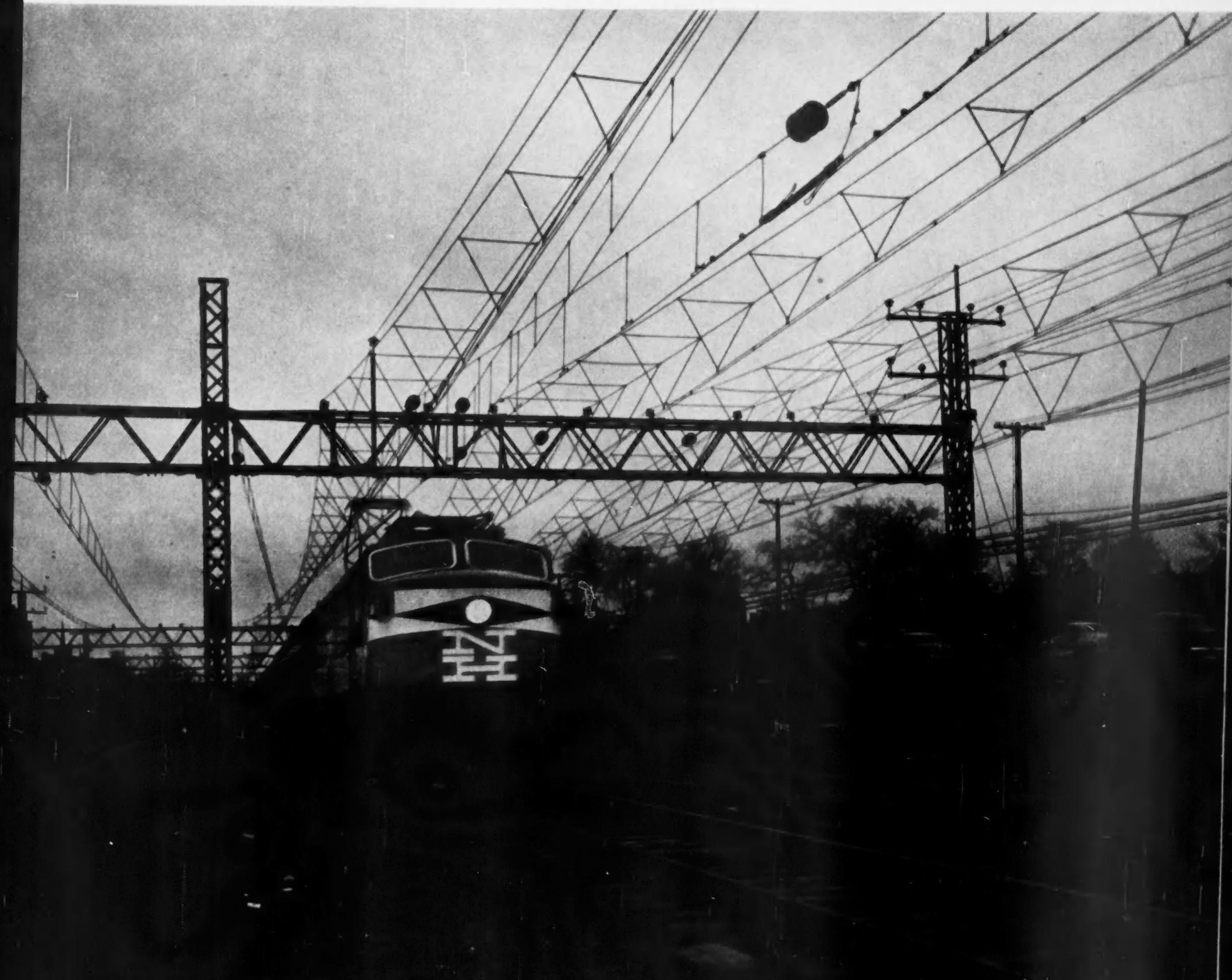
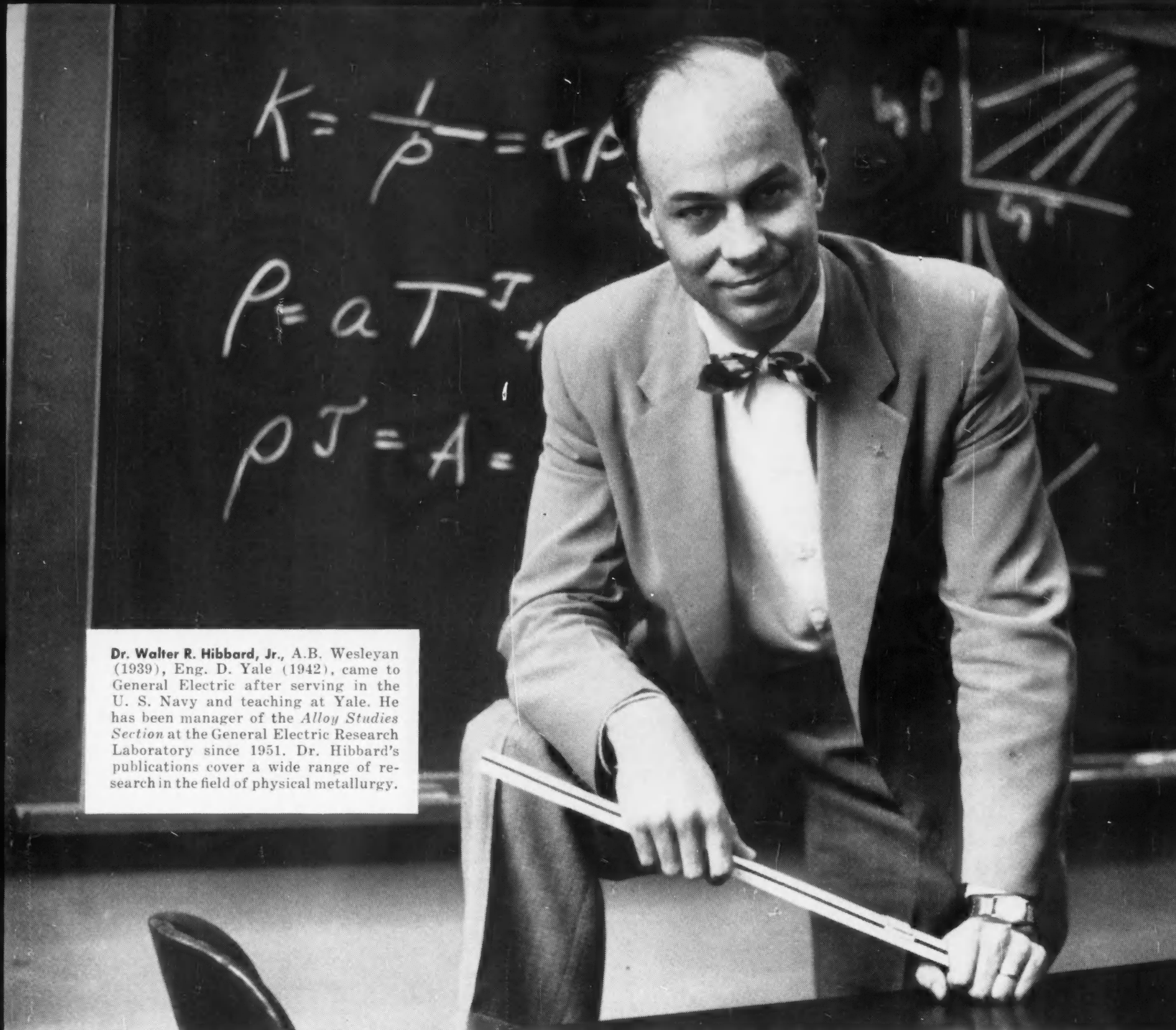
GENERAL ELECTRIC Review



SEPTEMBER 1955



SEPTEMBER 1955 • VOLUME 58 • NUMBER 5

GENERAL ELECTRIC Review

EVERETT S. LEE • EDITOR

PAUL R. HEINMILLER • MANAGING EDITOR

COVER—The New Haven Railroad's crack *Senator* glides out of the dusk at New Rochelle, NY, on its daily Washington-to-Boston run. Its new high-speed electric locomotive, one of 10 furnished the New Haven by General Electric's Locomotive and Car Equipment Department, Erie, is helping to set new standards in train performance. For more details, see pages 56–60.

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 U.S.A. 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 CONTENTS OF THE GENERAL ELECTRIC REVIEW ARE ANALYZED AND INDEXED BY THE INDUSTRIAL ARTS INDEX, THE ENGINEERING INDEX, AND SCIENCE ABSTRACTS. . . . SIX WEEKS' ADVANCE NOTICE, AND OLD ADDRESS AS WELL AS NEW, ARE NECESSARY FOR CHANGE OF ADDRESS. . . . ADDRESS ALL COMMUNICATIONS TO EDITOR, GENERAL ELECTRIC REVIEW, SCHENECTADY 5, NEW YORK.


AFTER YOU GRADUATE...
What will you do to put atomic power to work?
In this model of a possible atomic power generating station you see the future of electricity in miniature. It typifies General Electric's farsighted research and planning to harness the atom. And the young men studying it typify the Company's accent on youth to solve problems arising in this new, dynamic field. They are L. O. Sullivan (left), BS, Union '48, operations supervisor, and G. E. Martin, MME, Vanderbilt '50, design and development supervisor at the Radioactive Materials Laboratory in the AEC's Knolls Atomic Power Laboratory, which is operated by the General Electric Company.
Along with other recent college graduates working to tame atomic energy—whether in electrical, mechanical, metallurgical or chemical engineering fields, or in such areas as physics and aeronautical engineering—you will find that you are able to increase your scientific background in an after-college program of technical assignments. In this program as in your career, you select location and field from the broad scope of G-E activities that include atomic power, jet propulsion, electronics, plastics, electrical apparatus and automation components.
Working with experienced engineers, you can make contributions early in your career at G.E. For full data on the G-E opportunity suited to your skills, see your college placement director, or send a summary of your qualifications to General Electric Company, Engineering Personnel Section, Schenectady 5, New York.
TR-3
Progress Is Our Most Important Product
GENERAL ELECTRIC

THE ENGINEER—AND ENGINEERING FRIENDSHIPS

One of the great strengths among engineers is the abiding friendships which make their lives happy, helpful, and full of service. These friendships reveal the creative life of the engineer, bring a human recognition into his products, and are an inspiration to greater achievement. Without such friendships, engineering life would indeed be drab.

The other day Doc Kinnard, one of my best friends, stopped in—just to talk. Doc's engineering life has been devoted to the design and advancement of meters and instruments. We had a wonderful visit, laughing over old times—the accomplishments, the hard work, the fun.

I had just been reading Fisher Black's *Electrical World* editorial on the watthour meter. He wrote . . . "Nobody attends the dedication of a meter. No bands blare. No dignitaries orate. Yet these unhonored devices, twirling faithfully in 50 million yards and basements, measure the very life-blood of the electric utility industry. They are the cash registers which record the income to pay for epochal new generating stations which orators proclaim 'another milestone on the American way of life.' "

As Doc and I talked, I recognized that our friendship had brought to me an intimate knowledge of all that he and many other meter engineers had accomplished to give a human impact to Fisher's great tribute.

That is the charm of an engineering friendship. You sail with your friend through uncharted seas to the glory and the majesty of a completed accomplishment. Then, from one harbor, you put forth to another. As his friend, you see him intimately form his dream into a product or a service useful to mankind.

When I told a prominent engineer that I was thinking of writing this editorial, he immediately said: "Good; we need more engineering friendships." In the busy rush of daily tasks, happy is he who will take the time to form engineering friendships, and nurture them, and live with them through thick and thin. From school days on, they are one of the outstanding blessings of an engineer's life. They grow in professional association.

I was privileged to form friendships with many of our creative engineers:

There was, for example, Henry Warren, who years ago dreamed a dream of electric time, long before it was available, and who had the ability to bring it into being.

Then there was Chris Steenstrup, who brought to perfection the refrigerator mechanism sealed in steel with a permanent oil supply and thus made the electric refrigerator practical for use in every home in America.

And Bill Merrill—"Yankee Ingenuity" we called him. He guided the development of a better oil burner than ever before conceived and dolled it up into an attractive package to make the basement a homey room in the house, thus starting us on the way to the air-conditioned home.

And Leonid Umansky, contributing his engineering life to the electrification of industry, in particular the steel industry, to undergird us in time of war and to keep us in prosperity in time of peace.

To know these lives, and many more, is to see clearly revealed the greatness of these engineers in the service of their fellow men. Their creative minds brought from nature to man that which God placed there for man to have. And engineering friendships were a motivating force in their lives.

When we know and consider how these men worked, we realize anew what General Electric's former president Charles E. Wilson meant when he said to us, "Leadership resides in the individual." For it is the heritage of each and every engineer that he make himself a leader in the field where he can lead. As he forms engineering friendships and lives in them, he sees this more clearly, and he is inspired to go onward, leading in his way for service. Some will become great; some will not. Yet all will be great in the lives of those who know.

There is still ringing in our ears the inspiration we received so powerfully from another of our former presidents, Gerard Swope . . . "that the world needs men of ability, personality, and character; and that the greatest of these is character." These are what engineering friendships are made of. May they be increased.

Everett S. Lee

EDITOR

AS GENERAL ELECTRIC SEES IT...

Here are 5 ways to

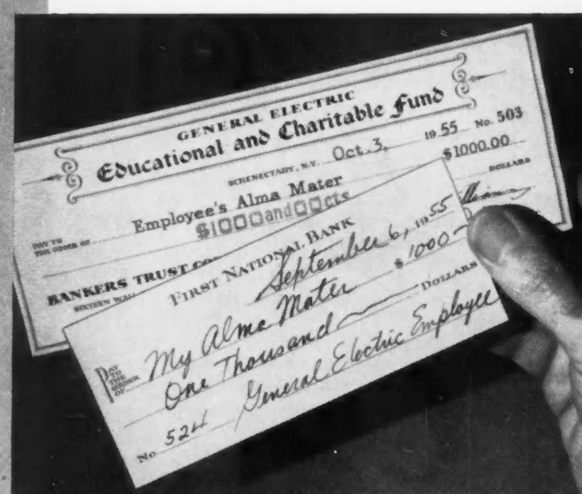
For every 5 new engineers industry needed this year, there were only 3 graduated from U. S. colleges

In 1955, U. S. industry had jobs for an estimated 37,000 engineers; our colleges graduated 21,500.* This shortage, typical of recent years, is creating an increasingly serious problem — for engineers and scientists hold the key to progress in this swift-moving technological age.

At General Electric, for example, nearly 17,500 of our people are trained in engineering or science, and we have opportunities for a thousand more technically trained people each year. The need may double in the next 10 years.

As we see it, industry, working with educational institutions, can do much to solve the shortage. On these two pages are some of the things we believe will help:

*Estimates are from the Engineering Manpower Commission of the Engineers Joint Council.



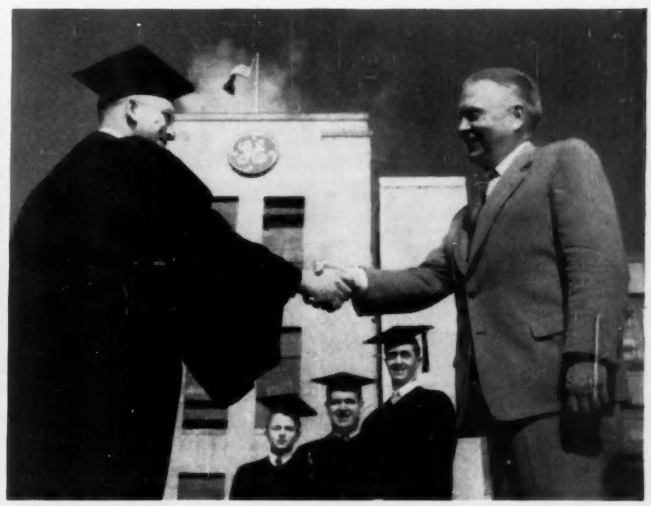
3. Help schools financially. Nearly half of U. S. colleges operate in the red. Since 1922, G.E.'s aid-to-education program has included fellowships, scholarships, and other financial support. In addition, the General Electric Educational and Charitable Fund matches, dollar for dollar up to $1,000 a year, contributions by each employee to his college.

For a detailed discussion of our views on "Basic Relations Between Education and the Economy," write General Electric, Department H2-119, Schenectady, New York.

help solve America's critical shortage of engineers

1. Help guide young people's careers. More high-school students will take the courses they need to become engineers if they know of the wide opportunities in the field. Since the 1920's, General Electric has tried to create interest by distributing a variety of school training aids. (Above, a teacher counsels students, using a G-E career guidance booklet, "Why Study Math?") In the past 10 years, schools have requested 63,000,000 copies of our training aids.

2. Bring businessmen and educators together. An understanding of the role math and science play in business can help teachers prepare students for careers. The group above is the latest of 1,450 high-school teachers to attend G.E.-sponsored summer fellowship programs. Here they have the opportunity to study at several leading colleges and to see firsthand the value of their work to business. We have also conducted conferences for college educators since 1924.



4. Educate employees on the job. The development of young people must continue after they start to work. At General Electric, we have 12 formal educational programs; the oldest — Engineering — was started nearly 60 years ago. (Above, Clarence Linder, Vice-President — Engineering Services, reviews work of engineers enrolled in our Creative Engineering Program.) More than 10,000 technically trained men and women have participated in these programs.

5. Encourage self-development. Young people with aptitude should be helped to move ahead. For example, the young men above joined our Apprentice Training Program as high-school graduates in 1949; this year they are graduate engineers from the U. of New Hampshire after a 6-year work-and-study program sponsored by our Meter Department. Donald E. Craig, General Manager of the Department, congratulates the men and welcomes them to full-time jobs.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Industry Support of Education—A Two-Way Street

By PHILIP D. REED

What does, or what should, industry expect in return for corporate support of education?

That there must be a *quid pro quo* would seem to be beyond argument. But this concept of something received for something given has been much too myopic. With the startlingly rapid growth of corporate requirements for college-trained people and the simultaneous enlargement of the colleges' needs for funds—operating as well as capital—thorough and thoughtful re-examination of the whole subject is obviously in order.

Six Categories of Grants

Most of the grants that have been made to educational institutions in the past—whether corporate or private or government—break down into six categories . . .

- Funds for research
- Capital funds for buildings
- Scholarships and fellowships
- Underwriting of specific instruction programs
- Funds for new equipment
- Capital funds for endowments

The absence from this list will at once be noted of the contribution most sought after by educational institutions—the unrestricted grant. This discrepancy between the gift and the need is probably as old as the history of educational philanthropy. William James, writing a little after the turn of the century, in an address at Stanford University on Founders' Day, spoke a little scornfully, perhaps, of the tendency of men of wealth to follow the beaten track in their donations. "What they usually think of," he said, "is a new college like all the older colleges; or they give new buildings to a university or help make it larger, without any distinct idea as to the improvement of its inner form."

Within the past few years there has been a growing movement on the part of business to reappraise its relations with and responsibilities toward education. This has, no doubt, been accelerated by the growing competition for and potentially great shortage of adequately trained manpower; by the 5 percent tax exemption privilege of the Internal Revenue Code; and by the decision of the Superior Court of the State of New Jersey in the case of the A. P. Smith Manufacturing Company — but it is doubtful that they have been the cause. For example, in General Electric, our concept of our responsibilities to education is part and parcel of a very broad concept of our responsibilities as a corporate citizen to employees, customers, share owners, suppliers, and the public.

The recent attention to corporate support of education has led to some rather striking developments. Within the past year . . .

- General Electric announced a Corporate Alumnus Program to spur gifts to colleges. Under this plan the General Electric Educational and Charitable Fund matches funds up to $1000 donated to their alma maters by graduates in our employ.
- General Motors announced a College Scholarship Plan under which at least one scholarship is made available to each private institution which has 20 or more graduates employed by General Motors.
- The Ford Foundation announced a $50-million appropriation to raise college salaries.
- U.S. Steel announced a $480,000 provision for unrestricted operating grants to colleges and universities. This is in addition to $500,000 for capital grants.

Basis of Corporate Giving

It is obvious from these few examples that industry has started to view aid to higher education in a new and wider sense. It is also obvious that even with this broader interpretation, a clear and entirely appropriate sense of *quid pro quo* remains as a basis for corporate giving.

Let us look a moment at why tnis is so. In a recent novel, a character remarks of wealth that it makes possible "life's greatest grace—the ability to be impetuously generous." If this indeed be the greatest grace, it is a luxury that modern business management cannot afford. Conscious of our corporate responsibilities to many different groups of society, we must make hard but not tough decisions. Business enterprises operated by professional managers on behalf of their share owners (frequently tens of thousands of them) are not and should not be charitable institutions. When they dispense corporate funds, there must be in their judgment some ultimate value redounding directly or indirectly to the benefit of the company.

This is a two-way street. If we are not a charitable institution, we do not believe that any college should be a suppliant. We would like to take philanthropy out of educational support by industry. We believe that there is a better basis than that.

The A. P. Smith Opinion

The principle of corporate support of education is generally recognized and has been tested in our courts. In the case of the A. P. Smith Company, which undertook to give an unrestricted grant of $1500 to Princeton University, the opinion of the presiding judge of the Superior Court of the State of New Jersey read in part:

"I cannot conceive of any greater benefit to corporations in this country than to build, and continue to build, respect for, and adherence to, a system of free enterprise and democratic government, the serious impairment of either of which may well spell the destruction of all corporate enterprise. Nothing that aids or promotes the growth and service of the American university or college in respect of the matters here discussed can possibly be anything short of direct benefit to every corporation in the land . . . .

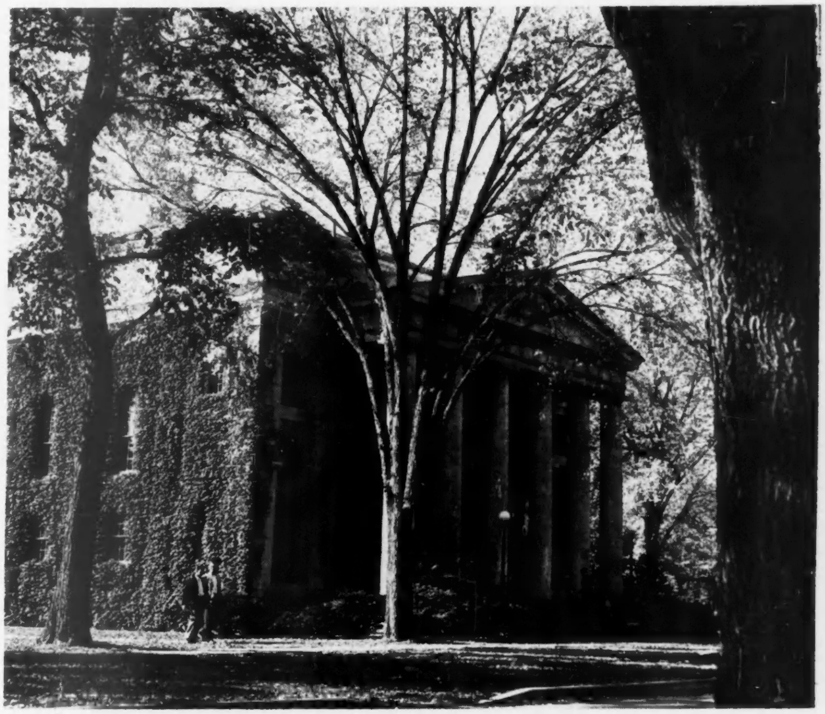
"I am strongly persuaded by the evidence that the only hope for the survival of the privately supported American college and university lies in the willingness of corporate wealth to furnish in moderation some support to institutions which are so essential to public welfare and thereof, of necessity, to corporate welfare.

•

Mr. Reed is Chairman of the Board, General Electric Company.

"It is settled law here and in England that a corporation or association possesses not only those powers which are expressly conferred upon it by its charter, franchise, or articles of association, but also all incidental powers reasonably designed or required to give fuller or greater effect to the expressed powers . . . . Such giving may be called an incidental power, but when it is considered in its essential character, it may well be regarded as a major, though unwritten, corporate power. It is even more than that. In the court's view of the case it amounts to a solemn duty . . . ."

This concept being accepted as sound, the right of industry in its own enlightened self-interest to help education balance its budget would seem to be beyond question. But broad principles require bills of particulars, and there the difficulties begin. To give or not to give is no longer the question. The big question is: How?



INDUSTRY SEEKS AN EQUITABLE, EFFECTIVE PATTERN FOR AIDING HIGHER EDUCATION.

How To Choose Between Colleges?

How does business choose between some 1300 colleges and universities? How do we determine the ones who deserve unrestricted gifts and the ones who will use them wisely? And how, as Peter Drucker has asked, do we assume industry's rightful share of responsibility for the support of education, without exerting an unwanted authority over it?

One approach to these troublesome questions is to set up a fund or foundation. But while this delegates the responsibility, it does not automatically assure answers to all the questions.

The truth is that there are no quick and easy answers. The right relation of the corporation to educational institutions is being slowly and sometimes painfully worked out.

One approach to the problem of how to give, which has been confirmed by considerable precedent, is for a company to make a grant to institutions located in the same community as its main plants or places of business. This would seem to be a reasonable basis for selectivity. All our concepts of good citizenship, individual and corporate, are rooted in the community.

Local College Concept

General Electric is fortunate in having many of its plants located in close proximity to outstanding colleges and universities. We deeply appreciate having such educational facilities available to us and our employees and will continue to come to their support in proportion to our responsibilities. Yet when we look at the picture at a national level, we find that the Company has 135 plants in 105 cities in 28 of the 48 states, and places of business in all of them. The local college concept becomes very difficult on a nationwide basis.

Another approach, which would seem to apply with special emphasis to a company like General Electric, involves such items as grants, scholarships, and fellowships to foster an adequate supply of technically trained men. We are particularly proud of the very high proportion of engineers and scientists to all other G-E employees.

Yet, of approximately 25,000 employees with degrees from 650 institutions of higher education about one fourth are nontechnical.

Of the people with college degrees added to our payroll in recent years, 45 percent have been nontechnical.

A Re-examination

Industry has had to re-examine its concepts of potential manpower and adequate training. And this re-examination has applied to both technical and nontechnical graduates. We have observed in recent years the application of new disciplines to many functions and operations of industry brought by nonengineering graduates holding A.B. and M.A. and Ph.D. degrees in the sciences and other fields who have moved into jobs of increasing specialization or management responsibility. Similarly, we have seen technical graduates moving into areas of management or specialization widely diverse from their educational backgrounds. The obvious connection between technical education and the future of industry remains, but the nonobvious connection between education and industry through the educated man in almost any field you can name has been illuminated. In other words, students generally must be regarded as potential employees of General Electric.

Still another approach to the problem of how to give is exemplified by the Corporate Alumnus Program. It recognizes that the immediate beneficiary of American higher education is the educated individual, and through him the organization of which he is a part. It is only appropriate and fair, therefore, that both the individual alumnus and the employing organization should join, in some fashion, in any giving plan. It delegates to the individual alumnus the responsibility for deciding the ultimate benefits of his education to himself and his organization and what share of support for his college or university they both shall bear. It is hoped that under this plan, if generally adopted by industry, the individual decisions of tens of thousands of alumni will form a wiser and better basis for widespread support of education than any other plan now extant.

These are some of the approaches by industry to working out a basis for corporate giving. We come now to a point that I have been leading up to. Industry cannot construct a policy and a program for the colleges that will justify it in coming to the support of education. That is up to the individual college or university and to its alumni. We can only give you hints of what we will require.

On What Basis?

If location in the same community is not enough, or if a college cannot compete as a source of technically trained manpower, then on what reasonable basis can the liberal arts college in America today construct a case for the general support of industry?

