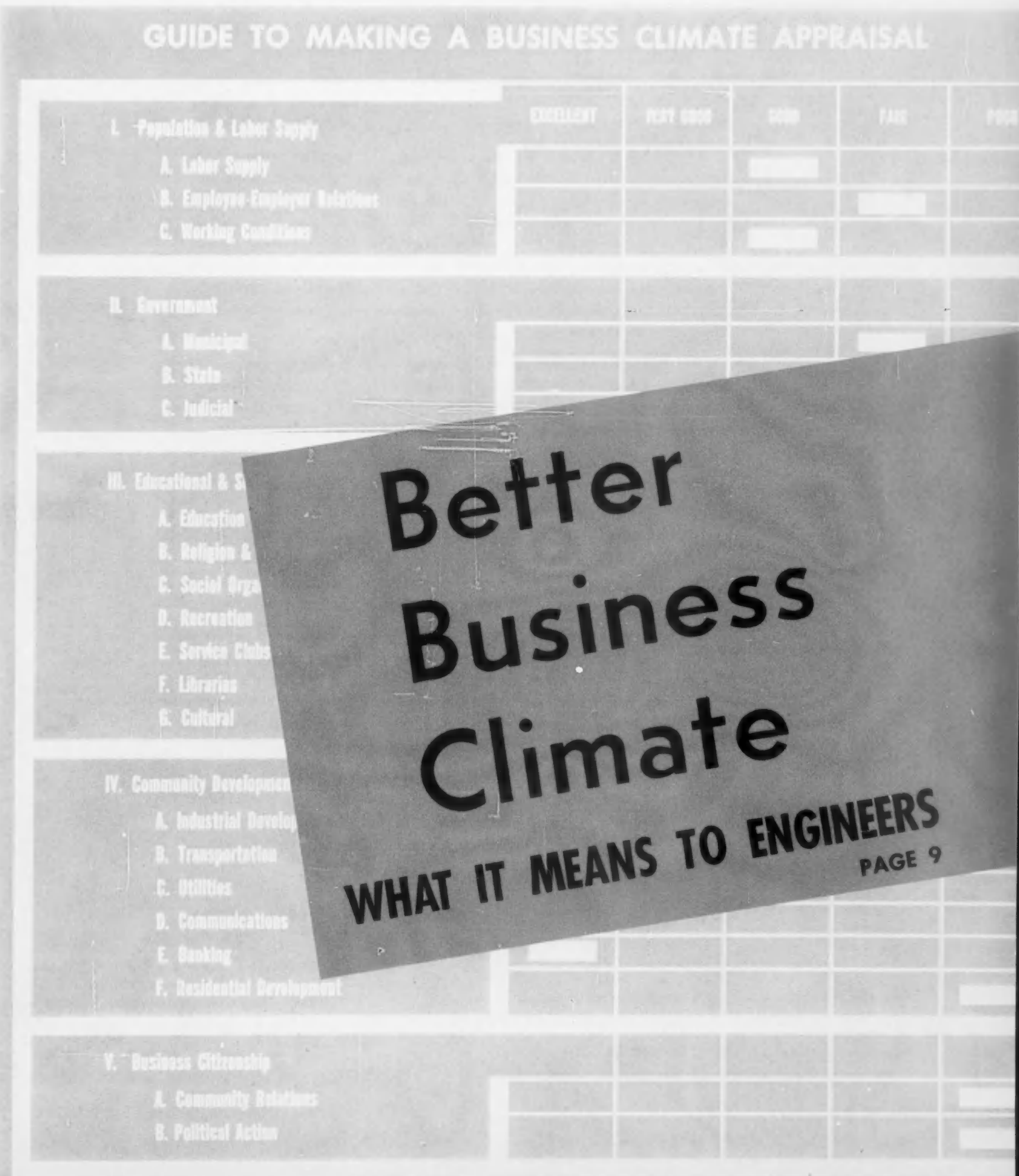
GENERAL ELECTRIC
Review
NOVEMBER 1958

Appraising Defense R & D

Cryogenics: Promising Future

Russian Decentralization



Better Business Climate

WHAT IT MEANS TO ENGINEERS

PAGE 9

An Important Announcement . . .

G-E Review Discontinues Publication

Because the GENERAL ELECTRIC REVIEW will discontinue publication with this issue, I should like to give a few words of explanation—and appreciation—to the REVIEW's many loyal readers.

Every magazine sponsored by an industrial concern must constantly evaluate its effectiveness, significance, and cost in the light of what is being done by other communication media.

The business, technical, and professional-society press has grown spectacularly since World War II, both in variety of publications and usefulness to their audiences. In 1850 there were only 10 business publications in the United States; 50 years later the number reached 800. The figures on total engineering and scientific publishing today are even more surprising: of the total of 2093 business publications presently independently published in the United States and nationally distributed, nearly half—979—are in industrial technology, covering all aspects of engineering and science.

Newspapers devote more and more space to new developments in science and technology. "Progress Reports" on the General Electric Theater regularly bring news of General Electric research and engineering progress to nearly 40-million television viewers.

General Electric sales engineers keep their customers apprised of recent products and engineering developments with appropriate publications.

The increasing ability of the majority of these information channels to keep engineers and scientists up to date underlies General Electric's decision to discontinue publication of one of the oldest and most widely respected engineering and scientific journals in America.

For 55 years the G-E REVIEW has objectively reported General Electric research and engineering progress to leaders in science and technology. Survey after survey showed the G-E REVIEW was exceptionally well read, had high readership loyalty, and was accepted and recognized as the publication that brought its readers information about General Electric research and engineering developments.

And we thank all our many friends—readers, authors, and advertisers—for their continued support over the years—support, stimulation, and encouragement that helped make the G-E REVIEW one of the foremost publications in the technical and scientific world.

Paul R. Heinmiller

EDITOR

GENERAL ELECTRIC
Review

NOVEMBER 1958 VOLUME 61 NUMBER 6

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

Emphasis on EXTRA VALUES is an important feature of General Electric's campaign for a business upturn in 1958. Extra values contributed by comprehensive and balanced research and engineering programs are important constituents of General Electric products.

COVER

Engineers and scientists with their unique capabilities can contribute effectively toward creating a Better Business Climate. For ways and means of fostering a Better Business Climate and an analysis of the benefits to be derived turn to page 9.


SOVFOTO

C. W. LAPIERRE

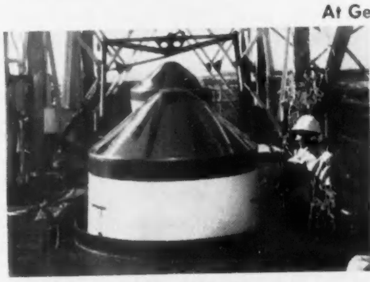
Vice President and Group Executive
Electronic, Atomic and Defense Systems Group, General Electric Company

"If we wish to face the future confidently . . ."

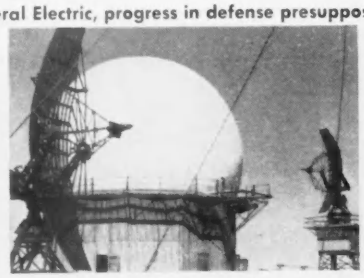
"We must not handicap ourselves with grave doubts and misgivings about the ability of free men in a free economy to out-plan, out-invent, and out-produce a controlled economy.

"If we can continue to subject our methods and our system to critical analysis and appraisal; if we cut through red tape, and simplify prevention-of-mistakes machinery, and eliminate restrictive practices that put the brakes on innovations, to allow for continued bold technological leaps forward; if we organize and administer the work of R&D more effectively—we can face the future, whatever its dangers, adequately equipped, confidently and without fear."

At General Electric, progress in defense presupposes extensive research



RESEARCH FOR MISSILES. Thor nose cone being readied for test flight at Cape Canaveral is a dramatic example of research progress at G.E.'s Missile and Space Vehicle Dept., Philadelphia, Pa.



RESEARCH IN RADAR. New height-finding radar developed by General Electric's Heavy Military Electronic Equipment Dept., Syracuse, N. Y., will help improve this nation's air defense network.

RESEARCH IN PROPULSION. Mighty G-E J79 turbojet, powerplant of Convair's supersonic B-58 (above), typifies progress at General Electric's Aircraft Gas Turbine Division, Evendale, Ohio.

This public information message also appears in current issues of NEWSWEEK and FORTUNE.

Abstracts

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

The Engineer's Responsibility in Creating a Better Business Climate *Classification:*

GARDNER, F. C.

Mr. Gardner analyzes the special talents an engineer can offer toward a better business climate through participation in civic affairs. An interview with C. P. Fisher Jr. adds the specific factors that govern business climate, with a Box on appraisal steps.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 9–12

Cryogenics: Rapid Growth, Promising Future *Classification:*

SCHMITT, R. W. and
FISKE, M. D.

The article explains cryogenics—the study of superbehavior of common materials near absolute zero. Applications range from infrared detection to computer elements. Increasing availability of liquid helium and hydrogen refrigerants furthers research.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 13–15, 45

Designing a Better Portable Dishwasher *Classification:*

KAUFFMAN, M. R.

From housewife-opinion polls to design and manufacturing methods, the author describes the elements that formed the decision to market an improved portable dishwasher with the newest customer conveniences. Two 4-color photos are included.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 16–18

Russian Decentralization: Will It Work? *Classification:*

ROUAULT, C. L. and
CROWTHER, F. D.

How Russia intends to decentralize her important industries, by Rouault, and an analysis of that implementation by Crowther permit the reader to forecast the system's success or failure. A Box on compensation and incentives supplements the text.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 19–23

What's Ahead in Industrial Lighting? *Classification:*

LINDSAY, E. A.

In interview form, a leading lighting specialist foresees fluorescent lighting capturing 90 percent of the market, with filament and mercury equally splitting the remaining percentage. He predicts expectations for electroluminescence and suggests trends.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 24–27

Appraising Research and Development in Industry and Defense *Classification:*

LAPIERRE, C. W.

The author compares research and development techniques in weapons-defense and civilian goods, attempting to find the most effective basis for building a strong, continuing defense industry capable of meeting the long-range requirements of a Cold War.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 28–30, 45

***G-E Review* Readers Urge Social Studies for Engineering Students** *Classification:*

HOLZMAN, DAVID L.

Second in a series on The Socio-Economic Scene, the article reveals REVIEW reader opinions on the educational requirements for engineers. The majority recommended that at least a fourth of the curriculum be devoted to the social sciences.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 31–32

Voltage-Tunable Magnetron, Heart of Radar, Heralds New Benefits *Classification:*

REED, R. I.

Already finding their way into equipments for aircraft navigation, altimeters, warning devices, missile guidance, radar, and radar countermeasures, voltage-tunable magnetrons will extend into the fields of medicine, chemistry, and agriculture.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 33–35

Industry's Increasingly Bigger Stake in Developing Its Personnel *Classification:*

Review STAFF REPORT

Three broad categories are receiving greater attention as industry provides employees with the opportunity to achieve their full capabilities. A bar graph shows General Electric technical-course participation, and a Box lists the courses one department offers.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 36–38

Melt the Snow Off Your Driveway—Electrically *Classification:*

MAHER, JAMES R.

Using diagrams, charts, and photos, the author describes a method of snow removal using electric heating cable. System requirements depend on the average rate of snowfall, temperature, wind velocity, and humidity that prevail in the specific area.

GENERAL ELECTRIC REVIEW Vol. 61 No. 6 pp 39–42

One of a series

Interview with General Electric's Frank T. Lewis Mgr., Manufacturing Personnel Development

The Next Four Years: Your Most Important

The United States is now doubling its use of electrical energy every eight years. In order to maintain its position as the leading manufacturer in this fast-growing electrical industry, General Electric is vitally interested in the development of young engineers. Here, Mr. Lewis answers some questions concerning your personal development.

Q. Mr. Lewis, do you think, on entering industry, it's best to specialize immediately, or get broad experience first?

A. Let me give you somewhat of a double-barreled answer. We at General Electric think it's best to get broad experience in a specialized field. By that, I mean our training programs allow you to select the special kind of work which meets your interests—manufacturing, engineering, or technical marketing—and then rotate assignments to give you broad experience within that area.

Q. Are training assignments of a predetermined length and type or does the individual have some influence in determining them?

A. Training programs, by virtue of being programs, have outlined assignments but still provide real opportunities for self-development. We try our best to tailor assignments to the individual's desires and demonstrated abilities.

Q. Do you mean, then, that I could just stay on a job if I like it?

A. That's right. Our programs are both to train you and help you find your place. If you find it somewhere along the way, to your satisfaction and ours, fine.

Q. What types of study courses are included in the training programs and when are the courses taken?

A. Each of our programs has graduate-level courses conducted by experienced G-E engineers. These courses supplement your college training and tie it in with required industrial techniques. Some are taken on Company time, some on your own.

Q. What kind of help do you offer employees in getting graduate schooling?

A. G.E.'s two principal programs of graduate study aid are the Honors Program and the Tuition Refund Program. If accepted on the Honors Program you can obtain a master's degree, tuition free, in 18 months while earning up to 75% of full-time salary. The Tuition Refund Program offers you up to 100% refund of tuition and related fees when you complete graduate courses approved by your department manager. These courses are taken outside normal working hours and must be related to your field of work.

Q. What are the benefits of joining a company first, then going into military service if necessary.

A. We work it this way. If you are hired and are only with the Company a week before reporting to military service, you are considered to be performing continuous service while you are away and you will have your job when you return. In determining your starting salary again, due consideration is given experience you've gained and changes in salary structure made in your absence. In addition, you accrue pension and paid-vacation rights.

Q. Do you advise getting a professional engineer's license? What's it worth to me?

A. There are only a few cases where a license is required at G.E., but we certainly encourage all engineers to strive for one. At present, nearly a quarter of our engineers are licensed and the percentage is constantly increasing. What's it worth? A license gives you professional status and the recognition and prestige that go with it. You may find, in years to come, that a license will be required in more and more instances. Now, while your studies are fresh in your mind, is the best time to undertake the requirements.

Your next four years are most important. During that period you'll undoubtedly make your important career decisions, select and complete training programs to supplement your academic training, and pursue graduate schooling, if you choose. These are the years for personal development — for shaping yourself to the needs of the future. If you have questions still unanswered, write to me at Section 959-6, General Electric Co., Schenectady 5, N. Y.

