

In a matter of moments, the iron simultaneously stretches the still-limp fabric and dries it out by virtue of its heat; thus the fabric retains its new shape. The steam merely makes the fabric limp, enabling it to be smoothed out and then dried in this condition.

The Best Liquid

Almost any liquid will make the fabric limp. Although not recommended, alcohol, paint, naphtha, or even oil would make the fabric suitable for ironing. The liquid used for making the fabric limp must be removed in the last step to have the fabric dry and smooth. And when removed, the liquid should leave no stain or residue. That eliminates paints, oils, and many other possibilities.

Naphtha may not stain, but it is flammable, so naphtha and alcohol also are eliminated. If you look at the desired properties of water—cheap, nonstaining, noncorroding, no residue, will not burn or explode, nontoxic, and readily available—this relaxing liquid becomes the only satisfactory liquid.

Designing the Spray

With the ironing process analyzed and water decided upon as the liquid, the next step was to build an iron with a sprayer attached. A boiler iron was arranged to generate a small amount of steam pressure, and then an atomizer was developed. This sprayed and dampened the clothes to just the right amount.

One operating sample had the spray coming out of the bottom of the iron. You had to pick the iron up to spray the clothes. Another had the spray coming out the top. Other designs had water bottles on the side; some used the boiler water.

After a series was developed, the home economist decided which would be the most practical. Her decision: the spray coming from the top and spraying in front of the iron would be easiest to use. Picking up the iron for any length of time was tedious and tiring.

Developing a production iron from an experimental version is a challenging assignment. In Advance Engineering we might wait half an hour for the iron to start steaming, but this would never do in the home. To obtain steam immediately, a flash-type boiler was needed, which allows one drop of water at a time to hit a hot soleplate and flash into steam. But it possesses a serious drawback: the steam pressure tends to prevent or impede water flow into the steam boiler. However, product engineers for steam irons at the Ontario, Calif., Plant, had developed a system that allows the water to continue to drip even though the steam built up a small amount of pressure. This was it. An iron was obtained and a steam-operated sprayer built into it.

A few holes had to be filled up and a few parts added here and there, but it sprayed—a nice warm mist. One hitch developed: a small amount of pressure built up in the water tank; and when the steam was turned off, the tank immediately was vented to the air. The pressure built up in the steam came out the water-fill hole with a little pop; it was startling more than anything else. Appropriate valving cured this annoyance.

An Improved Product

At this stage of the development, we took stock of the situation. We had an iron that could be used as a steam iron for those fabrics that needed steam; it could be turned on and off any time; and it could also spray, which would allow the housewife to iron anything. In fact, she could do something that was impossible before—iron out a dry wrinkle.

With the old system, if—after she had dampened the laundry and started ironing—she accidentally ironed in a wrinkle, she was out of luck. But not with the new spray iron. She just sprays the wrinkle and irons it out.

It was now time to turn the new iron over to production engineers and at the same time give Industrial Design a chance to work it over. The development sample had pipes sticking out the side. Appearancewise, this would never do; it would never do for manufacturing, either.

The factory-design group had a big job. If one of the valves leaked on the development iron, it was all right. It was only a test sample. But for the production design, new valves had to be made that would seal the water and the steam and would functionally allow the tank and the system to work as a coordinated unit.

You'll find a description of the iron's operation in the Box.

A color-key system helps the housewife in understanding the iron's operation. The red steam button has a corresponding red marking on the dial where it would be used for steaming. The turquoise spray button has a turquoise color on the temperature control indicating where she can spray.

Since its introduction, the simplicity and universal usefulness of the spray iron has made it one of the most popular of all irons. Ω

CREDITS

11	William Benedict
15	National Petroleum News
30 (left)	Black Star: Nolan Patterson
30, 31 (center) 32 (top left)	Burns Photography, Inc.
33 (lower right)	Black Star: Werner Wolff
40	U.S. Navy

SORRY . . .

. . . for the error published on page 17 of our March issue. The name William E. Miller should read Charles E. Miller.

DATA CAPSULE inside a mis

Atomic energy in defense work includes study of radioactivity in the atmosphere. Atop a General Electric operated AEC installation at Hanford Atomic Products Operation, Richland, Wash., smoke generator and blimp serve as a monitor team.

NEW DIMENSIONS OF AMERICA'S ECONOMY—3

Increased Emphasis on Research and Developm

***Review* STAFF REPORT**

On the door of an experiment room in one of the nation's leading industrial research laboratories a sign proclaims: "Obsolescence is our Most Important Product." Because an increasing proportion of our national defense budget today goes for research and development, this attitude becomes more important in defense planning.

To a greater extent than recognized by even some research and development men, the vital technological burdens of defense today are shifting increasingly from the assembly line to the laboratory, the pilot plant, and the experimental working model. The measure of our recognition of this fact, as national military planners, may well be the measure of our ability to cope with threats to the security of the free world. This trend toward greater emphasis on obsolescence and on the continuing research and development that make obsolescence practically a guarantee is an index of the times. Never before in our national history have we faced such complex decisions in the area of military procurement.

When muskets and cannon balls were making arrows and spears obsolescent, we could stockpile the tools of our defense. Strategic planners of those days could have used neat linear graphs to show that the more kegs of gunpowder stored in the armory, the more secure the citizens became.

When more sophisticated products came along, the great American production machine steadily met the challenges. It turned out the necessary inventory of Springfields for World War I, radar sets for World War II, and jet fighters for Korea. While the *product* changed, the *philosophy* did not. Stock phrases were "war preparedness," "lead time to prepare for a war," "tooling up for the all-out effort." As late as the war in Korea, American production lines poured equipment into the traditional pattern of quantity warfare.

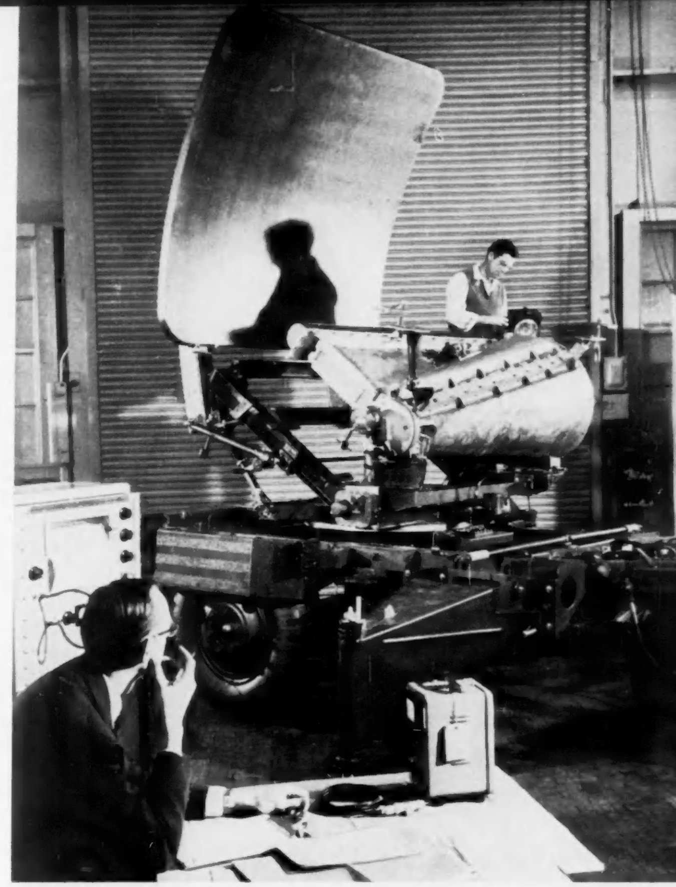
Today, time has run out. There isn't any lead time. Estimates of early warning of enemy attack are given in minutes. All-out war can be launched simultaneously against the capital cities of the globe by pressure on a few push-buttons. Defense capability, then, appears to center on just what is connected to those all-important push-buttons.

ICBMs? Very well, for today—but tomorrow we may substitute even more refined space vehicles. Oxygen fuel? All right for the launching set for Saturday—but the boron compounds, or some still unnamed substance, may be in the fuel tank on the next trip. Research and development activity thus becomes the heart of defense.

With research and development thus assuming new and more massive proportions in our defense effort, the important consideration is how well we as a nation are promoting these vital activities. How much true recognition is being given to this basic change in our national approach to defense?

In the national defense effort today, research and development work is inadequately recognized and generally

sile's nose cone will bring design data back to earth.



ELECTRONIC LOCATOR will spot an enemy mortar before first shell lands.

ent for Defense

yields only very low returns. Enterprises participating in defense developmental projects frequently find high proportions of their skilled manpower and material resources assigned to work that brings only a small, administered profit.

The low returns realized on defense projects reflect in part a false but widely accepted belief that defense is always a low-risk business, which justifies only nominal profits. This may have been true in that past era when military procurement was concerned primarily with mass production of standard stockpiled items. But today, when development and design are bulking ever larger in the defense effort, the risk picture is markedly changed. Companies must make sizable investments in laboratory and production facilities and commitments in design possibilities that may, because of rapidly changing defense needs, never materialize into more profitable quantity production orders.