The long-run value of the college or university is not, at least at the undergraduate level, in creating technical specialists. We employers are both staffed and qualified to provide the specialized training needed by our college graduate recruits, technical and nontechnical. The broader and much more important contribution of the college or university is that course of study which gives men balance, perspective, understanding, and the ability both to communicate and reason. History, languages, public speaking, and economics, together with mathematics and the basic sciences, are fundamental requirements—standard equipment if you will—of the college graduates of a country which is successfully to maintain the social, economic, and political climate of a great democracy. Without such a climate, business could not survive, and certainly it could not prosper and continue to make progress. These are the ancient gifts of education to any civilization, and on a long-range basis they promise the greatest returns.

In short, business is not asking, except in special cases, that colleges produce specialists in this, that, or the other skill but, rather, that they turn out good and soundly grounded citizens. And business asks of a particular institution in which it may invest that it be, for lack of a better term, a "going concern." Business can understand and appreciate a going-business-in-search-of-new-capital approach.

What Business Wants

Such an approach is not always easy to take. It involves not only looking educational programs and college business management "squarely in the eye," as Dr. Wilson Compton puts it, but also realistically facing up to some of industry's problems in coming to a college's support. What does business want to know?

- Business is interested in the quality, the efficiency, and effectiveness of educational administration. This is one thing that business and education have in common, and one criterion that business is particularly competent to apply.
- Business likes to see budgets. We don't expect a college or university to make a profit, and we don't see any reason why a college should, even if it could, run an educational institution on the income from an endowment, but we do like to know that someone knows what are the expenses of an academic year and where the funds to meet those expenses can reasonably and properly be obtained. If an institution is seeking the support of the public and its private sectors, it must expect to make its financial statements public.
- Business expects a college to be extraordinarily concerned with the quality of its product—which is our most essential raw material.
- Business is impressed by widespread alumni support: First, because we know that the needs of education for private support cannot be met except by infinitely more, and wider spread support by all the private sectors of our society; and second, because we respect the judgment of alumni of those needs.
- Business is sometimes more impressed by the cutting out of one program than by the adding of new ones. It is always easy to add new programs, particularly with the rapid development of our society and technology in recent years. It is not easy to measure established programs against rigorous performance standards and to incisively carve out those that don't work. But this kind of self-help may be the best evidence of the virtue and vitality of an educational institution that justifies an investment in it.

The College's Case

If this approach seems a bit rough, let me point out that it has nothing to do with academic freedom and is nonrestrictive in regard to the aims, purposes, and methods of education. In fact, it may be the first step in helping to insure that freedom for the future.

Dr. Lawrence A. Kimpton, Chancellor of the University of Chicago, has suggested that the best way for a private college or university to get the kind of aid which will preserve it on a free basis might be for each educational institution that believes itself worthy of support to make a case to industry and have these cases freely judged in a competitive market. The products of the university—both its great men and its great ideas—must ultimately be tested in the competition of the market, as Justice Holmes has reminded us. He once said, ". . . the ultimate good desired is better reached by free trade in ideas. The best test of truth is the power of the thought to get itself accepted in the competition of the market." Are there any considerations that make it unwise for an institution openly to recognize that it is basically in competition for private support?

Finding Patterns for Giving

The matter of finding an equitable, effective pattern for corporate giving is a matter of concern to everyone in education and industry. As Clemenceau said of war, that it was "much too important a thing to be left in the hands of the generals," I believe that the private support of education is too important to be left to college presidents and administrators. And the combined efforts of a few companies, even very large companies, cannot begin to fill the gap.

But fill it we must, for its importance is self-evident. Indeed, our greatest potential shortage in the United States may well be people—educated and trained people.

Nor is this unpleasant truth a recent discovery. Alfred North Whitehead summed up the situation for our times as long ago as 1917 when he wrote: "In the conditions of modern life the role is absolute, 'the race which does not value trained intelligence is doomed.' Not all your heroism, not all your social charm, not all your wit, not all your victories on land or sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated." Ω

WITH TODAY'S MORE POWERFUL LOCOMOTIVES, RAILROADS MUST SOLVE THE PROBLEM OF . . .

Why Do Locomotive Wheels Slip?

By R. K. ALLEN

Railroad men have wrestled with the problem of wheel slip ever since George Stephenson built the *Rocket*. Some early inventors even designed locomotives with cog wheels to run on toothed rails because they believed smooth wheels and rails would not give sufficient coefficient of friction to pull a train.

Through practical experience with the steam locomotive, engineers learned much regarding wheel slip and its prevention. However, the advent of the diesel-electric locomotive accentuated this problem for two reasons: its low-speed pulling power is greater than its steam predecessor's, and each driving axle is motored separately and not connected to the others by driving rods, permitting each axle to slip independently.

Fundamental to a railroad's operation is the ability, known as adhesion, of a locomotive driver to hold the rail without slipping, defined as . . .

$$\frac{\text{locomotive tractive effort in pounds}}{\text{locomotive weight on drivers in pounds}}$$

The limiting adhesion is equal to the coefficient of friction between the wheel and the rail. And years of experiment and experience brought about substantial agreement among steam-locomotive designers on the limiting values of adhesion that could be used—a prime factor in locomotive design for more than a century. Today, high-powered diesel-electric and electric locomotives can work beyond adhesion limits previously used in the design of steam locomotives. Thus they magnify the manifold problems resulting from wheel slip—rail damage, damage to electric equipment, and sometimes complete stalling of the train.

Wheel slip and its associated troubles seriously hinder maximum operating efficiency on railroads. And so two questions naturally arise: Why not design locomotives below the critical limit of adhesion? what is this limit? Actually, limiting adhesions as high as 40 percent and as low as 2 percent have been observed in service on locomotives with electric drive. Designers decided to live with this wide variation, attempting to protect against uncontrolled wheel slip. But lack of dependable adhesion values presents a barrier to the design of higher powered locomotives and eternally plagues railroad operation. Several years ago the Reading Company discussed this problem with the General Electric Company, resulting in a study of the fundamentals of rail to wheel adhesion.

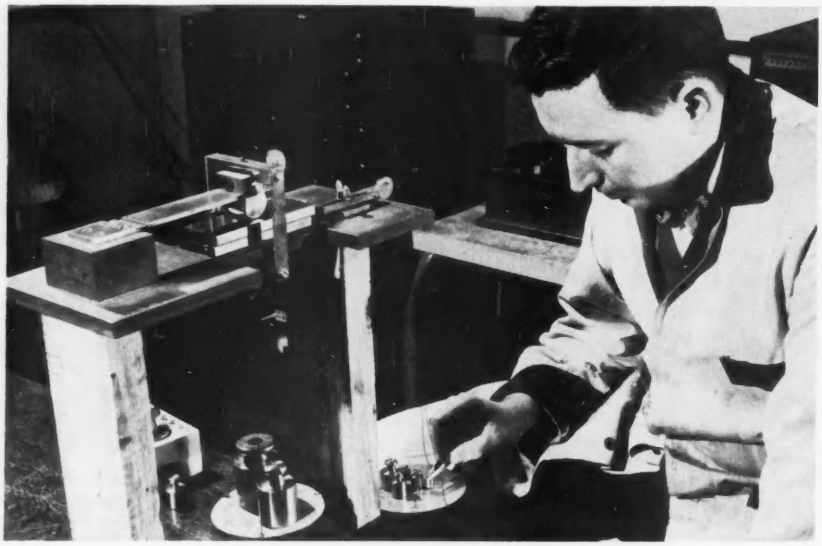
Studying the Problem

For day-to-day operation most railroads limit train tonnages to amounts that can be hauled with 16 to 18 percent adhesion on the locomotive drivers. Even then, wheel slip occasionally occurs and may become excessive at certain locations. With weather a contributing factor, the worst conditions occur during heavy dews or with the onset of rain. Because general opinion believed the culprit to be incipient rust film on the rail, laboratory work was directed toward isolating the slippery ingredient arising from this condition.

Simulating the rail with a steel plate, rust films ranging from a mere trace to heavy reddish-brown deposits were formed on it. Breakaway coefficients of friction were measured on each of these films. The trend indicated that the heavier the rust film the higher the friction coefficient. No radically low readings were observed. Several weeks of testing only served to deepen the riddle. Evidently, either rust films were not slippery or the techniques of producing and measuring them were not sufficiently refined.

In an effort to get more conclusive results, the test equipment was completely redesigned to duplicate as nearly as possible actual railroad conditions. A study was made to determine the area of contact, the area-shape factor, and the contact pressure existing between a locomotive wheel and a rail. And the results indicated that for a 40-inch diesel-electric locomotive wheel with a nominal axle loading of 60,000 pounds the contact pressure was between 70,000 and 100,000 psi. The exact amount depended on rail and wheel wear. When a wheel at half of its permissible wear is in contact with average mainline rail, the area is nearly rectangular except for rounded corners. Its dimension across the rail is approximately three times that along the rail. And the contact area is 0.4 to 0.5 square inches.

To be as authentic as possible, a



AN ENGINEER in the Physics and Applied Mathematics Unit, Materials and Processes Laboratory, Locomotive and Car Equipment Dept., Erie, Pa., the author came to GE on the Engineering Program in 1951. His work involves investigation of small contacts, insulation studies on locomotive components, and laboratory and field work on the adhesion project.

2x5-inch flat plate was machined from a piece of 100-pound rail. Also made from this rail was a barrel-shaped 1¼-inch-diameter piece with a 3½-inch transverse radius. This piece, hardened to conform to American Railway Engineering Association (AREA) specifications for Class A and B locomotive wheels, contained the curvature of the wheel and the rail crown. A cantilever support held it firmly fixed. Being supported on two parallel rows of ball bearings, the flat plate was free to move. A wire attached to this plate extended over a pulley to a weight pan (photo). A force representative of the locomotive tractive effort was applied by placing weights on this pan. The device was so designed that the contact width was three times the contact length, and the contact pressure was 75,000 psi.

Although hopes were high that the new device—designed to simulate railroad conditions as closely as possible—would solve the riddle, the results were most disheartening. For in initial tests, measurements to determine the coefficient of friction on clean rail varied indiscriminately from 10 to 30 percent. No matter how carefully the surface was prepared, it was impossible to obtain consistent results. All variables seemed to be accounted for. The surfaces were even cleaned with alcohol before each test to remove contamination. Still, the wide spread of the data seemed to indicate a missing variable. No analytical solution was readily apparent. But tests continued in the hope that careful attention to detail might produce some clue that would lead to a solution.

Oil Film Discovered

But after some time, a pattern began to appear. It was noticed that after a test in which the friction coefficient was high the plate could be wetted with water. Conversely, when the test showed a low friction coefficient, water would not wet the test plate. What did this mean? An electroplater might have spotted it as a telltale sign of film contamination. But to anyone unfamiliar with electroplating techniques, its significance was recognized more slowly.

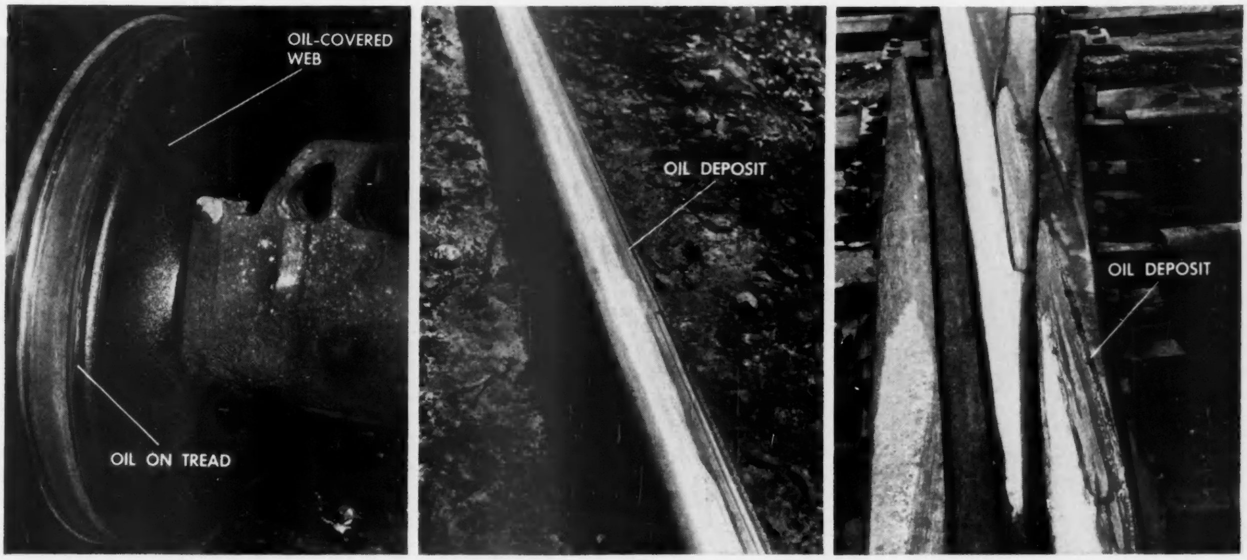
All the steps made in the surface preparation and making of measurements on the plate were carefully retraced, finding that the condition of nonwettability occurs during a rinsing operation. The plate was polished with several emery cloths of increasingly finer grit. Then it was rinsed in running water. If the rinse water contacted any finger marks on the edge of the plate, the water was immediately repelled from that area. Eventually, the water film was literally chased off the surface of the plate by these repelling films. The actual phenomenon was substitution of an invisible oil film in place of the water film through surface-tension action. If the plate were carefully prepared so that this did not occur, the friction coefficient was 30 to 35 percent. Whenever the invisible creep film did occur, the coefficient dropped to between 15 and 20 percent—even with a contact pressure of 75,000 psi. This accidental film contamination was the clue that eventually led to an understanding of fluctuating rail adhesions.

Following the discovery of the effect of human oil in forming films and reducing friction coefficients, various other animal and mineral oils were tried. Sperm-whale oil produced exactly the same effect as the fingerprints, with creep-film coefficients of 15 to 20 percent. A uniform layer of whale oil wiped over the plate and then removed with a clean cloth gave a coefficient of 10 percent. Clean mineral oil did not produce the creep effect when in contact with water. Rather, it tended to float on top of the water layer instead of displacing it from the plate. A uniform layer of mineral oil wiped from the test plate gave friction coefficients from 15 to 27 percent, depending on the amount of wiping. This film was neither tenacious nor tough as was the film formed by human and whale oil.

The results indicated an essential difference between the human (or animal) oil and clean petroleum oil films. The petroleum films are not formed by creep action and do not give the drastically reduced friction coefficients. Also, the coefficient may be increased by vigorously rubbing the film with a clean cloth.

The laboratory measurements indicated a range of friction coefficients from 35 percent with careful cleaning to a low of 10 percent with invisible human and animal oil films. The original range sought was the 40 to 2 percent that had been measured in actual service. However, tests run in Switzerland and Germany showed that the adhesion limit decreases with increased train speed. This effect is explained by unevenness in the roadbed, track joints, friction in moving truck parts, and rocking of the weight applied to each axle. The low figure of 2 percent was measured on passenger trains at 60 mph. According to the European test curves, this 2 percent at 60 mph would be approximately 10 percent at zero miles per hour and hence would correspond exactly with the lowest figure measured on the laboratory test device. The first hurdle was passed. And the negative results first obtained with rust films were correct—the real culprit was oil creep film.

Having accidentally come across boundary lubrication effects with in-



OIL LEAKING FROM JOURNAL BOX spreads over the wheel face (left) and onto the tread. When the oily tread strikes the rail, a slippery film is deposited on the running surface (center) and is concentrated particularly at switches and crossovers (right).

visible oil films on the laboratory replica of a wheel and rail, the question arose as to whether this might actually be occurring on the railroad. Because the good agreement between the range of laboratory measurements and those reported from the field strongly indicated this, a study was made of actual track conditions in the Erie area.

Performance in the Field

Mainline rail has a highly polished wear band in the center of the head produced by the rolling action of the wheels. On bright, sunny days or following a prolonged heavy rain, it could be wetted with water. But on some cloudy days, especially when the relative humidity was high, the wear band could not be wetted and a greyish, streaky discoloration was observed. A sample of this opaque film was wiped up with filter paper and analyzed as being 86 percent moisture; the remaining 14 percent consisted of oil, iron, silica, and a trace of copper.

Further inspection showed that curved track contained a heavy black paste deposited on the outside edge of the inside, or low, rail of the curve. A sample of this deposit was also analyzed and found to contain oil, carbon, silica, iron, and traces of aluminum, copper, and manganese.

Noting the oil content of both samples, some of the heavy deposit was collected, brought to the laboratory, and placed along the side of the test plate's top surface. Water was then introduced on the clean metal surface. When it reached over to the deposits, a creep film began to form and the water was displaced from the plate surface. Measurements of the coefficient of friction on this invisible film corresponded to those with human and animal oil creep films.

It now seemed evident that oil films and boundary lubrication were important factors in fluctuating friction coefficients. To further clinch the matter, the laboratory device was modified so that it could be used to measure actual values on the railroad. Essentially, it became a sliding-block arrangement (photo, left, next page). The barrel piece was mounted in a frame containing weights so that contact area and pressure were the same as in the laboratory device. The device was placed on the rail so that the barrel piece contacted the actual rail instead of a test plate as in the laboratory. Limiting adhesion was measured by reading the force on a pull scale at the instant that motion occurred. Dividing this figure by the weight of the device gave the measure of the friction coefficient.

The measurements varied with the condition of the wear band which in turn depended on the weather. If the wear band was wettable, the coefficient of friction was high; if not, it was low. The lowest coefficient on apparently clean rail occurred adjacent to visible oil deposits on damp, cloudy days. These two conditions—moisture plus oil—were the same ingredients that gave low coefficients on the laboratory test plate. Water alone did not change the value when the wear band was wettable. Under such conditions of no film on the wear band, the friction coefficient was the same on wet or dry rail. If any water reached over to an oil deposit, the value would be lower when a repeat measurement was taken.

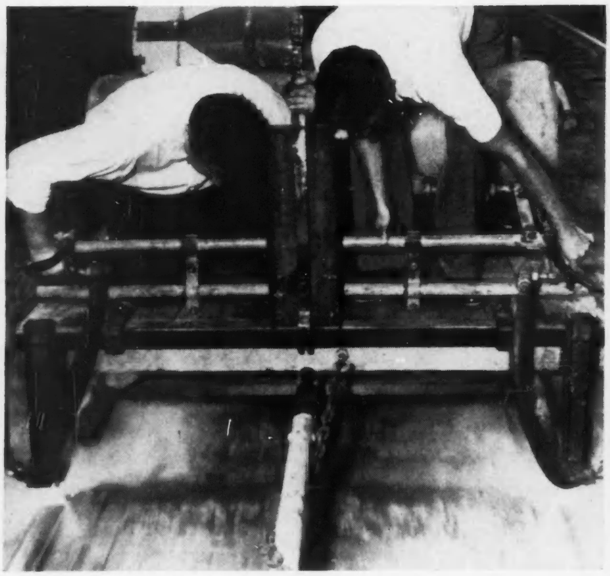
The results of these local field tests further confirmed the theory uncovered by the laboratory tests. The indications seemed so positive that the laboratory phase of the project was brought to a close. It now remained to prove the theory conclusively under actual railroad operating conditions.

Service Observations and Tests

Arrangements were made with the Reading Company to conduct tests with locomotives hauling regularly scheduled freight trains. These locomotives were equipped with recording instruments to measure traction generator horsepower and to indicate locations of wheel slip and sanding. From these measurements, the locomotive tractive effort and the adhesion at the time of each wheel slip could be calculated. Also, a chart of the limiting adhesion on each grade could be obtained, plus the precise location of each point of limiting adhesion.

Some 3000 miles of observations and tests showed definite and repetitive patterns. The first was the weather's influence. Wheel slip was considerably less on clear days and on days immediately following a long, heavy rain. Fog,

TO SUBSTANTIATE laboratory findings on the importance of oil films, test equipment was modified for use on actual railroad track.



TO FURTHER STUDY wheel slipping, a special train was assembled to clean the rail by spraying it with detergents and washing it.

dew, and the onset of rain always increased the occurrence of wheel slip. Examination of yard tracks at the end of a trip on a foggy, moist evening showed that the rails were film coated and thus not wettable.

The second pattern was the location of wheel slips. Virtually all slips occurred either on curves or at special track work (switch points, frogs, and crossovers) or at highway crossings. Locations of slips were all accurately marked to the nearest telephone pole along the right of way. Following a series of tests on a particular grade, a ground inspection was made of these locations of limiting adhesion. The slipping always occurred in areas adjacent to visible oil deposits. Thus the question arises: How do these oil deposits get on the rail?

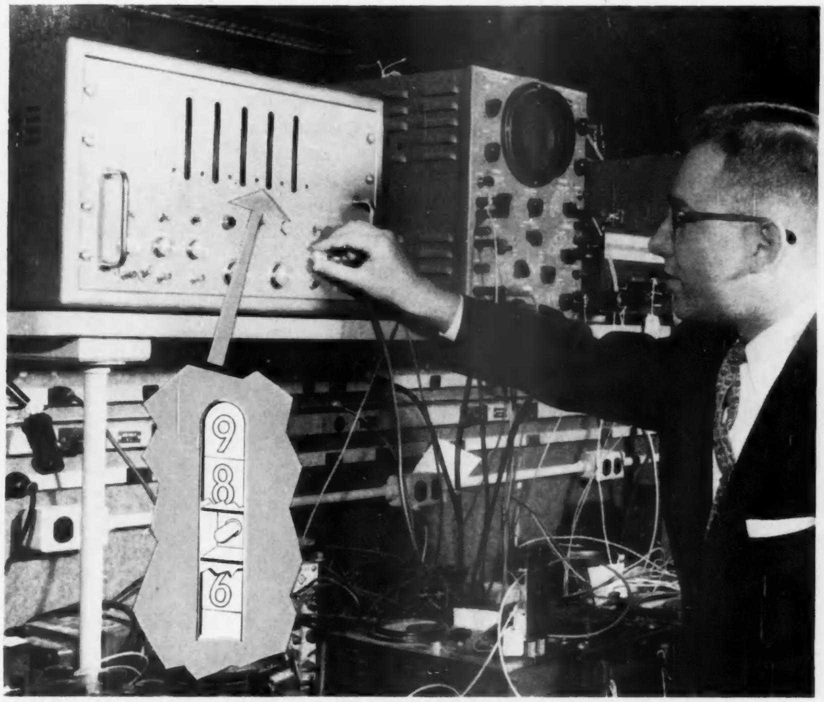
The journal boxes on almost all freight cars leak oil to some extent. On approximately half of these cars at least one journal will have a bad oil leak. This oil finds its way out of the journal box and over the outer wheel face until it reaches the wheel tread (photo, left, page 13). Here it collects on the outer tread surface. When rolling on level, straight track, this portion of the tread extends beyond the rail and thus does not contact the running surface. The track gage on curves is slightly wider. The action of centrifugal force causes a lateral shift of the car. This brings the oily part of the wheel rim into contact with the outer edge of the inside rail. As a result, oil is deposited along the edge of the rail (photo, center, page 13). Similarly, when crossing frogs, switch points, and crossovers, the oily part of the wheel rolls over portions of the rail, depositing oil directly on it (photo, right, page 13). Slipping at road crossings seems to be caused mainly by oil contamination from highway vehicles spread over the rail.

Knowing how oil deposits get on the rail makes it possible to disclose the conditions leading up to low adhesion limits. When these oil deposits are exposed to the sun, they oxidize and develop the same creep effect as human and animal oils—verified by one of the laboratory tests. Under the proper conditions, such as the onset of rain or a heavy evening dew, the rail temperature approaches the dew point. A thin, invisible moisture film forms on the rail and reaches over to one of the oil deposits. Surface tension draws a thin, invisible oil film back over the rail, displacing the water. The result: a moisture-propagated creep film covering the head of the rail.

Because smooth surfaces greatly enhance this creep effect, the highly polished wear band and the manganese steel in frogs and crossovers are especially susceptible. Once established, the thin film will remain until further oxidation by sunlight destroys it or the wear of traffic abrades it from the surface. A heavy, prolonged rain will deplete and eventually exhaust the oil-deposit reservoirs. This explains the restoration of high adhesion limits under these circumstances.

What is the effect of these creep films? The laboratory measurements indicated that they generally reduced adhesion limits to approximately 15 percent—in extreme cases, 10 percent. Measurements on train tests showed values as low as 12 percent at 10 mph and 5 percent at 40 mph. Measurements made during ground inspections of these locations showed limiting adhesions from 10 to 30 percent, depending on the time of day, the traffic, and the weather. In many locations heavy, visible oil deposits were spread over the whole rail head, especially along sharp curves. Truly, these were locations of limiting adhesion. The results obtained in these tests explained the mystery of tremendously high and incredibly low adhesion limits that have been reported in the past.

As often happens, this project snowballed into far more than was originally anticipated. With the discovery that regions of limiting adhesion did exist and with an exact knowledge of how they were caused, a new phase of work began—that of devising a practical means of eliminating these regions from the railroad. For a section of rail with a friction coefficient of 10 percent had been raised to over 40 percent by meticulous scrubbing with detergents and rinsing (photo, right). The elimination of the age-old barrier of low adhesion limits will permit railroads to make better use of today's locomotives, preparing the way for the more powerful locomotives of tomorrow. Ω



TINY NEON GLOW LAMPS in large quantity are utilized in events-per-unit-time instruments and other counters of various types. Simplified design in inset shows lamp mounting.

Miniature Lamps— Marvels in Size, Performance, Reliability

By G. F. PRIDEAUX

A small light source can perform a large service. Sometimes in an emergency, even a flashlight has heroic value. And every day, surgeons rely on miniature lamps to examine eyes, ears, or nasal passages. The grain-of-wheat lamp, tinest of all, has long been famous for its use in operative surgery. Besides such service to safety and health, the miniature lamp has large-scale uses for the community, playing a vital role in the telephone switchboard, for example.

Today, much attention focuses on automation—a field demanding an abundance of miniature lamps. This integration of production processes, promising vastly increased output, involves a complex system of co-ordinated elements. And miniature lamps equip the instruments and dials that report the state of co-ordination and that give warning when some function is threatened.

In myriad other ways, designers rely on these small light sources as components in countless products and services. Because miniature lamps are available in a wide range of specifications, it is too often assumed that whatever the problem some lamp will solve it. Although this suggests the confidence that lamps have created, they should not be taken too much for granted—and for good reasons.

In certain applications calling for miniature lamps, the designer may be restricted in his choice of bulbs. The lamp must be adapted to the nature of his products, a condition that often limits his choice. Other applications may permit him to choose the lamp before the design is frozen, giving him considerable latitude. This way, he can select a lamp especially well suited as a component in his product. But too often it happens the other way. Then he must compromise his choice of lamp, often adding higher initial cost and subsequent maintenance obligations. Perhaps a better acquaintance with the fundamentals of miniature lamps could have saved a lot of trouble and expense. A better product is worth the effort. (Miniature lamps include small standard-voltage incandescent lamps [photo, left, page 17] and neon glow lamps, as well as the lamps long listed by manufacturers as miniature lamps.)

Miniature lamps generally are divided into three broad classifications—flange-seal, butt-seal, and pinch-seal.

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Mr. Prideaux began his G-E career with the Edison Lamp Works, Harrison, NJ and for the past 33 years has closely followed miniature-lamp applications. For his development of the photoflood lamp, Mr. Prideaux received the Charles A. Coffin award in 1933. He is now Illuminating Engineer, Miniature Lamp Department, Nela Park, Cleveland.