LOOK FOR other interviews discussing: • Salary • Advancement in Large Companies • Qualities We Look for in Young Engineers.

GENERAL ELECTRIC

Review EDITORIAL

A Professional's Contributions to His Community's Educational System

Professional leadership carries with it social responsibilities. In a real sense, the recognition of these responsibilities forms the test of professional stature as distinct from the demands of just a trade or job. It is summed up in the term "noblesse oblige," once applied to the obligations that go with rank or noble blood. In our day it is equally binding on those who have had special advantages of education and experience.

In the current concern over America's educational system—its problems and future policies—the professional engineer has specific responsibilities because he represents a profession dependent on education.

Directed toward his community's educational system—primarily grade schools and high schools—these responsibilities go beyond the duties of citizenship—voting in school elections, being active in the PTA, and serving on school boards. They involve making available to the schools and to young students the special knowledge that can come only from the practice of a profession that is based on continuing education and extensive experience.

Education offers three areas in which an engineer can be especially helpful in his community . . .

- *Career Guidance*—Whether on a formal basis such as Career Days, or on an informal, individual counseling basis, this activity explains to young people the nature of an engineer's job, its rewards and accomplishments, and the necessary preparatory steps to following a career in engineering.

Career guidance activities provide a platform for individual action by people who, having had the advantages of sound education, can speak with authority. School guidance personnel recognize that young people are often baffled by broad generalizations—engineering and an engineer in the abstract are hard to visualize. But when a successful individual can tell in his own words what his work is, what satisfactions he gains from it, and the type of preparation he had to have to attain his position, then these vague uncertainties disappear.

- *Citizens' Advisory Councils*—These "sounding-board" groups, which give counsel and advice to school boards, utilize effectively the knowledge and experience of engineers in the area of curriculum building for math, science, chemistry, and physics courses—including recommendations for facilities for such courses. School expansion programs also can benefit from the engineer's objective analysis. Because engineering deals with facts, such programs can be analyzed logically and unemotionally. The engineer's specialized talents and background are admirably suited for making significant contributions in these areas.

- *Informal Question Answering*—Making yourself readily and easily available to answer questions about the exciting world of science and engineering—for the neighbors' children across the back fence or an informal classroom discussion—can do much to clarify in young minds the opportunities in a technical career, dispel some of the mystery surrounding the profession, and nurture and encourage the desire for further knowledge.

Although these three areas aren't all-inclusive, they do point up the need for your talents and how you can effectively use them to aid community educational systems.

Such activities will help an engineer discharge his obligations to his community's educational system, set a good example for others in the profession to follow, and assure the future of the profession being carried on by responsible individuals in keeping with the needs of society.

Paul R. Heinmiller
EDITOR

GENERAL ELECTRIC
Review
NOVEMBER 1958

The Engineer's Responsibility In Creating a Better Business Climate

The President of Ebasco, and a well-known engineer, correlates the needs of business-climate planning with the engineer's specialized abilities.

By F. C. GARDNER

Many diverse factors comprise business climate. They range from physical plant to matters of opinion and belief, involving all phases of human existence. When examined closely, its composition seems to indicate that while business climate originates at the grass roots level as an expression of the will of the people, the opinion leader is a factor in its development. The engineer, while not commonly considered as an opinion leader in the community, has had an important part in its creation and betterment.

The professional engineer forms an intimate part of American industry. He has been trained to think straight, to solve problems, to consider and plan for the future, and to select the best course when faced with a choice of decisions.

Group Participation . . .

Requiring the talents and skills of the engineer, many industries are making long-range plans to provide for the future needs of the people of this country and to keep ahead of the expanding economy. They are concerned that this growth take place in an orderly, well-planned manner in a favorable environment.

Consequently, many industries are participating to a greater extent in area-development programs, designed to help the communities meet future responsibilities to their citizens and the businesses and industries that operate within their borders.

Qualified by training and experience to undertake the particular task, engineering consultants often handle planning in both the industrial and community fields.

The federal, state, and local governments employ a large number of engineers. Some design, build, and operate public works, with an increasing number engaged in planning for the future. In addition, engineering data play an important part in many government decisions.

Thus in both private and governmental fields the engineers have excellent opportunities for making valuable contributions to the betterment of the business climate.

. . . and Individual Contributions

As an individual, the engineer can make even more important contributions to the business climate by taking part in civic affairs.

Of the more than half a million professional engineers in this country, more than 140,000 of them hold membership in the four major engineering societies. Most of the remainder belong to the smaller national, local, and state associations. With their families and close relatives, they constitute a group of more than two million people.

The engineering societies—large and small, national and local—are well organized. They meet regularly and consider many current engineering problems through the medium of prepared papers and the discussions that follow. However, current events are seldom considered. They well could be.

Associated with the work of professional engineers is another large group, consisting of draftsmen, construction men, scientists, and accountants. With this representative background, professional engineers should be "opinion leaders" for large groups of people located in every section of this country and should influence nearly every segment of the nation's economy.

Because the engineer is best fitted by training and experience to improve the tangible factors contributing to favorable climate for the development of our nation does not mean that the engineer should neglect the intangible factors that are an important part of the business climate. Like every citizen, he has a duty to his country to do everything he can to protect it and contribute to its growth. He should be in the forefront of the battle that is being fought today to preserve our freedom and our way of life.

The major opportunities for service are in the fields in which the engineer has his being and earns his living. Mainly, these opportunities will be at the grass roots, where business climate really originates.

Well worth a few hours of an engineer's free time, many problems require the clear thinking, good judgment, and

Mr. Gardner—President of Ebasco Services, Inc., an engineering, construction, and business consulting subsidiary of Electric Bond and Share Co.—began his career with that firm after his graduation from North Carolina State College in 1917 with a degree in civil engineering. First employed in Raleigh as a draftsman investigating hydroelectric power sites in North Carolina, he then worked for 10 years as construction engineer in Pennsylvania. In 1929, he transferred to the company's general offices in New York and assisted supervising their construction activities. Mr. Gardner assumed the positions of head of design and construction division in 1939, engineering manager in 1943, and vice president in 1945. Seven years later he became executive vice president and was elected President in 1954. Mr. Gardner—a member of the American Society of Civil Engineers—is a Director of Electric Bond and Share Co., Ebasco Services, Inc., Chemical Construction Corporation, and Commerce and Industry Association of New York.

ENGINEERING CONSULTANTS reduce traffic congestion for a growing city, improving the business climate for local industry and increasing community ability to attract new business.

PLANNING COMMISSIONS need the sound judgment and clear thinking characteristic of an engineer. Elected to public posts, engineers serve a wide variety of civic responsibilities.

forward-looking ability that are characteristic of a good engineer.

An Informed Opinion Leader

What should he do as an individual to meet his responsibilities in creating a better business climate?

The engineer should identify, study, and be informed about the various factors in his own area that affect the business climate. He should discuss them with his family, his neighbors, and his friends; write letters to the newspapers; and join various civic organizations and take part in their discussions, especially those that involve the many civic problems that affect the business climate.

The expenditures and debts on the ledgers of nearly all local governments have attained their highest peak in history. With the increasing population migration to the suburbs, conditions detrimental to the maintenance of a good business climate have begun to appear in many local communities. . .

- Spiraling tax rates
- Obsolete water and sewage facilities
- Inadequate educational facilities
- Outdated regulations and building codes
- Hodgepodge development through lack of a master plan
- Inadequate transportation
- Uninformed local government officials.

Almost every community in this country wants to attract new industries and to retain and expand those it already has, giving rise to tough competition among localities for new industries. While the availability of raw materials and proximity to markets remain important factors in the selection of a site, the final choice depends on the quality of the local business climate. An analysis of the successes and failures scored in securing new industries will effectively appraise the quality of the business climate in the particular area.

The communities outside of the large cities are growing rapidly. Older areas that have become victims of urban blight are waking up to the fact that they must bring themselves up to date without delay.

Need for a Plan

If an expanding community is to avoid further growing pains and permanent deformities, it must have a well considered community plan. Such a plan will, of course, have as a base a physical plant to take care of the future needs of the area in the best possible manner.

The finest physical plan will not in itself create a favorable business climate unless essential factors are included to insure that the community will be a good place in which to live, raise a family, conduct businesses, and operate industries.

There is no substitute for participation in public affairs as a means of improving the business climate. State and national business climates depend on the local climates, although the average citizen is not in close touch with the climate at these broader levels.

The problems involved are handled by the elected representatives of the people. But these representatives are responsible to the people who have elected them to office, and they are responsive to what they hear from the folks back home—from the grass roots, where all business climate originates.

The engineer should do his part in assuring that good men are nominated and elected to public office—individuals loyal to our country and its principles and that have the understanding and ability to cope with the complex problems confronting government at all levels.

Besides his responsibilities as a good citizen, the engineer has some compelling reasons for concerning himself with the business climate. A large proportion of the professional engineers of this country are employed by large industries or consulting and engineering groups. Even from the narrow viewpoint of an individual engineer's material well-being, he gains by putting forth his best efforts to help his organization do a better job in its particular field. However, from the broader viewpoint, the kind of job an organization can do will be materially affected by the business climate in which it must operate. It behooves the engineer to broaden his outlook and start tackling problems that, while outside the scope of his direct professional interests, will probably have a greater effect on the future well-being of his organization and himself than most of the purely technical and professional problems with which he deals in the course of his job.

Participation in civic affairs designed to improve the business climate will provide the professional engineer with satisfaction and rich rewards—both spiritual and material. Ω

How Better Business Climate Aids A Community

Better Business Climate depends on the relationship and common goals that exist between a community and its employees. To outline the specific factors that contribute to this beneficial relationship, REVIEW *Editors recently talked with C. P. Fisher, Jr.—Consultant on Business Climate Development, Public and Employee Relations Services, New York. In this interview Fisher describes the new dimensions of business-community responsibility that contribute to a planned growth and prosperity for both.*—EDITORS

How would you define the term "business climate"?

Briefly, business climate is the net result of all outside conditions affecting the cost and ease of operating a business in a truly rewarding way in the community.

What sort of outside conditions?

They can be social, economic, or political. They may have their origin at the local, state, or national level. They may be tangible factors, relating to such things as tax rates, schools, and vocational training, local laws, and their enforcement. Or they may be intangible, like the general attitude of the community towards business. A surprising number of outside conditions can affect the ability of a business to compete successfully for the customer's dollar. And, of course, a business which can't compete successfully can't provide the good job opportunities and good local payrolls which raise the economic level of the entire community.

You mean the community and its employers have a common stake in a good business climate?

Exactly. The same kind of conditions that affect business success also determine the attractiveness of the community as a place to live and work.

Aren't most thoughtful business men and professionals aware of these conditions?

Actually, many of these conditions are not at all new to business men and professionals. But recognition has not necessarily resulted in effective action or improvement. Traditionally, business men and professionals have regarded these conditions as outside their responsibility—or ability—to influence.

Who determines what business climate conditions need improvement?

Business climate improvement is a "home folks job." It can't be directed from some remote headquarters location. Goals and action needed to achieve them must be set at the local level. Each business is best qualified to assess the strengths and weaknesses of its own business climate. It's up to the manager to see that a program is devised to meet his particular problems.

Do you recommend a way to go about this?

We do. Experience at a number of General Electric plant communities shows that a four-step approach is helpful. We call this approach the Better Business Climate Plan.

What are the four steps in the Plan?

The first step is an appraisal of the business climate factors that influence profitability and growth of the business. From this appraisal, as a second step, local General Electric management can pinpoint its most important short- and long-range goals. The third step involves the development of a program and timetable for meeting the goals through activities by the department and its employees. The fourth step calls for cooperation with other employers and community leaders who want to join in this work. Business climate improvement is a cooperative job which all can, and should, share.

As a consultant, do you provide help in making a business climate appraisal?

We provide help in the form of an appraisal guide, which components use to organize and do the necessary research and evaluation. This guide contains 187 questions that help local managers consider all aspects of their business climate. Incidentally, these questions are the same ones looked at in studying a community as a possible new plant location.

The four-step plan sounds like a

businesslike approach, but isn't it just a lot of extra work?

Using the BBC Plan does not represent extra work. Actually, it is a work simplification tool. The BBC Plan helps the manager be sure the money and manpower he is spending for community relations is programmed to bring best results, both from the standpoint of his business and that of the community.

That makes sense. Can you cite some of the specific steps to improve business climate?

Yes. They include support for a state highway program bond issue; endorsement and promotion of a new school program; opposition to a state-imposed machinery tax; backing for a state legislature's proposal to increase unemployment benefits and distribute their cost more fairly; an urban renewal program; a workshop with city officials for better local law enforcement.

Then, the local managers favor some things and oppose others?

Yes. The locally determined goals will usually call for initiation or support of a variety of measures to improve the community and individual well-being. Business-climate improvement is a positive activity. It requires that the employer let people know where he stands, and why, on important matters affecting his business, or his employees, or others who have a stake in its success. He can't limit himself to the relatively noncontroversial conditions, but must be willing to take a straightforward, responsible stand on any matters affecting business climate.

HOW'S THE BUSINESS CLIMATE IN YOUR COMMUNITY?

This guide to making a business climate appraisal helps determine the degree to which a community possesses the following eight desirable elements. No community will be expected to have all the good features implied here. How would you say your community measures up? What can you do to maintain its strength and help eliminate its weaknesses?

Community progressiveness: A realistically progressive attitude on the part of political, religious, and professional leaders toward sound community growth and city planning, along with citizen understanding of community and business problems.

Government: Honest and efficient government, supported by a safe majority of alert, intelligent voters who have the balanced best interests of the community at heart, with an absence of unreasonably restrictive regulations or financial handicaps.

Employee relations: A sound working relationship between employers and employees and where collective bargaining contracts are in effect, an absence of unwarranted strikes and slowdowns over a number of years, and a constructive and fair union officialdom which acts as a servant rather than as a master of its membership.

People: Adequate supply of people to fill employment needs, who have a good work attitude, who are properly educated, trained in required skills, and who have a good understanding of how our business system operates and their stake in its success.