A new jet-engine design, for example, may require three to four years' development work by several hundred engineers and technicians, backed by a multimillion dollar investment in facilities. This work is done at very low rates of compensation and with no assurance that equitable returns will ever be realized.

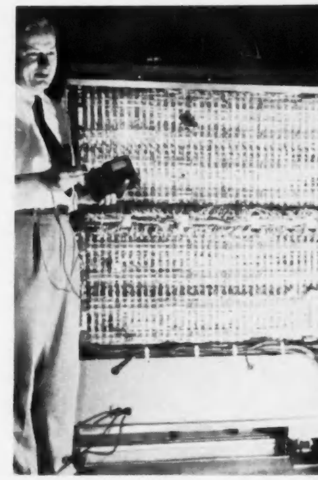
Thus a company may find that it has invested large amounts of talent and capital in an undertaking that results in completely inadequate compensation.

Industry repeatedly has pointed out this essential fact—that defense work entails a large number of special or extraordinary risks that are given inadequate recognition in military procurement. While the government has taken some action to mitigate these risks, the defense effort still falls far short of encouraging the kind of bold risk-taking that is an everyday occurrence in the commercial market.

These risks must be seen not as unwelcome intrusions but rather as welcome challenges to the nation's enterprises—if accompanied, as in civilian

LETHAL F104A, now developed to operational stage, refuels for night flight.

REPRESENTATIVES of prime contractor, subcontractor organizations, and the military pool experience to analyze and improve values in defense products, saving taxpayer dollars.



ELECTRONIC "MEMORY" is de
Atomic Power Laboratory, Schenec

NEW DIMENSIONS OF AMERICA'S ECON

Adequate Incentives Sti

WORLD'S LARGEST known radar system will evolve from such units as this one.

business, by adequate profits. Business is accustomed to risks—indeed, thrives upon them. For the good of the nation, this willingness to assume risk needs to be *encouraged* rather than hindered, as at present by the low returns that are possible in defense work.

Let's examine a few of the kinds of risks a typical defense contractor takes.

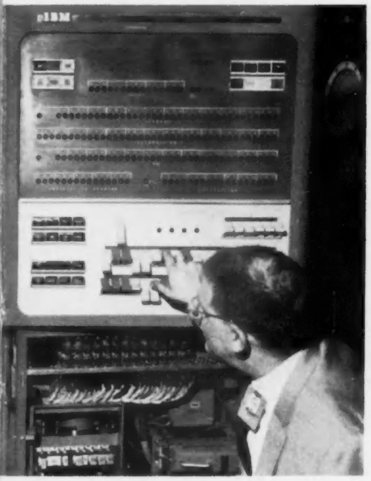
A common risk in defense work is that involved in production facilities. Orderly advance planning of facilities for new products or expanded production of existing ones is vital to business balance, to preserve profits and markets. Such advance planning is virtually impossible in government contracting. "Hurry up" decisions often saddle a company with future white elephants. After renegotiation, typical elephants become even whiter. One company, asked by government to increase output of product *X*, was obliged to purchase additional space and equipment. After it attained the specified production level, the entire demand was slashed 30 percent without warning. This left useless capacity, caused over-all rescheduling of the organization, and raised costs.

Personnel for research and development represents another important risk area. Government work is so exacting that the best men available must be relieved of their commercial work and replaced by less experienced persons. This brings lower, sometimes fatal, commercial profit levels. It takes effort to weld the personnel into an effective team for government work. If the project is cancelled, you can't put the team on the market and realize its value, as with a surplus locomotive. Nor can you import a new one when the next "get busy" signal comes from government. Even if personnel *could* be shifted at this rate, morale problems would outweigh benefits.

One company estimates its civilian work was set back two full years when it diverted all technical personnel from civilian research and engineering projects during the Korean outbreak. Foreign competition moved profitably into the vacuum.

Renegotiation is probably the greatest risk of all. First introduced in war time, when military dollars dominated the gross national product, this practice is quite unnecessary in today's economy. A defense contractor who has carefully estimated his costs, secured the contract competitively, and met his commitments is still not assured of adequate profit for his performance. He is subjected to the renegotiation procedure years after the fact. The practice destroys incentives, discourages investment, encourages careless procurement, and penalizes all contractors.

Uncertain subcontractor relationships



voted to nuclear development at Knolls
tady, operated by General Electric for AEC.

HEAVY RESEARCH and development investment is more significant difference between jet aircraft and guided missile (left) than shift from human to electronic pilot.

mulate Research and Development for Defense

are another hazard. Prime defense contractors are obliged by government policy to bear responsibility for delays or defaults beyond their control, to guarantee subcontractor performance beyond sound financial practices, and to accept less than adequate profits when renegotiation time arrives. Experienced prime contractors generally agree with this plain statement by one of their number: "The Government's insistence on the right to interfere in the affairs of our suppliers, often at a supplier's shops, has caused repeated incidents of delay and higher costs to us."

A contractor's loss of proprietary information or right to use inventions is an unfortunate result of some defense work. It is possible for a defense contractor to lose the right to utilize inventions made by its own men.

As incentive to meet these risks, adequate profits in recognition of superior performance in the face of the risks involved must be made available. The first step toward this end is to increase public realization that investment, cost-reduction, and risk-taking in defense work, stimulated by adequate profits, will benefit not merely the enterprises directly engaged in such work but also the nation as a whole.

Responsible companies will, of course, continue to serve the national defense with skill and ingenuity, despite these obstacles. They will continue the needed investments in research and development work. But for a sustained defense effort lasting many years, the best results will come from a combination of patriotic and economic incentives. The traditional stimuli of our free-enterprise system have proved themselves effective in the commercial market. There is no reason why they should not effect even more positive results in the national defense.

Certainly the size of some present defense projects warrants such carefully designed cost-control programs. General Electric has current responsibility for $158 million for one research and development contract alone—for nose cones for the *Atlas* and *Thor* missiles. As an incentive for control of costs, for superior performance all along the line, we must make greater use of the traditional incentives that have served us so well in the civilian sectors of our economy—all of them based upon adequate profits. These profits must be appropriate to the size of the job, the degree of risk, the size of the affected area of the nation's economic or military well-being, and they must reward superior performance.

In each of the key areas of defense equipment today—electronics, missiles, atomic energy, aircraft—the emphasis is on a *handful* of hardware, some of it shown here, and on a *great deal* of research and development. While the hardware appears on the surface, like the iceberg, it is supported by the far larger base that is invisible to the casual observer. To preserve the integrity of the research and development base, to keep it healthy and productive in the best tradition of our American economic system, is the core of our defense need today. The sooner we recognize this fully in all our military planning, the stronger our country will be.

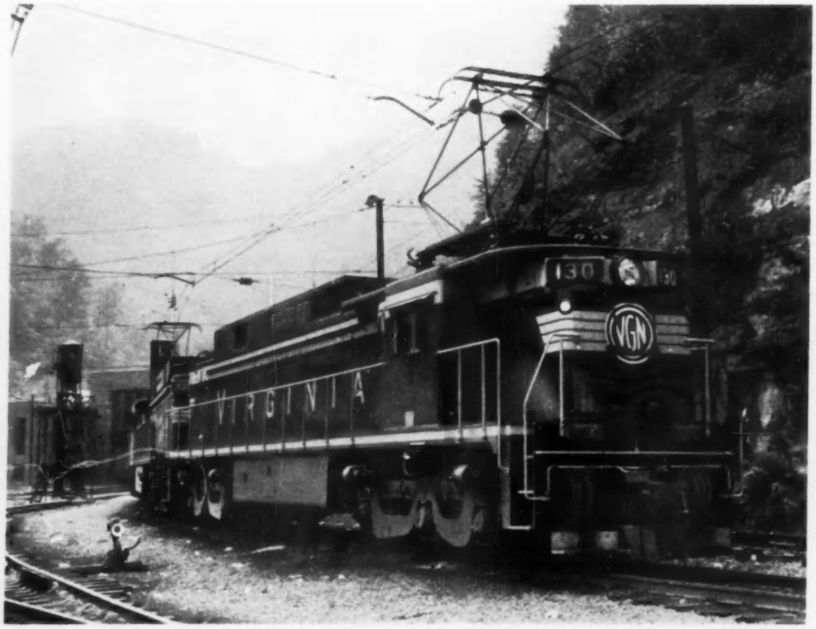
—GWN

NUCLEAR REACTOR core research continues to accumulate defense knowledge.

ENGINEMAN PHILLIPS: "I like an electric locomotive. . . . I wouldn't go back to those old steam days for nothing."

ENGINE 130 EAST EXTRA trailing 9000 tons of fine Pocahontas

"Flat Tops," "Round Noses," and



ON READY TRACK at Mullens, Engine 130–131 awaits signal to proceed to Elmore Yards and pick up eastbound train. Mines from around Mullens funnel high-quality coal into Elmore.