Flange-Seal Lamps

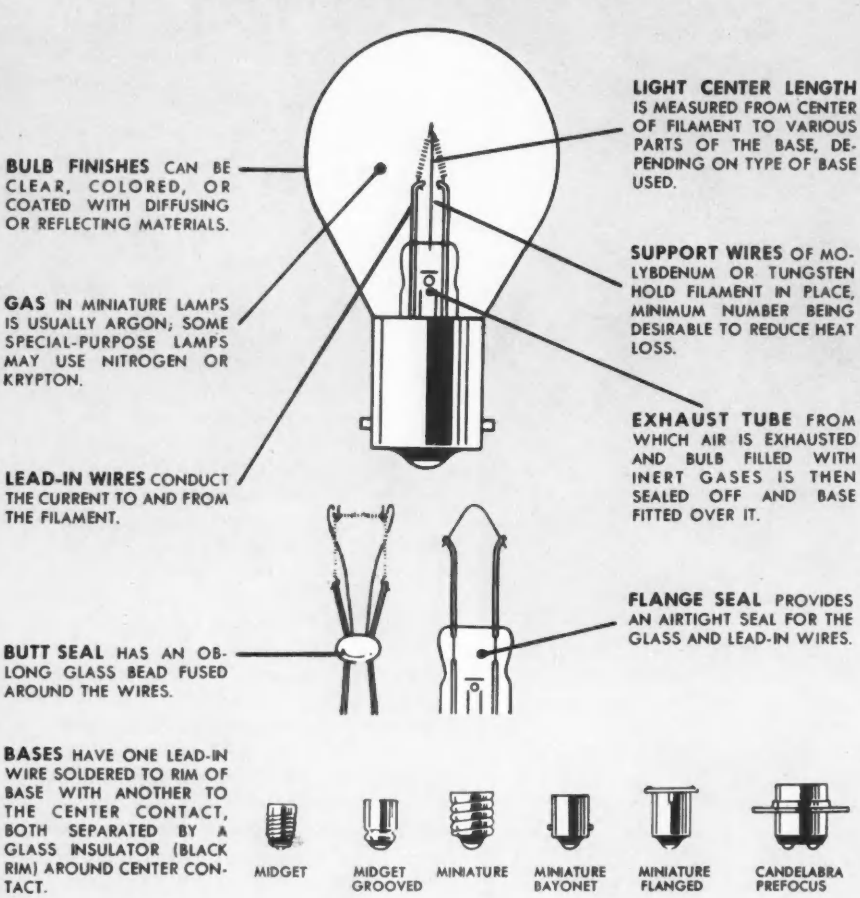
Some special characteristics of the flange-seal lamps are: 1) higher current lamps can be made successfully; 2) in the miniature lines, this has made ampere ratings up to 12 amp practical; 3) the plane of the filament is generally in the plane of the lead wires; and 4) when these lamps are made with bayonet bases, the plane of the filament and lead wires is normally at right angles to the plane of the base pin, though no close limit applies (illustration, next page).

A large percentage of miniature lamps are used in optical systems of various types, the majority having parabolic reflectors or reflector-lens systems. These require concentrated filaments for the proper control or redirection of the light emitted from the filament. Such reflectors can build up a narrow beam of light 1000 times stronger in its brightest part than light from a bare lamp. For such precision work, the filament should always be located within a few thousandths of an inch of the focal point of the reflector.

Butt-Seal Lamps

Widely used, the butt-seal lamps are employed in such applications as telephone switchboards. Airplane pilots depend on them to report the vast array of information on their instrument panels. Flashlights, clocks, radios, and coin machines use them. And a great variety of inspection tools are also equipped with them.

MINIATURE LAMP COMPONENTS



The term "butt-seal" comes from the way the lamp is made. A mount—consisting of lead-in wires, bead, filament, and, occasionally, anchors—is dropped into the open end of the bulb. The lead-in wires are bent to locate the filament at approximately the desired distance from the end of the bulb. An exhaust tube is then dropped down and butted against the lead-in wire and glass bulb. Flames then seal the parts together. The lamp is later exhausted and tipped off. The seal of this lamp is fragile. For the lead-in wire may break off or, more particularly, a tiny air leak may develop at the seal point of the lead-in wire. The base applied later, together with the basing cement, becomes important in this connection. The base and cement not only provide the lamp contacts but also protect the delicate seal.

Butt-seal lamps are generally limited to about 0.8 amp. A few are made with a higher rating; but at 1 amp, quality control is more difficult to maintain. Because only the force of gravity holds the small mount and because the glass is worked during sealing, the filament seldom seals exactly in the center. This peculiarity led to the specially designed prefocused flashlight lamps. Dropping an extended lead-in wire into the top tip of the one-half-inch bulb tends to locate the filament. At basing time, three magnified views of the filament are projected on a screen. By means of three separate adjustments, the bulb is moved to position the filament closely with reference to three bosses on the base flange. The application of heat to the basing cement sets the filament.

Pinch-Seal Lamps

The pinch seal has been used for many years on the small neon glow lamps. Lead-in wires are sealed and pinched in the glass at one end of the small tubular bulb and the lamp tipped off at the other end.

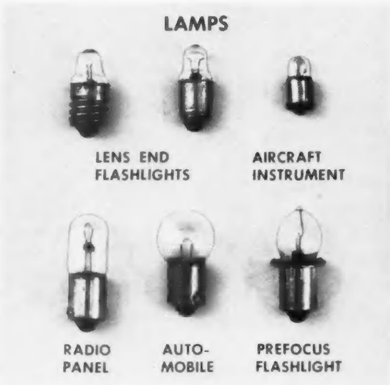
Recently announced was a new baseless miniature indicator lamp having a pinch-type seal. Differing from the neon lamp, the exhaust tip is located at the bottom rather than the top of the lamp. In this instance the lead-in wires are two rigid pins for mounting and electric contact. Because the conventional screw base, basing cement, and soldered connections are eliminated, some of these lamps may operate up to 600 F instead of the 350 F of conventional miniature lamps. Logically, their initial use appears to be in electric hotplates, waffle irons, casseroles, broilers, fryers, irons, toasters, and other appliances where operating temperatures are high. The $2\frac{1}{2}$-volt lamp was first, followed by 6.3- and 7-volt lamps for radio, television, and coin machines. Other ratings are expected for additional applications.

Glow Lamps . . .

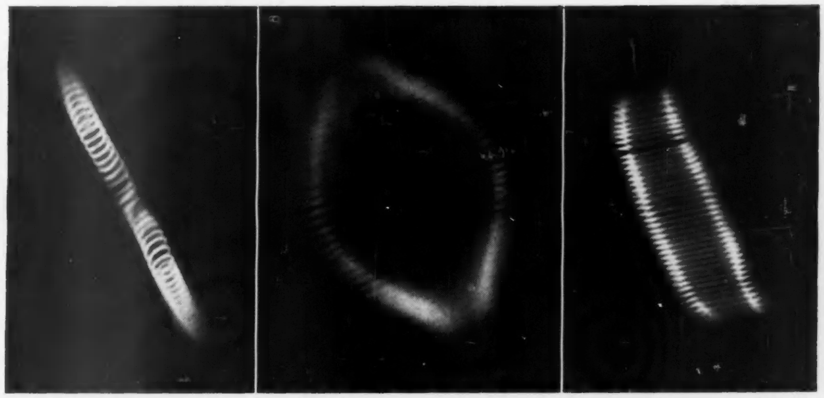
Glow lamps have a critical breakdown, or starting, voltage. When this starting voltage is reached, the discharge begins and light is emitted. Once started, the glow will continue at its maintaining voltage; on d-c the discharge will maintain at close to 15 volts below the starting voltage, permitting various applications. The glow lamp, like all electric discharge lamps, has a "runaway" characteristic and must be operated in series with some current-limiting device such as a resistor. The lamps, equipped with candelabra- or medium-screw base, have a built-in ballasting resistor to limit the current when operated at normal volts. Those with bayonet base or wire terminals require an external limiting resistor or other impedance.

Ionization time and starting voltage increase appreciably in total darkness for most lamps. Some specially treated lamps are an exception. Deionization time under average conditions may be about one millisecond. The light output follows current approximately linearly up to the flashing rate of 15,000 cycles. Glow-lamp characteristics are not noticeably affected by ambient temperatures below 300 F. When exceeding this temperature, gases evolve from the bulb walls to seriously affect lamp characteristics.

At normal current the brightness of the glow-lamp electrodes is approximately 50 to 100 footlamberts. The glow lamp has an inherently long life compared with filament lamps. The useful



WIDE SCOPE of miniature lamps is suggested by a few of their representative uses.



RADIO–PANEL LAMP synchronizes filament and lead-in wire resonant frequency (right) vibration formerly moved filament in one direction (left), lead-in wires in another (center).

life of the glow lamp—limited only by the gradual rise in starting voltage, slow bulb blackening, and gradual reduction of lamp brightness—is a function of lamp current, varying approximately with the inverse cube of the current. Most glow lamps are filled with neon gas; but a few are filled with other gases, such as argon.

. . . and Their Applications

Glow lamps make excellent live-circuit indicators due to their small size, low wattage consumption, and low cost. By utilizing their critical starting voltage, they can also be used as voltage indicators. When connected across a potentiometer, or voltage divider, they can indicate the presence of any voltage above their starting voltage.

Essentially constant-voltage devices, glow lamps can sometimes be used as voltage regulators—subject, of course, to the limitations of maintaining voltage and not exceeding safe current values.

The lamp's critical starting voltage and differential in d-c maintaining voltage also permit its use in a flashing, or oscillating, circuit of the relaxation type. The capacitor charges at a rate determined by the resistor. When the capacitor has charged to a voltage equal to the lamp's starting voltage, the capacitor discharges through the lamp, beginning a new cycle. Because of the drift of the lamp's frequency, it cannot be used in applications that require precise frequency maintenance.

Glow lamps will give a visual indication of currents as low as one microampere; thus they can be used as indicators of very high resistance short circuits or extremely small leakages. They are finding increasing use in counters (photo, page 15) and computers.

Indicator Lamps

Small 115- to 125-volt incandescent lamps are most frequently used as indicator lamps. Usually rated 3, 6, 10, or 15 watts, they are used to illuminate a message or the colored jewel of an indicator. The bases usually supplied are candelabra screw or double-contact bayonet. These lamps' greatest drawback is filament fragility—the 3-watt lamps having the most fragile filament. In this lamp, the 0.0003-inch-diameter wire is much smaller than human hair. Larger size wire, used for 6-, 10-, and 15-watt lamps, consequently increases their strength. Variations of standard lamps containing special filament forms, additional anchors, special wire, and other features seek to increase their resistance to mild shock and vibration (photos, right). These special features naturally result in higher lamp costs. However, if they eliminate one service call during the life of a device, they will more than pay for themselves.

The strongest of the group is the 15-watt lamp. Where 24-hour-a-day burning of the lamp is encountered, plus some mild shock and vibration, consideration should be given to operating the 20-watt 230-volt lamps at 115 volts. Don't expect the lamps to last indefinitely, as theoretical calculations might indicate. But they may last two or three years, depending on the severity of the vibration.

Small Fluorescent Lamps

Small, cool fluorescent lamps are ideal in many instances for lighting instrument faces. They range from 25- to 40-lumens-per-watt in efficiency. Four-watt fluorescent lamps are approximately five-eighths inches in diameter and 6 inches long, including the socket; 6-watt lamps, 9 inches long; and 8-watt lamps, 12 inches long. In common with other discharge-type lamps, these small fluorescent lamps require a suitable ballast that also consumes two or more watts. Small fluorescent lamps have special value because they offer an extended line source and withstand vibration extremely well. Also available in various colors, they have a rugged construction affording long life if burned continuously (in excess of one-half year). Although such features place these lamps in a growing field of applications, they compete with glow lamps for markets.

Glow lamps are at the other extreme of the scale as far as luminous efficiency is concerned—about 0.3 lumen per watt. And their demand far exceeds that of small fluorescent lamps. Small neon glow lamps, primarily 115- to 125-volt lamps, are preferred as indicator lamps where the neon color of the light is satisfactory; the lamps can be viewed directly; low wattage is important; and a premium is put on ruggedness.

Lamp Size

In public-opinion polls, popular admiration has rated the large electric lamp today's number-one convenience. The less conspicuous service of miniature lamps makes their contribution seem an incident chapter. The use of small light sources comprises a field completely differing from large lamps. In manufacturing and product design, this necessitates a distinct category of techniques and purposes.

Today, while contemplating the prodigious capacities of the atom, it could serve as a reminder that large consequences derive from little things. And in the lamp world, miniature-type applications have their own area of modern miracles. Ω

The airplane behind Maj. Aamodt, although worth some $2.3 million, represents only about one fifteenth of the dollar investment that the Strategic Air Command has made him responsible for keeping in flying trim. How he does it—and what he does—is the story of . . .

Maj. D. A. "Monk" Aamodt: Engineering Officer with SAC

Review STAFF REPORT

With an operating budget of $842 million for 1954, assets of some $8½ billion, and a payroll of about 175,000 officers and men, the Air Force's Strategic Air Command (SAC) is big business any way you look at it. (In comparison, General Electric had total assets of about $1.7 billion with an average of 210,000 employees during 1954.)

A good part of SAC's abundance is evident at the lower levels. In the case of Maj. Duane A. Aamodt, Engineering Officer for the 369th Squadron of the 306th Bomb Wing at MacDill Air Force Base, Tampa, Fla., the abundance he is responsible for keeping in full production totals some $35 million. Aamodt is accountable for all engineering and maintenance work on the Squadron's 15 Boeing B47 *Stratojet* bombers—one of the most complex, unforgiving, and admired pieces of apparatus ever devised by man.

SAC's doctrine for top management does not dictate that an Engineering Officer must be thoroughly skilled and schooled in every last nut-and-bolt detail of B47s, even though he is responsible for their upkeep. That would be too much to ask of any one human being. Instead, Aamodt sees his job primarily as a manager rather than a functional specialist in the field of aircraft maintenance. He terms it "organizational maintenance . . . maintenance and routine inspections on systems and engines, preflight and postflight inspections, and an occasional engine change."

In a broader sense, his main efforts are concentrated on organizing, coordinating, and integrating the efforts of his men so that the jobs get done and the Squadron's airplanes remain in the air. How the specialists do the job—that is, whether they replace an electron tube or a capacitor—is of no particular concern to Aamodt. He feels that because the specialists have been trained in the various skills necessary to service engines, armament, and radar they know best how to handle individual problems. Basically, as stated by his job description, Aamodt is responsible for deciding *what* problems must be solved so that the effort fits in with the over-all maintenance concept. But *how* these problems are solved is left to the specialists. This philosophy is backed up by a recent remark of a Wing Staff Officer: "We have the specialists on tap, not on top."

All this is not to say that Aamodt is unfamiliar with the B47. Although not a graduate engineer, his schooling and career in the Air Force has given him an excellent concept of basic engineering fundamentals. He admits that he couldn't go into a shop and repair a search-radar set, but he has enough working knowledge to communicate intelligently with the specialists. Another one of his functions is to interpret Technical Orders and to recognize the relative importance of the many compliance orders that involve B47 modifications.

Aamodt reports directly to the Squadron Commander, Lt. Col. Harold B.

HOME "Scooter," seven, wants to be a jet pilot. Judy, his mother, prefers that he choose some other vocation.

OFFICE Beset by paper work, Aamodt, like any manager, must consult frequently with his Line Chief.

HOME BASE Supervising loading of the B-47s GE armament system or checking a flight crew's report is all part of the day's routine.

Lawson, and functionally to the Wing's Director of Matériel. A Line Chief reports directly to him, and three Flight Chiefs report to the Line Chief. Each Flight Chief supervises five Crew Chiefs—one for each airplane. In all, an Engineering Officer supervises about 100 men.

Aamodt's problems become complicated when the entire Wing moves, such as its flight to Ben Guerir (pronounced Greer) Air Force Base in French Morocco, North Africa. His part in this particular training mission was unusual. In addition to his responsibilities as Engineering Officer, he also had the duties of Squadron Commander because Lawson had been injured shortly before the Wing departed. Aamodt not only had to supervise the organizing and operation of Squadron maintenance routines at Ben Guerir but also had to see to it that the Squadron was always functioning at full combat capability.

At Ben Guerir, just as at MacDill, meetings on a squadron and wing level consumed much of Aamodt's time—as they do for any manager. Shortly after the Wing moved in, Maj. H. J. Markiel who headed Maintenance Control called a session for Squadron Engineering Officers and Line Chiefs. He discussed facilities, the week's schedule, requisitioning of supplies from the Base warehouse, forms and certificates, accident reports, and ground safety.

The men, sitting on crates in a loose semicircle, asked many questions: "Why can't the Mobile PX come closer to the flight line?" (Markiel said that he thought something could be worked out.) "Rocks on the taxiways cut tires. Why can't they be swept clean?" (Markiel said that sweepers were busy, but they had a lot of area to cover.) "Has anyone had trouble with rocks being kicked up into the jet engines?" (Aamodt suggested slower taxiing speeds and staying a greater distance from the aircraft ahead.) And, "What can be done to relieve the chow-line congestion at breakfast?" (Markiel said to get up earlier.)

(After the first week at Ben Guerir, Maj. Neal Johndrow of the 369th assumed the duties of Engineering Officer and held the position during the remainder of the stay in North Africa. Aamodt continued as acting Commanding Officer of the Squadron.)

A SAC Wing refines maintenance procedures to an exceptional degree. Three B47 squadrons of 15 planes each are part of a Wing. But instead of each squadron having its own private group of specialists, they're all concentrated in either the Field Maintenance Squadron or the Armament and Electronics Squadron or the Periodic Maintenance Squadron. These squadrons are responsible functionally to Maintenance Control, which controls their work. (The work areas of Armament and Electronics are self-explanatory. Field Maintenance includes such things as engines, structures, and hydraulics; while Periodic Maintenance performs planned periodic inspections and minor modifications.)

Aamodt describes Maintenance Control's work like this: "Every time a B47 of the 369th lands, we meet it in a radio-equipped truck. We receive the Aircraft Commander's flight write-up and check it over to find out if any trouble had occurred. Say that a variable-frequency alternator had acted up. We radio the information to Maintenance Control, giving the time, aircraft number, and any other information. The dispatcher at Control in turn calls the Field Maintenance Electric Shop and issues a work order for the job. The Electric Shop dispatches a specialist to the aircraft. When the job is finished, the specialist reports the amount of time it took and what was done. We keep duplicate work orders and a log. At the end of every month, we make up a complete report on the number of man-hours it took to maintain the Squadron's aircraft."

Punched cards are used by Maintenance Control to keep complete records on all jobs; they know within a minute how long it should take to repair any given item. From these records and other coded information, many things can be determined. For instance, on any specific mission, SAC knows statistically how many planes will never leave the ground and why; how many planes will fail the mission en route to the target and, of those that fail, what percentage will have engine trouble and what kind of trouble it will be; how many will have radar bombing equipment failure and when it will occur; how many will have partial radar failure and how much it will throw off the bombing accuracy; and probable aircraft losses to enemy action. SAC knows its combat capability down to the last electron-tube failure.

Aamodt—34, soft-spoken, and generous—was raised on a farm in North Dakota. He attended State Teachers College at Mayville, a small town between Fargo and Grand Forks in the eastern part of the state. "I would have

ADVANCE BASE A flight-line maintenance center for the Squadron must be organized and briefing sessions attended.


MEMENTOS OF RECENT WARS DECORATE THE AAMODT'S COMFORTABLE APARTMENT. FATHER CONSULTS WITH SON ON A WEIGHTY MATTER.

been a school teacher," he recalls, "except for the war." After enlisting in 1941, he received basic instruction in aircraft maintenance at Chanute Field, Ill. Sometime during flight training he picked up the nickname "Monk," but he doesn't know why. He flew A20s in the Southwest Pacific during World War II; then attended Officer's Engineering School at Chanute; taught engineering to pilot trainees at Waco, Texas, for two years; and flew B26s in the recent Korean conflict.

In Germany in 1947, Aamodt married Julia Hayes, daughter of the late Col. E. T. Hayes. Judy calls herself an "Army brat" because all her life has been spent on military posts. She was a premedical student at Kalamazoo College, attended Westhampton College and the University of Richmond, and is a "thwarted doctor," as she expresses it.

The Aamodts live in a pleasant six-room apartment fronting on Tampa Bay at MacDill Air Force Base. The Major's activities center around a new Buick *Century*, golfing, hunting, and reading, with emphasis on Civil War history and early Americana—that is, when he's not studying for his Bachelor's degree in Business from Florida Southern College (three hours a night, two nights a week). Sometime during his career with SAC, he will attend the B47 Transition School and become qualified to handle that airplane.

Judy is spirited and gracious, and her interests are outgoing to a bounteous extent. She is a member of the Officers' Wives Club and is active in many Wing and Squadron affairs. She also exerts a strong influence in the "Dependents' Assistance Program," a new effort of SAC to help wives solve the problems that sometimes arise when husbands are away.

Aamodt is proud of being in SAC; he likes the life, his associates, and the travel. Judy finds it a continuation of what she has always known, but admits, "If you don't like this type of life, you'll be miserable." Both believe morale in SAC is high. Judy says, with an insight sharpened by her long exposure to the military, "I hear the men gripe and moan, but it doesn't mean anything. They wouldn't be in any other Command." —PRH

PROFILE OF SAC ENGINEERING OFFICERS

Aamodt is one of the 800 Engineering Officers (or Aircraft Maintenance Officers as they're officially called) in the Strategic Air Command. Of the 800, some 200 perform duty as Aircraft Maintenance Staff Officers and 100 are Warrant Officers in Aircraft Maintenance Officer positions. The remaining 500 consist of 100 majors, 230 captains, 150 first lieutenants, and 20 second lieutenants.

Aamodt also falls within the profile of the typical SAC engineering officer holding a major's rank: age, about 35 to 39; Air Force career, about 15 years. (A major's pay is $680 a month, plus hazard pay if he's also a flying officer.)

Captains are slightly younger (30 to 34) and their Air Force experience is somewhat shorter (about 10 years). A captain draws approximately $580 a month.

First lieutenants are between 26 and 29 with an average of four years of service. Their pay is about $475 a month.

Second lieutenants usually have less than 18 months' service, are about 24 to 26 years old, and make $340 monthly.

Many SAC engineering officers have college degrees, both from engineering and liberal arts institutions. And with few exceptions all have attended at least one, and in some cases many, Air Force maintenance schools and factory schools of various aircraft and engine manufacturers. Many have come up through the ranks as aircraft mechanics with years of experience behind them.

In the engineering field, SAC is planning for the future: it hopes to have at least one aeronautical engineer assigned to each combat wing that operates high-performance aircraft. Also, plans call for all engineering officers to receive industrial engineering training that will enhance their over-all management potential. At present, continuous programs are in effect—with more in the planning stage—that will increase the professional knowledge of all engineering officers.

The SAC manual lists the engineering officer's key responsibilities . . .

- Insure the performance of quality maintenance on assigned aircraft.
- Fully utilize specialist support and supervise the work accomplished by specialist personnel.
- Establish personnel controls necessary to obtain maximum availability and utilization of assigned personnel.
- Maintain an effective training program.
- Prepare and submit Unsatisfactory Reports on all unsatisfactory conditions occurring within the flight-line activity.

More Efficient Alloys Through Vacuum Melting

By W. E. JONES

Should you have charge of heavy equipment in an industrial plant, the reduced maintenance required for bearings would probably impress you. Or, if you took a trip and drove along the streets of Detroit, you would likely see an experimental gas-turbine-powered automobile being put through its paces. And from the newspapers, you know about the tremendous speeds of jet-propelled aircraft and that better nuclear reactors are just around the corner.

All these developments to some extent can be traced to vacuum-melting techniques now used by metallurgists to obtain better metals—metals to meet requirements of the fast approaching "jetomic" age.

For some time, metallurgists and engineers have realized that metals and alloys processed by conventional methods have certain drawbacks often associated with the presence of unavoidable impurities or inclusions. The need to transform the melting and processing of metals and alloys from an art to a more exact science has long been recognized by General Electric. And the necessity for superior metallic materials in many diversified products led the Company to investigate the vacuum-melting technique in 1946. During that year, a small pilot plant was placed in operation at the G-E Research Laboratory in Schenectady.

Since that time, the Laboratory and various operating departments including Carboloy co-operated in producing and evaluating under experimental conditions an ever-increasing number of metals and alloys.

Not until engineers cracked the vacuum-making barrier did this method of melting become feasible, developing at a fast pace during the past five years. In 1950, 50-pound batch-type melts were rare, but 1000-pound melts are now becoming common. And engineers already are talking in terms of 10,000-pound melts and such things as continuous operation.

Vacuum vs Conventional Melts

What happens when you melt metals in a vacuum? With the closer composition control, the metals and alloys produced are free of inclusions or impurities. They experience less loss of critical alloying elements than in conventional practices where oxidation or undesirable side reactions occur.

Sometimes, the process develops and produces a completely new family of metals and their alloys. For many existing alloys, melting in a vacuum so markedly improves their mechanical properties that these too can be classed as new alloys.

Benefiting through vacuum melting, nickel- and cobalt-base alloys, for example, undergo a minimum loss of hardening elements due to oxidation. Their superior cleanliness reflects substantially improved fatigue and stress rupture properties. Ductility and over-all workability are so improved that fewer rejects are produced. In addition, the scrap has excellent remelt value.

Vacuum melting also imparts similar properties to low-alloy steels. High-chromium alloys such as 430 and 446 normally exhibit brittle fracture at room temperature. Producing these alloys with substantially lower transition temperature and, consequently, a greatly improved room-temperature impact strength broadens their field of use.

The reduction of dissolved gases in copper and nickel appreciably improves their use for electronic-tube applications. Emission characteristics of cathodes of vacuum-processed metal are superior because of increased purity and closer control of composition. Copper melted in vacuum exhibits a conductivity close to 100 percent of the calculated theoretical value.

The process even improves the purity of iron. Vacuum-melted iron shows as much as 60 to 70 percent greater resistance to rupture; and elongation often increases as much as 400 percent with comparable increases in tensile and yield strength.

Service life of bearings and springs frequently depends on fatigue strength of the alloy they are made from. This strength in turn is closely related to metal or alloy cleanliness. Bearings of 52100 steel processed by vacuum techniques show a fourfold increase in service life. Tool and die steels of superior qualities also can be made by excluding dirt, or inclusions, through the process.

The much lower inclusion content of vacuum-melted spring alloys makes it possible to draw wire to finer sizes, with improved surface finishes and fewer breakages. The presence of surface imperfections in parts of conventionally melted alloys often leads to galvanic corrosion or pitting during service. Usually a function of purity, over-all corrosion resistance of various metals and alloys will undoubtedly improve substantially. The process may even render a less costly material suitable in current applications.

Thus, removing the normal atmosphere from the melt being processed prevents undesirable reactions on the raw materials used in the charge—the primary function of melting in a vacuum. For example, oxygen and nitrogen cannot react with the molten bath during the working of the heat or after refining and final deoxidation.

Technical Fundamentals

As a corollary, the control of analysis of elements affected by nitriding or oxidizing reactions is more simple. Because a vacuum is dynamic rather than static, reactions can be driven more nearly to completion if the reaction products are gaseous. For deoxidizing purposes these products can be pumped from the system rather than separated in slags or entrapped in the metal.