Labor costs: Wage and salary rates and payment methods which are fair to employees and at the same time provide an opportunity for employers to operate profitably and in competition with other manufacturers of their product lines.

Community services, facilities: Adequate community services and facilities, such as banks, hotels, utilities, shopping facilities, health facilities, and required commercial services needed in operating businesses.

Social, cultural, and educational institutions: A social and cultural atmosphere that will attract and hold good employees, including good schools, an enlightened press, radio, and TV, and an abundance of healthful recreational opportunities.

Business citizenship: A serious-minded assumption of business citizenship responsibilities on the part of *all* employers in the community, as evidenced by consistently good employee relations and courageous leadership in civic and political affairs.

You said earlier that business climate improvement is everyone's job. Does communication by the manager help employees play a constructive role?

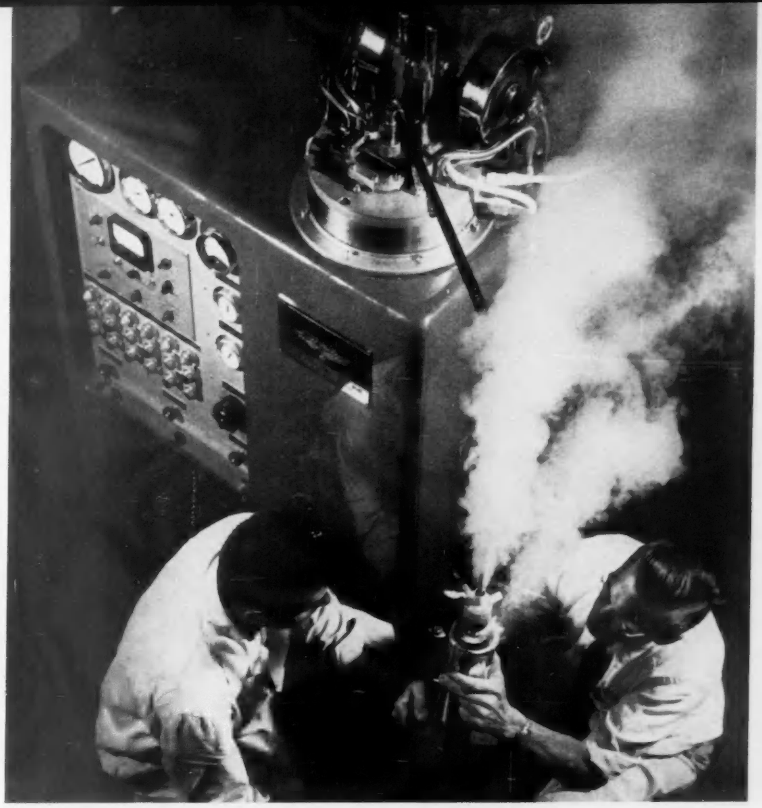
Right. At the very least, all employees—and particularly engineers and scientists—should be informed about the business climate goals of their company and be able to decide for themselves how they might work towards accomplishment of the goals as individual citizens.

What are some examples of what engineers and scientists can do?

There are many, many examples, not just what they can do, but of what they *are* doing. Engineers and scientists are performing a wide variety of civic responsibilities. They are serving as city officials, councilmen, school board members, on planning commissions, etc. They perform in consulting capacities on special municipal problems; they teach various adult education classes. They take an active role in the affairs of the political party of their choice, serving in various capacities from the local district or precinct level on up.

Most of the emphasis today is being placed on our nation's technical gains. But I believe that in the long run the ability of our nation to fulfill its full potential—and to realize technical gains completely—depends on our social progress. To me, engineers and scientists, individually and as a group, can make substantial contributions in the area of social progress. In our American enterprise system you can't get something for nothing, and I believe engineers and scientists know this better than anyone else. They're dealing with "inputs" and "outputs" all the time. They can do much to assure the exercise of good judgment and the attainment of well-balanced decisions on matters of public interest. This directly affects the future economy, strength, and security of our communities, our states, and our nation.

If you add up the total effect of individual citizenship activities, especially if they are conducted with an understanding of their relation to the locally determined business climate improvement goals, you should have tremendous progress. With each engineer and scientist deciding what needs to be done and then setting out to make his contribution to reaching a worthwhile goal, the business climate of a good many fine communities throughout the nation is in for a wholesome boost. Ω



Man's coldest refrigerant, liquid helium, flows economically from Collins liquefier. Once a rare and costly art, hydrogen and helium liquefaction is easy today. These gases will be as broadly available to tomorrow's industry as liquid air, oxygen, and nitrogen are today.

Cryogenics: Rapid Growth, Promising Future

By DR. MILAN D. FISKE and DR. ROLAND W. SCHMITT

Fifty years ago researchers first entered the silent world a few degrees above absolute zero: −459.6 F. They discovered that ordinary matter displays "superbehavior" in that extreme cold. Subsequent investigation uncovered "superconductors" that carry electricity without resistance to current flow and a "superfluid" that flows uphill and conducts heat 300 times better than copper at room temperature. The term "cryogenics" (from the Greek *kryos*, icy cold) describes the new science of low-temperature phenomena.

No longer a scientific curiosity, superbehavior today serves some interesting devices and promises to serve many others. The first hydrogen bomb depended on liquid hydrogen at −423 F for its operation. An infrared detection device, a heat switch, and nonlinear circuit elements for amplifiers and computers have developed to the point where commercial application may soon be considered. And the development of truly frictionless bearings—another intriguing low-temperature possibility—may use the peculiar magnetic repulsion of a superconducting metal.

Tomorrow's larger rockets may utilize liquid hydrogen to generate substantially greater thrust than today's fuels. The same fluid makes an excellent target for high-energy bombardment in nuclear research.

Dr. Fiske—Personnel and Administration, Metallurgy and Ceramics Research Department, Research Laboratory—joined the company in 1941. Since then, he has worked on gas switching tubes for radar, cryogenics, and low-temperature physics and radiation damage. Dr. Schmitt—Manager, Physical Metallurgy Section, Research Laboratory—joined General Electric in 1951. Prior to his present position, he worked in the areas of low-temperature physics and the electrical conduction of metals and alloys.

Parable of Progress

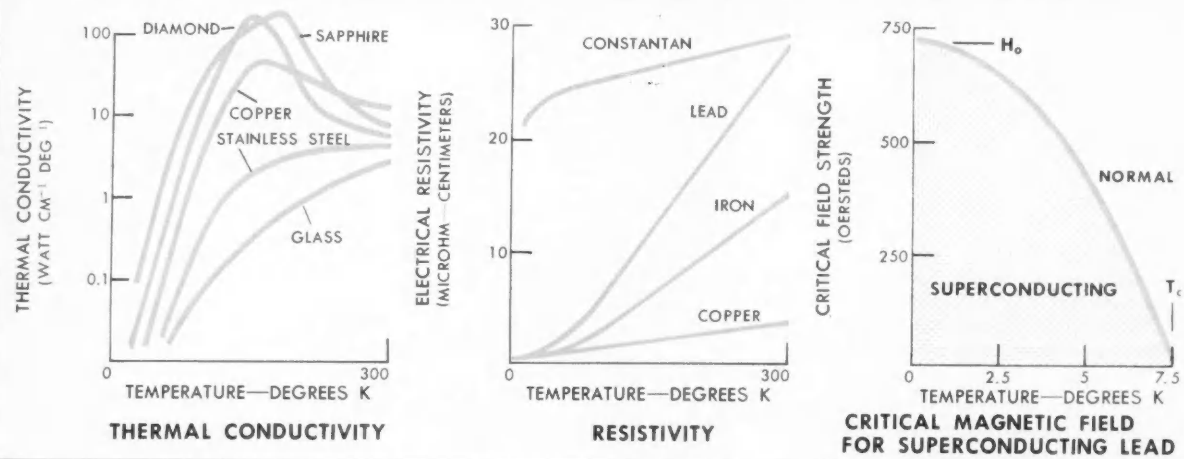
To reach the world of very low temperatures, we use liquid hydrogen or helium as a refrigerant. For use in liquid form, steam must be cooled to its 212 F boiling point. Similarly, we must cool hydrogen to −423 F and helium to −452 F. Because helium requires such a low temperature, it was the last of all gases to be liquefied. The development that followed this achievement forms a parable of scientific progress.

Helium, alone of all the chemical elements, was discovered outside our planet, on the sun—by spectroscopic observation of the solar eclipse of 1868. In 1908, 13 years after its discovery on earth, helium was liquefied by H. Kamerlingh Onnes at the University of Leiden. For many years the technique remained an art. A rare and costly commodity, Onnes obtained it by heating monazite sand, a mineral found in Brazil and India. To provide the gas for a liter of liquid helium in this primitive way would cost about $65,000 today. In Onnes's day that first liter was as priceless as man's first gram of radium—a triumph of skillful research in pure science, it remained unique for 13 years.

Hydrogen and helium liquefiers based on Onnes's work were built by McLennan in Toronto in 1923. Knowledge spread slowly to other laboratories: even in 1940 only a dozen laboratories in the world had these liquefiers.

After World War II, Professor S. T. Collins of MIT developed a simple helium-liquefying machine. An improved model of that machine (photo) operates today in an estimated 130 university, industrial, and independent research laboratories. Several companies now manufacture vessels for the trans-

MANY COMMON MATERIALS DISPLAY SUPERBEHAVIOR AT LOW TEMPERATURES



port and storage of liquid helium and hydrogen. While the storage vessels use the same principles as Onnes's early glass vessels, their rugged metal construction allows storage of these elusive liquids for weeks and shipment over hundreds of miles.

The $65,000 price for helium gas has decreased to 50 cents. The liquid price currently ranges from $15 to $30 per liter. Large-scale production could lower the figure to around $1. Within a few years, liquid helium and hydrogen will be as universally available and important to industry as liquid air, oxygen, and nitrogen are today.

Hundreds of engineers and scientists annually attend a conference at the Cryogenic Engineering Laboratory of the National Bureau of Standards. These men have already made significant new inventions in the low-temperature field. Considering the new and different properties of cold materials, it will be surprising indeed if they do not uncover new technological opportunities beyond those we already know.

Thermal Behavior

We shall never attain absolute zero, if Nernst's Theorem, the Third Law of Thermodynamics, is correct. But imagining ourselves at that point, we can estimate the amount of heat necessary to raise the temperature of a body to 1 degree Kelvin (K). To raise the temperature still further, from 1 to 2 K, requires an additional but larger amount of heat. And the trend continues. The higher the starting temperature, the more heat is needed to raise the temperature another degree. The "heat capacity"—the amount of heat needed to increase a body's temperature one degree—increases with higher temperatures. This trend dwindles in most materials by the time they get as "hot" as room temperature. About 6000 times as much heat must be applied to raise a piece of copper from 300 to 301 K as is needed to bring its temperature from 2 to 3 K.

Mechanical Design for Cold Studies

Thermal expansion coefficients of solids follow the same pattern, approaching zero as temperature approaches zero. This fact greatly simplifies testing equipment designed for low-temperature work. At room temperatures we build equipment that the chilly world of our research will shrink. Differential stresses from parts made of different materials could really "freeze" their operation. Usually we can test our equipment adequately by cooling only to liquid nitrogen temperature, 78 K.

Despite the Victory ships of World War II that split apart in the frigid North Atlantic, brittleness does not always accompany low temperatures. Nickel and zirconium show no loss of ductility at liquid nitrogen temperature, and tantalum retains ductility down to 4.2 K. No reliable generalization describes cold brittleness, because scientific investigation of mechanical parameters lags behind work in most other properties.

Thermal Conductivity

The heat conductivity of pure metals and of crystals—such as sapphire, diamond, or rock salt—increases below room temperature. As temperature continues to fall, thermal conductivity stops rising and then begins to fall. This is true for nonelectrical conductors as well as for metals (illustration, left). Thus in certain temperature ranges you can find materials that are electric insulators and also excellent thermal conductors. This unusual behavior should certainly have unique application as low-temperature technology grows.

Decreasing thermal conductivity with decreasing temperature is caused in part by physical imperfections in the crystals. By controlling the state of crystal perfection, we can influence thermal conductivity.

Electrical Conductivity

Electrical resistivity of metals usually decreases with falling temperature. The decrease is less for alloys than for pure metals (illustration, center). The difference between electrical and thermal conductivity stems from this fact: electric current can flow through a material only as a result of the motion of relatively free electrons. Thermal currents travel not only in this manner but also via atomic vibrations through the crystalline lattice.

Superconductivity

Superconductivity occurs in many metals, alloys, and compounds. Electrical resistance drops with temperature in a way normal for metallic conductors, until suddenly—at some very low temperature—resistance disappears altogether, and the material becomes a perfect conductor. We immediately envision lossless transmission lines and transformers—but a strict limitation is imposed by another property of the superconductors: they expel magnetic fields below a certain size but will not remain superconducting if the magnetic field exceeds this size.

By cooling a superconductor below its transition temperature and then externally applying a magnetic field, you will soon reach a critical value (illustration, right) where the superconductivity is destroyed, the field penetrates, and electrical resistance returns.

A current flowing in a transmission line sets up a magnetic field around the line. When the current carried becomes large enough to create the critical magnetic field, the transmission line regains its normal resistance. In spite of this limitation on power transmission, superconductivity offers interesting and important contributions to technology in low-current applications.

Technicium, at 11 K, has the highest transition temperature of any element; a compound of niobium and tin becomes a superconductor at 18 K. An empirical search over a long period covered a host of materials, ranging from common copper to complex alloys and compounds. Recently developed theories (by Bardeen of the University of Illinois and Pines of Princeton) explain the empirical failure in finding a superconductor for ordinary temperatures.

Superfluidity

Superfluidity occurs only in liquid helium. Liquefying at 4.2 K, helium undergoes another phase change at 2.2 K. It becomes not a solid but a one-of-a-kind fluid that conducts heat remarkably well. Just above 2.2 K the liquid boils, forming tiny vapor bubbles in considerable agitation. Below 2.2 K boiling ceases—the liquid cannot sustain temperature gradients high enough to let bubbles form.

The "super" liquid also flows uphill, by forming a thin film that creeps up the sides of a vessel (photo, top). Held over a larger bath, a test tube of the liquid will empty itself.