***Review* STAFF REPORT**

Somber mountains circle the Elmore Yards of the Virginian Railway at Mullens, W. Va., in the southern part of the state.

From these mountains, laced with rich veins of high-grade Pocahontas coal, diesels snake long loads of hopper cars, funneling them into the marshalling yard at Mullens.

From Mullens eastbound to Roanoke, Va., is a formidable 134 miles. After the rigorous 1100-foot climb of 13 miles to Clark's Gap in the Alleghenies, most of the Appalachians still remain as the final hurdle. From Roanoke eastward, the Blue Ridge Mountains are crossed on a general 0.2 percent grade. And from there to Norfolk tidewater, the grade is light and level, or favorable for tonnage movement.

Steam motive power, in the form of husky Mallets, did the initial chores over the mountains during the '20s. But a constantly increasing demand for coal meant more tons had to leave

coal roars through a Virginia valley. Dynamic braking saves brakes on downgrades.

M-G MOTIVE POWER with a string of empties rumbles west through Appalachian foothills. Coupled units generate 6800 hp.

CURVES AND GRADES are characteristic of the Virginian's electrified mainline through the rigorous Allegheny Mountains.

"Square Heads" on the Virginian

Mullens. To get more tonnage out, Virginian management had two alternatives: extend the double-track stretch to allow more train movements or electrify the single-track section and haul more tons per train at higher speeds.

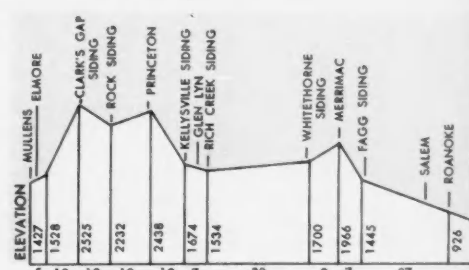
Electrification proved the answer. During 1926, the single-phase 11,000-volt a-c 25-cycle system went into operation. The 12 three-unit locomotives originally furnished for the electrification were of the split-phase type with cab-mounted induction motors driving through jack shafts and side rods. These units, dubbed "square heads" by Virginian crews, broke the bottleneck at Mullens and moved coal up the steep grade to Clark's Gap at 14 mph—about double the steamers' speed.

During 1948, 4 two-unit 6800-hp General Electric motor-generator type locomotives with more than one-million pounds on the drivers went into service. Semipermanently coupled as a two-cab unit, they have conventional axle-hung d-c traction motors. Through the years, these "round noses" (photo, top right) gained an enviable reputation for steady, solid performance and fine control with the motor-generator (m-g) sets. To many a Virginian engineman, they're "the Cadillacs of the electrics."

Last year, 12 new rectifier-type electric locomotives were working tonnage freight over the mountains. They are similar in general design to the locomotives on the New Haven (Sept. 1955, REVIEW, page 56).

Today, these 3300-hp giants, operating in multiple, consistently haul 3000-ton trains (Cover) eastbound up the 2.07 percent grade to Clark's Gap at 16 mph. At the Gap, another 6000 tons is added, and a twin-unit "flat top" easily handles the 9000 tons to Roanoke at the road speed limit of 35 mph (photos). From Roanoke to tidewater, two-unit diesels packing 14,500 tons whistle over the Virginia countryside.

What are the advantages of rectifier-type locomotives? How was the Virginian design arrived at? For the answers and an interview with a General Electric application engineer, turn the page . . .



PROFILE of 134-mile electrified section from Roanoke to Mullens shows the steep grades. Climax is Clark's Gap: elevation 2525 feet.

WHY RECTIFIER-TYPE ELECTRIC LOCOMOTIVES?

Forrest A. Mitchell of General Electric's Locomotive and Car Equipment Department, Erie, Pa., has responsibility for application engineering on electric locomotives. In the following interview with a REVIEW *editor, he discusses further aspects of the Virginian locomotives.*

By what methods do electric locomotives utilize the a-c power from the catenary for traction?

There are two conventional ways: a-c series motors used as the traction motors and d-c traction motors using power converted by m-g sets or mercury-arc rectifier tubes. Each system, of course, has its advantages.

What basic requirements were specified by the Virginian Railway for their new locomotives?

The locomotive could not exceed a maximum weight of 396,000 pounds. Operating requirements dictated that these locomotives be capable of multiple-unit operation, up to four units in multiple, in either direction and that they also be capable of performing both road and switching duty. Moreover, they had to be able to operate in the same train with the m-g locomotives furnished by General Electric to the Virginian in 1948.

The basic specifications also called for a two-unit locomotive to haul 3146 tons at 15¾ mph up a 2.07 percent grade at 20 percent adhesion. This is the grade between Mullens and Clark's Gap.

The Virginian also specified that the trucks and traction motors on the new locomotives be interchangeable with the trucks and General Electric d-c traction motors used on the road's Fairbanks-Morse diesels.

If the Virginian had satisfactory operating experience with the m-g locomotives furnished in 1948, why weren't m-g sets used on the new ones?

Initially there was some discussion about using m-g sets. And m-g sets give very fine control. But they are expensive. Our studies showed they would be about 50 percent higher in cost than rectifiers. The primary reason for this is the large size and weight of m-g sets required for operation on 25-cycle power.

Rectifier equipment has few moving parts, is efficient and clean, and has proved to be reliable in service. It has a high horsepower-to-weight ratio and the possibility of operation from either 25- or 60-cycle power.

By using rectifiers across-the-board—for both high-speed passenger service such as the New Haven units or the low-speed high-tonnage equipment for the Virginian—we are more or less able to standardize the design of electric locomotives. We firmly believe that we've got a versatile piece of equipment that could be used on all a-c electric roads in existence or planned for the future in the United States.

The components, for instance, are adaptable to both high-speed freight operation—such as on the Pennsylvania—as well as low-speed freight operation and high-speed passenger work. Also, the traction motors are standard d-c diesel-electric motors. The use of interchangeable parts minimizes the number of spare parts that the customer must stock.

I note that the units used on the New Haven are of the box-cab type, while the Virginian locomotives have the road-switcher configuration. What were the reasons for such a design?

We recommended the road-switcher, or hood-cab, design to the Virginian. They are less expensive to build; and also of primary importance to the railroads, they are easier to maintain. All equipment is easily accessible. I would say that the road-switcher design is becoming more and more universal. Where a railroad wants style on prestige trains, the box cab is probably more satisfactory from an appearance standpoint.

These Virginian locomotives have another unusual design factor not generally found on locomotives that operate on more level terrain. Fabricated from steel plates, the locomotive platform is designed with sufficient strength to support the equipment and withstand an impact force of one-million pounds. The heavy steel-plate ends of the platform extending to within five inches of the rail are strongly braced. This design prevents damage and possible derailment when encountering rock slides in the mountain.

What has been the Virginian's experience with these new locomotives?

On acceptance runs, two units hauled a 3140-ton train from Mullens to Clark's Gap and a 10,000-ton train from there to Roanoke. Westbound from Roanoke, two units will handle an empty train of 3844 tons—approximately 162 cars.

Close cooperation between the railroad and the builder resulted in a locomotive well suited to the service in which it is being applied. The locomotive design permits a maximum of equipment accessibility for inspection and maintenance, as well as easy removal of components for overhaul. Maximum use was made of equipment previously proved in railroad service.

The locomotives are maintaining specified schedules. Experience indicates that the rectifier-type electric locomotive is well suited to heavy freight work.

VIRGINIAN rectifier-type locomotives gather speed for an assault on the Alleghenies.

With a table lamp containing touch control, you need only touch the base and the lamp goes on. Another touch and it's off. Engineers developed touch control for lamp switching, but it can also be used with other appliances.

Developing Touch-Control Switching

In addition to simplifying lamp switching, touch control enables the handicapped to command electrical energy with only the movement of a finger.

By LEON H. CUTLER

Several years ago it became apparent that table- and floor-lamp manufacturers wanted something new and different in lamp features—something other than styling. Accessory equipment engineers thought a new approach to switching would best meet this desire. Aside from the novelty, it would permit lamp designers to deviate from patterns dictated by the use of conventional socket switches. General Electric engineers planned to place the switch in some easily accessible part of the lamp—for instance, the base for a table lamp and the stem for a floor lamp. Thus began the development of the Touchtron (registered trademark of General Electric) control.

Mr. Cutler—Control Accessories Engineer, Advanced Engineering, Accessory Equipment Department, Bridgeport, Conn.—began with General Electric 11 years ago. He has spent most of this period working on industrial and domestic electronic controls.