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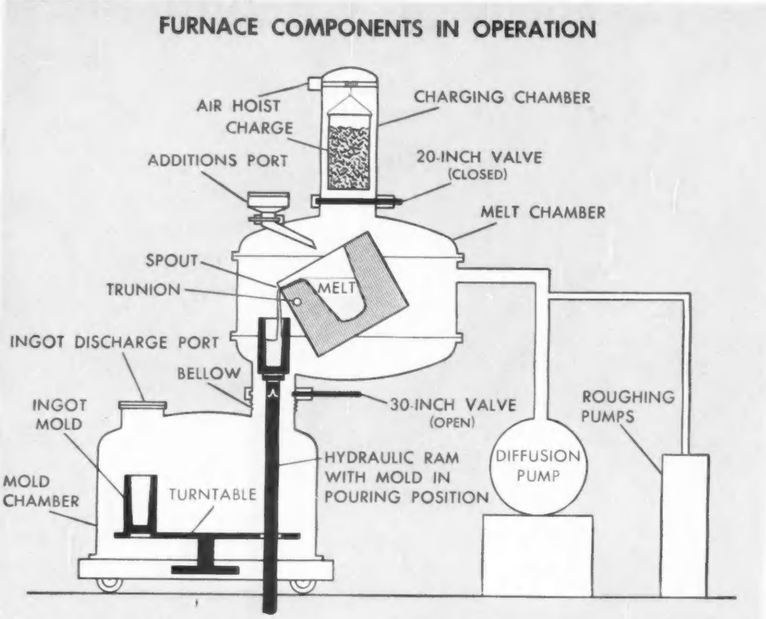
Thirteen years ago Mr. Jones joined General Electric's Thomson Laboratory, West Lynn, Mass., working primarily in the development and application of high-temperature alloys for aircraft gas turbines. Transferring to the Carboloy Department, Detroit, Mich. in 1951, he established a vacuum-melting pilot plant for the production of high-temperature and other specialty alloys. Today he is Manager—Vacuum Melted Products Engineering.

TEXT CONTINUED ON PAGE 26

OVERLEAF: OPERATION OF NEW VACUUM FURNACE



OPERATION O

Vacuum melting requires flexibility of equipment to meet specific needs. For example, the equipment must be designed to allow interchanging bottoms of the vacuum chamber or adding another pumping system to handle larger poundages. This makes cleaning easier, simplifies repairs in event of spillouts, and offers alternate methods of casting.

The new 1000-pound furnace recently completed at Carboloy Department typifies an installation that not only provides flexibility of operation but also lends itself to expanded capacity. Built by Consolidated Vacuum Corp. in Rochester, NY, it presently can produce two 1000-pound heats per shift. Of the so-called modular type, its operation can be expanded or curtailed, much on the order of building blocks.

By providing various chamber bottoms with suitable accessory equipment, the same furnace produces single ingots, multiple-shaped castings, or centrifugal castings. Semicontinuous operation is provided by interlocks through which the crucible can be charged, the alloying elements altered, and the ingots removed without breaking the vacuum in the main chamber.

Basically, the three systems making up the units are so interrelated that one operator can handle the main furnace and auxiliary operations. But for efficiency and safety reasons, two attendants are the normal practice.

Three control panels co-ordinate all functions of the power and the air-evacuating systems with those of the furnace itself.

One panel used strictly for power balances out the capacitor banks of the 350-kva motor-generator set supplying power for induction heating. The second controls the vacuum system and includes a schematic diagram of the vacuum lines tied in with indicating lights keeping the operator informed at all times. This panel lends consider-

THE NEW 1000-POUND VACUUM-MELTING FURNACE

able flexibility to the system by controlling or shutting off any section when necessary.

The smallest panel acts as an index for the turntable that holds the ingot molds, as well as the mechanism that raises them up into the main furnace chamber section for pouring.

Three pumps—two roughing and one oil diffusion—are included in the air-evacuating system. All three can be operated simultaneously or individually. One of the roughing pumping systems, the 500-cubic-foot Kinney, handles the furnace operation alone. However, the addition of a 300-cubic-foot unit increases the furnace's efficiency and speed and primarily expels air from various chambers as operations demand. While the roughing pumps lower pressures to around 500 microns, extremely low pressures of less than a micron are obtained with the oil-diffusion pump.

The control panels as well as other operating equipment are located near the top of the furnace. Here also are found an immersion thermocouple for controlling pouring temperature and a sampling device plus equipment for inserting certain working tools into the furnace as necessary.

The water-cooled tilting induction furnace used for melting is mounted on a trunnion inside a stainless-steel tank. The introduction of power to the furnace by means of a coaxial arrangement eliminates the use of flexible leads. When power is needed, air-actuated shoe-type contacts are clamped onto the water-cooled coaxial cable, making the electric contact.

In this arrangement, power can be cut off for pouring or turned on again when the furnace is locked in tilted position. Two levers control the movement of the induction furnace: horizontal movement of one engages the first of two microswitches that de-energizes the capacitor bank. When the lever in its continuing movement engages the second microswitch, the latter activates an air cylinder that disengages the contacts. The other lever tilts the furnace after the locking pins are removed.

Charging cans, about the size of a large garbage container, are filled with the desired metallic elements for the melt in predetermined amounts. Because the can also melts, the container is selected by what it will contribute to the analysis of the melt. For example, if an appreciable iron content is permitted, an iron container can be used.

The filled container is lifted to the top of the vacuum-melting furnace and hooked on the inside top cover that is in a raised position. After replacing the cover, a windlass arrangement lowers the charge in the charging chamber. At this point, the charging chamber is sealed, and a roughing pump evacuates the air from the chamber.

Lowering the pressure sufficiently takes a matter of minutes. A pneumatically operated sliding valve under the chamber opens, and the charge continues its descent to be positioned in the crucible of the induction furnace. Then the hook is disengaged and hoisted out of the way; and the valve is closed off.

Once the melt starts, the charging chamber can again be readied with a second charge. Melting, ranging in temperature from 2800 to 3200 F, takes about one hour. Including refining, the total cycle requires about five hours.

As melting continues, the shrinkage of the original charge necessitates making bulk additions through a separate valved-off charging lock to bring the heat up to capacity. After the additions are made, a pump roughs out; and when the pressure is lowered sufficiently, the charge is dropped onto a vibratory chute leading to the furnace.

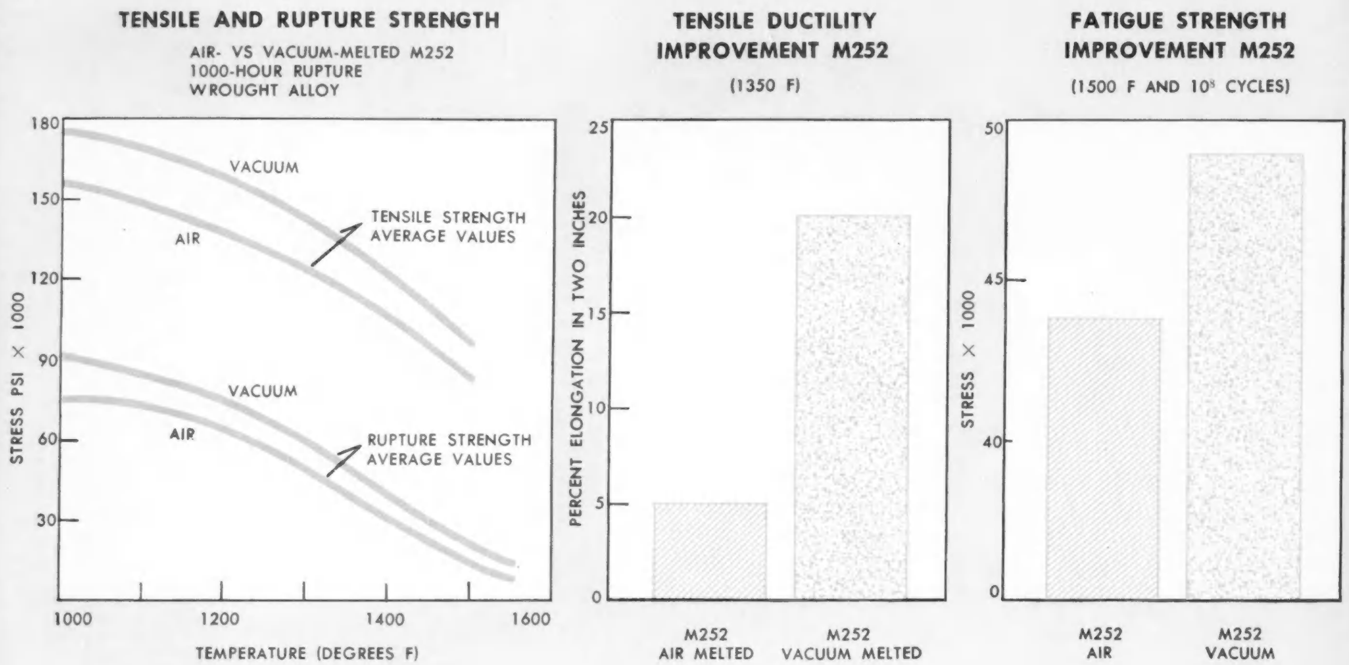
During the melt, considerable gas is generated and pumped out continuously until the pressure drops to a predetermined level. Impinging hydrogen gas directly on the liquid bath reduces oxides, and the resulting water vapor is also continuously pumped out. This reaction process continues for about an hour, allowing it to arrive at reasonable completion.

Late additions such as highly reactive zirconium, titanium, and aluminum follow this phase of the melting process. After the hydrogen is cut off, the melt is evacuated until it reaches reasonable pressure when it can be poured.

Ingot molds for pouring rest on a turntable that forms the bottom of a large bell-shaped container, or jar, mounted on a platform that runs on tracks. At pouring time, this huge jar is pushed into position and spotted under a 30-inch valve that leads to the induction furnace. Then through a bellows arrangement on top of the jar, the flange is raised to meet the 30-inch valve.

After sealing the connection and evacuating the jar with the roughing pump, the 30-inch valve is then opened and the turntable indexes the mold. A filling-station-type lift raises the mold through the valve into pouring position in the main chamber. After pouring, the hot ingot is then lowered into the bell jar, and the operation is repeated by indexing the turntable.

Heats in the Carboloy unit can be divided into as many as six ingots before disengaging the ingot platform. This platform handles molds for any size ingot ranging from 100 to 1000 pounds and is equipped for hot topping—the process of keeping the ingot hot at the top while solidifying to prevent piping. Adjustable electrodes inside the huge jar accomplish this, and they can be lowered in contact with the metal while cooling. Then the ingots are stripped from the molds and allowed to cool.



VACUUM MELTING SO ENHANCES PROPERTIES OF M-252 ALLOY THAT IT IS WELL SUITED TO A VARIETY OF HIGH-TEMPERATURE APPLICATIONS.

Similarly, volatile impurities such as Pb, Bi, Cd, Ca, and Sb, readily vaporize from the molten bath and condense out in the system, preventing further reaction. Dissolved diatomic gases—their solubility varies as the square root of the pressure—are removed in vacuum. This leads to lower final gas contents in vacuum-melted metals and to sounder castings where gas porosity is important.

These technical fundamentals of vacuum melting usually apply regardless of the metal or alloy system.

System Components

Vacuum-melting equipment consists essentially of the furnace and vacuum-pumping system. A charge lock, cover, crucible and coil assembly, and mold platform constitute the furnace. The pumping system varies, depending on the operating procedure and the materials being melted.

Many furnaces of 350-pound capacity, for example, require a 16-inch diffusion-ejector pump having a throughput of 40,000 micron-liters per second at a pressure of 10 microns or 2500 micron-liters per second at 1 micron. Such a system maintains pressure necessary for gas-free atmosphere and also provides enough pumping capacity for handling pressure surges that occur during alloy additions and pouring to return the chamber quickly to required operating pressure. A similar vacuum pump would be needed to increase this pumping capacity for a 1000-pound furnace. A complete description of Carboloy Department's vacuum-process furnace appears in the Discussion on pages 24 and 25.

Improved Alloys

With the process, GE succeeded in greatly improving M-252, a high-temperature alloy—produced for several years by conventional melting. The metal is a nickel-base alloy strengthened with moderate amounts of titanium and aluminum.

Developed for use in jet-engine buckets, it is now being utilized in other parts of the jet engine, as well as in other unrelated high-temperature applications.

When made by the vacuum process, this metal's mechanical properties are appreciably enhanced (illustrations), and its formability, or workability, improved. And it can be produced in a wide variety of useful mill shapes with excellent finish.

Converting expensive high-temperature alloys produced by conventional melting practices from ingot to bar stock averaged a 40 to 50 percent recovery. Today, with vacuum-melted M-252, the recovery averages 60 to 70 percent, producing much cleaner bar scrap with its hardening elements undiluted by oxidation. Thus the scrap can be remelted without appreciable loss of properties.

Melting high-temperature alloys in air limits the addition of hardening elements—titanium, molybdenum, zirconium, boron, and others. Titanium, for example, is limited to about 2.5 percent. Vacuum or controlled-atmosphere induction melting permits these percentages to be upped—titanium up to 6 percent—to produce alloys of greater ductility and strength to withstand higher operating temperatures. This promises to create a new family of high-temperature alloys with even better mechanical properties.

For example, the recently developed alloy 1570 contains about 4 percent titanium—an amount beyond the point that can be melted in air. Extremely difficult to melt in air and to obtain the desired properties, this alloy has superior strength at higher operating temperatures when it is melted in a vacuum furnace.

Promising Applications

For the much-talked-about gas-turbine-powered automobile engine, the present experimental models use elements of high strategic value such as cobalt. Manufacturing as many as 3 million of these engines would require about 15-million pounds of cobalt—an amount prohibited not only by cost but also by this country's supply of 11- to 12-million pounds.

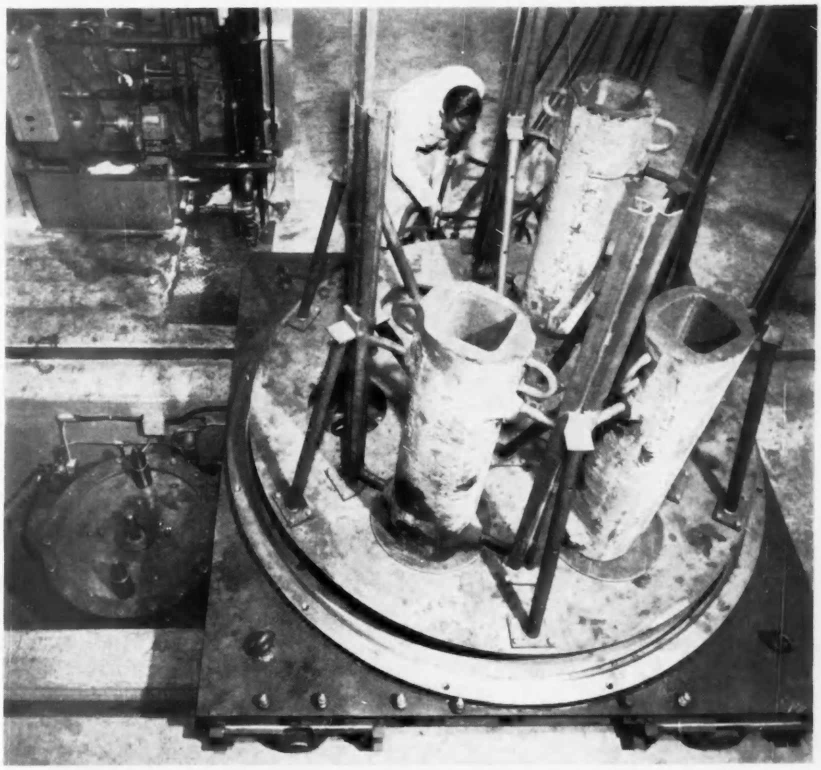
However, vacuum melting may change the picture. Possibly, alloys of low strategic value will perform the same functions in the engine as the present high-temperature alloys, making an economically feasible engine.

The alloys in the aluminum-iron and chromium-iron systems look promising. Preliminary investigations by the Navy and some of the automobile companies indicate that these systems may offer a new base for establishing high-temperature alloys. Derived from these systems, a typical alloy could consist possibly of 16 percent aluminum, 81 percent iron, and 3 percent molybdenum. If successful, these alloys would benefit the entire turbine field—jet engine, land gas, and eventually steam.

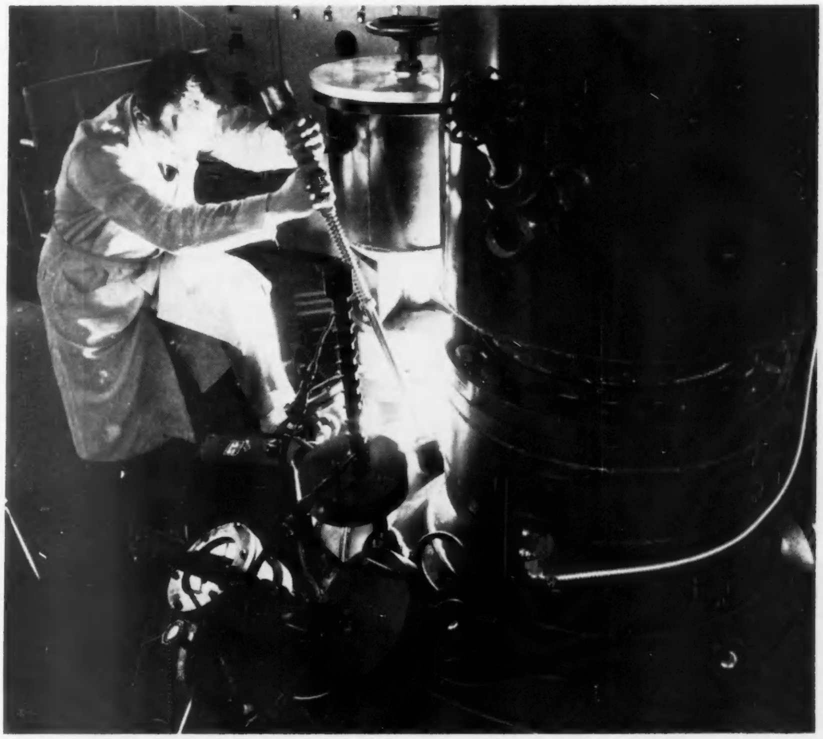
In the bearing field, vacuum melting accomplished advantages in fatigue strengths and bearing life for the well-researched alloy 52100. Thus it might make the use of tool steels M-1 and M-10 attractive for high-temperature bearings. Although the hot hardness of these steels (Rockwell C55 to 58 at 1000 F) would enable them to be used for bearings up to 800 to 900 F, their fatigue life is not well established and little data is available. And because they are not as metallurgically clean as alloy 52100, producing them under a vacuum may bring about some unusual results.

Already one automobile company's interest in vacuum-melted steel for valve springs may lead to its appearance in its 1956 cars.

And, finally, vacuum melting provides a superior cleaning action. This also makes it a natural for producing film-casting wheels, finishing rolls, extrusion dies, wire, and other products that necessitate the use of inclusion and gas-free materials. Ω



MOLD CHAMBER designed to hold up to six ingots is indexed directly over the opening in the turntable so that the lift (lower left) can push the molds up into pouring position.



STANDING ATOP HEAT, operator checks molten metal in the new 1000-pound vacuum-melting furnace located just beneath him where temperatures range from 2800 to 3200 F.

BALING Tractor-mounted generator, new concept of mobile power, not only permits electrifying trailing equipment but also furnishes emergency power.

DRYING Crops such as baled or loose hay, small grain, soybeans,

What Is Electrification Doing for Agriculture?

By KARL H. RUNKLE

Most urban adults whose last rural experience dates back to that two-week stay on Uncle George's farm in the summer of '36 would be shocked if they visited a modern American farm. For many people still think of farming in terms of back-breaking labor from sunrise to sunset.

As in so many other realms in this country, agricultural methods have undergone a major revolution since 1940—particularly since the end of World War II. The farmer who still relies only on his back and hands is becoming as obsolete as the coal-oil lamp. The urbanite might get nostalgic for the old days, but surely the farmer won't.

A 40-Hour Week for the Farmer

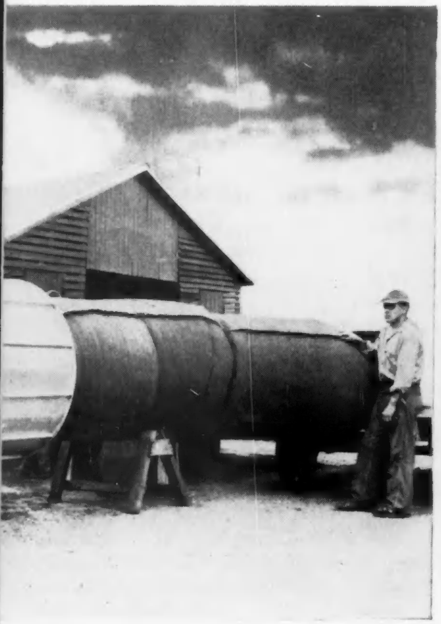
For the first time in history, the farmer is approaching a 40-hour week—that is, if he keeps abreast of technological advances that are tailored to his needs. And most farmers are keeping up, both with the times and with our zooming population. Only 100 years ago, the American farmer toiled about 90 hours every week just to feed himself and his family, with little remaining for the city dwellers. This helped to keep city populations low, for most people had to till the soil in order to eat. Fifty years ago, our farming population had dropped to 40 percent of the total population, with each farm worker feeding seven people. By 1940, 23 percent were providing the food, with each farmer feeding 11 people. Today, hardly 5 percent of all Americans are engaged in farming, but every one of these 8½-million farm workers must annually produce enough food for 18 people besides himself—a $31-billion job.

Progress like that is never an accident. Many factors contributed to this agricultural revolution: newly developed machinery, new and improved fertilizers, new methods of pest control, and better soil- and water-conservation practices. But farmers themselves recognize that one of the greatest advancements has come from the increased use of electric power (illustration, page 31) and electrically powered farm machinery.

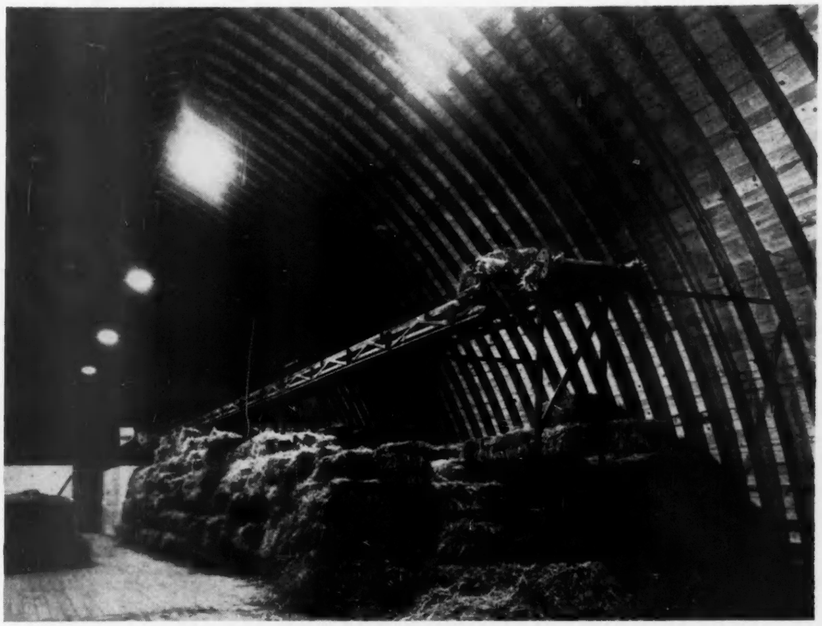
Selling the Idea

We have come a long way since first encouraging electricity for farm use. In 1913, General Electric produced what is believed to be the first industrial motion picture on electrified farming: *Back to the Farm*, a crude effort by modern standards. But in its own way the film told the story well. Graphically, and sometimes melodramatically, it depicted the long hours of arduous labor the farmer of yesteryear expended just to support his family. Rather than promoting specific electrical uses, the film was selling the idea of farm electrification. For in 1913, the application of even a few small electric motors would have lightened the back-breaking burden of farm chores and made life on the farm more endurable for the entire family.

Scarcely a memory now, coal-oil lamps were then the only light source in most of the 6½-million farm homes, when 13½-million farm workers and 25-million animals did most of the work. And as for mechanization, the 14,000 tractors in use in 1913 have increased to some 4½ million. Just since the outbreak of World War II, the number of tractors has increased 153 percent, motor trucks on farms 127 percent, milking machines 233 percent, grain



peanuts, and corn can be harvested damp and dried electrically in this equipment.



CONVEYING Electric hay handler moves grain to bins or hay to any part of this well-lighted mow. Farmer diverts bales with a board shoot.

combines 318 percent, and corn pickers 429 percent—a few of the more than 200 applications of electric power on American farms.

Electrification Amplified

This year, farm families will be using 500 percent more electric power than in 1940. In the 10 years since the end of World War II, electrical usage by farmers in this country has doubled twice—from 5.8-billion kilowatt-hours in 1945 to 12.3-billion in 1950; by the end of 1954, this figure had jumped to well over 20 billion. This year, it should easily reach 23 billion. If statistics don't impress you, think of it this way: In 1955, fewer than 5-million American farmers will be using well over half of all the electric power consumed in France and two thirds of that used in Italy.

And the end is not even in sight. By the most conservative predictions, the American farmer within 15 years will be using 70-billion kilowatt-hours annually—about as much power as was expended for all uses in the entire country in the late 20's. Average farm usage in the foreseeable future is expected to be 18 times the present consumption. This sounds like a fantastic jump in such a short time, but consider this: until recently, just extending electric service to rural America was the primary job. Now, that task is practically complete, for by the end of last year almost 95 percent of all farms were receiving electric power. In more than one fourth of the states, the farms are nearly 100 percent electrified, in the sense that power is available to them. In Connecticut, an outstanding example, only eight of the 15,000 farms in the entire state are without electric power—and even those farms could have it.

Streamline for Profits

Increasing his electrical usage has not been and will not be entirely the farmer's choice. The hard facts of economic life have and will push him into it. Like all businessmen, the farmer wants to make the best possible profit. And he is beginning to realize that to keep his head above water over the next few years, he must do everything possible to streamline his operations and increase his efficiency. Unless he reduces costs through the use of electrically operated labor and timesaving devices, it will be difficult for him to survive. The farm hand is not only harder to find but also more expensive. It looks now as if the farmer who works hardest may also be the poorest.

And the problem of filling the American stomach grows bigger every day. By 1975, our population will have jumped to 210 million—about 35 percent. To take care of the increase at the present rate of production, farmers would need about 100-million new acres, the equivalent of all the crop land in Minnesota, Illinois, Michigan, Indiana, and Ohio. Not the slightest hope exists of finding that much new crop land; indeed, we'll be lucky if we can get 30-million acres by reclamation and irrigation projects over the next 20 years. The only answer will be more and more farm electrification.