Another astonishing sight is the "fountain effect." A small tube containing a heater is connected to a bath of superfluid helium through a fine capillary. Heat causes the liquid to rush through the capillary and out the top of the tube (photo, center). The resulting fountain can be a foot high.

Application on Earth . . .

The ability to produce, store, and transport these peculiar fluids, hydrogen and helium, on a large scale stimulates scientific and technological applications. Liquid hydrogen, for example, has wide use as a target material for high-energy nuclear particles from accelerators, because a unit volume contains more hydrogen nuclei than an equal volume of other targets, such as paraffin or hydrogen gas.

Theoretically one of the very best rocket fuels, liquid hydrogen holds promise for large rockets. When burned with oxygen, it should provide 40 percent greater thrust per pound than does kerosene, a common rocket fuel. But this application will require extremely large rockets, where the bulk of the insulated storage tanks will be a relatively small part of the total weight of the vehicle.

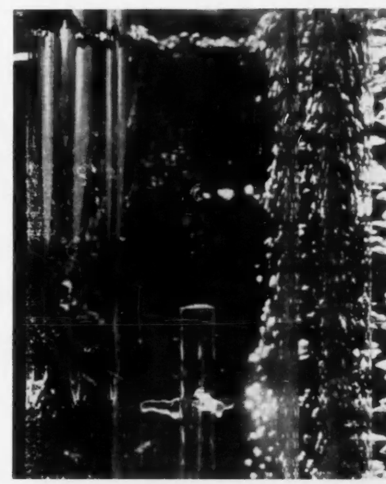
Industries using gaseous helium may benefit directly by improved transportation methods. Cross-country shipment of liquid helium by special tank car should become more economical than the present, bulky, pressurized cylinders.

During World War II, the first application of superconductivity led to a bolometer for infrared detection. Its sensitive element was a strip of niobium nitride, superconducting at about 15 K. Temperature adjustment placed the strip midway in its transition. Impinging radiation brought a temperature increase, and the corresponding resistance increase was followed electronically. The strip's small heat capacity made the detector both sensitive and fast. Demonstration units outperformed any other existing bolometers for applications involving heat detection of enemy targets, such as factories or troops.

The frictionless bearing of the future may be based on a superconducting plate or ball (photo, lower). The magnetic repulsion between such a plate and a permanent magnet can support a free-floating load without friction. The geometry can use either member as bearing or journal.

The use of superconductors as nonlinear elements in circuits, where current is not proportional directly to voltage, currently offers great promise. Because an appropriate magnetic field can restore normal resistance to a superconductor, we can make an "output" loop of a superconductor near its transition temperature. A "control" current, through a coil surrounding the loop, can restore part or all of the output's normal resistance. This is easily used in a d-c amplifier with no electrical connection between input and output. The

SUPERFLUID liquid helium film creeps up over sides of test tube and drips from bottom.



FOUNTAIN EFFECT demonstrates helium's superfluid flow rate, produces foot-high jet.

MAGNETIC REPULSION of superconducting metal ball supports it above toroidal magnet.

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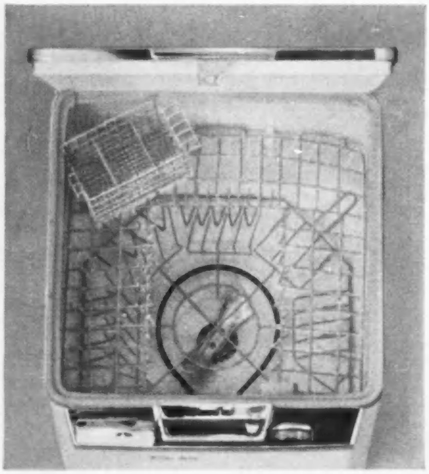

The new portable dishwasher has a stainless-steel impeller that drives wash water up through the dishes; reversed, it "pulls" the water down, forcing it out the drain. In addition, the sharp leading edge of the impeller chops up soft chunks of food soil for easy disposal.

Designing A Better Portable Dishwasher

By M. R. KAUFFMAN

Washing and drying dishes can be one of the most depressing and common aspects of homemaking as your wife—and possibly you—know from experience. Nothing so effectively takes the edge off the full enjoyment of a successful dinner party as a stack of dirty dishes after the guests have departed.

And a plumbed-in (undercounter) dishwasher isn't always the answer. In some homes it is difficult to install a built-in unit. Families who rent need a dishwasher they can take with them when they move. Consequently an inexpensive portable dishwasher looks like the solution to the problem.

Ten years ago, we were well aware of the situation—from the facts uncovered by a market survey of the American consumer.

Initial Design

As a result of the survey's encouraging results, we launched a full-fledged project to design and develop a portable dishwasher. For volume sales, the unit had to be relatively inexpensive. So to help cut costs, we designed a round unit—the easiest and least expensive to produce. Also, because the housewife would be accustomed to a round appliance, wouldn't the new portable dishwasher look almost the same as the popular wringer clothes washer we were then making?

Although this first portable dishwasher's operation required the housewife's attention, it unquestionably washed her dishes clean and was inexpensive.

In April of 1949, after receiving a development tool authorization for $350,000 the year before, we started production. Unfortunately, an enthusiastic production schedule flooded the market with 38,000 of these portables in 1949 and 10,000 more in 1950. A year later, more than half of the machines were still in stock.

Why had such a "desirable" and useful appliance failed to gain customer acceptance? Further analysis revealed several important factors. Operation of this dishwasher required the houswife to 1) load her dishes, 2) add detergent, 3) turn on the hot water until a reservoir in the cover was filled, 4) shut off the hot water, and 5) actuate a switch that dropped the water into the tub and started rotating the impeller. Later, when the housewife decided her dishes were washed enough, she actuated still another switch that pumped the wash water out of the machine into the sink. And to rinse her dishes, she repeated the same lengthy procedure one or more times, omitting only the detergent step. In addition, she knew it wouldn't dry

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Mr. Kauffman—a project engineer in the Dishwasher and Disposall Department, Appliance and Television Receiver Division, Louisville, Kentucky—began his career with General Electric in 1928. He was first associated with the Erie Works Laboratory; since joining the Dishwasher and Disposall Department in 1951, he has held positions as supervisor of drafting and standards, quality-control engineer on kitchen cabinets, and administrative engineer.

her dishes because it had no heater. You can see that over-all consumer convenience rated low for this model.

Reappraisal—New Design

Further surveys plus analysis of the original survey revealed that the housewife really wanted a fully automatic dishwasher, square in shape so that it would *not* resemble her laundry equipment.

After our Department moved to Appliance Park, Louisville, Ky., we reexamined the portable-dishwasher market potential. Consumers told us it should be 1) as much like the plumbed-in model in features as possible, 2) completely automatic, 3) modern looking, and 4) economical to buy and use.

With these general specifications before us, we sketched out preliminary plans for such a portable dishwasher in a few weeks. Designing in as many components of the undercounter model as possible, we used the same tub, motor, impeller, racks, timer, and detergent dispensing system.

In 1953 this portable model received a development tool authorization for $285,000. Production of 28,600 units in 1953—marketed under the General Electric registered trademark of *Mobile Maid*—started an entirely new business for the department.

This 1953 version approached a square shape as closely as was economically possible with the use of a porcelain tub designed originally for the undercounter dishwasher. The cycle differed from the undercounter model: it had two final rinses instead of three and did not have a timer-controlled dry cycle. At the end of the second and final rinse, the cover popped open, and the dishes "flash" dried in the air circulated by the hot dishes.

We stayed with this same basic design for three years (photo, page 18), constantly improving the product's performance and manufacturing methods.

In 1955 we began another major design program. The challenge: conceive a new design, lower in cost and higher in performance than its predecessor, which had been thoroughly refined.

This time, the design was given as much thought as the undercounter model. Specifications called for real engineering initiative and skill . . .

- Improve the washing performance with the addition of another rinse and a dry cycle to give it the same cycle as the undercounter model
- Increase the capacity for dishes
- Give it a high-style appearance with a square look
- Use automated manufacturing methods to facilitate greatly increased volume production without major rearrangement of the factory.

We met the challenge at a substantial cost reduction, compared with the unit then in production.

Single-Wall Construction . . .

One of the first specifications tackled was the square-looking single-wall tub-cabinet design.

We wanted small radii on the tub corners and sharp angles for several bosses. But it was impossible to reduce the radii to less than 3½ inches by seam welding because of excessive welding equipment maintenance. Also, seam welding put a groove in the tub that was undesirable for appearance.

For the tub liner we needed a protective coating. Ideally, it had to fill corner gaps and spaces between spot welds, even if we didn't use welds in corners. While considering this problem, we received some encouraging test results. Plastisol, the dip-coating used on our racks since 1950, could be used as a spray for a dishwasher tub liner. This material not only could be applied to carbon steel but it also had few of porcelain's manufacturing limitations. Plastisol permitted us to use sharper corners and angles. And it filled gaps between metal and metal. We therefore abandoned seam welding in those areas where it would affect tub shape and cause appearance blemishes.

Single-wall construction was desirable for the housewife, and it also reduced manufacturing costs. The space between the tub and the outer shell of the original dishwasher was then *inside* the tub—thus increasing the dish capacity.

All problems surrounding the single-wall construction were tough. But in retrospect, success seemed to hinge on whether the team pursuing the proper application method for the plastisol would reach its goal.

We formed the tub by seam welding ordinary carbon-steel sheet into a cylinder. A front panel later hides the seam weld, thus eliminating any appearance problems. The cylinder is next expanded into the finished tub shape, which incorporates the bosses and wells containing the timer, latch, and other components. The plastisol liner permitted us to bring the corner radii down to 1½ inches. The tooling job on the tub was so well done that we could maintain a close fit between the tub bottom flange and the tub wall. Attaching the bottom only requires spot welds in the front and back of the tub. Plastisol fills in the gaps and acts as a sealer and an adhesive to assist in holding the remainder of the assembly together.

To finish the dishwasher, the tub is painted, and all necessary components are added.

. . . Plastisol Tub Liner . . .

Preproduction tests proved that the plastisol tub liner will adhere to the interior surfaces for the service life of the tub if scrupulous care is observed in preparing the metal surface for fault-free application of the adhesive binder and plastisol coating.

When the final decision to use plastisol was made, our laboratory had obtained eight years equivalent use on complete machines. This test simulated household use, with automatic injection of food acids and detergents interrupted by typical drying cycles with the tub exposed to room air. We cut through the plastisol film with a sharp knife to expose bare steel in "X" marks on the bottom of the tub. These cuts have not rusted nor has the adhesion of the plastisol been impaired in this or other areas.

Before finally deciding to use plastisol, we analyzed field-test results: 6 plastisol dishwashers were on field test 2 years; 10 plastisol dishwashers were on field test 14 months; and 350 plastisol dishwashers were on field test 8 months in areas across the United States.

"Very satisfactory service" keynoted these machines. With use, the plastisol coatings had improved in appearance and toughness and seemed to stay cleaner and smoother than other coatings we had used, including porcelain! To satisfy ourselves and others that plastisol could be substituted for the "old standard of cleanliness in water-containing vessels," we commissioned the Department of Microbiology, School of Medicine, University of Louisville, to conduct a series of dishwashing tests, beginning in January 1955.

Using porcelain and plastisol tubs, the scientists contaminated both types of tub surfaces and dishes with Bacillus Subtilis spores and other types of contaminants. After 100 dishwashings and more than 1500 individual bacteriological examinations of the plastisol tubs and the articles washed, they issued this statement on March 15: "The University of Louisville School of Medicine Research Team concurs that there is no


INITIAL DESIGN continually evolved to incorporate the newest user conveniences.

possible health hazard presented by plastisol-coated dishwasher tubs in themselves."

As a result of the University's bacteriological examinations, areas susceptible to the lodging of bacteria were found. We immediately changed our design to eliminate these areas. For example, we moved the cover hinges from the inside to the outside of the tub. We experimented with the tub-bottom slope and arrived at an angle that would eliminate this area of possible hazard. Other areas that were in the least questionable were redesigned to be germ-safe far beyond the porcelained models.

Plastisol also protects the carbon-steel inner portion of the dishwasher's cover. The cover's outer portion is reinforced Textolite (registered trademark of the General Electric Company for laminated plastic), familiar to you as a durable work surface in the kitchen. Stainless-steel molding edges the cover and gives it a finished look similar to many kitchen counter tops. Two adjustable counter-balancing hinges on the back of the cover balance it in almost any position.

. . . Washing and Drying Cycles . . .

Another product-plan specification: the mechanism must be able to dispose of up to ½ cup of soft-food waste to minimize dish preparation. This requirement greatly influenced our product design, because it meant . . .

- A "clean" design for the tub's interior
- Good drainage angles
- Satisfactory clearance between dishes and tub wall
- No crevices
- Correct positioning of dishes in regard to drainage angles and having their soiled side "seen" by the impeller.

We designed a stainless-steel impeller—its sharp leading edge chops up large chunks of food soil into pieces small enough to be whisked out by the stainless-steel pump.

Another novel development was the machine's cycle; the mechanism we designed to circulate the water and pump it out is unique in the domestic dishwasher field. With a ⅓-hp motor driving it clockwise, the wash impeller—just above the "floor" of the tub—picks up water and forces it through the dishes held in the lower rack and on up to the inverted dishes in the upper rack. During the washing and rinsing cycles, the impeller drives the water (we call it "fire-hosed") over the dishes at 80 gallons per minute for a total of 920 gallons. Only 10 gallons, however, is used for the complete cycle. When reversed, the pump impeller blades force the wash water through an opening just below the wash impeller. The water is then pumped through the drain system and out into the sink.

This "flushaway-drain" mechanism eliminates the small drain pump used on all other pump-type dishwashers. The ⅓-hp wash pump is powerful enough to "liquefy" food particles that might jam smaller pumps. The dishwasher therefore handles larger quantities of food soil on dishes without using screens to filter out large food particles. The flushaway-drain and wash mechanism has been described as a most significant advance in dishwasher development.

The multiple function latch allows the cover to "pop" open during the drying cycle to provide air flow for the convection-drying system. The latch contains an interlock switch that protects your wife from the unexpected shower that would occur if the cover were opened during the cycle's "wet" portion. A small button under the recessed handle on the front can be lifted to release the cover latch and to interrupt the cycle to add that forgotten dish.