Initial Steps

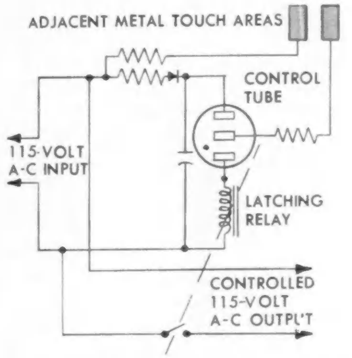
Engineers worked out various circuits for touch actuation. One of the first relied on the capacitance to ground of the person. Touching the lamp caused a thyratron tube to conduct. This in turn operated a stepping relay so that, once the hand was removed, the relay contacts remained in their last position until the thyratron tube was made to conduct again. However, disadvantages existed: the package consisting of the tube, relay, and power transformer was too bulky; the components cost too much; all wiring had to be properly polarized; and side ground capacitance effects of the necessary lead wires made stability marginal. To overcome the stability problem, an artificial ground plane was brought out to close proximity with the main touch area. And although it was now necessary to simultaneously touch both areas, it became possible to lower the sensitivity of the device and improve stability. This same ground plane took the place of the electric supply ground so that plug polarity was no longer a factor.

Although stability and polarity problems were removed, the use of a hot-cathode thyratron control tube required a continuous filament-heater supply. Aside from the standby power consumption, the tube required relatively fre-

HOW TOUCH CONTROL'S BASIC CIRCUIT OPERATES

The circuit (below) operates as the a-c input charges the capacitor through the resistor and rectifier. This rectified voltage never becomes high enough to cause the tube to fire.

When the control-grid voltage is elevated toward the anode—by bridging the two touch areas with the hand—the tube fires, discharging the stored energy in the capacitor through the relay. Passing a minute current through



the portion of the hand bridging the touch area elevates the control-grid voltage. Impedance internally connected in series with each touch area limits this current, in microamperes, to well below the threshold point of sensation. Any external impedance, however, serves only to further desensitize the operation of the control.

Because lamp manufacturers use a lacquer coating over the metal parts to prevent tarnishing, the touch-control circuit had to tolerate the impedance added by the lacquer film. Type and thickness of film, skin resistance, and the area bridged by the hand normally determine the magnitude of this external impedance. Combined, these factors usually add up to roughly a megohm. Substantially more can be tolerated but at the expense of raising the lower usable limit of input a-c voltage.

Where nontarnishing metal surfaces—such as nickel or chrome finishes—make up the touch areas, skin resistance offers the only added impedance. This results in even better touch sensitivity, a good reason for using such finishes wherever possible.

The circuit possesses complete stability throughout the a-c voltage range of 100 to 125 volts. For operation, it doesn't depend on the a-c plug polarity nor on any ground planes—conduits, armored cables, or pipes. Because it employs no heat-contributing components such as heater-type tubes, the chassis runs cold. Although normally kept continuously energized, the unit consumes only negligible standby power. This amounts to less than five cents a year.

This 120-volt 5-amp a-c control also has a 5-amp L or a-c tungsten lamp load rating. Lamp loads react more severely on switch or relay contacts because of the approximately 10-times-normal-current inrush. The 5-amp L rating more than suffices to meet all table- and floor-lamp requirements.

quent replacement. Along with the disadvantage of customer expense for replacement, the design was complicated by making it possible for customers to replace the tube. A cold-cathode tube had to be used to satisfy the power standby consumption and the maintenance accessibility problem. Because available cold-cathode tubes couldn't handle the power requirement of the stepping relay, a pilot relay had to be employed. This circuit worked very well. Contacting both touch areas simultaneously brought the potential of the control grid high enough to cause the tube to fire—ionize the gas—operating the pilot relay, which in turn operated the stepping relay. Normally, impedances are in series with each touch-area lead to limit the touch current to below the threshold levels of sensation. The use of an isolating transformer in this particular circuit permits direct grounding of the anode, eliminating the impedance usually required in series with the touch connection to the anode.

Again bulk and cost constituted the main disadvantage to this device. In its original concept the control unit rested on the floor in a box having outlets to receive both the power plug of the lamp and the touch-area leads—all terminating in a plug. This permitted any design for a lamp base but left an objection: an electric object on the floor.

Broad Study Begins

The problem of eliminating the pilot relay required a completely new approach if we were to meet our objectives. In early 1954, the Company's General Engineering Laboratory entered the picture to make a broad study of possible methods to overcome the bulk and cost problems. The laboratory investigated several approaches. The most fruitful: a new concept of employing an impulse-type latching relay, an energy-storage circuit to operate it, and a neon glow tube to trigger the stored energy into the relay coil. Although it still required relatively heavy current to operate the relay, the short duration of the current pulse assured long tube life.

The Laboratory completed its work in the early fall of 1954, and the accessory-equipment engineers undertook to reduce the basic principles to operating practice. Several major problems remained to be resolved, of which the wide latitude of the operating characteristics of the neon tube constituted the most serious. The Laboratory had done most of its work with a modified neon diode. After months of statistical testing in close liaison with the Lamp Development Laboratory at Nela Park, the diode was discarded in favor of a neon triode—one of its special developments, which required about six months of intensive effort. Determining circuit parameters and allowable tolerances—another major problem—was necessary to make provision for the existing tube tolerances, wide range of input voltage, and a reasonable latitude of allowable touch capacitance for the customer's application. To develop and design a manufacturable low-cost relay was no easy task.

Another problem that had to be solved consisted of the development of circuits to provide reliable operation and yet stay within the leakage current requirements imposed by the Underwriters' Laboratories and the electric utilities. These and other problems were finally overcome, resulting in an acceptable circuit (Box).

The Completed Switch

This versatile electronic touch switch controls lamps, various other appliances, and electronic equipment where touch operation is desirable.

While the switch is presently shaped like a disk approximately 4¾ inches in diameter and 1⅛ inches thick to facilitate mounting in the base of portable lamps, the components can be rearranged in any suitable configuration with a minimum volume of about 9 cubic inches. The lamp manufacturer makes the connections easily with wire nuts. The leads provide for power input and controlled power output with a touch lead for one of the two adjacent touch areas. The other touch-area lead terminates internally to make the whole can cover act as one of the required leads. This allows the whole metallic structure of the controlled device to become one of the touch areas when the touch unit is mounted in contact with the device. A lamp or any other device to be controlled requires two metal or otherwise electrically conductive touch areas spaced and arranged to permit simultaneous touching by the hand. In table lamps, one metallic section completely insulated from the rest of the lamp usually rests just above the lamp base to permit touching both areas simultaneously.

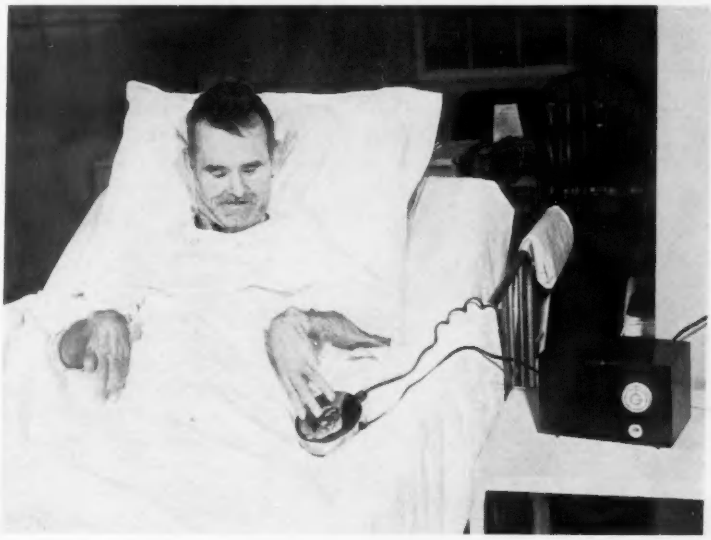
Such a control costs relatively little. However, to expand its acceptance into lower-priced lamps and other potential devices, a still lower cost is essential. To that end, engineers are working to adapt the components for use with printed wiring boards. Engineers redesigned the relay to permit greater tolerances and less critical assembly techniques along with incorporating printed circuit-board terminations. The design of the electronic chassis permits automated production eventually. With the board and its soldered-in contacts inserted in a molded case just large enough to contain the assembly, the package becomes usable in a greater number of lamp-base sizes.

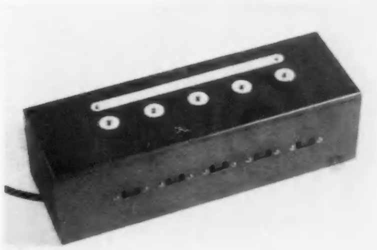
In lamp application the desired operation involves touching the appropriate areas, having the lamp go on or off and remain that way until the touch areas are again contacted. Slight modifications of the relay transform it into a clapper type having contacts normally closed with momentary break or normally opened with momentary make. For either one, the make or break lasts less than a second even though the hand may remain longer on the touch areas. When the touch unit is used as a pilot control for a solenoid or alarm system, such modifications become desirable. You can also delay the relay's return to normal action. For example, you may desire to initiate a pilot control with just a momentary touch but still have the pilot control continue its make or break contact for some interval after the hand is removed from the touch area. Where desirable, the touch areas can be extended within limits by leads and terminated appropriately for the application.

Physical Rehabilitation

These special application requirements show up in experimental medical rehabilitation work performed at Bellevue Hospital in New York City and various other rehabilitation centers. The primary function here consists of providing a physically handicapped person with almost effortless switch control for any appliance (Box).