Today, 90 percent of all eggs are hatched by electric incubators, and 80 percent of our farmers use electric milking machines. And yet, many farmers are only scratching the surface of opportunities for further progress through electrification. Only 20 percent of our farms, for example, have milk-house heaters; only 10 percent have electric barn cleaners (photo, left, page 32); and less than 5 percent have silo unloaders (photos, next page) or electric hay dryers. To put it another way, the

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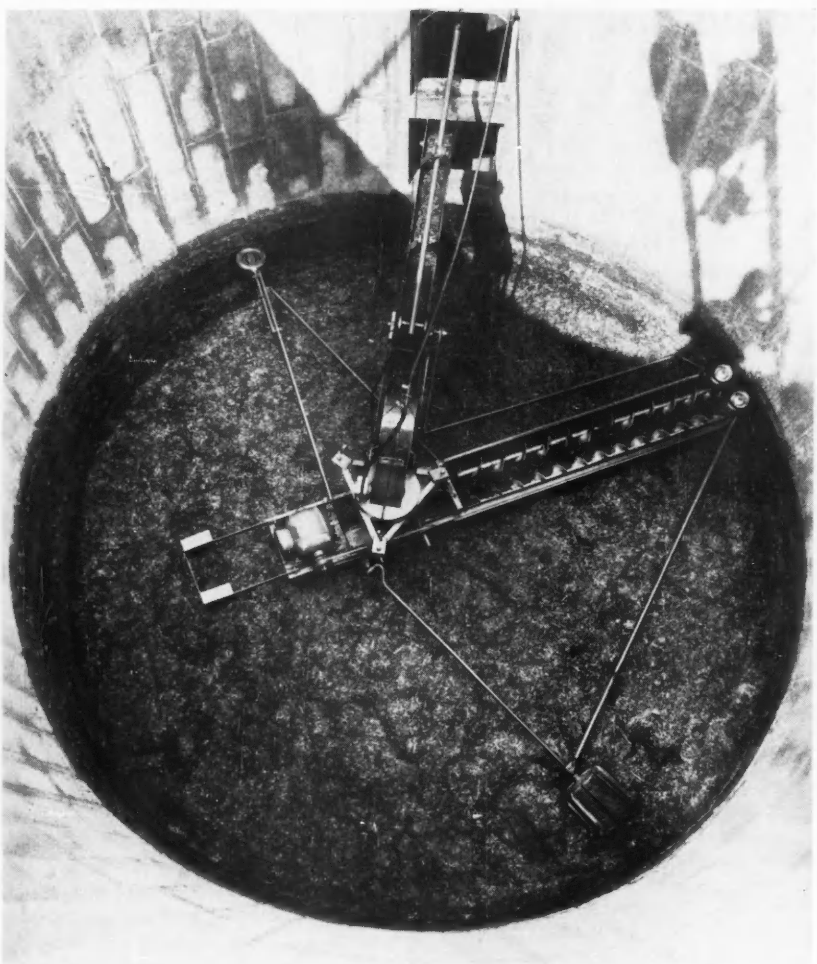
Mr. Runkle came with General Electric 38 years ago on the Test Course. After completing the course, he entered the Industrial Department where he held several managerial positions that culminated in Department Manager. Presently, he is Manager—General Industry Sales Development, Apparatus Sales Division, Schenectady. Mr. Runkle served as Chairman of the National Farm Electrification Conference during 1954.

EXTERIOR SILAGE HANDLING: Electric-driven wagon unloader dumps grass silage into blower that sends it into storage by way of the vertical pipe outside of the silo.



INTERIOR SILAGE HANDLING: Unloader throws silage through silo's portholes to feeding carts in the barn. On 75 New York farms, moving belts deliver silage directly to the cows.

average farmer—revolution or no revolution—is using only 700 kw-hr a year for his production operations, less than a third of what he uses in his home. A tremendous job remains in electrifying rural America.

Progress in Poultry

Some poultry farmers are really setting a progressive example. The margin of profit on poultry products has been narrow in recent years, and prices are expected to remain steady in the next 10 years or so. Good hired men—when and if you can get them—cost a dollar and more an hour. To stay ahead of the bill collector and to make a decent return for his work, the poultryman has turned to electric power for help. On today's poultry farm, most of the chores —from watering and feeding to thermostatically controlled ventilation—are done by electric servants. Poultry rarely see a human being until it's time to go to market: electricity incubates, broods, ventilates, waters, feeds, gathers eggs, and lights by time switch.

A farm near Albany, NY, exemplifies the efficiency made possible with electrification. Three hired men plus electricity take care of 12,000 laying hens and 12,000 broilers, including the delivery of eggs and dressed poultry to retail outlets in Albany. They also give their attention to a half-dozen riding horses for the family.

The electricity used for chore mechanization on that farm amounted to 175,000 kw-hr last year, costing much less than wages for one hired man. To do the same work by hand would have required at least 6 or perhaps 10 men. Thus for less than one man's wages, this farmer achieved the production of three to seven men.

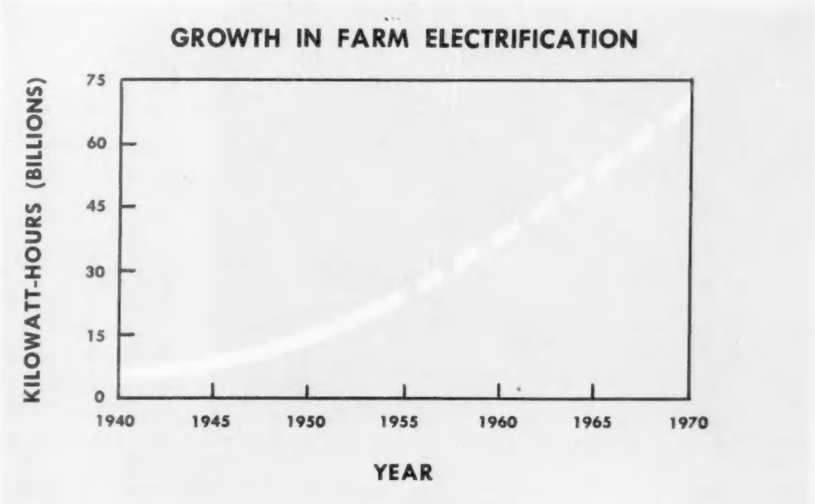
The eggs on many modern poultry farms are even washed automatically, saving both time and money. After cleaning, the eggs move by conveyor belt to another machine for grading and sizing. This Rube-Goldberg-like contraption sorts the eggs by weight and drops them into place for boxing— a welcome improvement over the old method of grading each egg by hand.

Such electrified operations as watering, feeding, lighting, and ventilating are basic requirements if the farmer is to meet his high costs, but others would measurably increase his annual profits. Refrigeration, for example, will be a must in his egg-holding room. Minutes after each egg is laid, it will be picked up and delivered by conveyor belt to this high-humidity room where the temperature is held at 50 to 55 F to assure Grade-A products for maximum selling price. In some areas, heat pumps will maintain a proper year-round temperature condition in the laying house. The use of heat pumps not only improves production, egg quality, and shell structure but also increases the size and weight of the eggs.

Tests indicate that the increased production and improved quality more than compensate for installation and operating costs of these air-conditioning systems.

Over the next few years, with poultry farming fast becoming big business, one thing is almost certain to happen: the small producer with a few hundred hens will have to make adjustments to compete with the highly mechanized farms with their thousands of hens.

There will be exceptions, of course, such as Robert W. Adair of Amherst, Mass. Adair is a town fireman, but he decided about four years ago to start his poultry farm as a side line. He and his father, who also holds a full-time job, realized from the outset how little time they could spend on their poultry business. Full-time production on a part-time schedule is possible only with electrical help. And so they installed automatic feeding, watering, lighting, and even thermostatically controlled heating cable to keep the water from freezing. Young chicks and turkeys are incubated electrically; brooding is made easier with infrared heaters. An electric debeaker prevents the birds from pecking one another. An electric semiscalder and an electric picker dress the birds for market. Annual result: 1200 laying hens, 1500 broilers, 600 turkeys, and 200,000 eggs—and this as a side line.



INCREASED USE OF ELECTRIC POWER CONTRIBUTED GREATLY TO AGRICULTURAL REVOLUTION.

Dairy Electrification

Electrification in the dairy industry is a somewhat different story. Well over a million dairy farms in America require electrification because of their size and production, but thousands of them have scarcely begun to modernize. True, 80 percent are using milking machines, and some 50 percent have installed milk coolers, but they need more equipment to maintain a proper profit level. For instance, electrically barn-cured hay will help raise milk production per cow by 10 percent or more, as well as net an extra 50 cents per 100 pounds for milk.

A recent survey among New York and New England farms revealed that the better farms are using more than 10,000 kw-hr a year, even without the barn ventilators, the milk-house heaters, and the hay dryers that they ought to have for efficiency's sake. Within 10 to 15 years, annual consumption of 40,000 to 50,000 kw-hr of electric power will be commonplace.

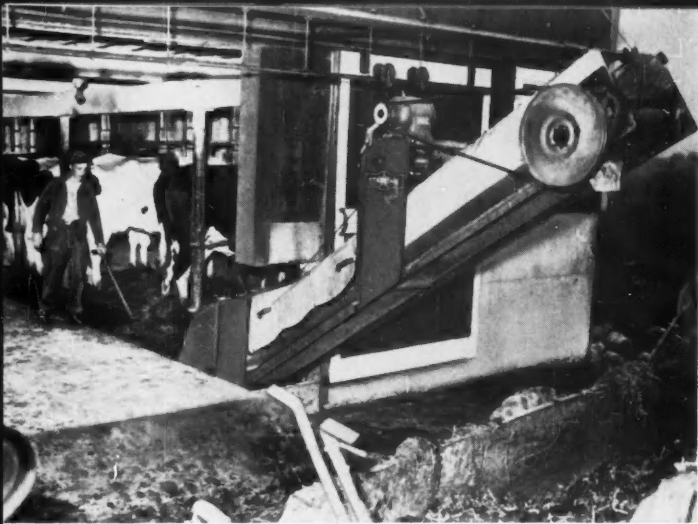
Let's consider a typical 1965 well-run family-size dairy farm. This farmer's 40 cows will each produce 10,000 pounds or more per year, or 4650 quarts. The national average will be about 7000 pounds, or 3255 quarts, compared with 5550 pounds, or less than 2600 quarts, in 1954. The 3200-quart cow may be a friendly companion around the barn, but she'll little more than pay for her keep. Because the farmer with a small herd cannot afford to hire human help, his hired hands will have to be electric. And they'll really be working for him all over his farm.

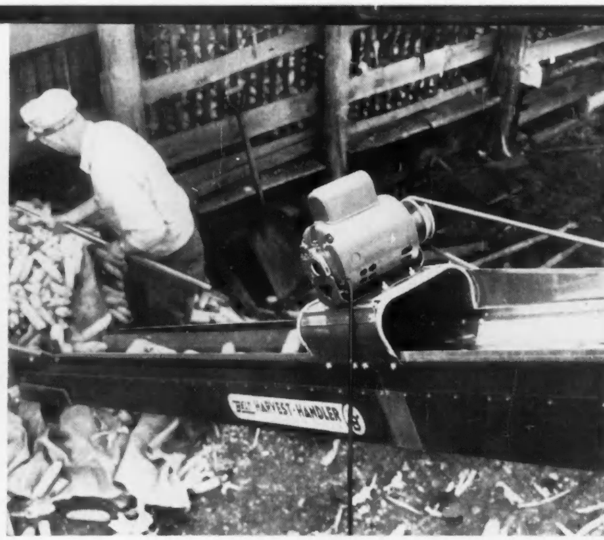
For milk-house operations a bulk milk cooler, hot-water heater, and milking machine will work for only $15 a month; and barn-curing hay will cost only $1 a ton. Drying grain and corn and grinding feed for his stock will cost this farmer hardly $3 a month, keeping his barn properly ventilated another $2. He will be able to take care of his pasture irrigation problem for $10 a month during dry periods, his lighting for less than a dollar. Watering, barn cleaning, heating water for his young stock, silo unloading, the silage conveying by invisible electric helpers at any hour of the day or night will cost him under $3 a month. For less than three cents a day, he will be able to keep his young calves snug and warm with infrared lamps in the barn.

Just as important will be electrical usage in the modern farm home; by 1965, the farmer's wife will be buying nearly $9 worth of electric current a month, or about 30 cents a day. But think what she'll be getting: a completely equipped all-electric kitchen with refrigerator, automatic range, food-waste disposer, dishwasher, freezer, automatic clothes washer, dryer, and ironer. Light conditioning of living areas will provide excellent illumination, as well as dramatic decorative effects. A heat pump in the house will give both summer cooling and winter heating. All this electric equipment exists already; they'll be in farm homes 10 years from now just as surely as they will be in millions of urban and suburban homes all over America.

Thus an average, modern family-size dairy farm of 1965 will consume perhaps 2500 kw-hr every month for $50 to $55. A farmer could hardly pay one third of a human hired hand for that amount, even at today's prices.

Of course, even 50,000 kw-hr a year will be trivial for the livestock farmer with 200 to 300 acres of corn and grain. Such crops will be harvested damp and dried electrically (photo, center, pages 28 and 29). Because tests have shown that electrical crop drying means more and heavier wheat per acre, agricultural experts emphatically recommend that wheat be harvested at 15 to 20 percent moisture and corn at 25 to 30 percent. Drying will be mandatory on every progressive farm because grain must be reduced to 12 percent moisture and corn to 14 percent for safe storage. Feed grinding, as well as mixing, elevat-





BARN CLEANER COMPLETES THE DIRTIEST JOB ON DAIRY FARM IN MINUTES. PORTABLE ELEVATOR ALSO LIGHTENS FARMER'S WORKLOAD.

ing (photo, right), conveying (photo, right, page 29), and delivering to self-feeders or feed bunks, will be handled electrically as a matter of course.

For dairy farmers, a breakdown of the ratio of installation cost to savings for crop-drying equipment would look something like this. First, savings: the farmer milking 30 cows and feeding them 60 tons of hay annually can save at least $900 a year, plus the 5 to 15 tons that would have been ruined by rain if the hay had been left out for field curing. For an initial cost of $1000 to $1250, one 7½-hp motor-driven fan will dry 6 tons of hay each day during good haying weather. Therefore, the farmer can expect a return of better than 50 percent on his investment the first year and each succeeding year. Many farmers, in fact, have even saved the price of their complete installation in the first year.

Even the figure of 70-billion kilowatt-hours for farming by 1970 may be too low. A whole new field of electrification may open up in the near future: the use of electrically driven trailing machinery for field operations, where an electric generator powers a motor to drive hay balers (photo, left, page 28) and other field machinery. Thus the farm tractor has become a mobile source of electric as well as mechanical power for field operations.

Most important of all, electrically operated trailing equipment is more economical to manufacture and to operate than the conventional gasoline-driven engine. Trial runs have repeatedly shown that the electric hay baler is up to 25 percent more productive than the baler with a gasoline engine.

Most of these improvements, already in fairly common use, portend many new ideas—some in the experimental stages or on drawing boards or yet undreamed of—that will cut the farmer's future costs and measurably increase his profits. In tobacco- and cotton-growing, for example, experimental moth traps with black-light lamps show considerable promise in combating the tobacco hornworm and the pink bollworm moth. One trap per acre has effectively eliminated the moth menace and the need for spraying in at least one Carolina tobacco area. In Texas, 40 moth traps were used by one farmer to protect 800 acres of cotton. His neighbors, who did not have traps, used airplanes to spray their crops 10 times at $2.50 an acre. The farmer with the electric traps saved about $20,000, and he claimed a higher crop yield than his neighbors.

New Equipment and Methods

In the corn belt, the heat pump has already proved its merit in hog breeding. Tests have repeatedly demonstrated the importance of proper temperature regulation in feeding. Extreme temperatures can be expensive for the hog farmer. For example, when hogs are kept at 40 F, 1000 pounds of feed are required to add 100 pounds of weight. At 90 F or higher, 800 to 900 pounds of feed are needed to add 100 pounds. However, when the animals are kept at a comfortable temperature of 55 to 60 F, only 300 pounds of feed will add 100 pounds.

A heat pump enables a farmer to get a hog to market in 100 days instead of the average 180 days. Further, a representative of one Midwestern power company estimated recently that the farmer who spends $1 for electricity for a heat pump is getting the equivalent of $1.50 in feed. For maximum feed efficiency, hog production in the Midwest—like broiler production in the East—will undoubtedly be conducted on a streamlined basis in completely air-conditioned houses.

Sometime in the foreseeable future, cathode-ray bombardment may be commonly used for sterilizing our food, perhaps even for prolonging the storage period for food. Tests conducted by the Brookhaven National Laboratory, for example, demonstrated that potatoes exposed to medium doses of gamma rays showed no sprouting and no softness as late as 18 months after exposure.

In the great wheat-growing areas, cathode rays have also been used experimentally for destroying weevils in wheat. A 2-inch depth of wheat flowing on a 2-foot belt at 125 fpm past a cathode-ray machine could be sterilized for less than a penny a bushel. Now, of course, installation costs are too high for the average farmer, but cathode-ray equipment may soon be economical for farming co-operatives.

A new electronic machine recently developed by the United States Department of Agriculture (USDA) detects green rot—the bane of the poultry farmer. The bacteria in infected eggs produce a chemical that fluoresces green under ultraviolet light. By measuring the color wave lengths under this light, the user can easily identify an infected egg.

Electric power, plus an adventurous spirit characteristic of America, has allowed the industry-wide production of more and better goods at the lowest possible cost. To the farmer, also, large-scale production and electricity mean less man-power and more earning power at less cost. Today, the average industrial worker has well over 200 electrical helpers at his bidding. And now the farmer is fast approaching the equivalent. Ω

SOCIETY OF PLASTICS ENGINEERS, INC.

By P. J. UNDERWOOD

The early 1940's saw unprecedented important discoveries of materials made by man through the use of synthetic resins. And applications for these plastics materials multiplied rapidly—partly the result of the urgent wartime demands of that period. However, technology lagged behind these new developments. To promote in all lawful ways the arts, sciences, standards, and engineering practices connected with the use of plastics as its purpose, the Society of Plastics Engineers (SPE) was founded in 1942—early during those intensive war years.

In the two years prior to the formation of the national Society, several groups met independently in such metropolitan areas as Philadelphia, New York, Pittsburgh, Detroit, and Seattle. By an open interchange of ideas at regular meetings, members increased their knowledge in the vast new field of synthetic resins, from which engineers were to bring forth the myriad plastics products that are abundantly available today.

The Detroit group, formed in 1941, recognized the need to be national in scope. As a consequence, in the following year they were the first to organize as a geographical section of the Society of Plastics Engineers, Inc.

Organization

The Society of Plastics Engineers is incorporated under the laws of the State of Michigan as a nonprofit organization, with the national executive offices located in Greenwich, Conn., and a branch office in Athens, Ohio.

A National Council—consisting of Directors, each elected by one of the geographical sections, and a Director-at-large, who is the retiring national president—governs the Society. From this body of Directors, the Council elects four national officers who serve for a term of one year. The 1955 incumbents are . . .

PRESIDENT—Frank W. Reinhart, Chief, Plastics Section, National Bureau of Standards

VICE PRESIDENT—Ernest P. Moslo, President, Moslo Machinery Company and Mid-America Plastics, Inc.

SECRETARY—Jules W. Lindau III, Professor, University of South Carolina and President, Southern Plastics Company, Inc.

TREASURER—Haiman S. Nathan, President, Atlas Plastics, Inc.

Various national operations committees develop SPE's management policy, which is implemented by a staff headed by the Executive Secretary.

Sections

After the Detroit Section organized, many more followed: Chicago organized later the same year, Cleveland the following year. By 1948, 24 Sections had been formed; and only last June, the National Council accepted a petition recognizing the 33rd Section. Now SPE Sections meet in every major plastics center across the United States and Canada.

Local officers govern each Section under bylaws that are in harmony with the national Society's constitution, bylaws, and rules. At the regular monthly technical meetings, a speaker or panel of speakers discusses a current important topic.

Sometimes, the Sections hold joint meetings with the local groups of other national engineering societies—American Society of Mechanical Engineers, American Society of Tool Engineers, and others. This way, Section meetings provide a forum for the dissemination of technical and engineering information on plastics and related fields, as well as an opportunity for plastics engineers and their associates to meet and interchange ideas for mutual education and understanding. These meetings represent a cornerstone of the SPE's contribution to the advancement of plastics and of the engineering profession generally.

Membership

A plastics engineer is an engineer mainly concerned with the application of principles of engineering and allied science to the production or utilization of plastics materials.

To obtain the grade of Member in SPE, an individual must demonstrate that he is qualified to . . .

- Engage in the prosecution or direction of technical research, engineering, or designing that relates to the utilization of plastics
- Exercise responsible supervision of the production or fabrication of plastics or of the manufacture of apparatus and equipment vital to the use of plastics
- Impart technical instruction in the chemistry of plastics or the design and fabrication of plastics products.

Associate Members of the SPE are persons competent to co-operate with plastics engineers in the plastics or related industries. Persons who can fill subordinate technical positions in plastics or related industries and students in the plastics field qualify as Junior Members.

In 1950, SPE offered another class of membership — Professional Member. The requirements for this grade constitute at least 10 years of qualified experience or a combination of educational credit based on degrees received, plus experience.

Additionally, the Society has five Life Members and three Honorary Members.

Growth of SPE

During the past two years the Society has entered the greatest period of growth since its inception. It presently receives about 1000 membership applications annually. In the 13 years of its history,

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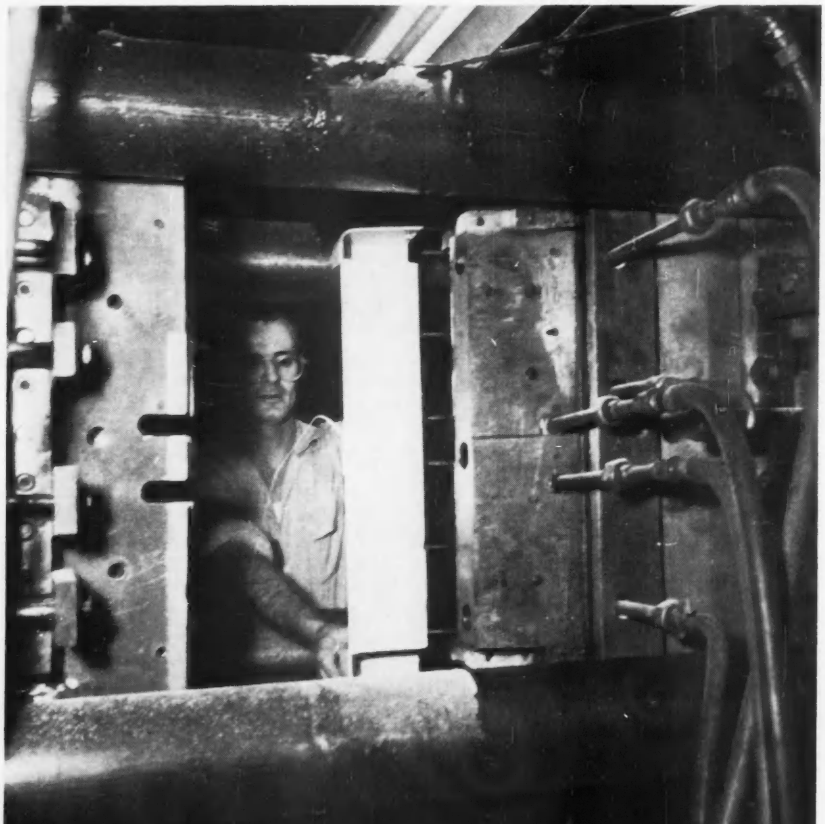
For the past two years, Mr. Underwood has been Executive Secretary of the Society of Plastics Engineers, Inc.

MOLDING of refrigerator control boxes—just one of the many applications of plastics—occurs in General Electric's Plastics Department located in Pittsfield, Mass.



INTRICATE injection steel molding equipment is used for making plastics parts for air-conditioning units that eventually find their way into many homes, offices, schools, and stores.

SPE's membership has increased from 40 to more than 4000. And conditions promise that the 5000 mark will be reached by the close of this year.

The geographical distribution of the membership indicates that approximately 60 percent are located in the East. Other heavy concentrations appear in Ohio, Illinois, Michigan, and California. Outside of the United States and Canada, members are located in Argentina, Australia, Brazil, Burma, Denmark, England, France, Germany, Holland, India, Japan, Spain, Sweden, and Switzerland.

Meetings

In addition to SPE members, interested nonmembers are invited to attend the Society's yearly technical three-day conferences. At these meetings, papers on many phases of plastics technology and engineering are presented and discussed. At both the Toronto conference in 1945 and the Boston conference in 1953, more than 1000 technical men concerned with the plastics field participated. At the 11th conference held in Atlantic City, NJ, during January this year, an attendance of nearly 2000 was reached. This conference was the source of 60 technical papers that were presented during 15 sessions, three running concurrently. The 1956 conference will be held in Cleveland, Ohio, January 18, 19, and 20.

Portions of the technical proceedings of these national conferences are published in the Society's *Journal*, as well as in several commercial trade journals interested in plastics and the electrical, automotive, and other industries. Beginning this year, Regional Technical Conferences will also be held on specific branches of plastics engineering. They will serve to provide an additional outlet for the technical information available from SPE membership.

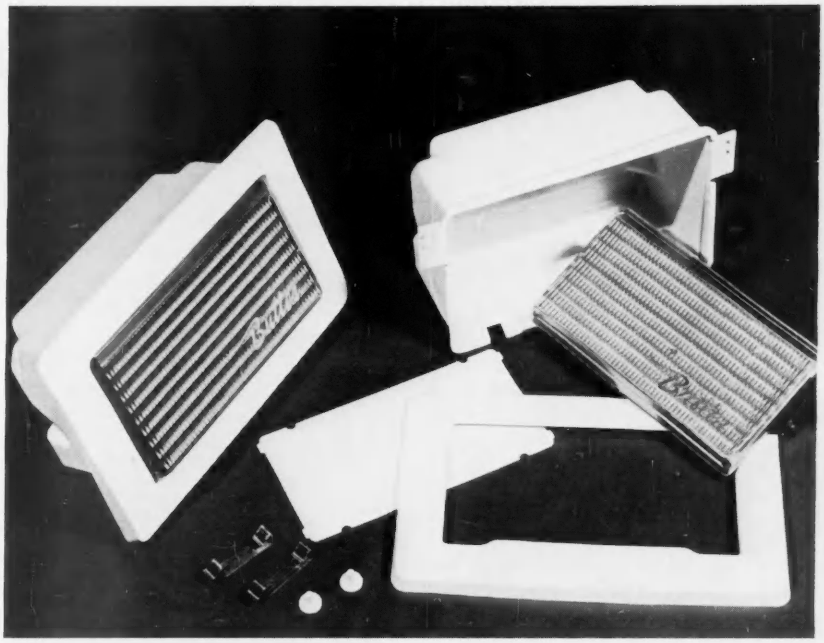
Publications

This year the Society published its first volume of SPE Conference Papers, containing more than 500 pages of text, diagrams, and illustrations. Scheduled for annual publication, this series is designed to provide a permanent record of all the data presented at these national technical conferences.

The Society's other major publication is the *SPE Journal*, now celebrating its 10th anniversary of publication. A monthly technical magazine, its editorial content consists of articles on the technology, science, and engineering of plastics, selected by the Society's Editorial Advisory Board. It also contains abstracts of articles on plastics from every major plastics' magazine in the world.

The portion devoted to the SPE News serves as a medium for preserving and spreading to the entire membership and others interested the proceedings of all the Society's local technical meetings. Each Member automatically receives the *Journal;* nonmembers and company libraries can subscribe to it.

Other SPE publications are the responsibility of the Education Committee and Professional Activity Groups.



REFRIGERATOR BUTTER CONDITIONER, molded from styrene material, contains two pinions, housing, and bezel cemented together to make one unit; baffle plate snaps into place.

Professional . . .

Since the early days of the Society when the first Sections were formed, SPE has maintained Professional Activity Committees to work on such projects as test procedures, standards, and statistical quality control in the plastics field. Although organized on the national level, these projects are accomplished entirely by the voluntary work of the local Sections. The reports of these committees are published in the *SPE Journal* and the work annually reviewed at the national conferences.

In January 1954, the Council decided to direct the work of these professional activity committees to the preparation and writing of a series of engineering volumes on plastics. The Society expects the first volume of this series to be ready for publication by the end of this year.

. . . Co-operative . . .

In 1954, the Society of Plastics Engineers helped to sponsor the *Statement of Principles of the Plastics Industry*, a code to guide management and technical men alike.