For the two succeeding models we used the basic design just described and may use the same one for several more years. Later models were changed to incorporate quality improvements, cost reductions, and new customer convenience features.

The latest unit (photos, page 16) has the same cycle and wash system as its predecessor—38 minutes, 12 seconds; two power pre-RINSES (one of which can be a wash); one WASH; three after-RINSES; and a 15-minute DRYING period.

. . . and Tub Capacity

Later we designed the racks and silverware basket so that each item they contained would receive a forceful blast of water, with a minimum of "shadowing," from the impeller. This feature cuts down dish preparation before loading. We increased rack and silverware basket capacity, made the racks more versatile in accommodating mixed dish loads and odd-shaped and -sized dishes, and designed them for automated production. The result: the Mobile Maid will hold up to 64 glasses, or 28 cups and saucers, or 10 formal place settings, or a 116-piece mixed load used in preparing and serving a dinner for five people, or up to 75 flat pieces including dinner plates, salad plates, dessert plates, bread and butter plates, and saucers.

In my opinion, the greatest difference between today's portable dishwasher and the first one we made in 1949 is in the user-convenience area. Your wife no longer needs to carefully rinse the dishes before she loads the racks. Today's dishwasher also holds many more items in a larger variety of shapes and sizes. And operation is simple: load the dishes, fill the detergent cup, connect the unicouple to the hot-water faucet, plug in the power cord to the nearest receptacle, and close the cover.

Today's Mobile Maid, I believe, has about all the features and convenience that we can economically build into a portable dishwasher. Perhaps someday we shall devise a system to automatically remove the dirty dishes from the table and store them after washing. Meanwhile, we will continue to refine the art of automatic dishwashing so that in the future no household will be able to afford the inconvenience of living without one. We all have better things to do than wash dishes. Ω

Russian Decentralization: Will It Work?

Russia wants industrial decentralization. But too much grass-roots control would be politically dangerous. So, she'll use some principles of decentralization and ignore others. By doing this, does Russia invite failure?

"The managers we met were technically competent, capable of command, and very 'result minded.' Within limits, this adequately describes a management function, but I question whether this is sufficient qualification for management." —**Rouault**

"In Russia there have been several attempts to 'decentralize' . . . but whenever a goal was not met, the control was again centralized, and the cycle repeated. This inevitably results from a parallel-authoritarian organization." —**Crowther**

By C. L. ROUAULT and F. D. CROWTHER

Decentralization of large business organizations became an increasingly important management philosophy after World War II.

More than a geographic relocation or regrouping by product, decentralization gives those who are actually doing the work the responsibility and authority for decision making to the maximum extent possible. With responsibility and authority goes accountability for results. True decentralization also requires belief that individuals will do the job well if given the opportunity. And the success of decentralization must be judged in the long run in terms of better value for customers, better earnings and satisfactions for share owners and employees, and improved relationships with other businesses, the public, and the public's representative—the Government.

More than a year ago the Soviet Union announced decentralization plans for its technical economy.

A few months after the decision, Charles L. Rouault—Consulting Engineer, Heavy Military Electronic Equipment Department, Electronics Park, Syracuse, NY—visited Russia. Jointly sponsored by the U.S. State Department and the IRE, he and three other engineers attended the annual meeting of the Popov Society, dedicated to the early experimenter in wireless communication. (REVIEW Editors interviewed Rouault on the subject of Russian electronics, March 1958, REVIEW, page 12.)

We're presenting the following abstract of Rouault's report on Russian decentralization, giving you more information on the subject so that you can better make your own estimates of the state of affairs within the Soviet Union. Further analysis by Mr. Crowther begins on page 22.
—EDITORS

During a chance discussion, I was given a rundown of proposed changes in the Soviet Union's economic system. My informant, fortunately, was willing and anxious to discuss this subject and to answer any number of hypothetical questions.

When first set up, the Soviet economic system consisted of an originating, directing Ministry, responsible for numerous, specialized plants throughout the Soviet Union. These plants followed a programmed schedule provided by the Ministry—output, input, labor, material, and facilities. The Ministry performed all paperwork necessary

"Those who produce are rewarded, sometimes extravagantly."

for the working of the economic system.

According to my informant, however, experience proved it was impossible for Moscow to control the complex, technological society of the Soviet Union. Distances were too great, and the geography, temperament of the people, and local situations were too diverse.

Much discussion in many conferences led to the decision to decentralize the Soviet technical economy—involving some 40-million people.

This decision in all its implications is, I think, one of the most important made by any nation in the last few years. Not just a fundamental change in the system's philosophy, it is actually a recognition that one of the system's essential elements—competition—must be preserved to assure low-cost high-volume products, marketed in the right places.

Implementation

The general plan of decentralization: 90-odd economic units will be set up in the Soviet Union. They will not be the same as the political units of which they are a part. Each unit will have a subsidiary, directing and correlating Ministry, but each plant in a particular economic unit will stand essentially on its own feet.

Each plant manager will be responsible for all areas normally associated with the management function in the United States: procuring material, controlling the plant, scheduling production, arranging for marketing and distribution, procuring labor, and managing all other facilities except supply of capital, which the state will furnish. Research and development will also remain under centralized control.

To clarify my understanding, I posed a number of hypothetical questions.

If a plant in Moscow, making the same product as a plant in Leningrad, manufactures its product at a lower cost so that it can transport its products to Leningrad to sell in the same market, what happens?

The Moscow-manufactured product can be sold in the competitive Leningrad market without prejudice. If it is a better product, it will win.

What happens to the plant in Leningrad that is not making the product as economically as the one in Moscow?

The Leningrad plant gets a new manager, or it goes out of business.

What happens to the labor that might be displaced because the Leningrad plant was forced out of business by the Moscow plant's superior performance?

In our socialistic economy, this is unlikely to happen. But if it does, the people in Leningrad will be assured of job continuation until suitable other industry is arranged for them by the ministry.

What happens to those who decline to work?

They go hungry.

If the Moscow manufacturer makes his product so economically that he is able to sell his excess product in Leningrad and thereby is able to raise the wages of his employees in Moscow, what happens in the Moscow area where you now have a new and higher price for labor? Is the manager entitled to raise prices for labor?

Certainly.

How will the Moscow plant manager—who makes his product so efficiently—be able to market his product in Leningrad?

He's the manager. That's his job.

Is he permitted to advertise the superiority of the Moscow-built product in the Leningrad market?

Certainly.

If this truly is a socialistic state, why should there be any difference between two products manufactured by the state?

It is obvious that the two products cannot be equal, because tastes differ. It is an obligation, therefore, to make known your product's superior properties.

What happens to a plant when its costs are out of line with those in a comparative area?

Capital can be advanced—or withdrawn—as operational efficiency indicates.

Who makes this decision?

The Ministry involved.

Who is responsible for performance—the Ministry or the manager?

The manager.

If the manager is responsible, how can the Ministry be responsible?

Eventually the Ministry cannot be responsible.

Would it be fair to describe your present transition to the new system as an introduction to the question of competition?

Yes.

How will the manufacturer of the superior product make known the superior properties of this product to consumers?

Through a lower price, through improved return to the plant workers, and through such means as he can obtain to make known the superiority of his wares.

Does this mean newspaper and radio advertising?

Possibly, but this has not been decided yet.

How does a plant manager propose to secure the materials and equipment necessary to obtain required output?

He is responsible for the procurement of all materials, according to the proper specifications, for the product he is obliged to make.

Is the manager empowered to establish the necessary sales, marketing, and procurement staffs to implement his managerial functions?

Yes.

What will he do about cost control? Does the Ministry take care of that?

The manager is responsible.

Does this mean that the Ministry will delegate the function of financial control of costs to the manager?

Yes, but the Ministry maintains control of the manager's operating funds.

How many Ministries are being decentralized in accordance with the previous discussion?

Only a few are being decentralized at the present time. The radio industry, for example, is not being decentralized as of now, but will be relatively soon.

Will this decentralization eventually apply to all state-owned functions of the USSR?

The decentralization will be complete insofar as the economic units discussed are concerned.

Does this mean that there will be no over-all control from Moscow?

There will be a sort of surveillance

and inspection function, but no control as it is presently constituted.

Does this mean that large numbers of technical personnel will be moved out of Moscow and into smaller cities of the Soviet Union?

Yes.

Do you believe that you can make the technical labor move without great difficulty?

They will be provided equivalent housing and cultural facilities to those which now exist in Moscow. We believe they will do it because it is their duty.

Do you plan any special benefits for those who move?

Yes, in the same way that we provide special incentives for those who now live in the northern part of Siberia.

Won't these benefits upset the normal balance of supply and demand for labor?

They may, but the manager has full responsibility to correct any unbalances that may occur.

How will your labor rates be established for these economic units?

The rates will be established in accordance with usage of the area and will be sufficient to yield a satisfactory income from the operation.

In other words, you plan to pay rates that are commensurate with the standard of the region?

Yes.

Who determines whether these rates are equitable?

The Ministry.

Who finds the markets for the products of these various local units?

The manager and the Ministry.

In other words, the manager runs the show?

Yes, but the Ministry has the right of veto.

Rouault wrote his report on Russian decentralization more than a year ago. REVIEW Editors recently asked him for further remarks based on the perspective furnished by a year's passage of time. —EDITORS

"Charlie, when can you leave for Moscow tonight?"

A year after that telephone call has come the opportunity to reflect on the observations and conclusions resulting from my 10-day visit in the Soviet Union. Much of what was then new, and even startling, has become common fare, for the Soviet Union has shown little reluctance to hide its light under a bushel.

Everyone who has visited Russia tends to make authoritative statements based on little real knowledge. To place such comments in proper perspective, try to estimate how long and how carefully a Russian would have to study the U.S.A. to explain so simple an everyday affair as a ball game in Yankee Stadium. In my own defense I can fortunately draw on a fairly complete report, written within two weeks after returning from Russia, while my impressions were still vivid. At that time, it was deemed politic to draw no conclusions, simply report. (But this did not prevent conclusions.)

Defining by Comparison

One area in the report, which has been studied very carefully in General Electric, covers a long discussion regarding "decentralization" of the Soviet Russian economic system. Currently, General Electric can claim considerable experience in the mechanics of successfully initiating a decentralization policy; and having viewed this operation from the underside, I took advantage of an opportunity to question the Russians on this subject.

My familiarity with several foreign languages and the great difficulties that beset the translator prompted some direct, immediate questions: What do the words mean? what is the chain of command? what are the resources available? what are the objectives? what are the ground rules? why? Although I naturally couldn't obtain definitive answers, the interview did clarify a few points.

Before we analyze the questions asked, let's discuss some related material.

Profit . . .

Of the several kinds of profit, the 20 percent return on investment most concerned the Russian managers. (Note the similarity to the G-E criterion—7 percent on sales, 20 percent on investment.) We were unable to determine the technique by which the investment is computed. Nowhere did we see the accounting staffs or facilities necessary to reconcile either cost or investment. Nor did any answers to the questions in the factory interviews indicate a knowledge of the fundamental procedures of cost analysis. It is fairly clear that any relationship between sale prices and costs is casual, at best.

. . . Facilities . . .

The resources required for decentralization are great in number. But of particular interest to me were personnel (managers and engineers), communications, and market-analysis techniques.

The managers we met were technically competent, capable of command, and very "result-minded." Within limits, this adequately describes a management function, but I question whether this is sufficient qualification for management. In the accepted sense a competitive economy depends strongly on the communication facilities and the ease with which communication occurs. When, as stated in the interview, the manager becomes responsible for marketing, labor relations, and others, the need for communication up and down the chain of command—as well as transversely to suppliers and customers—imposes a whole new set of operating conditions that seemed unfamiliar to all the managers. Granted, they can be learned; but can they be learned fast enough to avoid severe dislocations?

The transition to a decentralized status is difficult enough, having at hand most of the essential tools and a cadre of experienced men. How much more difficult it must be in Russia!

Decentralization is an absolute necessity there, for it is inconceivable to experienced American engineers (and also to the Russians) that a product could be designed that would be universally acceptable over the vast expanses of Russia. How then are these markets to be analyzed, designed for, and sold? And above all, on what reasonable and equitable basis will satisfactory performance be measured? There may be no answers to these questions if the criterion must conform to Marxist-Leninist economic theology.

. . . and Incentives

The incentives to satisfactory performance in Russia are primarily financial but include considerable recognition as well. Those who produce are rewarded, sometimes extravagantly. As a

COMPENSATION AND INCENTIVES

In any discussion about the output of a Russian manufacturing plant, the subject of wage and salary rates arises. During one discussion, we learned that the average monthly income of an assembly-line worker ranged between 700 and 1200 rubles. The next question was, "How much do you pay the managers and engineers?" We were told that very good engineers, scientists, and managers, grouped on about the same performance level, were paid salaries up to 100,000 rubles per year. This represents about a ten-to-one ratio in the take-home pay. (Similar high salaries also are received by such people as artists, ballet dancers, and people doing hazardous work, such as coal miners.)

We pointed out that in the United States this would be modified drastically by our present income taxes. For example, a yearly income of $100,000, representing the salary a good manager earns in a large United States plant, might be subject to tax in excess of $75,000 per year. When one of the Russian engineers heard this, his immediate comment was a startled, "That isn't fair—how do you get anyone to take risks or chances in management?"

We also were told that good plant performance was reflected in bonuses to the manager and to the workers. Was the income derived from this type of superior performance again subject to the same rules? We were told that the maximum income-tax rate levied on the managers and everyone else was 13 percent. In answer to the question, "Is there a tax on the bonus?", we were informed, in a rather surprised tone, "Of course not, because next year there might not be a bonus due to conditions beyond their control." I must confess that there was a rather strong flavor of unreality during the discussion, because the Russians were obviously unaware of the tremendously complex income-tax structure of the United States and most of Western Europe.

Besides the bonus, managerial and engineering personnel receive extra compensations. For example, cars and chauffeurs are supplied as part of the job. The manager always has a car supplied, required to maintain his station in life. Our main guide, Professor Siforov, has a car assigned to him, which he regards as perfectly normal, a part of his job.