USING TOUCH CONTROL IN REHABILITATION WORK





KID BOZO, former featherweight boxer, now a quadriplegic in Hillside Hospital, Bridgeport, Conn., has lost the use of his extremities because of a damaged spinal cord. But he can move his hand slightly to contact a touch-control unit, which turns on his radio. With the multiple touch-control unit (right), handicapped persons can control five different operations from a unit the size of a shoebox.

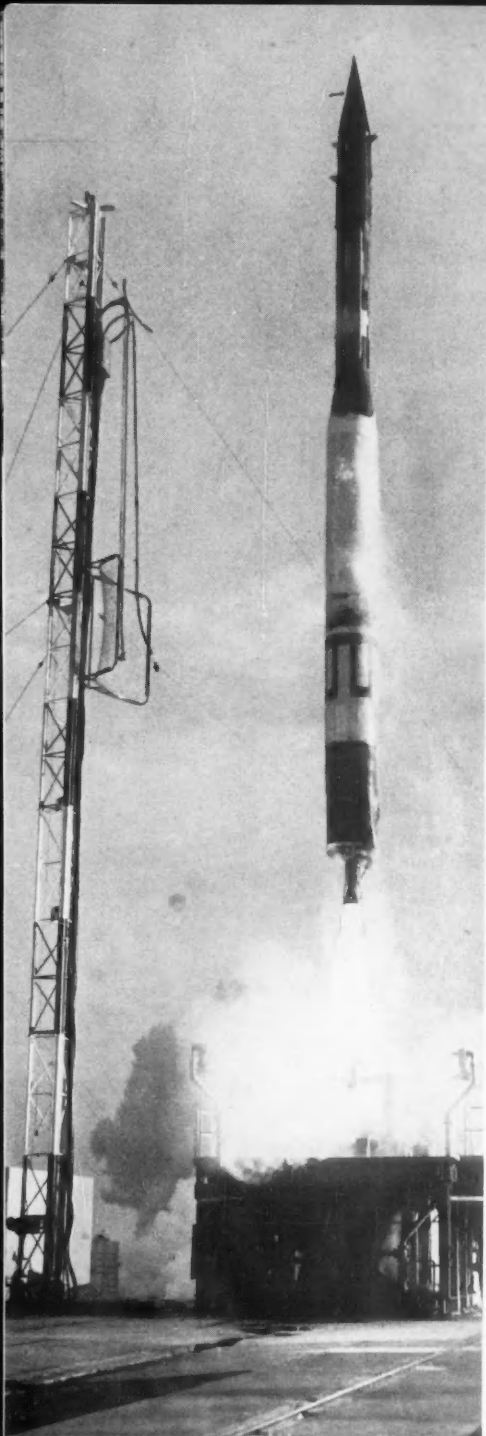
Initially, the patient operates the control by just laying a finger across the strip and one of the disks. The strip constitutes the common ground plane for all five circuits. At this point, the patient reacts favorably psychologically as a result of his newly found ability to administer to his simple needs with the help of the controlled appliances. The therapist can now begin to space the touch areas farther apart in elevation with screw fasteners, requiring the patient to raise his fingers or hand to actuate the controls. In stages, the mobility of the patient's fingers increases, spurred on by the intense desire —common to most physically handicapped people—to be as self-reliant as possible.

Through this therapy, the bedridden patient develops the will and ability to move paralyzed or arthritically immobilized fingers. Even a patient unable to move his hands but possessing some control of head movement can operate a touch control by contacting an extended touch area—which has been pinned to his pillow—with the side of his face.

Varied Applications

Another version consists of a single-control touch unit having a controlled outlet and a built-in touch area. Here again you can make many varied uses of the device. With several units spotted around the house at key locations—controlling lights, TV sets, radios, or fans—arthritically or otherwise handicapped people unable to manipulate ordinary switches obtain a new capacity for self-reliance.

Touch control represents a new concept in convenient switching. The device comprises a compact package easily wired and easily applied. Printed wiring techniques pave the way for future automated production. Your use of touch control may not necessarily be a luxury. For it frequently accomplishes awkward switching functions without impairing or limiting the design of the device it controls. Ω



VANGUARD launching experience will increase the probability of future successes.

Dr. Porter—Consultant, Communication and Control, Engineering Services, New York Office—recently provided a statement on *1958 Alpha* for REVIEW readers (March 1958). He is 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.

Miracle at Canaveral

By DR. RICHARD W. PORTER

When the first plans for the *Vanguard* Program were drawn up 2½ years ago, the announced goal was to place at least one small, instrumented satellite in orbit during the International Geophysical Year. At that time, experienced engineers and scientists believed that it would be necessary to launch, or at least attempt to launch, six or eight test vehicles, in order to study the performance of the three different rocket engines, the guidance and control systems, the structural components, and the separation mechanisms plus, of course, the interaction of these and many other parts of the over-all vehicle.

An additional requirement was to develop and prove the feasibility of suitable launching and handling equipment. Even after such a program of test-vehicle firings, it was considered that at least six fully instrumented launching attempts would be needed to insure a reasonable probability of achieving one successful satellite flight during the IGY.

About a year ago, it was announced that, although the purpose of these launchings was unchanged, four of the test vehicles would be designed to carry small test spheres, which, if everything worked perfectly, would be placed in orbit. In making this announcement, I believe I stated publicly that I thought it would be a minor miracle if any of these test-vehicle launchings should result in establishing a satellite.

On Monday, March 17, the miracle happened!

Whether St. Patrick, whose memory is honored on that date, had anything to do with the success I do not know; but whatever the reason, the success was indeed welcome news.

From the viewpoint of the scientists in the program of the International Geophysical Year, the test gives added confidence in the scientific satellite program to follow. Even this tiny satellite will provide useful information about the effect of environmental conditions at very high altitudes on equipment such as radio transmitters and solar energy converters. Furthermore, scientific information concerning air density at high altitude and ionospheric effects may be obtained as valuable by-products of the experiment.

From the viewpoint of the designers of the launching vehicle, this was an almost perfect test. The over-all velocity and height achieved exceeded the nominal values, and the direction of the velocity vector at burnout of the last stage was well within predicted limits. An unexpectedly severe test of the flight-control equipment occurred, when at takeoff, one of the pins that aligns the vehicle with the launching stand stuck for an instant, giving the vehicle a severe yaw. The displacement was immediately corrected, however, and the resulting oscillation quickly damped. Complete coverage was received at several ground stations from the three different telemetering systems carried by the vehicle. The two transmitters in the little sphere both began transmitting even before takeoff, and their signals were received loud and clear at several ground stations throughout the entire launching process.

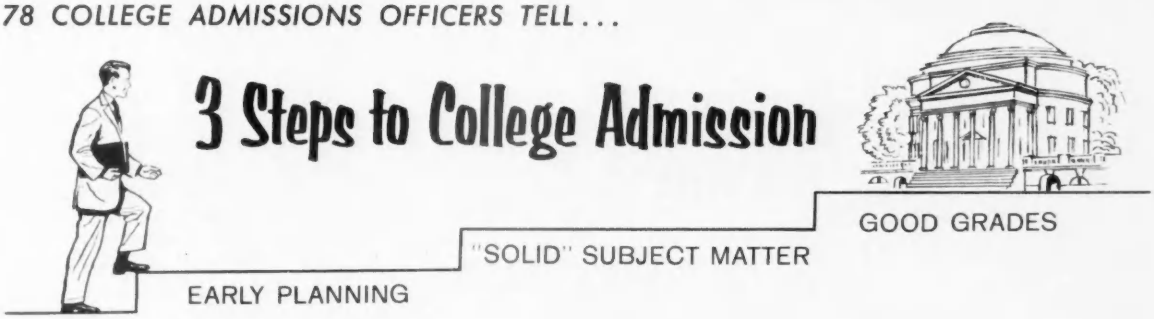
From the viewpoint of General Electric, the successful flight can be regarded as proof of the excellence of the General Electric rocket engine, which lifted the heavily loaded three-stage vehicle off the stand and gave it its first increment of velocity.

It would, of course, be wrong to expect that results of this kind can now be repeated on every succeeding attempt. No basic change has been made in the design of the vehicle since the two well-publicized failures that preceded this one success. The failures resulted from improper operation of relatively small components; the reason for this success was that by very careful inspection and testing, all of the detailed troubles were eliminated. With increased experience, the probability of success will, of course, continue to increase. We should be well satisfied, however, if as many as half of the succeeding launchings are successful.

A miracle has indeed occurred. And as a result, we now have two different means for launching satellites, developed to the point where feasibility has been proved and useful results obtained. We are justifiably proud of both our Army and our Navy, and we look forward eagerly to the substantial fulfillment of plans for the IGY and to even greater things to come. Ω

78 COLLEGE ADMISSIONS OFFICERS TELL . . .

3 Steps to College Admission



In a previous article, we discussed the reasons why you may not be accepted into the college or university of your choice. Seventy-eight prominent college admissions officers revealed that high school students may not be accepted if they are not in the upper half of their graduating class. Also, they told you that a large percent of you are sorely lacking in important subjects such as mathematics, English, and science. In essence, the low grades and lack of subject matter are the reasons why you may be turned down when you apply for college admission. Now let's see what there is to be done to get "out of the woods and on the highway" while there is still time.