To further the development of standards on plastics, SPE co-operates with the American Society for Testing Materials (ASTM). SPE also has a permanent representative to the International Standards Organization to help in developing worldwide uniform terminology and standards on plastics. And SPE gives consideration to proposals for joint research projects with other engineering societies on subjects of mutual interest.

. . . and Educational Activities

The Society attaches great importance to the need for increased educational facilities on the subject of plastics in all its phases. SPE's Education Committee has co-operated with many colleges in successfully establishing undergraduate courses in plastics. The Lowell Technological Institute, Mass., now offers a four-year degree course in plastics engineering, and the Eastern New England Section of the Society has set up a scholarship fund there. Princeton University offers a graduate degree in engineering with specialization in plastics. And many other engineering colleges and universities include courses on plastics in their curricula.

One of the Education Committee's publications, *A Program for Engineering Education in Plastics*, contains a comprehensive list of the available educational opportunities in plastics engineering.

Under the supervision of the national Education Committee, the Education Committees of the geographical Sections contribute greatly to the SPE's educational activities. The national Education Committee also conducts a session on education at the national conferences and sponsors a comprehensive research symposium on plastics each year.

Contributions

The over-all contributions of the Society are many and varied and can be segregated into two distinct areas: those directly affecting the plastics-engineering profession and those pertaining to the advancement of the theory and practice of the engineering and the allied arts. The SPE contributes to the profession by. . .

- Maintaining high technical and cultural standards for entrance to the Society
- Promoting and adopting a comprehensive code of ethics for the guidance of engineers in the plastics-engineering profession
- Co-operating with educational institutions in maintaining high standards of technical education and in encouraging the establishment of undergraduate and graduate courses relating to plastics and their utilization.

And the Society advances the theory and practice of engineering by . . .

- Encouraging intercourse among engineers for the mutual exchange of information on plastics and allied technical matters
- Encouraging the preparation of original papers on technical topics
- Holding meetings for the presentation and discussion of original papers
- Publishing papers, reports, and reliable and accurate data pertaining to plastics and their utilization
- Developing and promulgating standards and recommended practices pertaining to plastics and their utilization
- Encouraging engineering research, tests, and other original work. Ω

On a rise above the Mohawk River, the new Metals and Ceramics Building houses 52,000 square feet of working space plus a variety of foundry equipment, metal-working machinery, and laboratory services. It represents a fresh approach to the problem of . . .

New Materials and Processes

Review STAFF REPORT

Metallurgists and ceramists the world over are giving their ancient arts a second look in the light of scientific progress. And at General Electric, the nation's largest employer of advanced graduates in metallurgy, scientists are investigating new materials and processes with the aid of an unparalleled facility: the new Metals and Ceramics Building of the Research Laboratory, Schenectady.

Why so extensive a facility for research? In industry, ideas for materials that go into products are generated in research laboratories and engineering departments. But before an operating component of a company can adopt a new material or process, it must know many things—obtainable only on a scale approaching industrial conditions.

In the new building, ceramics and metallurgy facilities are integrated. For metals and ceramics are closely allied fields; both are crystalline solids, and the general laws governing their behavior are identical. Accordingly, an extensive area for formulating, heat-treating, and evaluating ceramics adjoins a similar metals-treating area. Space is also set aside so that metallurgists and ceramists pool their knowledge to produce composite materials of outstanding properties, known as cermets.

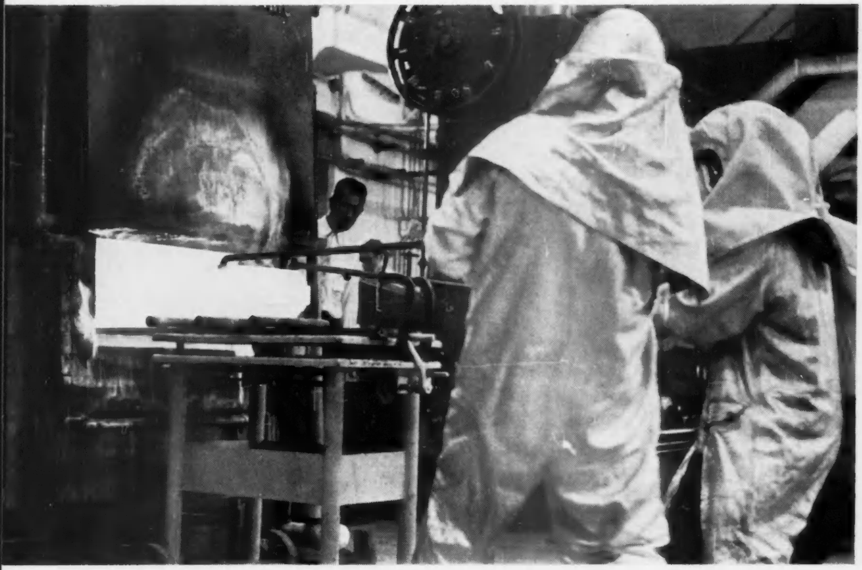
The laboratory's scientists collaborated on the design of much of the machinery used in the Metals and Ceramics Building. Melting conditions unattainable in normal commercial practice are required to produce the superalloys for tomorrow's jet engines, rockets, and other developments. During melting, these alloys must be protected from the atmosphere's contaminating effects. Far stronger than materials used in conventional metal-working machinery, superalloys also require special equipment to perform normal rolling and forging operations.

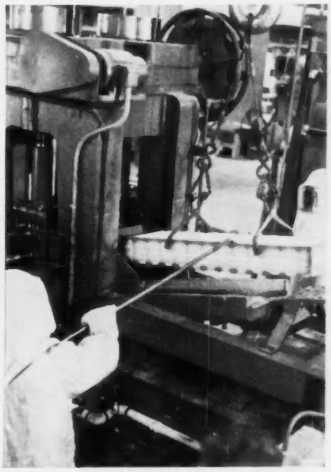
But however impressive the machinery, the most important items of "equipment" are the researchers. The building—its equipment, laboratories, and offices—were all chosen with only one thing in mind: to make it easier for scientists to develop, exchange, and try their ideas on a practical scale.

Some action photos of personnel and equipment at the new research center are presented on these and the following pages. . .

Metallurgy

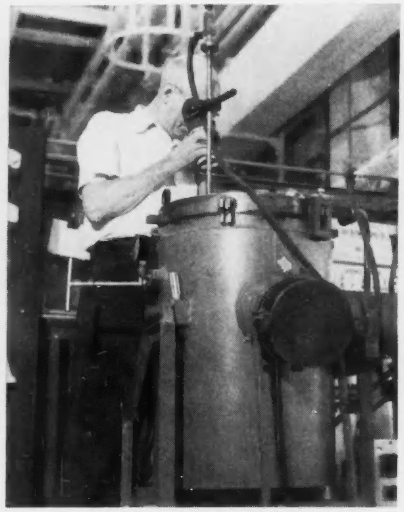
Members of the technical staff helped design the new building and collaborated in designing much of the equipment in the high-bay area (right). Because the new building will be used for a variety of pilot-plant operations, prime considerations in its design were flexibility and versatility.





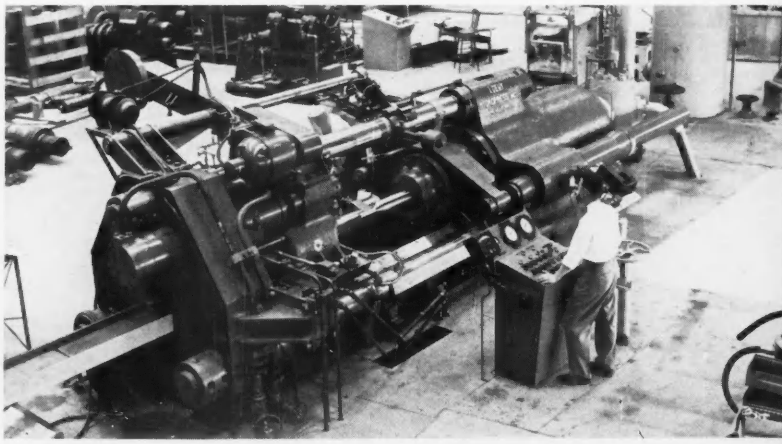
GUIDE BLOCK is removed from furnace and placed in a planetary mill (above), a machine so new that it is unknown to many metallurgists.

SINGLE OPERATOR at control console remotely operates the consummable-electrode arc-melting furnace in background. He views the entire melting operation by means of a closed-circuit system of television.

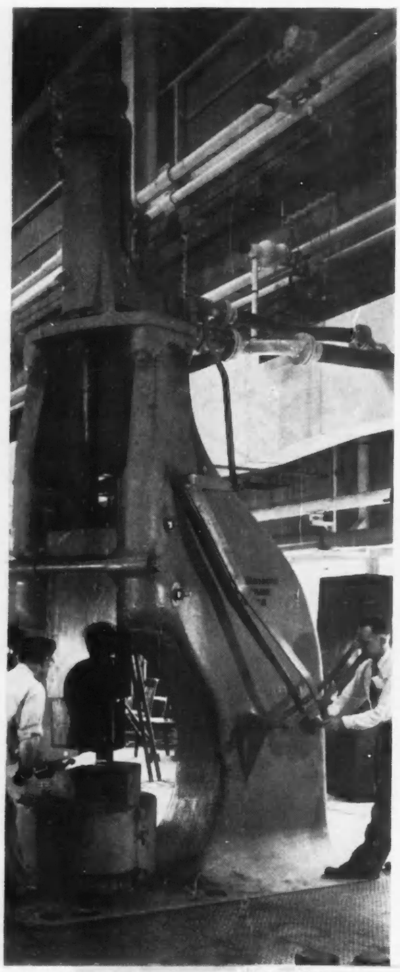


NEW AND OLD—Metallurgist shovels chemical into modern electric arc furnace (left). Operator (above) measures temperature of melt inside 15-year-old vacuum furnace designed by laboratory scientists.

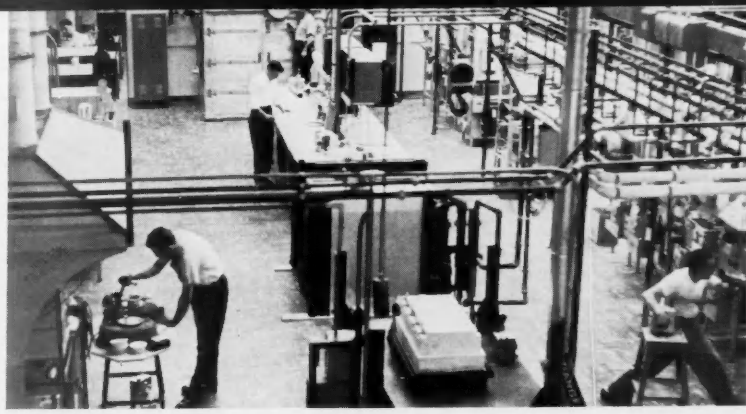
Metallurgy (CONTINUED)



POLISHED STEEL RAM of this hydraulic extrusion press—one of the fastest in existence—rapidly deforms superalloys at speeds up to eight inches per second.



WHITE-HOT INGOT is formed with forging hammer (left) to give it desired properties. Foundryman loads melting stock into a new 50-pound vacuum furnace (right).

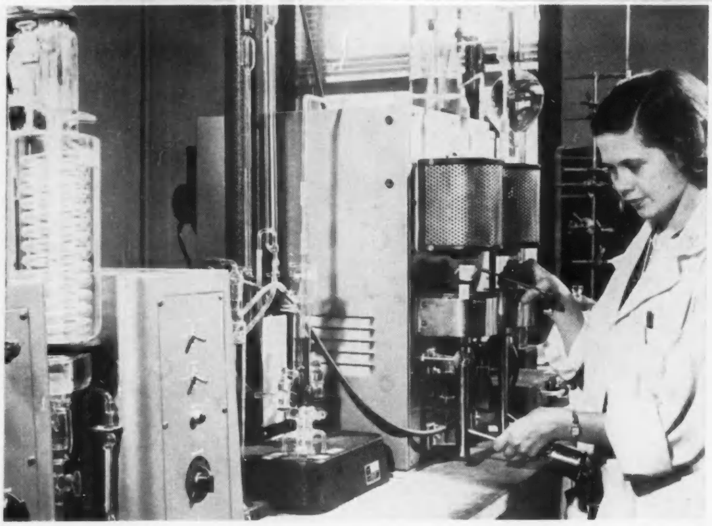


EQUIPMENT to meet all foreseeable future requirements is at the disposal of ceramists in the Metals and Ceramics Building. In this area, ceramic materials are melted and heat-treated; they are formulated, mixed, and pressed in adjacent rooms.

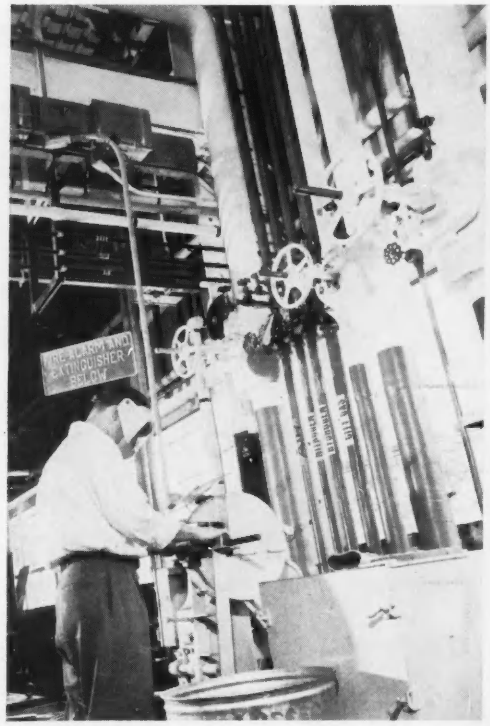
Ceramics

Ceramic materials are receiving much attention at the research center. For example, an operator presses out a ceramic disc synthesized from chemical compounds of high purity (above). Scientists look forward to the day when ceramics can be processed the same way as metals.

PLATINUM CRUCIBLE of glass melt being removed from furnace is part of the continuing research into ceramic materials. The cylindrical apparatus (left) is a rotating-hearth firing furnace where ceramics are manually fed in and heated under closely controlled conditions.

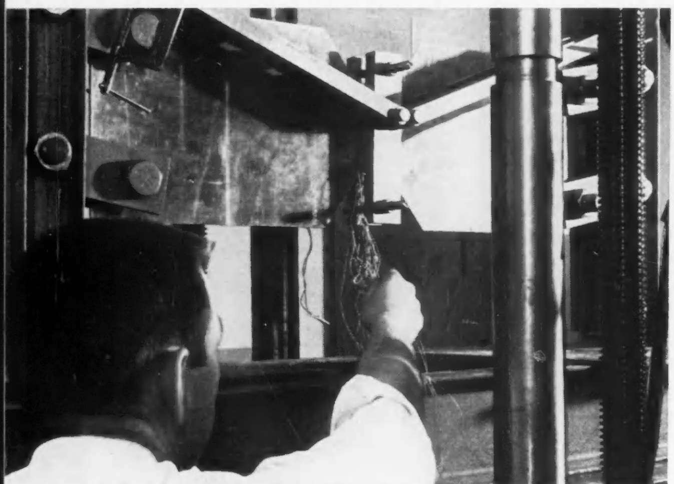


CARBON CONTENT of a metal is quickly analyzed in chemical laboratory. With this information, metallurgist can accurately control melting process.



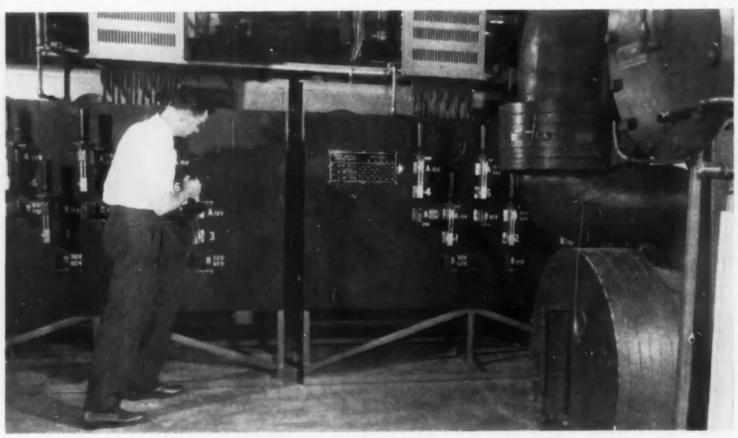
Testing and Services

Rapid analysis and testing of alloys are vital to operations at the research center. Equally important are the many supporting services, such as oxygen, nitrogen, dry hydrogen, natural city gas, compressed air, rough vacuum, steam, distilled water, and cooling water that are supplied to the new building on a "turn-the-handle" basis (above).



NOTCH TEST of metal plate is carried out in mechanical laboratory. Electric strain gages record the slightest bend.

AUTOMATIC RECORDER speeds search for new and improved magnetic materials. Direct current is switched on (right) from two germanium rectifiers with a capacity of 12,000 amp at 15 volts. Ω



MOTOCHRON CLOCK WITH SWEEPSECOND HAND USED IN FORD'S *THUNDERBIRD* COMBINES ACCURATE ESCAPEMENT WITH D-C TORQUE MOTOR.

Engineering a Really New Automobile Clock

By HANS SPRINGER

Clocks used in automobiles today are subject to a variety of conditions—dust, vibration, temperature, and voltage fluctuations, to name just a few. You wouldn't expose your wristwatch or, for that matter, a household electric clock to such vigorous treatment. But you would probably expect your automobile clock, without any service whatsoever, to perform with great accuracy during the life of your car. Contrast this with an expensive wristwatch. Watchmakers advise cleaning and lubricating it every two or three years to assure precision and long life and to prevent serious damage.

Statistics show that you drive your car 10,000 miles annually at an average speed of 30 mph. Based on these figures, the average car is moving only about 4 percent of the time, while 96 percent of the time it is parked in the garage or at the curb or in a parking lot. Additionally, the car receives several oil changes, adjustments, and other servicing during the year. But the clock in that car is expected to operate accurately and reliably 100 percent of the time without service.

How Automobile Clocks Function

A household electric clock operates from an a-c supply voltage with a frequency controlled at the power station. A self-contained synchronous motor, with its speed a function of the frequency, drives the clock's gear train and hands. Thus the accuracy of the clock depends on the power-supply frequency.

However, in the absence of a synchronizing signal, an electric automobile clock depends on the d-c voltage from the battery or generator. Therefore, the clock must have its own means for governing speed: a self-contained governor.

Operation of such a governor is usually based on some form of resonance involving oscillatory, vibratory, or some different cyclic motion. Instead of being constant, the instantaneous speed of a clock's mechanism controlled by this type of device follows a cyclic pattern. Only the average speed of the clock's mechanism is substantially constant; its instantaneous speed rapidly accelerates and decelerates near the average value.

One example of such a governor is the balance-wheel hair-spring escapement commonly employed in spring-driven clocks and watches. By rapidly interrupting the movement of the clock's gear train and bringing it to a halt four or five

WITH 20 YEARS OF EXPERIENCE in GE's Clock and Timer Department, Ashland, Mass., Mr. Springer is presently Manager—Development and Design Engineering, responsible for co-ordinating engineering, manufacturing, purchasing, and marketing of the Motochron clock.

EACH MOTOCHRON CLOCK undergoes a timekeeping test. The impulses of the clock's escapement are picked up by a microphone and then amplified and recorded for observation.

times a second, this type of escapement controls the average speed of the clock's mechanism.

A large percentage of today's automobile clocks use escapement-type movements that are powered by a spring. Through the opening and closing of electric contacts, an electromagnet periodically winds the spring. When the spring is almost unwound, the contacts close momentarily, energizing the electromagnet to wind the spring. The continual winding and unwinding action causes considerable variation in applied torque to the escapement, necessitating frequent closing and opening of contacts with attendant wear.

In other automobile clocks, an electromagnet keeps the balance wheel oscillating. But here again, the electromagnet requires the synchronized opening and closing of electric contacts four or five times a second.

Motochron Clock

A nationwide survey disclosed that many motorists weren't satisfied with the clock performance in their cars. Concurrently, GE's development work had progressed to the point where we could introduce an electric automobile clock based on an entirely new principle: combining a specially designed and highly accurate escapement mechanism with a d-c torque motor.

You might wonder why this wasn't done sooner. Perhaps tradition stood in the way. Or possibly watch and clockmakers lacked knowledge of electric-motor principles.

The result of this new principle is the Motochron clock used in the Ford *Thunderbird* (photo, page 41), Lincoln, Mercury, Continental, and Chrysler cars. In keeping with the established practice of synchronous electric clocks, it is provided with a sweepsecond hand.

For years prior to the formal introduction of the Motochron clock, GE made extensive laboratory and field tests to simulate the various operational and environmental conditions. For one extreme installation, we chose a police cruiser in service practically 24 hours a day. We also made an installation in a private airplane used for short, irregular intervals. The clocks in these two installations and many others operated with remarkable accuracy. Laboratory results and field tests indicated that the clocks would keep reliable and accurate time under various climates and voltages—well within the specification requirements of the automobile industry.

Considered for aircraft use, the Motochron clock was designed to withstand the military vibration tests for aircraft instruments. And, of course, any clock rugged enough to perform under the rigorous environmental conditions of military tests will not be affected by automobile vibration and shocks.

Checks and Balances

The Motochron clock has distinct advantages over any other automobile clock now in use. Designed to operate at 6 or 12 volts, its d-c torque motor continually rotates in step with the clock's escapement. Torque output at rated voltage always remains constant for a given ambient temperature. Because automobiles operate only about 4 percent of the time, the clock receives a relatively constant voltage from the automobile's battery 96 percent of the time. The d-c torque motor will therefore deliver substantially constant torque as long as the temperature remains constant, thus providing for accurate timekeeping (photo, lower, opposite page).

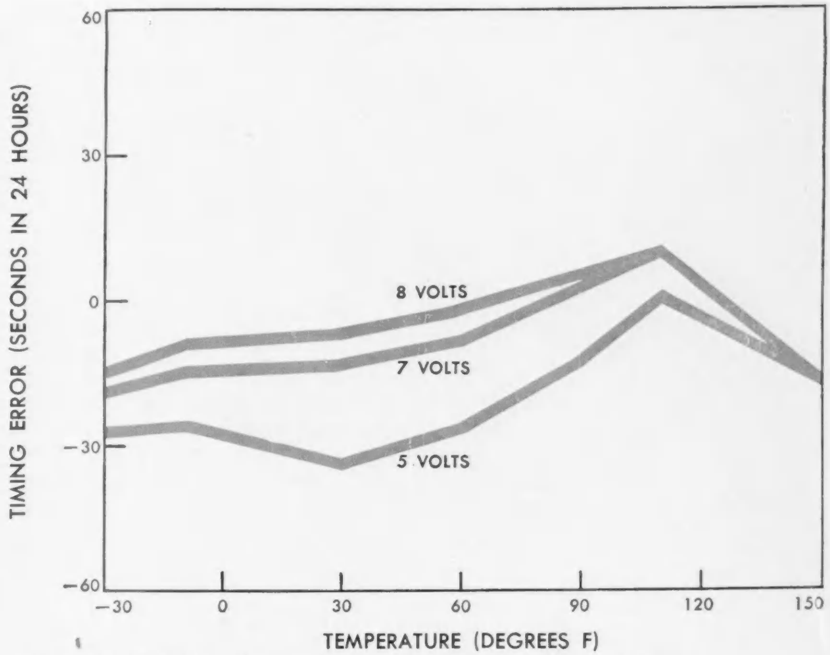
You might ask, what happens during the 4 percent of the time when the car is in motion and supplies the clock with variable voltage? Further, what occurs when the temperature varies?

With the engine running, it's rather unusual for a 6-volt ignition system to furnish either less than 5 or more than 7½ volts for any length of time. In the Motochron clock, torque output varies only slightly over this range, maintaining the clock's accuracy at well within acceptable timekeeping standards. What's more, the clock continues running on a voltage as low as 3 volts. This gives you an idea of its high built-in safety factor.

The torque motor has a low speed—less than one revolution per minute. Using this motor makes a protective fuse for the clock unnecessary because the motor, whether running or stalled, uses the same current.

Copper wire, as you know, changes its resistance to electric flow with temperature. Accordingly, when temperature decreases, more current flows through the rotor of the Motochron clock; magnetic flux increases, and the torque rises proportionately. On the other hand, as the temperature increases, less current flows through the rotor and torque output drops—a principle utilized to good advantage.

Because oil becomes more viscous when the temperature drops, it has a braking effect on the gears and pivots of a clock's mechanism, causing the clock to slow down or stop entirely. However, in the Motochron clock, this effect and the gradually increased torque of the motor compensate for each other as the temperature drops. Thus the clock will run at temperatures as low as −30 F.



TEMPERATURE-COMPENSATING characteristics of the Motochron's hairspring assure accurate timekeeping over a wide temperature range, matching the motor's torque characteristics.

Temperature variations of the hairspring in a primary timekeeper such as the Motochron clock can also affect accuracy. Serving a highly important function, the hairspring controls oscillatory amplitude and frequency of the balance wheel. (They, in turn, are related to the balance wheel's mass.)

But through the development of new alloys, the characteristics of high-quality hairsprings make up for these temperature variations in the Motochron clock. The temperature-compensating characteristics of the Motochron's hairspring not only assure accurate timekeeping over a wide temperature range but also match the torque characteristics of the motor (illustration).

The accuracy of a primary timekeeper also depends on lubrication. The need for a lubricant that would give maximum lubrication under the most adverse operating conditions was realized soon after work began on the Motochron clock. Confident that one would be found, our evaluation of every available domestic and foreign lubricant paralleled our electrical and mechanical development programs.

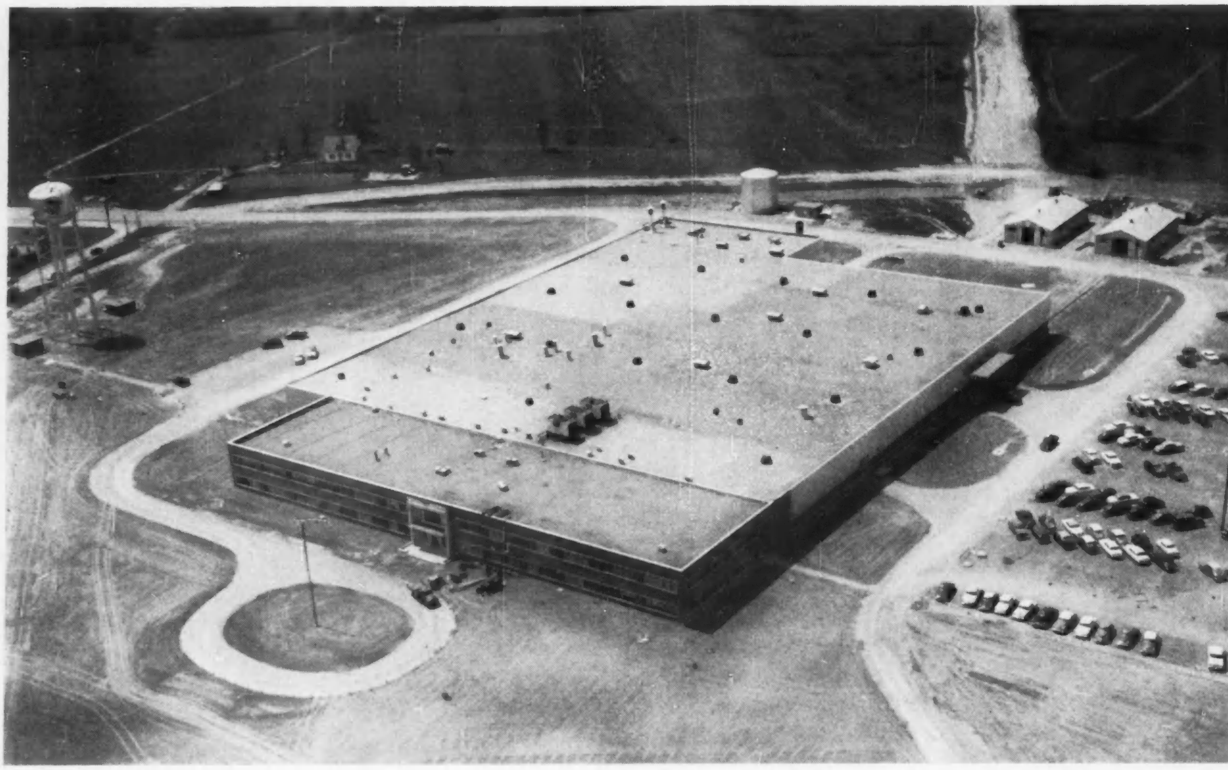
More than 80 different oils of varying basic compositions were evaluated on the basis of 25 chemical and physical properties—viscosity, pour point, flash point, specific gravity, creepage characteristics, and oxidation stability, to mention a few. The synthetic oil finally selected as most suitable for this application is compounded in the chemical laboratory of GE's Clock and Timer Department.