As we were transported around Moscow and Leningrad in the various cars supplied by the ministry, it struck us that these cars were uniformly clean, well maintained internally, did not have any dents, scars, bumps, or scratches on the outside, and in general were in a highly polished condition. We were curious about this. Our own experience indicated that such cars, not being the property of any one individual, should be in a state of near wreckage.

We were informed, however, that these cars were inspected when returned to the garage. If a car had no dents, scratches, or other defects, the fact was recorded. After several months a bonus of about 100 rubles would be received for satisfactory performance. This, along with satisfactory preventive maintenance over a year, would then assure the driver that the 100-ruble increment per month would become a fixed part of his pay.

On the other hand, if the driver returned the car in a damaged condition, or if he required other than normal road service and maintenance, he was penalized. We were told that after two or three penalties not much was left to dock. This system of incentives and penalties seems to result in devoting a reasonable amount of care to public property. —CLR

generalization, the total compensation of a factory manager approximated 10 times the average hourly rated pay. Bonuses and awards are not considered part of the income-tax base, even though the apparent maximum income-tax rate is only 13 percent. Russian management personnel seemed to feel that decentralization afforded an opportunity to improve their lot absolutely through larger bonuses and possibly relatively through personal recognition gained from success in a competitive business climate.

In subsequent discussions with Russian managers and engineers, I noted an instinctive reluctance to discuss "capitalism;" yet as soon as the discussion changed to a "competitive economic system," they became animated participants, assuring us, "Yes, this is what we want in Russia." This apparent contradiction could breed significant differences in opinion and technique.

With this and Crowther's commentary as a basis, the remarks on Russian decentralization can be placed in their proper, limited relationship to the experience that generated them.

How does a management consultant view Russian decentralization plans, particularly in the light of the answers given to Rouault's questions? To bring you an interpretative analysis, REVIEW Editors asked Fred D. Crowther—Consultant—Organization Practices, Management Consultation Services, New York—for his opinions. With the General Electric Company for 31 years, Crowther's career has included positions in Engineering, Manufacturing, Marketing, and Services work.

Crowther's comments are based on recorded history plus the observations of authors who have visited Russia and made their reports in books, periodicals, and newspapers.

—EDITORS

Among people familiar with the same language, many misunderstandings occur over the meaning of words. When opposing ideologies and centuries of differing cultures are added, the semantic barriers multiply.

A single word, such as "decentralization," is used with many meanings in the United States. In Russia it means something entirely different, because it is translated against the reference of a fundamentally different background of experience, culture, and ideology.

This is reflected in the answers given to Rouault's questions. For example, the tremendous difference in pay between managers or engineers and the factory worker and the status symbols of cars and chauffeurs reflect traditional class distinctions and a master-slave or servant relationship (Box).

An Autocratic History

Russia has a history of centralized rule originating in one supreme authority. At each level in the hierarchy, the "master" is the source of authority, and work is the result of fear. This was accepted by the Russians in the time of the Tzars; by practical interpretation the end result has not changed with the advent of Communism, though the ideology is different.

Lenin introduced the idea that there need be no political authority as such. The central bodies of the Communist Party merely "represented" the "true" interests of the proletariat. If the "leaders'" ideas differed from those of the proletariat, it was only because the party leaders were more "advanced" and were merely expressing what the people would think when experience brought them deeper insight. Thus, everything done by the party represented the real interests of the people; the party and the people were one and the same.

Consider the possible implications that flow from the concept of decentralization in a Western society where it means . . .

- The voluntary acceptance of responsibility and self-discipline
- Belief in the dignity of the individual. Those who have a wider scope of responsibility must believe in the dignity of the individual and have faith that those to whom responsibility has been decentralized will assume and fulfill that responsibility to the best of their ability
- A "situation oriented" emotional maturity with no search for a scapegoat on whom to place blame for individual failure
- An approach that asks, "In this new situation that we face, what is the best course?"
- Leadership by inspiration and persuasion—providing a climate of responsible freedom and initiative; teaching and being taught with confidence tempered by humility
- Placing decision-making in the organizational position that can bring to bear on a problem or opportunity the information, knowledge, skills, competence, and evaluation of probable impacts of the decision
- Accepting the results of such individual decisions without "second guessing" or reversal by higher "authority"
- A free flow of information to wherever responsibility has been placed—with no restrictions on the information necessary to make the best decision
- A belief that the aggregate of many individually sound decisions will be better than centrally planned and controlled decisions
- That all individuals in the enterprise understand and willingly subscribe to the objectives they helped prepare.

To accurately interpret the answers given to Rouault's questions, it is necessary to understand how the Russian system operates. It is quite different from the United States' competitive enterprise system.

In Russia there have been several attempts to "decentralize" since about 1939—but whenever a goal was not met, the control was again centralized, and the cycle repeated. This inevitably results from a parallel authoritarian organization.

Again oversimplified, production "authority" in a Communist dictatorship, such as that set up in East Germany to incorporate the latest managerial practices and ideologies, flows from the Soviet Control Commission to the Presidium of the Council of Ministries to the State Planning Commission to Special Ministries and State Secretariats to managers of industrial establishments.

A parallel hierarchy has authority stemming from the Soviet Control Commission to the Politbureau to the Central Party Secretariat to the County Party Secretariat.

Party Supervision

At each level in the hierarchy there is informal but effective supervision by the Party. Each organizational unit is under the surveillance of a party member within that unit, as evidenced by the answer to the question concerning over-all control from Moscow.

The manager has complete control over the operations within the factory. But the Party, on the other hand, based on its role of representing the "interests" of the people, still makes suggestions, inspects, and participates in the solution of problems, even technical. Thus the Party can—and does—second-guess the decisions of the manager, imposing its suggestions through its veto power and its control of capital, work force, and availability of materials.

The answers to just those few questions Rouault asked reveals the following withheld authority from the manager . . .

- Over-all responsibility (Ministry and manager both responsible, and operation subject to inspection and review by Party)
- Decisions (Ministry has right to reverse)
- Research and development
- Responsibility for developing market (divided between Ministry and manager)
- Selection of plant managers
- Supply of capital
- Control of operating funds
- Determination of wage rates.

With such broad withheld authority, how can a manager be responsible and accountable for the successful competitive operation of a decentralized "business enterprise?"

The answers disclose other differences from "decentralization" as we know it in the United States. . .

- People are moved to different locations and do move because it is their *duty*. Such a concept is unworkable in the United States except during a national emergency. Who defines "duty?"
- Wage rates are determined based on yielding a "satisfactory return" from an operation. This is not a free, mobile, labor market with level of employment and location being determined through roughly balancing supply and demand
- The answer to the question on displaced labor was that "it is unlikely to happen." This contradicts other statements. If wage rates can be determined to show a satisfactory return, rates can be reduced so that one plant can undersell another, with subsequent displaced labor. The maintenance of continuity of employment in some other industry can only be possible by creating other imbalances. It has been demonstrated in this country that money incentives alone will not produce as high an output as will other voluntary work-satisfaction incentives
- The answer to the question of how they would make known superior properties of a product referred only to price and increased wages, with advertising and sales promotion not yet settled. A characteristic of a competitive economy is competition of all values through salesmanship in *all* forms.

Russia has geographically dispersed, but hardly decentralized. *Verbalized* decentralization, such as that confirmed in formally published organization charts and other descriptions of work, including decision making, can be negated by words and actions that "pull back" authority to the center.

It will be a long, difficult educational job to convince a people—who are at least inhibited and at most prohibited, through fear, from freely discussing the underlying causes of their continuing difficulties—that there may be better ways of accomplishing the desired end results. A better understanding of the environment and of the different interpretations of the words will go a long way in facilitating such communication. Seeds still may be sown in Russia for growing individual "freedom of choice" —a little taste may whet the appetite! Ω

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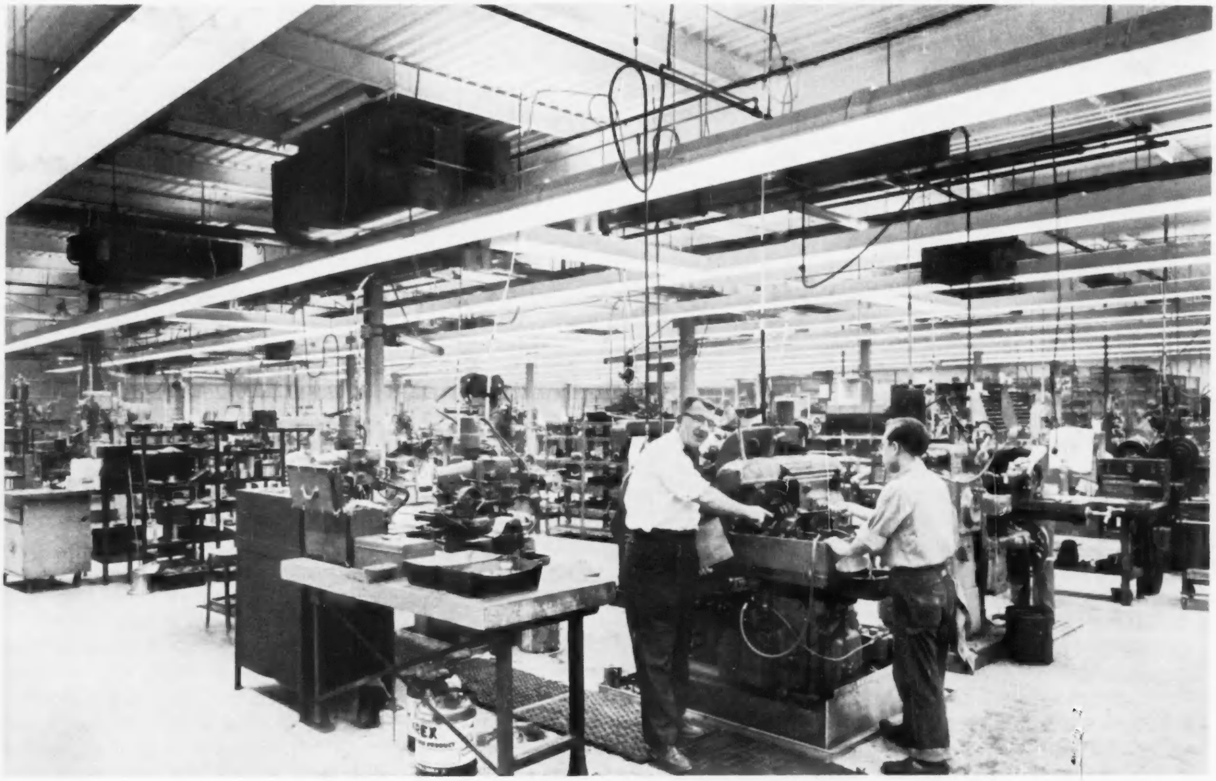
Write directly to the author (you'll find his address in the biographical sketch with each article) or to: Editor, GENERAL ELECTRIC REVIEW, Schenectady 5, New York.



EFFICIENT LIGHTING SYSTEMS reap large rewards for industry. After Power Groove fluorescents were installed at the Erickson Tool Company, Solon, Ohio, worker efficiency substantially increased, minor accidents reduced to half, and rejects fell off sharply.

What's Ahead in Industrial Lighting?

Recommended industrial lighting levels are reaching new highs. The increased efficiency of new lighting installations contributes strikingly to the morale and productivity of individual workers in industry. For a comprehensive analysis of the immediate industrial scene and hints on the horizon, a REVIEW *Editor interviewed E. A. Lindsay—Supervisor, Industrial Lighting and Application, General Electric's Large Lamp Department, Nela Park, Cleveland.*

With the Company since 1942, Mr. Lindsay has wide experience in lighting, including photometry, transportation lighting, and infrared development. He holds a number of patents and has written several articles on lighting. —EDITORS

What is going on in industrial lighting today?

The industrial lighting field is particularly active these days. A definite, established trend promises to raise lighting to a degree of usefulness within the next several decades that was not only unheard of but also economically impossible to achieve as recently as five years ago.

Several factors contribute to this trend. First, we have new lighting tools and application techniques—the Power Groove fluorescent lamp in well-designed fixtures to efficiently control its very high light output, vastly improved maintenance of mercury lamps, and the practicability of operating lighting systems on high frequency.

Second, modern lighting installations generally use 100's of footcandles—an important transition requiring a reorientation of thinking from increments of 10's of footcandles. Until recently, doubling the light in a factory meant increasing it by 20 or 30 footcandles. Today this would require 100 to 200 footcandles in a modern plant.

Third, and probably the most significant, industry as a whole is rapidly accepting light—or, more properly, the seeing which results from light—as a production tool. Industrial lighting is regarded as a tool that can increase worker productivity, reduce profit-killing scrapped work, and make heavy contributions toward raising worker morale.

With more automatic plants, will these higher lighting levels be needed?

As industry becomes more and more automated, seeing tasks become more difficult and more vital to profitable operation. Close observations of equipment, meters, and instruments together with quick physical changes indicated will call for more and better lighting to protect and get the maximum return from the major investments in machines and the highly trained operators.

Generally speaking, investment in better lighting pays better dividends than an equal investment in almost any other productive facility.

Until now what has been the trend in industrial lighting?

Historically, general lighting recommendations have just about doubled every 10 years since 1898. This year the average recommended level is roughly 100 footcandles. If this pattern continues, it is reasonable to expect that the typical or average recommended lighting level would be approximately 2000 in the year 1998. There are many indications that this rate of progress may be accelerated in the future.

You have been discussing recommended levels. What about the average lighting in industry today?

Unfortunately the average level lags behind the recommendations by 10 to 20 years. This means 1938 to 1948 lighting in the average industrial plant with a footcandle level of something like 35 footcandles.

Who determines or establishes the standards or the recommended lighting levels?

Our group here at Nela Park does a lot to encourage better seeing for industry. But the currently recommended standards are prepared by the Illuminating Engineering Society (IES) and presented to the American Standards Association (ASA) for their endorsement. I am chairman for the IES revising these standards, and we hope to get ASA approval of the new standards next year. I expect that the new standards on the average will be about twice the values of the previous (1952) standards.

How will industry react? Will it throw up its hands and say, what are you trying to do to us?