Henry C. J. Evans, Assistant Director of Admissions at Rutgers, spoke to you earlier on why so many high school grads are being rejected by colleges today. He goes on further to suggest, "Our advice to any young man who is considering college would be to learn to work efficiently and effectively in secondary school, to meet his academic responsibilities thoroughly, and to be an interested and contributing citizen in both his school and his community."

Begin Early

To become "an interested and contributing citizen," as Mr. Evans terms it, you must begin early in your high school career to plan your courses and then work hard to become proficient in them. There is only one effective way to become proficient in any art or skill and that is by practice. You must realize that practice means repetitious drill, mental discipline, and hard work.

You should plan your educational endeavors just as your parents study a road map before taking a vacation trip or the coach prepares fundamentals and plays for a football game. Proper course selection and good study habits cannot be acquired at the end of the senior year, but must begin on the ninth grade level—or in your sophomore year of high school. As a University of Washington educator said, "Counseling should start early. High school students and their families must come to grips with their education planning earlier than is often the case. Perhaps there should be a tentative decision as to whether Mary or John are college-bound while they are in the eighth grade. Planning the high school program of studies is extremely important. However, learning to apply oneself toward the mastery of the chosen subjects is as essential."

Although there is much to be learned directly from books while you are in high school, you should in no way limit yourself to that medium. You should supplement your actual high school courses with broadening experiences—such as visits to art galleries and museums, travel, participation in student activities, and visits to industrial plants and offices. For it is through this type of learning that you will become the well-rounded student that colleges desire to have on their rolls.

Omit "Frills"

R. G. Perryman, the Associate Registrar at Texas A & M, suggests preparation for college to run something like this: "Decide as early as possible the college or university you wish to attend. Make sure that college offers the type of training you desire and that you are well prepared for training at the institution concerned. Plan your program of studies in high school so as to include as many of the 'solid' subjects as possible. Do not side-step the difficult ones. 'Solid' subject areas are considered to be English, mathematics, natural sciences, and foreign languages. Omit the 'frills' that are offered in many high schools these days and take those subjects which will afford some fundamental training for college."

In the past fifty years, the scientific component of our American culture has been expanding rapidly. Such phenomenal growth is affecting all aspects of our society—political, economical, and social. With it, the need for technically trained young men and women has also grown. But while there is a definite demand for technically trained men to take the reins of American industry, we here at General Electric recognize the need for liberally trained young people. In hiring scientists and engineers here at General Electric, we look for young men who have a background in some liberal subjects—English, history, foreign language—

as well as a thorough knowledge of technical subjects.

Educators, too, recognize the advantages and needs of a liberal secondary education. John W. Frazer, the Registrar at Centre College in Danville, Kentucky, feels " . . . that preparation for a liberal arts course is the most adequate. The vocational or trade schools are fine in a terminal capacity, but they do not give a student the opportunity to realize the full scope of knowledge and consequently leave him only the skills to earn a living. They have no concept of the total picture of our world. In addition, I think that students should spend at least two years in college in the liberal arts tradition rather than specializing immediately. This broad foundation seems to give them a greater appreciation of the technical field that they choose as a vocational interest."

You may ask yourself, "Just how will a subject like English help me in becoming a successful engineer, or a proficient chemist, or a competent doctor? The answer lies in the word *communication*. As an engineer, you may have many fine ideas which will be of great aid in the progress of

humanity, but if you are unable to relay your ideas successfully to your associates, they will remain dormant in your mind. Gilbert C. Garland, Director of Admissions at Northeastern University in Boston, has recently completed an essay on the necessity for good communication on the part of prospective college students. "Scientific and technological progress in the United States," says Garland, "has focused the attention of countless numbers of students on the professional fields of engineering and scientific research. This is as it should be, for the continued productive might of our great nation depends on the skill and creative imagination of the youth of America . . . But, we hasten to add that their fine ideas are of little value unless they can be shared with others."

How often have you heard the words, "I know what I want to say, but I don't know how to express it"? A good, basic knowledge of the English language, all 100,000 words of it, will allow you to express yourself adequately and will afford you the ability to discuss things thoroughly and logically, an attribute which is extremely important if you are to become an adequate citizen. A good, working vocabulary will also aid you in advancing more rapidly in the business world, whether you are a scientist, a doctor, or a member of any of the professions which may loom in your future.

Talkable English

Recently, we attended an informal conference here at General Electric designed to discuss the continual advancements being made in our laboratories which might be of interest to the general public. Top-rate scientists and engineers were called upon to explain to newsmen several of their new products. Intricate technical data were explained clearly, concisely, and in good, everyday language so that everyone could understand it. Had these technical men had a poor background in the art of communication, the whole purpose of the meeting would have been wasted! Undoubtedly, then, whatever your field of endeavor may be, you will need a good foundation in the English language.

Why Mathematics?

On the other hand, one of your fellow students who has an aptitude for one of the liberal arts, such as history, English, or economics, may also ask a related question, "Why should I take mathematics or physics in high school when I want to major in one of the liberal arts in college? And besides, I never have been good at math, and I never will be!" The admissions officer at Cornell replies to this statement with one of his own. "Too often students come here with a block against mathematics or the sciences . . . This (preparation for college) must include an understanding of the fascinating aspects of the scientific frontiers as well as the vocational opportunities presented."

Science today *is* fascinating. Harnessing atomic power or building a mighty turbine is a tremendous undertaking, but it is not "black magic," nor is it impossible to understand. However, to understand it takes good, common logic with a little background in the field of science itself. As one educator puts it, "It seems to me that for the sake of our economy and national security, every student in secondary school should be urged and encouraged to take as high level a program of study as he is able. This level surely should include a basic foundation in mathematics and the sciences, no matter what he is to do later in his career."

There you have it, the straight-from-the-shoulder report from the men whom you will face when you make your application for admission to the college or university of your choice. If you are really interested in going to college, it's a good idea to take their advice and get your money's worth while you are in high school. Your chance comes but once in your life.

INDUSTRY PROMOTES THE STUDY OF THE THREE R's (PART 9)

You may want reprints of this article "3 Steps to College Admission" 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.

Undersea Defenders

(*Continued from Page 26*)

bow of the YF at a depth of 200 feet.

I clambered below, and soon after we submerged to periscope level. A submarine running underwater is an eerie thing. I felt no forward motion until the ship accelerated. Also there's no rolling sensation. And I heard no exterior sounds, only those from within—the rustle of a busy crew and the constant whine of the fresh-air blowers.

Even when submerged, the *Manta* was in constant communication with the YF by means of underwater sound equipment. Bearings and distances were checked by means of the sonar on both ships. At 10:53 the five-minute standby came over the system.

A minute later a call came for 200 feet, and we went into a 10-degree dive at two-thirds speed (4 knots). Another minute passed and the depth gage read 78 feet. The officer called for full-ahead standard speed, and at 2 minutes and 130 feet he called for a 15-degree dive and two-thirds ahead. A 15-degree dive is steeper than you might imagine; coffee begins to spill out of cups. At one minute to go the *Manta* leveled off at 210 feet and held two-thirds speed.

"Execute!" came down from above. I asked one of the officers in the control room what a hit felt like. He laughed and said we'd certainly know it. "And if it hits the shrouding around the conning tower, you'll think you've stuck your head in a bell. And regardless where it hits, it will sound as if it struck right where you're standing."

(Sometimes, especially during high-speed evasive action, the unit had hit the submarine without those aboard knowing it. A dent in the hull of the submarine and a damaged nose on the torpedo was proof.)

We waited in silence. Although I couldn't see the equipment, I knew that our sonar was following the unit's every movement. And in my mind's eye I could see the pip getting closer and closer as the torpedo neared the end of its deadly run.

"Stand by for hit!"

I braced myself; the crew stiffened.

Dead silence.

BRAAAM! We heard a metallic thud aft, deep and vibrant, but the *Manta* didn't shudder.

We relaxed. One of the officers said, "Good shooting."

After lunch I went to the forward torpedo room. Several crewmen were sprawled over bunks and on the floor watching a Western movie.

To the left of the bulkhead dividing the torpedo room from the rest of the submarine stood a sonar man who was running bearings on the YF and torpedoes being launched. I found watching him far more interesting than the movie.

A cathode-ray tube over his head glowed in the darkness. As the sound pulses were sent out from the sonar gear, a blood-red spot would appear in the middle of the tube's face, forming into a circle that gradually widened as it traveled to the edge of the tube. As it reached the edge, another spot would form in the center and proceed on its way, circling ever outward. Watching the ceaseless, widening circles had a certain fascination.

When the sound waves encountered a solid object in the water such as a ship's hull, a spot, or pip, would appear. The technician pointed out a pip that was always there—the *Manta's* propeller. Toward the edge of the tube appeared another pip, the YF.