Looking to the Future

Although the Motochron clock is an advance in the art of electric timekeeping and something that will please the American motoring public, we feel certain that continued development will improve its already outstanding performance, as well as increase its desirability to the public.

Lubrication, a limiting factor in all timekeeping devices today, is under constant consideration. And as better lubricants are developed and applied, they will extend the useful life of electric clocks.

Broad research and development programs now covering so many fields of endeavor will undoubtedly open up new possibilities for improved timekeepers. Whatever changes are made, the motoring public can be assured of getting a more accurate and reliable clock, representing the best product that engineering and manufacturing can produce. Ω



ON THE FORMER AIRPORT OF WAYNESBORO, VA., THE SPECIALTY CONTROL DEPARTMENT BUILT ITS NEW PLANT OF 190,000 SQUARE FEET.

New Plant Boosts Electronic Control Output

Review STAFF REPORT

Waynesboro lies a cool 1300 feet in Virginia's Shenandoah Valley, not far from either the southern entrance to that state's famous Skyline Drive or the northern entrance to the equally famous Blue Ridge Parkway.

About two miles from the center of this pleasant town of some 14,000 people and about 550 miles from its former Schenectady location, General Electric's Specialty Control Department built its new and completely integrated headquarters. Here is produced a variety of control equipment ranging from that used in aircraft electric systems to complex programming systems that automatically control machine-tool operations. Other items include resistance welding controls; hermetically sealed relays; ultrasonic generators; pinhole detectors; cut-off, side, and color-register controls; and electronic adjustable-speed drives.

At full production the plant will employ 600 to 700 (one of every five will be an engineer), with an annual payroll of about $\$2\frac{1}{2}$ million being poured into the Waynesboro area. In addition to what the plant will spend for construction, materials, utilities, and supplies, employees transferred from Schenectady have bought or are building $500,000 worth of homes in the neighborhood.

"There's more to locating a new plant than the obvious things such as transportation, access to the market, and a fair tax structure," Dr. Louis T. Rader, General Manager of the Specialty Control Department, told the REVIEW. "The community itself plays an important part. Are the schools paid for or will our employees be saddled with a big debt for the next 20 years? Are there adequate transportation facilities for people as well as products? How does the number of housing starts stack up with other communities of the same size? There may be plenty of churches, but are all three major faiths represented? How about educational facilities where engineers and management can take advance courses?

"Waynesboro came closest to satisfying these requirements. It's a comfortable community in which to live, as we Yankees are finding out [Rader was born and raised in Canada], a new hospital has just been completed and paid for, the shopping area is satisfactory, the utilities and community services are well run, and the University of Virginia is only 24 miles away."

The production problem facing Rader and his managers was this: how to efficiently produce short runs of highly specialized control items. That the new plant isn't a monstrous job shop, inundated by paper work and a swarm of fork trucks, is a tribute to a farsighted concept of the use of modern data-processing equipment.

On the following pages, you'll see how production is handled and some highlights of Specialty Control's new plant...

Punch Cards, Tote Trays, and Conveyors Help Speed Production

1 An order receives a preliminary checkover and then is sent to the Data Processing Room. There, a master deck of cards is pulled for the particular control device involved in the order. Each card of the deck represents an individual piece of the device. (If the order calls for any variations from the basic design represented by the master deck, cards are punched to take care of the variation.) The machine then transfers information from both the master deck and a "header" card to another set of cards, each card of this second deck containing such information as the part number, name, and quantity for the particular order. The information on the second set of cards is then transferred by machine to forms that are used by the Manufacturing Section to begin actual scheduling and production of the order.

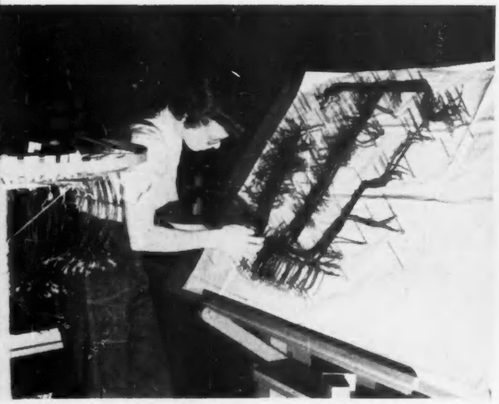
2 At the proper time, the stockroom pulls all parts referring to a particular order, loads them into tote trays, and puts the trays on a conveyor truck. All the trays on a truck contain parts for a single order. This system—mechanization of paperwork to a high degree—allows a running stock inventory and also keeps tabs on the "activity" of every part in stock (about 4000 standard parts). The data-processing equipment is also used for cost, payroll, and other accounting reports. To see how the trucks are conveyed to a work station, turn the page . . .

NEW PLANT BOOSTS ELECTRONIC CONTROL OUTPU

While Production Rolls, the

3 Three conveyor systems carry parts from stockrooms to various product-assembly areas throughout the plant. The trucks are disengaged easily from the conveyor at the appropriate work station. No traffic problems and a clean plant layout are two results.

4 At each work station, the operator not only gets the right parts at the right time but also has all parts for the order only an arm's length away. There is no chasing around the plant for missing parts.



SKILLED HANDS ASSEMBLE WIRING HARNESSES AND MICROMINIATURE RELAYS; DIP-SOLDERING IS USED ON SOME CONTROL COMPONENTS.

Concluded)

Laboratory Develops New Devices for Tomorrow's Factories

AIRCRAFT CONTROLS, such as voltage regulators, hermetically sealed relays, and generator-protective panels, are subjected to the same conditions they'll encounter on today's aircraft in one of the Product Development Laboratory's altitude-temperature chambers.

RECORD-PLAYBACK CONTROL (operating a machine tool by means of a magnetic tape) and the recently announced Numerical Positioning Control that uses standard business-machine cards for programming the operation of a turret punch press were developed in the Department's Laboratory. With the help of other new developments that will come forth, management expects the demand for the new plant's products to double within the next five years and to triple by 1965. Plans for plant expansion are already under way. Ω

ONE-MILLION-VOLT ELECTRON BEAM IRRADIATES MOVING POLYETHYLENE FILM TO PRODUCE . . .

Irradiated Polyethylene

By P. A. GOODWIN and DR. J. W. WETZEL

With a single stroke, GE's new development—Irrathene (Reg. trademark, General Electric Company) irradiated polyethylene—has started a new era in chemical processing. For just as Charles Goodyear's discovery of vulcanization in 1839 greatly extended the usefulness of rubber, so irradiation is expected to extend the application of polyethylene, already the fastest growing plastics in the United States.

Vulcanization is the special name given the process of chemically tying together, or crosslinking, the molecules in rubber for improved properties. Goodyear did it by reacting rubber with sulfur. Ever since, the molecules in rubber and plastics have always been crosslinked by chemical means. As a result, chemical impurities are left in the finished product. There is always danger that the heat generated in the processing steps prior to molding will cure the material prematurely. The chemical reaction and the heat transfer required to initiate it takes time that reduces the output of expensive molds.

With the new irradiation process (photo), rubber and plastics can be crosslinked at room temperature without chemicals. Using a beam of electrons to bombard polyethylene, rubber, and many other plastics leaves no chemical residues. Yet it vulcanizes almost immediately—at any temperature from zero to the decomposition points of the materials.

Both Mr. Goodwin and Dr. Wetzel came with GE as development chemists and are located in Pittsfield, Mass. With the Company 13 years, Mr. Goodwin is Supervisor, Sales Development, Chemical Development Department. In 1951 he received the Charles A. Coffin Award for his basic discoveries on polymerization and compounding of silicone rubber. Dr. Wetzel—Supervisor, Development Unit, New Product Development Laboratory—joined GE in 1950 after five years with Houdry Process Corporation.

Polymers and Irradiation

Polymers—the high-molecular-weight materials forming the major ingredient in all plastics—are not always improved by irradiation. Some degrade badly.

The effects of high-energy radiation on the properties of polymers—particularly thermoplastics that melt at high temperatures—have been studied extensively in recent years. These studies permit a simple classification of polymers as we know them today: they are either degraded by high-energy irradiation with loss of properties and lowered molecular weight or they are crosslinked to insoluble products of improved properties.

For example, such polymers as cellulose and polyisobutylene degrade, while others like polyethylene, polystyrene, and most rubbers crosslink. This type of fundamental knowledge leads to new products. Irrathene irradiated polyethylene is one of these.

The result of extensive research at General Electric on the chemical effects of high-energy radiation, Irrathene irradiated polyethylene can be traced historically to 1925. At that time Dr. W. D. Coolidge, inventor of the modern x-ray tube, started exploratory work on the chemical effects of high-energy electrons. Research in this field continued, and in 1954 the first commercially available irradiated polyethylene was introduced as Irrathene 101.

Basically, the process consists of bombarding polyethylene with a beam of high-energy electrons having one-million-volts peak energy. Still a matter for speculation, however, is the exact mechanism to account for crosslinking within the material. The net result is that hydrogen atoms are knocked off the polymer's molecules, leaving active sites to form crossties and, eventually, a three-dimensional network. Displaced hydrogen evolves as a gas.

Highly sensitive to crosslinking, polyethylene requires only a relatively small dose of radiation to make it nonmelting and insoluble in organic solvents at elevated temperatures. Processing problems cover such things as ease of manipulating the polymer into and out of the radiation source and the ability to focus and control the source. Other problems involve protecting personnel with shielding and obtaining the desired depth of penetration into the irradiated article.

Commercially speaking, polyethylene is an attractive material with which to develop irradiation. It not only crosslinks easily under a small amount of radiation but also is a reasonably priced petroleum-based material. What's more, polyethylene is popular with plastics fabricators. It has many of the most desirable plastics properties: excellent dielectric characteristics, low specific gravity (it floats on water), a toughness and flexibility even at frigid temperatures, and resistance to moisture and many chemical agents.

Irradiation enhances these desirable properties without degrading the material, thus bringing polyethylene a step closer to the rank of universal plastics. It doesn't melt. Neither does it crack when stressed in the presence of active liquid environments, such as household detergent solutions (photo, top left, next page). Eliminating the disadvantages generally associated with the unirradiated product greatly broadens its use, giving materials and design engineers a real opportunity.

TABLE I—PROPERTIES OF IRRATHENE 201

Properties	Rating
Tensile strength (5-mil film)	1800 to 2200 psi
Ultimate elongation	400 to 600 percent
Tear strength (50-mil sheet)	500 psi
Specific gravity	0.92
Water absorption	Negligible
Flammability	Slow burning
Chemical resistance	Excellent resistance to acids, alkalies, water-borne chemicals
Solvent resistance	Good below 60 C; swollen by hydrocarbons, chlorinated compounds above 60 to 100 C
Sunlight resistance	Must be protected
Power factor at 60 cycles to 10,000 megacycles per second	0.0005
Dielectric constant at 60 cycles to 10,000 megacycles per second	2.3

SHORT-TIME TESTS OF DIELECTRIC STRENGTH
(5-mil Film)

Temperature (Degrees C)	Dielectric Strength (Volts per Mil)
25	2500
50	2300
100	1800
150	1400
200	1100

TABLE II—ELECTRICAL PROPERTIES OF ENCAPSULATED IRRATHENE 210*

Temperature	25 C	100 C	150 C	200 C
Power factor (60 cycles)	0.0005	0.0004	0.0016	0.0034
Dielectric constant	2.3	2.1	1.9	1.9
Volume resistivity (ohms-centimeters)	20×10^{15}	1.8×10^{15}	4×10^{13}	9×10^{12}

* Tape applied to solid conductors by random winding; insulation thickness is 0.060 inch.

Some Applications

Presently, a large amount of polyethylene is used in the packaging field. This application should expand because the irradiated product doesn't melt and can therefore be sterilized in steam. Other less obvious merits of Irrathene irradiated polyethylene as a packing material are being actively studied.

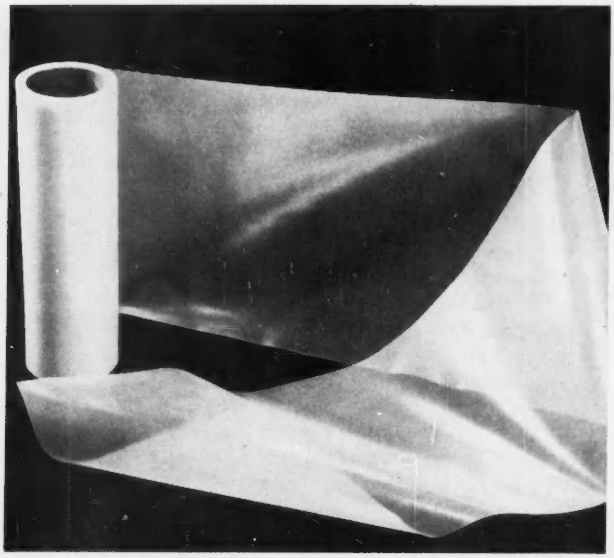
Unsurpassed in electrical properties, polyethylene finds its next largest end use as an electric insulation. Irradiating it gives added protection against the heat of electric overloads. Thus Irrathene irradiated polyethylene has outstanding advantages for the user of insulation.

Its ability to withstand heat and resist environmental stress cracking makes this plastics suitable for applications in the field of housewares, pipe, and equipment. For example, tanks lined with irradiated polyethylene for chemical resistance could operate at higher temperatures with no fear of immediate failure if design temperatures were exceeded. Household detergents and the high-temperature water in today's automatic dishwashers wouldn't adversely affect housewares fabricated of irradiated polyethylene.

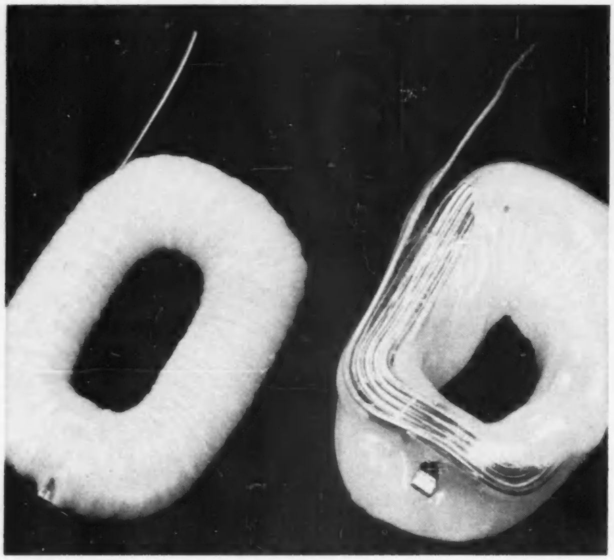
Certain limitations are imposed, however, when irradiation is considered as a tool to improve plastics. For one thing, Irrathene irradiated polyethylene can't be forced into a mold; that is, it can't be injection molded. A crosslinked material, it resists changes imposed by heat and pressure. This means that articles must be fabricated before irradiation. A large-volume application is required that can efficiently utilize the radiation source, such as the treatment of film (photo, top right, next page).

Electron penetration into polyethylene is related to voltage of the electron generator. For the standard million-volt

IMMERSED under stress in a household detergent solution, irradiated polyethylene (left) shows outstanding stress-cracking resistance.



ROLL of 12-inch-wide irradiated polyethylene film—an ideal large-volume application of irradiation—will be slit into insulating tapes.



NONMELTING at 150 C, irradiated polyethylene permits insulation of motor-starting coils. Conventional polyethylene melts away.

ENCAPSULATION of ink bottle illustrates unique means of insulating a conductor. Film heated to 150 C shrinks to fit all contours.

G-E x-ray machine currently used, penetration is about one-eighth inch from one side, or one-fourth inch from two sides—sufficient for most fabricated articles.

In developing Irrathene irradiated polyethylene, properties inherent in the conventional product but usually ignored at moderate temperatures had to be considered—oxidation, for example. Polyethylene, a hydrocarbon, will oxidize if exposed to air at elevated temperatures over a long period. Severe oxidation causes it to lose all its useful properties. To overcome this, oxidation stability was built into irradiated polyethylene to take full advantage of its nonmelting character at high temperatures.

Electric Insulation . . .

Having excellent properties for electric insulation, roughly about 20 percent of all polyethylene used in 1954 went into this application. Light weight, chemically inert, and resistant to fungi, its water absorption rate is low and its mechanical characteristics are good.

Polyethylene fails in many insulation applications because it can't tolerate high temperatures. Also, its expansion with increasing temperature is high, and it tends to crack under stress in the presence of active chemical environments.

To take advantage of its excellent physical and electrical properties, the insulation engineer had to overcome these weaknesses through proper design or application techniques. He was not, however, able to do anything about the high-temperature limitations because polyethylene is a thermoplastics and softens at 110 C.

But with Irrathene irradiated poly-

"... uses are developing for irradiated polyethylene in many fields."

ethylene tape insulation, high temperature no longer presents a problem (photo, lower left). For the irradiated product is nonmelting. At the same time it retains all the good properties of ordinary polyethylene. And additionally, its resistance to environmental stress cracking helps the insulation designer solve other problems.

Irrathene 101, an insulating tape introduced early in 1954, stirred a lot of interest, both in the electrical industry and among users of plastics films. It doesn't flow at temperatures up to at least 250 C, but it oxidizes rapidly at elevated temperatures. It is therefore suitable only for applications involving intermittent exposures to temperatures above 100 C or where it is completely protected from air.

A stabilized form of this tape, known as Irrathene 201, was developed especially for electric insulation. It contains an oxidation inhibitor that permits its use at 125 C—even higher in special applications—and offers protection against the high-temperature surges of electric overloads.

At room temperatures, irradiated polyethylene's physical and electrical properties are practically unchanged from those of the conventional product. It has high dielectric strength, low power factor, and low dielectric constant over the entire frequency range. Because of its low water-absorption rate, these properties are little affected by high humidity. In addition, Irrathene 201 maintains good dielectric strength at temperatures as high as 200 C (Table I, page 49).

As already mentioned, conventional polyethylene cracks deeply when stressed in the presence of detergents or solvents. This phenomenon is completely eliminated in the irradiated product. In fact, during standard tests conducted in over 30 of these environments, no sample ever cracked—even when exposed for one year.

... and High Temperatures

Irrathene irradiated polyethylene won't flow under its own weight at temperatures up to 250 C. In common with most other materials, however, it doesn't retain all its strength at elevated temperatures.

The tensile strength of irradiated polyethylene decreases linearly with temperature up to about 100 C. The tensile strength then levels out at about 100 to 200 psi, while retaining its residual strength up to at least 175 C.

Above the melting point of conventional polyethylene (110 C), the irradiated product behaves much like an ideal rubber. In other words, it deforms in proportion to an applied load, though only to a limited extent. After the load is removed, it will recover its original dimensions. Of course, excessive loads cause failure.

A new grade of film recently developed takes advantage of this rubbery nature, providing a unique means of insulating a conductor by encapsulation. This film, Irrathene 210, is manufactured in such a way that it shrinks in the lengthwise direction when heated in the range of 125 to 150 C. Wound on a conductor, coil, or other device (photo, lower right), it shrinks tightly around the object and into all surface irregularities. At the same time, the layers bond tightly together for a moistureproof form-fitting sheath with excellent electrical and physical properties (Table II, page 49).

The voltage at which corona forms around an encapsulated conductor depends on how well air is excluded by wrapping techniques. High values are obtained. Insulation applied in this way is completely resistant to penetration by water under high pressures at temperatures above 100 C.

One of the outstanding properties of Irrathene 201 insulation is its stability toward heat-aging—at higher temperatures than those recommended for older forms of general-purpose insulation. Accelerated aging tests indicate that it can function continuously up to 125 C. And when somewhat protected from air by overlayers of other materials, Irrathene 201 insulation can withstand temperatures above the 105 C maximum of Class A temperatures.

However, when this insulation is in contact with both bare copper and air, it shouldn't be used continuously above 100 C. But intermittent and short exposures to higher temperatures under these conditions are permissible. Protected from the air, the insulation is inert to copper.

But even in applications where it will not be exposed to temperatures above 100 C, Irrathene 201 provides valuable protection against unexpected electric overloads. Should the temperature rise as much as 200 C over a short period, for example, Irrathene 201 will neither flow nor decompose.

The decomposition products of irradiated polyethylene, incidentally, are not corrosive. Copper conductors or other metal parts would therefore not corrode under severe electric overloads—an important advantage not possessed by other plastics insulations.

Future Unlimited

Superpolyethylenes, publicized in recent news stories, are produced at low pressures in place of the extremely high pressures conventionally employed. (In fact, one periodical termed them "super-plastics.") Actually, they are less flexible than ordinary polyethylene and melt at about 15 C higher than the conventional product.

Thus they do not provide the protection against electric overloads afforded by a nonmelting film of Irrathene irradiated polyethylene. This new sheet insulation is the first tangible result of irradiation research. It will actually sell at a lower price than most of the materials now used, while at the same time provide superior performance.

Other uses are developing for irradiated polyethylene in many fields. And there's no doubt that irradiation will greatly expand its application. Beyond that lies speculation as to the course irradiation may take. It seems certain, however, that this is a first step into a field that will profoundly affect the chemical industry for years to come. Ω

CREDITS

Page	Source
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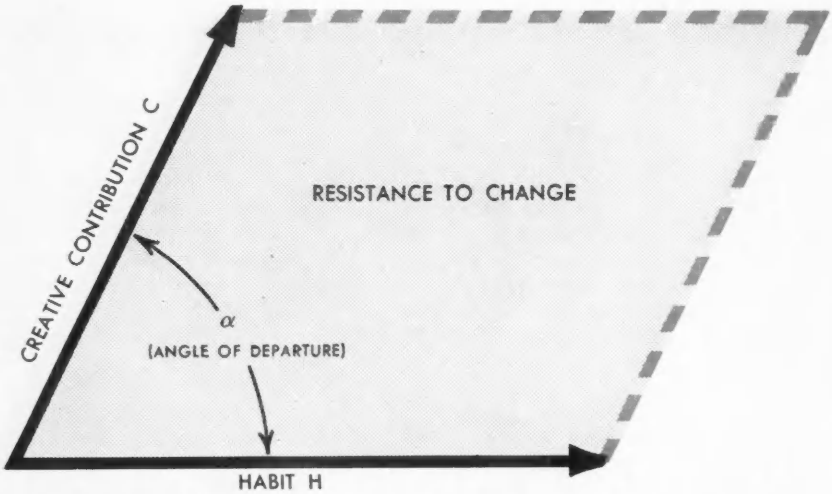
9	George Burns
11, 14	Reading Company Philadelphia, Pa.
18–22	George Burns
36–40	Research Laboratory Schenectady
41	Ford Motor Company Detroit, Mich.
44–47	Allwood Studios Waynesboro, Va. George Burns Howard D. Potter



IDEATIONAL TECHNIQUES—free flow of ideas—flourish in an environment that helps to establish focal points, break habits, increase knowledge, and create a permissive atmosphere.

Developing A Useful Imagination

By E. K. VON FANGE

The unique educational objective inherent in a course that develops the engineer's imaginative talent subordinates the conventional goal of transferring specified knowledge to the student. Instead, the challenge becomes that of cultivating his habits and attitudes and of increasing his ability to instruct himself. Rather than one-answer problems—and the intrinsic security that goes with a well-defined series of checks—more creative situations are assigned: the exact nature of the problem may be nebulous, the path to a solution unknown, and the means for determining the value of any solution uncertain.

The staff of General Electric's Creative Engineering Program faced such a situation when it inaugurated a course for young engineers in 1937. Many procedures and techniques were tried and different philosophies and curricula presented. The understanding achieved now seems to justify the course as a basis for developing engineers who are capable of making the successful and continuing advances that progress demands.

First, let's review a few of the conclusions developed in an earlier article (July 1955 Review, page 54) where creativity was defined in a general sense as a new combination of thoughts or things. Disregarding chance combinations, ideas can be no better than the understanding that led to their conception. And this understanding improves with the number of alternatives considered, indicating a regenerative cycle within the creative process that sometimes requires months or even years to complete.

Thus heredity apparently affects successful creation in two ways. First, intelligence—possibly defined as the measure of completeness with which the whole can be grasped—determines how complex a situation an individual can eventually understand and resolve. Second, man's other aptitudes indicate the vocation where he can make the maximum contribution.

Training, with its general objective of overcoming environmental effects, thus permits each man to be as usefully and efficiently productive as his intelligence allows—easier said than done. For a man contented with his present status feels no desire to develop or use his imagination. In performing routines, chores, or exercises, he relies on his predecessors' knowledge.

Only when he is discontented does he want such things as a greater understanding of nature; more security against disease, accidents, the elements, and his real or imagined enemies; a better competitive position; or an improved way of teaching, serving, or helping others. Of course, a man's particular environment will influence his choice of activity. Certain societies, past and present, were so content that no desire existed and no change in culture or technique was made for hundreds of years. In fact, a study of history finds the phrase "The rise and fall of . . . ." used repeatedly. Initially, a period of unusual prosperity and influence follows a great awakening, or renaissance. Eventually, however, a stage of blissful contentment takes hold, an ever-increasing corruption often becomes evident, and the once powerful forces become senile.

And this same pattern is all too evident within those segments of industry where precautions have not been taken. Product leaders, blissfully content with their designs, suddenly wake up to find themselves bankrupt or in a minor competitive position.

The same pattern can permeate the lives of individuals who do not take steps to prevent it. After the years of learning in school and the initial years on the job, these people eventually become content with their development and contribution, deteriorating into a stagnant liability rather than an aggressive asset. Though spoken to hypocrites, the Biblical passage "To him that thinketh he standeth, take heed lest he fall" is apropos.

Before you can develop your imagination, you must make the first and most essential step: accept the challenge that departure from past practices involves.

Suppose that you want to learn how to play the piano. You may buy or rent one and resort to self-teaching lessons, diddling with the keys once or twice. But not until you actually schedule regular practice time and earnestly use it have you made the decision to learn. And the same applies to creative imagination. Until you make scheduled efforts to practice and develop your imagination, you render lip service only.

Engineering offers unlimited challenges for making creative decisions. For instance, merely encouraging cost-reduction activity accomplishes nothing; only when responsibility for cost-reduction activity is assigned to specific individuals and when time and money are budgeted for it has the decision to reduce costs been made.

The idea of developing imaginative expression attracts many engineers. But when they encounter obstacles in the reduction of their ideas to usable practicality, they rapidly lose interest—especially if it necessitates acquiring new knowledge or understanding. Thus to accept the challenge of useful and repetitive creation requires a strong desire to do or to learn whatever will achieve the solution. Fortunately, the thrilling sensation of the hunt, plus the successful conclusion of a creative endeavor, exceeds the effort required.