Yes, we will undoubtedly hear some of that. On the other hand, that's the usual reaction from management that doesn't understand how better seeing will benefit its operation. The acceptance will therefore depend on how effectively management is informed of the profitability of investments in better lighting. Leaders will be quick to adopt the new values, and others will follow their example as the benefits appear and are recognized.

What is the main problem in getting industrial plants to use better lighting?

Communication is the basic problem —getting each management to understand the benefits of good lighting. They always voice one big objection, of course—cost. And compared with the amount they have spent in the past for light, modern lighting systems are expensive. But the benefit derived is much higher than from any other equal investment that could be made in plant facilities. So the gain from better lighting will do more to improve performance than an equal investment in machines, tools, automation, or what have you. The rate of return is higher.

Can you cite examples of improved performance and lower costs?

I have had several firsthand experiences with first-class lighting installations. At the Erickson Tool Company, Solon, Ohio (photo, opposite page) the production area is uniformly lighted to nearly 200 maintained footcandles—to almost 300 in difficult seeing areas.

Worker efficiency went up 10 percent; minor accidents were cut 50 percent; and rejects dropped 4 to 6 percent in one area, 10 to 20 percent in another.

Because 200 footcandles was installed at the General Bookbinding Co., Cleveland, its work areas can be arranged for more efficient layout. This results in increased accuracy and a more stimulating environment that is appreciated by employees.

Five hundred footcandles is used to assemble electronic equipment at Douglas Aircraft's El Segundo, California, plant (photo, next page). Continuous rows of four-tube eight-foot fixtures five feet above assembly benches help cut rejects due to wrong connections. Employee morale increased as tension and eyestrain were reduced.

One of the most interesting was at the General Iron & Metal Corporation, Chicago (photo, page 27). When sorting and salvaging metals, workers had difficulty determining the color. This led to customer complaints and poor employee morale. Installing Power Groove lamps that furnished 150 footcandles resulted in easier, faster operation, improved customer relations, and more efficient employees.

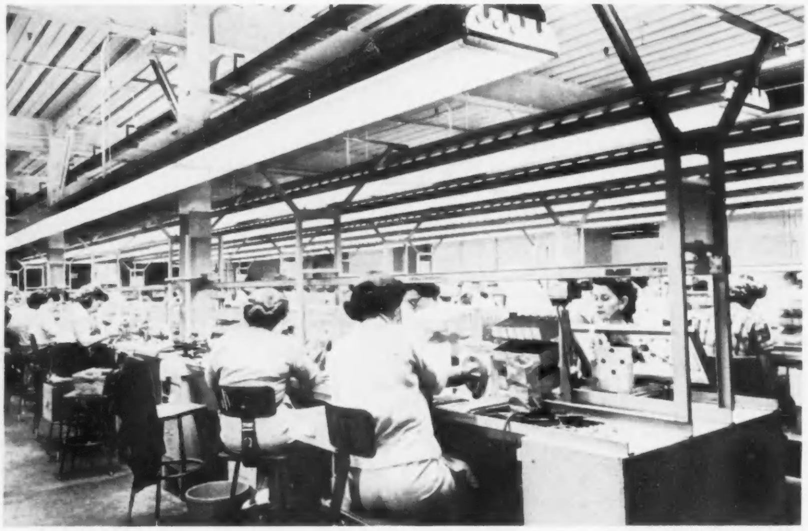
Which light source do most of the new installations use?

Industry is moving rapidly into fluorescent, which now accounts for about 70 percent of the new installations. My guess is that the potential for fluorescent runs close to 90 percent. The remaining percentage splits about equally between mercury and filament.

"Industry as a whole is rapidly accepting light as a production tool . . .

. . . this year the average recommended level is roughly 100 footcandles . . .

. . . lighting levels will increase toward something approaching full sunlight."



LOCATING LIGHTING FIXTURES five feet above work area at a Douglas Aircraft plant greatly cut wiring errors and improved employee morale by reducing tension and eyestrain.

There is no indication of a significant change in this relationship.

Why the swing toward fluorescent?

Fluorescent produces light at lower cost: about three times as efficiently as filament and somewhat more efficiently than mercury. Then too, it is a lower brightness source—a real advantage in lighting comfort both from the direct and reflected glare. It is also well adapted to the modern higher voltage distribution systems. And its long life and excellent lumen maintenance as well as its instant starting characteristics are corollary benefits.

What about lamp life for the three types of sources?

Basically, mercury and fluorescent lamps have long lives, 6,000 to 15,000 hours, depending on lamp type and the conditions of service. Many industrial areas get particularly long life because the number of hours per start is long. Filament lamps on the other hand have a life of about 1000 hours in lamps of standard design. Many industrial users recognize that they buy light rather than lamps and that the major cost of producing light is *power* rather than *light bulbs.* These educated customers don't want longer life lamps; they want lamps that give them light at the lowest cost. This usually indicates lamps of 1000-hour design. Of course, where the cost of changing a lamp is very high (several dollars) or where the cost of power is very low, longer lived lamps are justified.

How does number of starts affect lamp life?

The number of starts does not appreciably affect filament lamp life. But starts do affect mercury and fluorescent lamps: the more frequent starting the shorter the life. Published life ratings are on the basis of 3 hours per start for fluorescent lamps and 5 hours per start for mercury lamps. If starts are less frequent, lamp life is longer—up to two or more times the published values for continuous operation.

Do you feel that fixture design has kept pace with the lamp design?

There are many good fixture designers and we are working closely with them on several of their new designs. We often pass along new ideas to the fixture industry, and generally speaking there are excellent designs in all fixture types for all industrial areas.

Do you see anything in the offing that will improve the performance of fixtures?

Many interesting developments are under way in this area. Some of the metalized coatings on plastic look particularly intriguing. One method uses an evaporated coating on a thin plastic film which is then sandwiched onto a backing material, such as steel or aluminum. By this technique, higher reflectance materials, such as silver and aluminum, can be applied at low cost. Some of these materials are so durable they can be formed by pressing or bending after being bonded together. This may be an excellent opportunity for improved fixture performance and reduced cost. This is particularly important when you consider the relatively large area required to serve as an efficient reflector for a large source like the fluorescent lamp.

What improvements in fluorescent lamps do you anticipate?

We are working toward both increased output and increased efficiency. For example, we have recently developed what we call the *bonus phosphor.* By using only crystals of optimum size, we markedly increased the efficiency. Crystals that are either too small or too large are rejected. As far as higher output, the Power Groove lamp is the outstanding improvement in that direction since the first introduction of the fluorescent lamp. It has twice the output of the highest previous source, obtained by a change in lamp geometry utilizing formed glassware. This construction places the arc closer to the phosphor so that its energy can be utilized more efficiently. It also provides relatively cool areas so that the lamp will operate at optimum mercury pressure.

Is the Power Groove lamp more efficient than its predecessor? Or are you paying more for this output?

The output is almost directly related to wattage. Actually, the Power Groove lamp has twice the wattage as its predecessor and, therefore, twice the output. Efficiency is the same. It could be operated at lower wattage and slightly higher efficiency. But the big need in industrial areas is higher output from fluorescent lamps; so we elected to take the gains in output rather than efficiency. This means fewer units to install for a given lighting level and fewer lamps and fixtures to clean and maintain. This is an important contribution to reduced cost of light.

Are Power Groove lamps operated at conventional frequencies, or are you talking about 400 cycles?

All the installations of Power Groove lamps to date have been at standard frequency, except the experimental installation in the Lighting Institute here at Nela Park where we have tried to look ahead 5 to 10 years. We analyzed promising methods of operation, promising fixture designs, and the new Power Groove lamps and produced an installation which may be typical in 1970. It provides somewhat more than the amount of light in the shade of a tree—

about 1000 footcandles. This system is operated at high frequency and has some real advantage in reducing wattage loss where the lighting equipment is located. Some of the losses are simply transferred to the converter, but the over-all efficiency is somewhat higher. With some of the recent improvements in the cost of conversion equipment, it looks as though there is a real cost advantage even today for high-frequency operation in installations of 50 kw or more.

Do you see a trend towards high-frequency operation of fluorescents?

A clear opportunity for that type of installation is beginning, but I don't think the trend is established yet.

What are other future trends? Where are we going? How high an output is possible with fluorescents? What are some other future innovations?

It looks as though lighting levels will increase toward something approaching full sunlight for some industrial applications. That is about 10,000 footcandles. To achieve those levels requires development of sources not yet available. Today we couldn't provide much more than 2000 or 3000 footcandles comfortably over a large area.

The fluorescent lamp in something like the Power Groove construction looks to be about as far as we can go in fluorescent design. Some other internal construction changes, such as changing the filling gas, might enable us to double or triple the present output. In 10 years or so we might be thinking, at least experimentally, in terms of Power Groove lamps of 50,000 lumens for an 8-foot lamp.

In the mercury field predictions are not easy to make, definite advancements being more difficult to see. But the one phase of mercury operation—lumen maintenance—though traditionally poor has just been improved by almost 50 percent. The depreciation in light output over a period of time was much higher in mercury than in other sources. This new development makes it better than either fluorescent or filament in this characteristic.

In the filament area we can scarcely expect equivalent progress. After all, we have had 75 years of experience in this "hot wire in a bottle" method of producing light. Consequently I would say that improvements will be somewhat slower and less spectacular than in other fields.

POWER GROOVE UP-LIGHTS supplement ceiling fixtures in the General Iron & Metal Corporation, Chicago, and aid workers to distinguish between colors in sorting salvaged metals.

Modifications in circuitry are undoubtedly going to come along for discharge type sources—both mercury and fluorescent. The new experimental transistor oscillator converters are particularly interesting. Although limited in output and performance at the moment, they offer an excellent opportunity for improvement.

No discussion of the future would be complete without a mention of electroluminescence—an intriguing method of producing light by activating a transparent plate condenser with high frequency and high voltage. This undoubtedly will receive continuing attention, and we hope it will become reasonably practical within the next 10 years.

Electroluminescence probably will have less industrial significance than in other fields. Picture a room with all wall and ceiling surfaces covered with electroluminescence. The lighting level would have to be held at about 100 footcandles to keep the brightness within tolerable limits to the room's occupants. But 100 footcandles isn't sufficient for the adequate seeing of anything except the simplest visual task. So we expect electroluminescence without modification to be limited to office, commercial, and residential areas. Higher panel brightness can be tolerated, however, if it can be louvered or treated in some other manner.

Do you see any other light source on the horizon?

All research laboratories are continuously alert for new methods of producing light. But at the moment, to the best of my knowledge, nothing significant appears on the horizon.

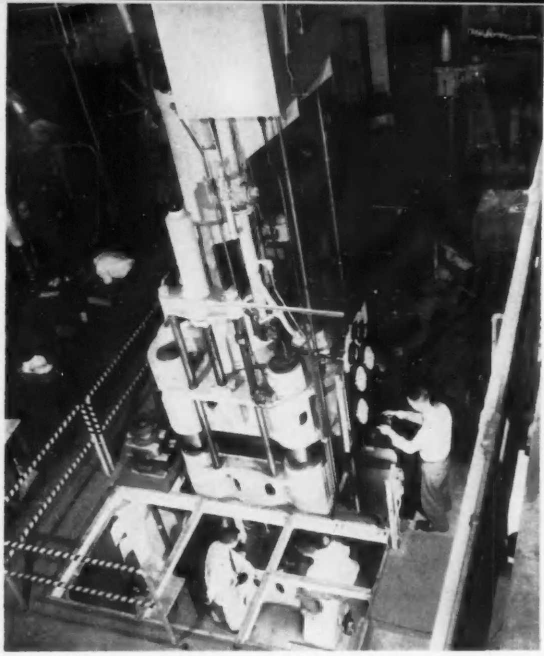
What are some of the challenges to engineers in the lighting field?

I believe the lighting industry generally has more challenge than almost any other part of the electrical industry. That may seem a little strange to you, knowing that it's a 75-year-old industry. Even so, the production of light by electric means is still the most inefficient use of electricity I know of—only 10 or 20 percent of the input wattage radiates as light. This area obviously needs great improvement—a tough assignment for engineers and scientists of the future.

After light is produced it must be controlled—with lamp shades, lamp finishes, or by building the control into the lamp's envelope so that it is not affected by dirt or moisture.

All three lighting sources respond to this control. Applying them to fixtures presents a threefold problem—the architectural, appearance design, and basic engineering performance. Fixtures today are generally efficient and perform reasonably well. But often the user is not particularly happy with the over-all appearance of his living or work space.

We recognize the need for improved appearance, improved performance, and reduced costs of fixtures and installations for all areas where lighting is used so effectively today. Ω



RESEARCH into super-pressure-temperature phenomena led to duplication of tremendous natural forces. The result . . .

. . . man-made diamonds. Equally important, the new knowledge accelerated further study, which produced . . .

Appraising Research and Development in Industry and Defense

By C. W. LaPIERRE

Technological innovation has long been an internationally recognized characteristic of American private enterprise. The Yankee ingenuity, which gave our pioneering forefathers the Colt revolver and the Winchester rifle among other things, was succeeded by more or less organized research and development programs that have given us tremendously efficient electric generating equipment to supply abundant power for our homes and industries; air transport equipment that has set the standards for the world; earth-moving machinery and construction equipment that invariably astonishes our foreign visitors.

In these and other areas, American industry under our private enterprise system has, year after year, turned out a continuous succession of new and improved products and services while growing and creating new jobs and new businesses and entire new industries. Incidentally, there is never an excess capacity for *wanted* new products that have not yet reached the market.

Until recently, there seemed to be few reasons for most Americans to doubt that we were the masters of technological innovation in almost any field that you might name. This too easy assumption was strikingly challenged last fall by the launching of the Soviet satellites. In the words of Hanson Baldwin, "We are not the best in the world in all things; we never have been; and we shall unquestionably be in for more Soviet surprises. But if we do certain things . . . we can probably retain qualitative superiority in key fields."