Bearings were also obtained by listening to underwater noises with earphones. With a handle, the technician can rotate his receiving apparatus through a complete circle. When he gets maximum noise in his earphones, he takes a reading on a calibrated scale, and thus accurately locates the object. Trained operators can estimate size, type, and speed of the sound source.

During one of the events, the sonar man let me listen; but what I heard made no sense until he told me that the high-pitched whine was the torpedo. He said it differed from the cavitation noise of the *Manta's* screws, or the watery chug of a larger ship.

I gave him back his earphones and watched the pip on the scope come closer and closer in a steady, relentless attack. In wartime this could be a harrowing experience.

"Stand by for hit!"

The pip merged into the center of the scope. I grabbed for support, and instinctively went tense. A pause, then a watery, vibrating buzz came closer and closer until it sounded directly overhead: then it receded as it had come. The sonar man lifted his head; I relaxed. "Went right over us," he said. Soon after I went to the wardroom and had a cup of coffee.

By two o'clock the last event of the 8N1 series had been run off; we broke surface for the trip home. The day's events had been highly successful.—PRH

Listening

(*Continued from page 10*)

practice. The boss-subordinate situation, as well as typical office, plant, and laboratory routines, offers obvious on-the-job opportunities. But you can utilize off-duty hours, too.

Do you really listen when your wife talks to you about domestic and neighborhood problems? Listening improvement in this situation is not only excellent practice but may also be a great boon to family relations!

Radio, television, and spoken-voice records afford an opportunity to practice listening. And with a tape recorder you can test yourself on how well you listen to specific verbal communication.

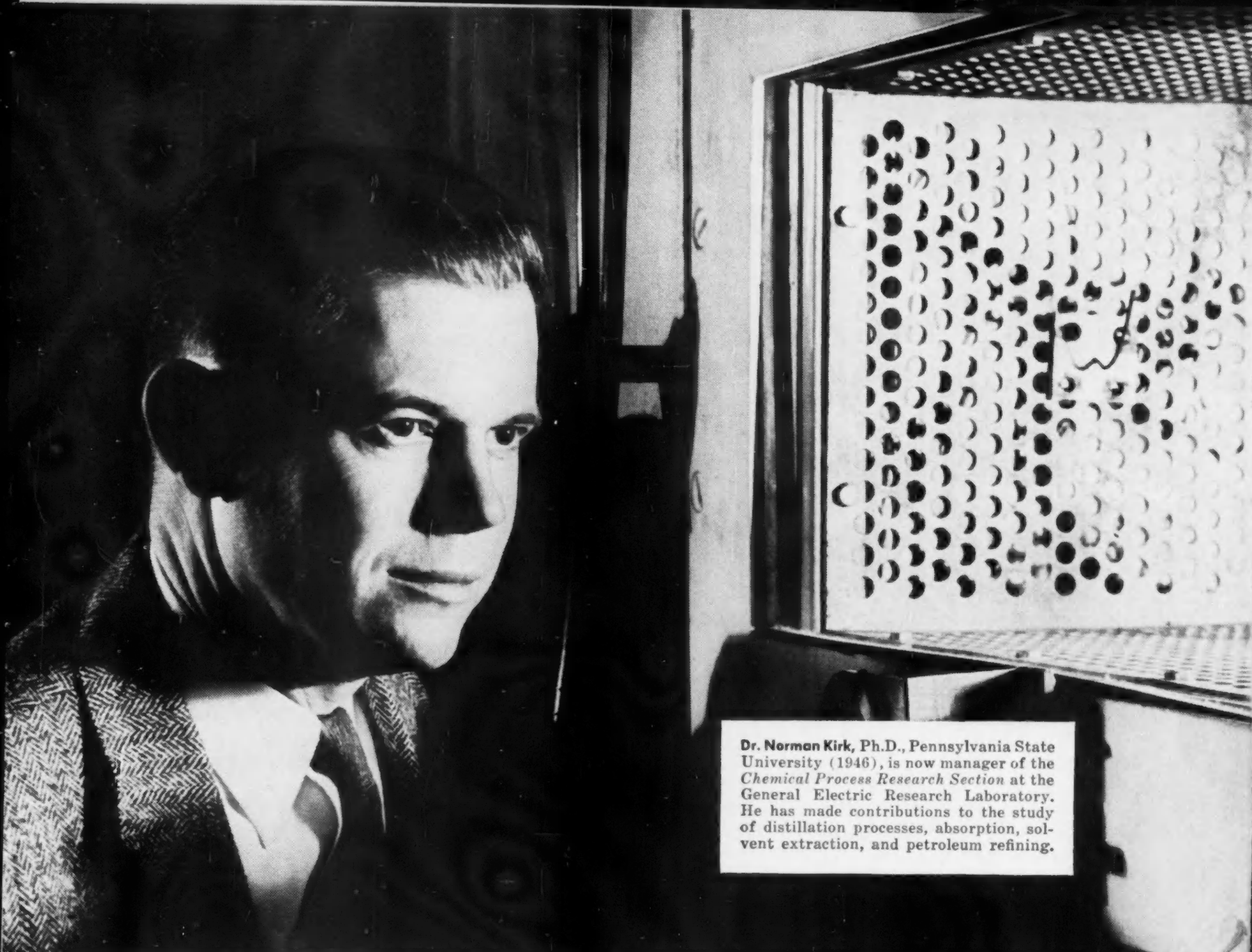
. . . Don't reject what you hear because it appears to be trivial, completely familiar, or completely unfamiliar. Most of us share the bad listening habit of tuning-out something that appears to be of little immediate interest. Sometimes it may be that we think we know everything of value concerning the subject matter. Or the subject matter may seem too remote or unfamiliar; for example, an engineer may be inclined to pay little attention when history or philosophy is being discussed. Or, sometimes, what is being said may appear so trivial that to listen would be to "waste" time. But the point is that rarely do you waste time by intent listening. On the contrary, better listening is perhaps the greatest single source of untapped potential for self development.

Regardless of how trivial, how familiar, or how remote something that's being said may be, a learning opportunity is present. And the good listener will likely enrich himself far more by capitalizing on that opportunity than by letting his mind wander ineffectually while another is speaking.

Thus you can do much to improve your listening skill: specifically, by avoiding these pitfalls to good listening; generally, by exercising greater self discipline in speaker-listener relationships.

If many people will make such self-improvement progress, and if the first, inadequate research by a few academicians and business organizations is used as a springboard into full-scale efforts to develop more knowledge about the listening process and better listening-training techniques, then one could safely predict a major breakthrough in the effort to provide the vital missing link in industrial communication.

It's an exciting prospect! Ω



Dr. Norman Kirk, Ph.D., Pennsylvania State University (1946), is now manager of the *Chemical Process Research Section* at the General Electric Research Laboratory. He has made contributions to the study of distillation processes, absorption, solvent extraction, and petroleum refining.

Research in exotic fuels

12 years ago Dr. Norman Kirk began contributions to this field at the General Electric Research Laboratory

During the past year, headlines have begun telling the exciting possibilities of new high-energy chemical fuels for jet engines and rockets. These boron-based fuels can produce half again as much energy per pound as the best petroleum products, and they are expected to give longer range and higher speed to missiles as well as aircraft.

The transition of *boron hydrides* from a test-tube novelty to an important factor in national defense began shortly after World War II when a group of chemists at the General Electric Research Laboratory entered upon a seven-year program to seek methods of manufacturing *diborane* (B_2H_6) and *pentaborane* (B_5H_9) in large quantities.

Dr. Norman Kirk had a key role in the development and construction of the first pilot plant for these early exotic fuels. He and his associates combined scientific knowledge and engineering skill to develop practical methods for making and handling boron hydrides. By the time General Electric's pioneering program had been completed in 1953, Dr. Kirk's group had successfully solved the problems created by the fact that boron hydrides have a toxicity equal to deadly war gas, and some have explosive characteristics so critical that contact with only a small amount of air can be catastrophic.

Until now, national security requirements have delayed public recognition of past work in boron hydrides by Dr. Kirk and his associates. But their contributions were an outstanding example of the kind of fundamental groundwork that must be done before new scientific knowledge can actually be applied to the defense of our nation.

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Abstracts

For your convenience to clip and file for ready reference: brief summaries of articles appearing in this issue.

Listening—The Missing Link in Communication *Classification:*

Dover, C. J.

This comprehensive treatment of a neglected area of communication stresses the high cost of shortcomings in listening skill in time and dollars and how to overcome them. Findings are based on research inside and outside the General Electric Company.

GENERAL ELECTRIC REVIEW May 1958 pp 7–10, 43

Electronic Clock Ushers in Wireless Timekeeping *Classification:*

Williams, Reade

Following a brief history of intricate time standards, the text reviews events leading to development of the electronic clock, describes its design and how it works, and suggests a revolutionary future in timekeeping technology.

GENERAL ELECTRIC REVIEW May 1958 pp 11–13

Enterprising Designers Turn Leaking Gas into Lubricant *Classification:*

Staak, L. E.
Carroccio, M. J.