Developing Imagination

In most individuals, the major outlet for imagination—more and more stifled in a world of habit and conformity—lies in the pleasant reverie known as daydreaming. Thus in their early efforts to usefully employ their imagination, they generally apply it in the same random and erratic manner. For example, in a recent speech course the students did reasonably well on assigned topics. Many, however, experienced difficulty when asked to speak on a topic of their own choice. They literally spent hours flitting from one subject to another, searching past experiences and hoping to grasp the entire content for a talk in one brilliant flash. Yet, when in final desperation they grabbed at some straw and started preparing the speech, they rapidly uncovered more than enough material. Thus even with a strong desire to create, the person who flits from area to area just looking finds nothing.

For example, if you are a product engineer after ideas, a cursory glance in a recent trade journal might not suggest anything to you; so you might turn to the sales features that could be added or designs that could improve packaging. Or wonder if standardization techniques could be applied or several functions combined. Skipping from one area to another, you may never get an idea, for you are depending on an instantaneous, rare flash of genius. But quickly establishing a focal point for your efforts would result in worthy idea contributions time after time.

Functional Fixation

Man's tendency to get into a rut may be described as a functional fixation. Having once ascribed a function to a device, people tend to think of no other function or application for it. The few who can, however, gain reputations for their ability to improvise. Development and design engineers have a reverse problem: having once seen a function accomplished in a specific way, they often find it difficult to think of a better means, rationalizing that the existing way is the only feasible method.

In an effort to combat this trait, some development organizations forbid their engineers to conduct a patent search or library study until a new project is near completion—and then only to determine whether their solution infringes on existing patents. But what needless duplication of effort and waste of engineering talent. For once recognized, fixations can be minimized by concrete measures. In fact, the main objective of most so-called creative techniques is to direct thinking away from habitual paths. After continued practice, the engineer no longer fears a search of prior art; rather, he accepts it as the most efficient and direct technique for quickly acquiring knowledge in a given area.

Diversified Knowledge

An avid thirst for knowledge was one of Thomas Edison's traits. To stay abreast of technical advances in other countries, he learned to read several foreign languages. Such diversity not only is essential to efficiently obtain the

HOW CREATIVE SESSIONS FUNCTION

Have you ever participated in small impromptu groups, dreaming of ways to play a trick on someone? Or have you experienced the delight of proposing an outlandish scheme, having it immediately topped by someone else, and then, through sheer inspiration, presenting an even more outlandish trick yourself? If so, you know the bouyant spirit and exhilaration permeating such an atmosphere. Occasionally, the resulting ideas are truly ingenious—creations brought into existence as a direct result of the mutual support and encouragement throughout the group.

Let's see how to apply the same technique in engineering activities to create the new ideas so necessary for progress. A look at why bull-sessions are so conducive to imaginative adventure may furnish some clues. The sessions create an atmosphere that allows you to . . .

Express the problem generally—free from all side specifications or conditions.

Assume that every idea will work.

Search for ideas without restrictions.

Participate with a competitive spirit.

Capitalize on the mutual atmosphere of praise and encouragement.

Carry these ground rules over into a creative session and you can tackle any tough engineering problem. Just remember these five simple rules.

Besides being a source of new ideas, these sessions are also valuable for their stimulative effect on the group and on each individual. When this effect is felt in a large degree, you know that creativity has had the best opportunity to exhibit itself. And if truly successful, this stimulation will be carried back to the job. Don't expect an immediately useful idea from every session. But do expect that as you continue to hold these sessions the percentage of useful ideas will increase. For your creative talents respond to exercise just as do all your other abilities.

After the creative session, evaluate each idea carefully. Ask yourself such questions as: Could this be made to work if I made it smaller? what if I used a different material? what if I changed its shape? what if I combined these two ideas? Finally, select the most promising ideas for further investigation and analysis.

Remember: Your creative efforts are stifled when the immediate response is either no or a look of derision. When this occurs, creativity crawls back into its little shell, and old blueprints, old approaches, and old techniques continue on as always. Use these creative sessions to break loose from inhibitions. Exercise your imagination. Have the will to succeed. And who knows, you may develop a product that will put the competition to shame. Try it!

IDEA NEEDLERS . . .

How much of this is the result of custom, tradition, or opinions?
Why does it have this shape?
How would I design it if I had to build it in my home workshop?
What if this were turned inside out? reversed? upside down?
What if this were larger? higher? longer? wider? thicker? lower?
What else can it be made to do?
What other power would work better?
Where else can this be done?
What if the order were changed?
Suppose this were left out?
How can it be done piecemeal?
How can it appeal to the senses?
How about extra value?
Can this be multiplied?
What if this were blown up?
What if this were carried to extremes?
How can this be made more compact?
Would this be better symmetrical or asymmetrical?
In what form could this be?
Liquid, powder, paste, or solid?
Rod, tube, triangle, cube, or sphere?
Can motion be added to it?
Will it be better standing still?
What other layout might be better?
Can cause and effect be reversed? Is one possibly the other?
Should it be put on the other end or in the middle?
Should it slide instead of rotate?
Demonstrate or describe by what it isn't.
Has a search been made of the patent literature? trade journals?
Could a vendor supply this for less?
How could this be made easier to use?
Can it be made safer?
How could this be changed for quicker assembly?
What other materials would do this job?
What is similar to this but costs less? Why?
What if it were made lighter or faster?
What motion or power is wasted?
Could the package be used for something afterwards?
If all specifications could be forgotten, how else could the basic function be accomplished?
Could these be made to meet specifications?
How do noncompetitors solve problems similar to this?

greatest number of possible problem-solving combinations but also is a source of inspiration for new products and advances. In fact, one of GE's prolific inventors used articles and announcements of new materials, processes, and devices as a never-ending source of ideas to improve products. Yet, many individuals, having used only the knowledge found in their textbooks, graduate successfully from school.

Failure to use the great reservoir available in libraries, government publications, laboratories, and trade journals denies students many good ideas and leads to needless duplication of effort. To combat this in a formal course, many homework assignments given could require extensive library work. To benefit from material in the various trade journals, each class member could be assigned to write a one-page study of new or unusual material from one or two such magazines each month. These could be duplicated and distributed to the entire class for a notebook titled *New or Unusual Devices*.

How-does-it-work talks form another instrument for enhancing knowledge. A student interested in mechanisms, for example, might be asked to remove the cover plate from a voltage regulator, signal flasher, or fuel pump on his automobile. He could study its operation and then explain it to the class. A continuing compilation of the hundreds of physical laws and effects might also be undertaken, and students could be asked to find new applications or even a first application for one or more of them. For example, a problem recently posed to a class involved measuring and recording small torques. One of the best solutions utilized the relatively obscure Inverse Wiedemann Effect.

Essential as it is to train engineers to locate and use existing knowledge, it is equally necessary to train them to separate factual knowledge from opinion and traditional thought. This may involve learning not only an equation or formula but also the assumptions that allow the concept to be expressed so simply. Further, it requires that he learn to get his knowledge from the best sources. If others state that an idea is already patented, will cost too much, or will not secure Underwriters' approval, he goes to the patent attorney, manufacturing planner, or Underwriters' Laboratory for the facts. If they say, "We've already tried that and it won't work," he investigates anyway to insure that all conditions are identical. Most fundamental advances in progress would not have been made if their creators had listened to opinions.

Humility

Perhaps the greatest single deterrent to progress is the unwillingness to stifle pride and aggressively accumulate the thoughts and ideas of others to assist in solving problems. In spite of this, some people seem to never change their conviction that this is cheating or a sign of weakness. This lack of humility is sometimes more apparent when a good idea is offered to someone whose security feels threatened because of the suggestion. Some go so far as to say that anyone who has ever had a good idea immediately encounters dogma, inertia, minimizing, rationalizing, complacency, apathy, narrow-mindedness, negativism, autocracy, or other stifling personality traits or conditions.

There is an interesting though speculative way of looking at this (illustration, page 52). Line H is proportional to the number of years since a major design change has been made, and line C is proportional to the potential value of a creative contribution. The resultant angle α is proportional to the departure from habit, fixations, or conformal thinking. The area defined has a magnitude proportional to the number of years that it will take to gain general acceptance of that contribution, and it can be expressed by

$$C\ H \sin \alpha = KT \text{ (in years)}$$

where K is the humility constant.

Thus an ideational technique can be defined as any method that will help establish focal points; break habits, or fixations; expand diversified knowledge; or provide the permissive atmosphere so necessary for the free flow of ideas.

Subdivide

In searching for an idea, not only the basic function but also the attendant specifications and limitations are usually weighed simultaneously. Then you look for ideas that will immediately and obviously satisfy all these conditions. A superintelligent person could possibly consider all variables, together with their ramifications and implications. But to fit the experience and aptitudes of most individuals, the complexity of engineering problems necessitates subdivision. First, focus on the basic function and accumulate all possible methods to accomplish it. Then attack each idea successively for ways to make it satisfy each specification—temperature extremes, atmospheres, fatigue, weight, or cost. This type of study permits you to quickly generalize an optimum solution or pinpoint the major obstacles to success.

Investigate Directions

When confronted with problems of a nebulous nature, acquire detailed knowledge and study the trends of the situation. When interpreting future trends, analyze which needs of the customer are served by the existing product; then search for ways to better fulfill them, plus ways that will satisfy still others.

Creative effort arises through man's desire to build a better future, and he does this best by studying the past. Many errors in judgment and resultant misdirected efforts are caused by incomplete investigations. For example, an individual may decide to improve himself socially. He sees someone who plays the ukelele enjoying social success and sends for an instrument and lessons. He may become a good ukelele player but still be a social flop. A thorough investigation of his needs would have disclosed the all-important foundation on which to build.

Quantity

Perhaps the most effective technique for quickly accumulating alternatives is to conduct a creative session (Box, page 53) made up of people with diversified backgrounds. After an engineer spends several months searching for ideas, he'll find that a half-hour creative session with a group of 10 or 12 engineers uninhibited with details will uncover all his ideas—and many more. These sessions allow more time later to evaluate the ideas and to make the best possible choice.

In the pursuit of new ideas, the preparation of a list of idea needlers (Box) stimulates thought flexibility. All such needlers are derived from the basic laws of association—similarity, contrast, and proximity—as postulated centuries ago by the ancient Greek philosophers.

Planning

An engineering project, naturally, can't be a continuous search for newer and better ways. Unfortunately, after some engineers become proficient in the definition and search phases, they find it difficult to stop looking and start building.

Each better way improves their understanding and lures them into more searching for an even better method. Sound planning should also determine when the search must stop to complete such phases as construction, testing, and redesign by the due date. In scheduling, you work backward from the objective and due date to the present, revising the goal or budget to fit the project to the time allowed.

The use of imagination for solving engineering problems involves two extremes: Use the first design that gives technical excellence—one that performs satisfactorily for the required length of time in the environment imposed. At the other extreme, you must never stop searching for a still better way. The road to product leadership lies between the two.

Summing It Up

In a course to develop imagination, knowledge should serve as a framework for the presentation and assimilation of new attitudes and techniques rather than as an end in itself. Intelligence becomes the limiting factor in creative effort once the adverse effects of previous environment are minimized. To resist the worst of these—reluctance to depart from convention or habit—requires persistent and directed effort, plus a deliberate development of the imagination to overcome daydreaming.

In any period of concentration, a thought train is attained with its own peculiar emphasis and direction. This should be recognized, and when results aren't obtained, ideational techniques should be employed in a conscious effort to get a different perspective. Imagination feeds on a diversity of knowledge, and its active accumulation should never cease. Factual knowledge in any area is outweighed by that based on custom, tradition, or opinion—and skill is needed to distinguish between them.

Pride senselessly prevents many people from seeking ideas and thoughts of others and even more foolishly causes negative rationalizations when good ideas are offered. Subdivide problems into as many discrete focal points as possible for their most direct solution. But before seeking any solution, determine the basic needs to be satisfied and the optimum direction and scope of effort—another area where creative sessions and idea-needler lists will be useful. Once aware of the alternatives, plan and schedule your efforts to minimize any perfectionistic tendencies that will prevent your achieving a concrete result.

If those who now think of an occasional original idea will make a conscious effort to learn to produce such ideas regularly, historians need never describe the rise and fall of the present civilization. Ω

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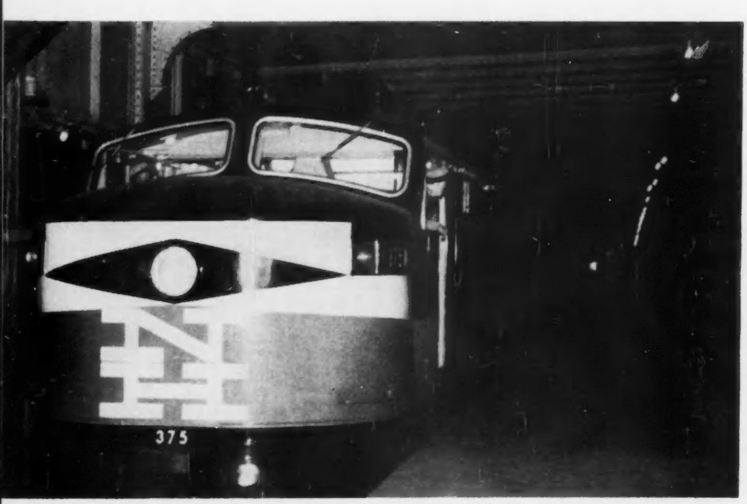
Mr. Von Fange—Second Year Supervisor, Creative Engineering Program, Engineering Services, Schenectady—came with GE in 1950. Contributing to the July 1955 Review, *he wrote "Understanding the Creative Process."*



GRAND CENTRAL ". . . Locomotive No. 375. Even with its vibrant colors—red-orange, black, and white—subdued by the dim light, it had a sleek well-groomed aura of power."

"NO. 375 RODE WITH HARDLY A PITCH OR A ROL

Railroad motive power has been undergoing a constant state of change ever since the days of George Stephenson's *Rocket.* One of the latest developments in the field is the rectifier locomotive, a conception that "opens up many new possibilities for existing as well as future railway electrification."

"The

NEW HAVEN ". . . Hennell was met by some New Haven people and got into a discussion of the wheel-slip system on the new locomotives. They became engrossed in the subject, as Hennell pointed out details of the axle-mounted contacts."

. . PORT CHESTER, GREENWICH, AND COS COB FLASHED BY . . . THE LIGHT-GREEN ATMOSPHERE OF A WARM SUMMER DAY DIFFUSED THE SCENE."

Electrics Are Doing All Right"

Review STAFF REPORT

Grand Central Terminal in New York, engineering marvel that it is, always has proved somewhat of a problem to the New Haven Railroad.

All locomotives operating in and out of Grand Central must be equipped to pick up power at 660 volts d-c from a third rail. This alone poses no difficulty until you remember that the New Haven's main line from Pennsylvania Station to New Haven is 11,000 volts a-c supplied from an overhead system. To feel equally at home, regardless of the power supply, New Haven locomotives must not only be equipped to pick up a-c power from the overhead but also be able to switch—on the fly—to d-c operation from a third rail. "New Haven locomotives are probably the most ambidextrous in the country," an industry observer remarked recently.

You can make an electric locomotive ambidextrous by two basic methods. One is to use a-c commutator traction motors (they're essentially a-c d-c devices). Although straightforward, the method receives strenuous competition from the d-c traction motor coupled with conversion equipment that changes a-c power to d-c.

Most of these factors entered discussions before the New Haven placed an order late in 1952 with General Electric's Locomotive and Car Equipment Department at Erie, Pa., for 10 high-speed electric locomotives to be powered by d-c traction motors fed by 12 standard rectifiers, modified for locomotive use.

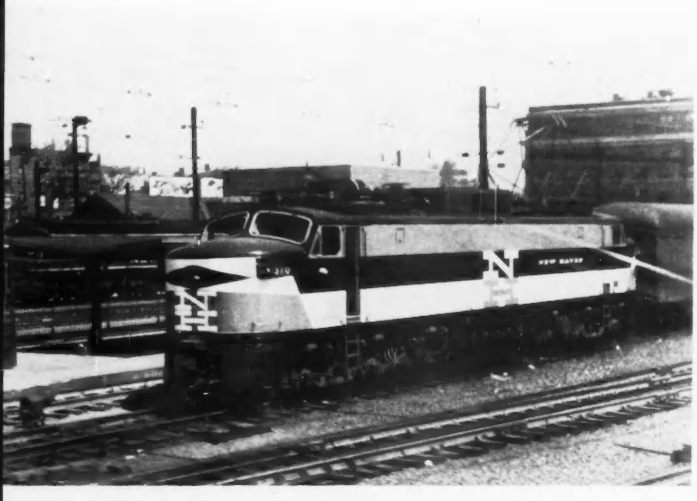
Shipment of the locomotives began early this year. Gradually they're replacing units—some are 30 years old—that can not accelerate and haul today's long trains at the schedules desired.

Rated 4000-hp continuously, with about double that for short periods, the new locomotives weigh 19 percent less and have 29 percent more weight on their drivers than do some G-E locomotives built in 1937 for the same service. Although published top speed is 90 mph, they're actually geared for 105 mph.

Another ruling factor on the design of all passenger locomotives for the New Haven is the load-carrying capacity of the so-called Park Avenue Viaduct, the stretch of elevated track from the tunnel exit at 96th Street to the Harlem River. The new locomotives were approved for 58,000 pounds per axle, all weight being on two widely spaced three-axle trucks, with each axle motored.

G-E engineers believe that this application of sealed-tube rectifiers is of significant importance to railway elec-

WELL-SCRUBBED and resplendent, No. 377 soon will be at the head of *The 42nd Street*, bound for New York.



NO. 370 was the first of the new locomotives shipped to the New Haven by the General Electric Company.

ENGINEMAN Burr, G-E Service Engineer Hennell, and a New Haven road foreman watch the performance of No. 377 during its New York run.

CONTROL PANEL (left) has clearly marked switches and lights. Below it is the throttle that swings in 35 notches. Six instruments (right) indicate speed and air-brake conditions (top row); the bottom three are ammeters. Handle of air-brake control can be seen below instruments. Engineman's hand in right foreground is on the throttle.

trification. F. D. Gowans, an engineer who was involved with the design of these new locomotives, told the REVIEW: "Today's rectifier tube represents a high-power package that can be used effectively in the transportation field. Its ability to convert commercial frequency a-c power to d-c for traction opens up many new possibilities for existing as well as future railway electrification."

"Another favorable aspect," Gowans said, "is that new rectifier materials now under development show promise of even more power in smaller packages, and with lower losses. We're also optimistic about the prospect of reducing costs. And highly developed components, such as traction motors and control equipment, are already available from long years of development on the diesel-electric locomotive. All these possibilities mean a good opportunity for reducing the first cost of electric locomotives—long a barrier to further electrification of railroads."

Shortly after 9:30 one morning recently, I walked across the concourse of Grand Central, passed through Gate 20, and trudged down one of the long, echoing platforms that project, fingerlike, into the shadows. To my right was the New Haven's Train No. 12, *The Bay State*, a 10-car daily of coaches and Pullmans. People filed hurriedly into the cars, and in the brightly lighted grill car early comers were being served.

Approaching the platform's end, I saw the markers of Locomotive No. 375. Even with its vibrant colors—red-orange, black, and white—subdued by the dim light, it had a sleek, well-groomed aura of power. I walked on. Ahead, light splashed from the cab, and nearby I met Howard Hennell, a service engineer from GE's New York Office, who was expecting me. Hennell is of medium build, has a shock of straight, unruly hair and an amiable manner, and has followed the new locomotives ever since shipment.

He looked at his watch, said we still had a few minutes and would I like to meet the crew of No. 375. I followed him aboard, and he introduced me to Engineman Clyde Davis and Fireman Charley Gunther, both veterans of more than 34 years on the New Haven.

Just before 10 o'clock, Davis pulled out his watch and checked it with Gunther. Hennell glanced at his. Davis was in his seat, peering straight ahead.

Gunther lowered his window and looked back along the string of cars, waiting for the conductor's go-ahead. It came exactly at 10 o'clock: Gunther pulled in his head, turned to Davis, and nodded. I moved over near Hennell, at a position off Davis's left shoulder where I could see the instruments and the track.

Davis notched back on the throttle, a few clicks at a time. Behind us the blowers increased their thin whine and held it; the three ammeters inched toward the 1000-amp mark. No. 12 was under way, moving slowly and cautiously over the network of switch points. Signal lights winked solemnly, and occasionally a flare of raw sunlight fell across the hood of the locomotive and into the cab. Gunther called the signals, Davis answered, and we converged on the mouth of the four-track five-mile tunnel that would take us to the brightness of day.

Although the tunnel's speed limit is but 35 mph, you experience the phantasm of much greater speed because of the naked light bulbs staggering by in an endless stream, the roar of wheels on steel being flung and torn from the cold stone walls to the glistening side of the locomotive, and the intense white beam of the headlight weaving a rocking, lurid pattern in the darkness ahead.

No. 12 broke into the sunlight at 96th Street, losing the noise and speed as it climbed the Park Avenue viaduct and slid to a stop at 125th Street.

Approaching Woodlawn, west of Mt. Vernon, Hennell motioned me aside. "Here's where we change over from third rail to overhead," he said. "Watch how Davis does it." Davis's first move was to push the throttle to the OFF position, his next to throw a switch on the control panel. "That raises the pantograph for the a-c and also lifts the d-c shoes," Hennell said. "Like this...." He held his hand in front of him, palm down, fingers together, and slowly raised it in an arc, pivoting it at the wrist. "We're coasting now . . . ," he said, letting the words trail. I noticed that the catenary was over us. After the changeover ritual, Davis opened the throttle and we soon picked up speed and headed east.

Between New York and New Haven there are no grade crossings over the four tracks, and the road speed limit on many stretches is 70 mph. No. 375 rode with hardly a pitch or a roll; the towns of Port Chester, Greenwich, and Cos Cob flashed by, station wagons and

Cadillacs crowded their parking lots, and the light-green atmosphere of a warm summer day diffused the scene.

The Bay State arrived in New Haven on schedule, 72.5 miles in 85 minutes. No. 375 was cut off and eased to another track. Davis picked up his "tools," such as the detachable levers from the air brakes and reversing device, and walked back through the inside of the locomotive to the other cab where he placed the levers in position to operate the locomotive.

A few minutes later we came to a stop on the engine pit; the pantograph was lowered and No. 375 became silent. Davis and Gunther climbed down from the cab and walked away; Hennell was met by some New Haven people and got into a discussion of the wheel-slip system on the new locomotives. They became engrossed in the subject as Hennell pointed out details of the axle-mounted contacts.

I moved away a few yards and had my first good look at No. 375. The cheery color scheme is a decided contrast to other Eastern railroads, although comparable motifs are used in the West. Three broad stripes run along the side of the locomotive; the top stripe is brilliant red-orange, the center one black, and the bottom stripe white.

Inspiration for the color design originated with Lucile Whitney McGinnis, wife of Patrick B. McGinnis, President of the New Haven, and Florence Knoll of Knoll Associates, Inc., a leading interior decorating studio of New York.

After initial color sketches were made of the new locomotives, the black and white stripes were definitely favored, but reaching the decision between red-orange or canary yellow for the theme color and third stripe involved more time. To solve the problem, two locomotives were painted at Erie, identical except that one had the red-orange stripe at top; the other yellow. After Mr. and Mrs. McGinnis observed the locomotives parade down the test track, they unanimously selected red-orange.

All other New Haven rolling stock—and timetables—will sport the new colors. Boxcars, for instance, will be red-orange with a large NH monogram in black and white on each side. Knoll Associates also designed the new monogram; at present they're planning car interiors.

From talking with several road foremen, I learned that the new locomotives work on a tight high-speed schedule. "Sure, they've got their share of bugs," one told me, "but what locomotive doesn't? It was the same with the diesels and the steamers before them. I just got a new car and you should hear about my troubles with that. But the new electrics are doing all right," he assured me. "Some of the men complain because they have a few more buttons to push. But I guess you can always expect something like that." He shrugged.

I was to take Train No. 13, *The 42nd Street*, scheduled to leave New Haven at 3:13 pm for New York. A few minutes before 3 o'clock, I went to the "ready" track near the engine pit where No. 377 was being scrubbed down. (No. 375 had long ago headed back to New York.) Hennell was returning also, and so we climbed aboard and met Engineman Clarence Burr and Fireman James Farley. Burr has been with the New Haven for 48 years and didn't hesitate to tell me what he thought about the new locomotives. "I've run these engines ever since we got them. I like them. A locomotive has a job to do, and it's got to do it fast. That's the only way I measure them. I can take one of these striped beasts out of here," he swung his arm in a wide arc that took in both the locomotive and the New Haven yards, "and get it over the hump 10 mph better than with any other. Just wait until you see how nice and easy this baby slides out of here . . . ." With a slow motion he projected his hand in front of him, palm down. "I'll take a motor any time. Besides that, they're clean." He paused. "My wife likes them, too." He grinned and we all laughed.

Leaving Bridgeport, Burr called me over to his side of the cab. "Now, watch," he said. "This is how we'll get these 14 cars out of here." He released the brakes and pulled back on the throttle; the ammeters swung around. "The idea is to get the most power you can without slipping the wheels or putting the needles into the red." I watched the needles; Burr kept them between 1000 and 1200 amp. The indicators were "red-lined" at 1400 amp. And if the wheels had slipped, a buzzer would have sounded, and a light would have flashed on the control panel. If the engineman doesn't cut back on the power within 5 seconds after slip is indicated, power reduces automatically. "That's the way it's done," Burr remarked as we rolled west.

East of Woodlawn, where the New Haven track makes a generous loop to join the New York Central, Hennell motioned to me. "See those two concrete blocks on both sides of the track?" he asked, pointing ahead and down. I looked; the blocks were squat and had a nasty hook on the top that arched toward the tracks. "Those are rake-off blocks," he explained. "If the engineman hasn't got his d-c shoes down, the blocks will rake them off." Hennell explained that this prevented the shoes from tearing up the third rail guard if they should be lowered too late. Fireman Farley opened the cab door and said that the shoes were in position; next he checked to be sure the pantograph was down.

Going down the Park Avenue viaduct, I saw the tower of the New York Central Building framed between the tenements of upper Park Avenue. No. 13 plunged into the tunnel, roared through the gloom, and decelerated to a crawl as it approached the terminal throat at 57th Street. Farley, sitting high on the fireman's seat, tensed as we entered the vast fan of tracks, pale lights, and reflections. Because the multitude of posts in Grand Central obstruct vision, the fireman often is the only one who can see the low signals—a maze of red and yellow blobs. We plodded through the murk, the noise from the running gear, and the occasional scream of metal-against-metal from a taut coupling marking our path, finally winding up on Track 42, on the western side of the Terminal. Burr brought No. 13 to a gentle stop, and the blowers subsided to a low moan. Minutes later, No. 377 was cut off and we proceeded around the loop—a half circle that extends to about 38th Street and brings locomotives around to the eastern side of the Terminal. We waited for the signals and finally stopped on one of the engine storage tracks next to the 49th Street Engine House and Tower A.

Burr and Farley climbed down and Hennell and I followed, making our way to the engine-dispatcher's office. Hennell talked with the men there, while I learned that in less than an hour No. 377 would be pounding east at the head of Train No. 28, *The Gilt Edge*.

"Well, one more trip for the records," Hennell mused as we left. "These locomotives are worked hard—and often. But that's the way it should be. As Burr said, they have a job to do, and they've got to do it fast. That's the way we'll find out how really good they are."—PRH