Located in the supply tank and cooled and lubricated by the gas it pumps, a recently developed submersible pump motor solves the major dispensing problem of vapor lock. Gasoline flows smoothly without the interruptions caused by high temperatures, high altitudes, or long supply lines.

GENERAL ELECTRIC REVIEW May 1958 pp 14–17

Undersea Defenders: Story of Acoustic Homing Torpedoes *Classification:*

Review Staff Report

The conclusion of two installments (Part I, General Electric Review, March 1958, pp 24–35), the article follows the development and refinement of the acoustic homing torpedo, with an epilogue devoted to recent developments. Testing, evaluation, and modification procedures at the Key West Field Test Station are presented through the Review editor's personal observations.

GENERAL ELECTRIC REVIEW May 1958 pp 18–26, 43

How Creative Engineering Cut Ironing Drudgery *Classification:*

Flowers, Theodore R.

The author tells how General Electric engineers not only recognized but also fulfilled a need of today's housewife by creating and incorporating into the modern steam iron a device that eliminates the predampening process. It is the story of the development of the revolutionary new spray iron.

GENERAL ELECTRIC REVIEW May 1958 pp 27–29

Increased Emphasis on Research and Development for Defense *Classification:*

Review Staff Report

The American economy places more emphasis on research and development for defense needs, as rapid obsolescence increasingly inhibits quantity production. The nation's principal need is to encourage optimum performance through full use of traditional economic incentives in the face of risks peculiar to defense work, such as renegotiation.

GENERAL ELECTRIC REVIEW May 1958 pp 30–33

"Flat Tops," "Round Noses," and "Square Heads" on the Virginian *Classification:*

Review Staff Report

This briefly summarizes the switch from steam-motive power to modern rectifier-type electric locomotives in the hauling of freight over mountainous terrain on the Virginian Railway. Accompanying the article is an interview with Forrest A. Mitchell of General Electric's Locomotive and Car Equipment Department, who describes how the design was arrived at and the advantages of this type of locomotive.

GENERAL ELECTRIC REVIEW May 1958 pp 34–36

Developing Touch-Control Switching *Classification:*

Cutler, Leon H.

The article describes the development of a new table- and floor-lamp control. Using the touch of a finger, it is contributing to rehabilitation work as well as appliances and electronic equipment.

GENERAL ELECTRIC REVIEW May 1958 pp 37–39

Miracle at Canaveral *Classification:*

Porter, Richard W.

Dr. Porter describes the initial objectives of the Earth Satellite Program, which shaped Project *Vanguard's* development. A severe test of the flight-control equipment occurred at takeoff. This successful launching of the *Vanguard* on March 17 put a 3½-pound satellite into orbit about the earth.

GENERAL ELECTRIC REVIEW May 1958 p 40

Industry Promotes the Study of the Three R's *Classification:*
Why Study Series: 3 Steps to Go to College

Ninth in a series designed to promote interest in education, this article urges students to fully prepare for college at the high school level. Three steps are emphasized: early planning, solid subjects, and good grades. (Reprints are available. Please ask for Publication PRD-110.)

GENERAL ELECTRIC REVIEW May 1958 pp 41–42

PEOPLE AND PROFITS:

Both are needed to make America's capitalism work

NEW challenges from abroad and economic readjustments at home make it more important than ever that our distinctive brand of capitalism be understood and encouraged by all Americans.

America's capitalism is a "People's Capitalism" that must draw its strength from the voluntary participation of free citizens. About a half million men and women are owners of General Electric. 10 million Americans—young and old, from small cities and large, bakers as well as bankers—have invested directly in America's businesses; another 100 million indirectly own shares through their insurance policies, mutual savings-bank accounts, pension plans, mutual funds, or other forms of investment.

All people—not just a few—benefit when businesses earn profits. In America's capitalism, the millions of men and women who have invested their savings in businesses may be rewarded through dividends. Millions more benefit indirectly in many ways—in their pension funds, or through the work of research foundations and charitable organizations which entrust capital to business. More important still, everyone benefits when profitable companies—by reinvesting a part of their earnings—are able to undertake the research and development and the expansion and modernization which lead to new jobs, products, and services.

Profit is the incentive to take the bold and imaginative risks needed for progress. Businesses are in free, vigorous competition to anticipate and satisfy the needs, the wants—and even some of the unspoken aspirations—of the American people. Companies that fail to provide what people want will become profit-starved and a national liability. Those that succeed are the underlying resource of a vital civilian economy and a strong national defense.

If you would like a copy of our 1957 Annual Report, describing progress for customers, share owners, employees, and the nation as a whole, please write: Dept. B2-119, Schenectady, N. Y.

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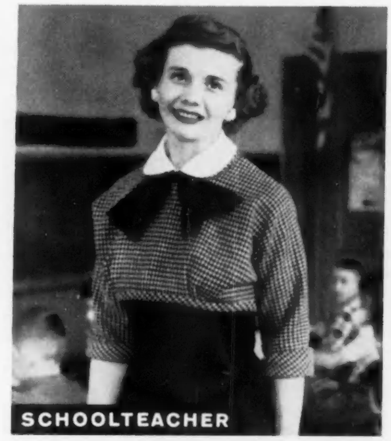
TYPICAL OWNERS OF

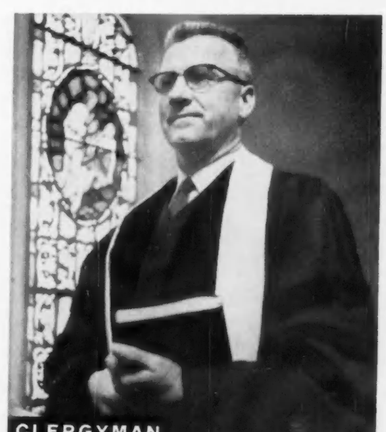


SCHOOLTEACHER

Mrs. Dolores Toporowski has owned shares in General Electric for 4 years. Two-thirds of U. S. share owners earn under $7,500.

BABY CAPITALIST

Jeffery Shore was a share owner before he could walk. His parents typify the growing number of young couples who own shares.



CLERGYMAN

Reverend J. Edward Carothers' church, like many churches, colleges, and institutions, depends on dividends for part of its income.

GENERAL ELECTRIC: *These capitalists come from all walks of life*

GROCERY BOY

Larry Cichy is learning early how America's capitalism works—his parents gave him his first shares on his 11th birthday.

REPORTER

Amy Jane Bowles is one of a growing number of women share owners; over half of General Electric's owners are women.

WELDER

Leopold Arbour was one of 14,000 new General Electric owners in 1957. The number of G-E owners increased 50% since 1952.

MULTIGRAPH OPERATOR

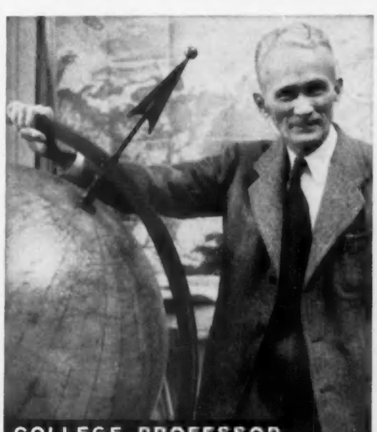
Mrs. Longine Furman is typical of people who participate in "People's Capitalism" by investing part of their savings regularly.

TRUCKING-COMPANY PRESIDENT

Arthur Gallagher is also a G-E supplier. His firm is one of 45,000 which furnish the company with vital skills and services.

GENERAL ELECTRIC EMPLOYEE

Mrs. Ann Shem is one of more than 133,000 employees participating in General Electric's Savings and Stock Bonus Plan.



COLLEGE PROFESSOR

Joseph Doty, Professor of History, teaches about the past and invests in the future with shares of General Electric stock.

PENSIONER

Mary Hammond supplements her income from General Electric's Pension Plan with dividends from General Electric stock.

GENERAL ELECTRIC DEALER

Share owner Allen Merriam also owns one of the 400,000 independent firms which sell and service General Electric products.

"Gentlemen, I understand one-at-a-time lamp replacement is disrupting some of our departments!"

Lamps burn out. Someone has to replace them. This takes time, costs money, interrupts labor *and* management.

But General Electric's Group Relamping Plan solves this problem. Every 12-24 months, maintenance men, working after hours, change *all* your lamps, dead or alive. New lamps go in—on a fast production basis.

At Brown Shoe Company's office in St. Louis, one-at-a-time lamp replacement used to take 20 minutes per lamp. Group Relamping cuts that time to 3¾ minutes per lamp, saves $500 each year. And the whole place looks cleaner and brighter.

Remember: the labor cost of replacing lamps one-at-a-time usually exceeds the lamp price itself.

Compare your costs and see how Group Relamping fits into your plant, office or store. Call in your local G-E Lamp Specialist for suggestions or send for your free Group Relamping folder. Write: General Electric Co., Large Lamp Dept. GER-58, Nela Park, Cleveland 12, Ohio.

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