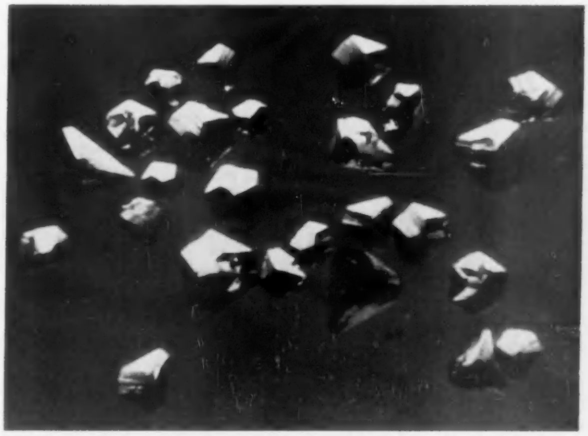
Acknowledging our great debt to European science, our industrial system with its own tremendous research and development resources has demonstrated its capacity to produce not only an enormous quantity but also a wide diversity of new products to fill our needs. Our national income, living standards, and output are yardsticks by which all other national economies are compared. In terms of material good to the greatest number, our economy leads by a wide margin.

Nikita Khrushchev's repeated statements that this won't last much longer confirms this lead. Up to now the Russian leaders have proved no more than that they can build some powerful basic industries and achieve some major technological innovations. They have not yet shown themselves willing and able to pass on the benefits of these on a large scale to their peoples.

Khrushchev's warnings that they "are declaring war upon us—in the peaceful field of trade," should not be taken lightly. We are faced with an opponent as relentless as they are ruthless. But the fact remains that we have much less need for concern about our comparative performance in producing civilian goods than we have in producing defense equipment.

This raises some very big questions. Why is there cause for apprehension and grave concern in our comparative performance in developing and producing new weapons and systems for defense, and why has American industry been so successful in developing and producing new products for the civilian market—frequently in advance of a *known* need or want?

Mr. La Pierre is Vice President and Group Executive—Electronic, Atomic, and Defense Systems Group, General Electric Company.



. . . Borazon—an element not found in nature and in some ways superior to diamonds. And research in this area promises still more.

Every research program uncovers promising areas for additional study. To insure the greatest progress, industrial research follows successful programs with further investigations. Could our nation's defense efforts realize similar benefits if given the same research freedom and incentives?

Two Innovation Systems

There are many answers. But I believe a simple one cuts across much of the confusion and many of the misconceptions that surround these questions. It is simply that the system by which we produce weapons and systems for defense is in many respects *unlike* the system by which we produce products for the civilian market. Some of these differences are of course inherent in the difference between providing for defense and for the market place. But the actual technological part of the process of innovation by which we get both our new products and weapons is, or could be, basically the same—for even the most complex systems and super systems. This nation cannot afford the mistake of trying to out-strip Russia's military power by "becoming a little more like Russia." After all, no one can beat the Soviets at that game—of detailed centralized controls, of objectives that are obscure or hidden in secrecy, of lack of adequate incentives for voluntary actions and superior performance and the substitution of compulsion instead. For the long run we must maintain our belief in the ability of free men in a free economy to outplan, outinvent, and outproduce a slave economy.

In this regard, it is interesting to note that "flattering" us by imitation, the Soviets are reported to be increasing incentives for certain groups of scientists and managers, and moving toward some decentralization of their industry.

The problem of how best to utilize the resources of industry for the maximum security at the minimum cost cannot simply be laid, as it is by many writers, on the doorstep of the military services or the Defense Department and left there. Lack of understanding of what is involved in innovation can lead to too high expectations and too great recriminations by the public, to curbs and restrictions and the elaborate prevention-of-mistakes machinery that we call red tape, and to the tendency to seek political solutions to what are basically technological problems.

Able and dedicated men on both sides of the military-industry team are working night and day to provide an efficient and effective defense for the nation. But our public insistence that there be no mistakes, where national security is involved, has frequently saddled them and defense industry with over-elaborate prevention-of-mistakes machinery. And all too frequently this has contributed to the greatest error of all—freezing in the inevitable mistakes of innovation long past the date when they can be corrected economically, thereby greatly delaying or preventing progress and enormously amplifying cost.

And when a program bogs down, the public outcry is for another Russian invention, a "czar" to cut through the red tape and accomplish what the armed forces and industry have been trying to do all along.

This is not to say that there should be no controls, nor secrecy—but, like incentives, they should be adequate and not exceed what is necessary to attain the objectives.

Against this background, let's review briefly the processes by which we obtain our civilian goods and defense products. At what specific points do they differ? Perhaps a comparison may suggest steps that could be taken—in addition to those efforts already initiated—with greater public understanding of the processes involved.

Industrial Research . . .

Technological innovation today presupposes research. Major innovation almost always involves basic or fundamental research to discover new knowledge. To insure the greatest progress, research should be quite broad, and scientists should have a good deal of freedom in probing nature, to explore a wide variety of possibilities.

It is also important that there be some continuity in the research activities. Unless new ideas continue to be fed in, today's projects will pass through the pipeline in five or ten years, with nothing following behind. The pipe will have an air bubble.

Today's largest and most successful industrial research laboratories meet these conditions. The director of the laboratory and his department heads have considerable authority and responsibility concerning the projects. And the individual scientists correspondingly have considerable freedom to explore new lines. If the company's products have a wide diversity or are technically complex, the research activities can also be quite broad and still compatible with profit, or hope for profit.

. . . Military Research

In military research and development, budgets are turned on and off and programs cancelled with the shifting needs of defense. Moreover, the armed forces' concern with maximum readiness and Congress's concern for immediate results from the expenditure of taxpayer dollars tend to place primary emphasis on short-term rather than long-range weapons development. And many research and development contracts leave the highly speculative hope of a production contract as industry's chief economic incentive, when the greatest need may be for more basic research and exploratory development.

Each new scientific discovery reveals new ranges of technical possibilities, but the process is not automatic. Nor does the new product always follow immediately upon the scientific idea. In fact, many years may elapse. That we began to bridge this gap prompted Alfred North Whitehead to call the greatest discovery of the nineteenth century "the invention of the method of invention."

Lead-Time Factor

To shorten this lead-time between idea and product is one reason for the existence of the modern industrial research laboratory. In business, we must first perceive an unsatisfied or perhaps even unfelt want. Then by using the new knowledge to produce a useful, serviceable product of adequate value, we can satisfy that need. When adequate liaison and communication exist, the research and development activities keep the company apprised of what is technically feasible, and its marketing activities keep it alert to what is needed. As Peter Drucker has accurately observed, "There may have been no want at all until business action created it—by advertising, by salesmanship, or by inventing something new. In every case, it is business action that creates the customer."

In the market place the incentives and rewards for successful innovation assure that few possibilities are overlooked, and very little time is wasted in filling a want that demonstrates technical feasibility.

In developing the new product, or planning the innovation, you will soon encounter various possible routes to the goal. Many of these will dead-end, for even optimum efficiency in innovation work is not very high. You'll find no substitute here for men with a demonstrated capacity for making the right decisions and for detecting and correcting the inevitable mistakes before they are frozen into the design.

Loss of Flexibility

By contrast, in military-goods production the producer is beset by a considerable number of people with the laudatory, if impractical, objective of preventing all mistakes. These people have tremendous veto powers, but the people with the go-ahead authority are rarely in evidence, sometimes disappearing for long periods. This procedure prevents turn-on-a-dime flexibility, and many initial mistakes must be changed *later* at much greater expense. Some valuable formulas help to reduce the number and cost of mistakes in innovation work, but none of them compensates for uncontrolled delays in correction of the mistakes that do occur.

In civilian-goods innovation, after gleaning the invariably numerous possible programs or products for the one or few that seem most practical by all requirements, the plans are carried out or executed on a limited scale, and the results tested. At this stage, it is important to find every possible mistake and correct it immediately. Changes in our rapidly developing technology must be factored in without delay. Every bit of work must be constantly checked and redone until all reasonable tests of product, market, and service give a favorable result. If followed through, this procedure can eventually save a great deal of time and money. Ordinarily, the cost of bringing a new idea to a practical demonstration, or the prototype stage, is a small fraction of what is required subsequently to turn it into a useful product.

In engineering the product, as a complete system or combination of systems down to the smallest component, the company or department undertaking the project holds the technical authority and responsibility. The engineers have considerable voice in determining how the desired performance and other product specifications should be attained.

Although the military services place responsibility on their contractors for weapons design and development, they frequently specify work methods and procedures, retaining authority to approve design drawings, engineering changes, and proposed deviations from the specifications.

This results again from the very laudable desire to prevent any mistakes for which we, the public, would hold them accountable. To prevent these and to avoid duplication of effort and the waste of time and money in pursuing blind leads, the program is planned in great detail, stage by stage, including all the innovations that will be required down to the final weapons system. Consequently, a great deal of time is spent in planning the R&D and in the necessary reviews, possibly incurring critical loss of lead-time.

Decentralized Planning and Control

Planning of innovation should be done if it is to be successful, but on a decentralized basis; the authority and the responsibility should be placed as closely as possible to wherever the necessary technical decisions must be made. Defense industry should permit greater latitude in deciding how the required performance can best be achieved and provide greater incentives for carrying projects to the practical demonstration, or prototype, stage.

Concurrent with the innovation process just described in abbreviated form, a psychological cycle also accompanies almost all innovation work.

In the first and second phases of the innovation process—research and planning—interest among those involved is usually very high, and everyone is excitedly optimistic. About halfway through the third stage of limited execution of the plan, discouragement appears, as one after another of the inevitable technical troubles develop. The public has received some insight into this phase of innovation work through the first attempts at launching a U.S. satellite. Even the most successful developments involve such periods.

Product Control

Civilian business operates under generally applicable laws, with violations punishable by economic and other penalties. In military procurement an elaborate system of detailed scrutiny and approval requirements attempts to prevent all mistakes and violations of rules and laws. The price here cannot be measured simply in direct Government costs in the form of extra payrolls or increased industrial costs from less

CONTINUED ON PAGE 45

G-E Review Readers Urge Social Studies for Engineering Students

By DAVID L. HOLZMAN

A popular conception of long standing is that engineering colleges do not provide enough liberal arts instruction—and that engineers prefer it that way. Accompanying this concept is the frequently expressed opinion that scientists and engineers are "antihumanistic." Sensitivity to these allegations as well as concern for the future of their profession has motivated a number of engineers and scientists to evaluate the educational requirements of their profession.

Notable among these evaluations is a recent report of the American Society for Engineering Education (ASEE). As its purpose the Society sets forth an academic pattern that would enable an engineer to cope with the rapid developments in science and engineering, to become aware of his social responsibilities, and to develop to his full potential as an individual. It specifically recommends that one fifth of the undergraduate engineering curriculum be devoted to humanistic and social studies.

With this recommendation in mind, we questioned a sample of GENERAL ELECTRIC REVIEW readers—for a description of the sample and research design, see Box, page 32—as to what percentage of an engineering curriculum they would advise devoting to the humanities and social sciences. Fifty-six percent recommended that *one fourth* or more of the curriculum be devoted to the humanities and social sciences. Only 28 percent recommended less than that suggested by the ASEE, and the remaining 16 percent coincided with ASEE's recommended one fifth.

It seemed reasonable to assume that opinions as to what constituted an optimum engineering curriculum would be influenced by the number of years that the respondent had been out of school. And the Dean of a leading engineering school backs up this assumption: he could predict his ex-students' complaints about their educational training by knowing the year they received their degrees. The Dean's formula: graduates of 15 years or more would feel the need for a greater background in the liberal arts, whereas those of 10 years or less would feel they lacked the necessary training in the basic sciences and mathematics.

Our findings were consistent with the Dean's formula. Those who had received their degrees in 1941 or before tended to recommend that a larger proportion of the curriculum be devoted to the humanities and social sciences, while those who had graduated later than 1941 favored more attention to the basic sciences and mathematics.

The ASEE also made specific recommendations regarding the basic sciences and mathematics: that one fourth of the curriculum be devoted to them, and the sample of G-E REVIEW readers generally agreed. Thirty-eight percent recommended exactly one fourth, 44 percent recommended more than one fourth, and 18 percent recommended less than one fourth.

Most Valuable Subjects

After evaluating broad fields of study, the respondents were asked to evaluate specific subject areas in terms of their contributions to job advancement. They selected from a list of 20 subjects those that contributed most to advancing him in his job. Analyses of the subject areas selected showed no difference in the top three choices between the more recent graduates and those who received their degrees prior to 1942. Both groups selected as their top three: mathematics, electrical theory, and English, in that order. Furthermore, the two groups differed only slightly in the order of their first 10 selections. Appearing in the top 10 for both groups, in addition to the three previously mentioned, were analysis and design of circuits and electric motors, the mechanics of solids, modern physics, thermodynamics, economics, psychology, and sociology.

Because it is reasonable to assume that a subject area's value is related to his type of work, the engineers interviewed were separated according to their special fields of interest. Forty-six percent of the sample were electrical engineers, and they comprised the largest single group of engineers in the sample. All other engineers in combination made up the remaining 54 percent of the sample.

Here again, both groups closely agreed on the value of mathematics, electrical theory, and English. The combination group of engineers selected mathematics, electrical theory, and English in that order as the top three contributors to their advancement. The electrical engineers selected electrical theory first, mathematics second, analysis and design of circuits third, and English fourth. There was less agreement on the other top selections. Notably, the electrical engineers ranked analysis and design of electric motors fifth, while the other engineers tied modern physics and thermodynamics at the fifth position.

Importance of English

The consistently high rank achieved by English is significant in light of the expressed interest of industry that engineers be able to speak and write in clear, concise, and fluent language. When representatives of industry were asked to comment on the ASEE's recommended pattern for engineering curriculums, they emphasized the need for instructing engineers in the skills of writing and public speaking. The majority of engineers interviewed in our sample were employed by industry, and 9 out of 10 held supervisory positions. How much of their success in attaining supervisory positions reflects their effectiveness in communicating ideas is only indicated. However, the findings coincide with evidence obtained in a survey

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of General Electric college-graduate employees. (For a description of the sample and research design, see Box.) When the engineers were asked to select college subjects that had contributed the most to their present position of responsibility, they rated English second only to mathematics.

Antihumanistic?

Common in the public's stereotype of an engineer or scientist is the image of a man more at home in his laboratory than with people. To indicate whether our sample of engineers appeared to be antisocial, they were questioned as to their extracurricular college activities. The findings showed that 61 percent had belonged to a professional society or fraternity, 39 percent to a social fraternity, 38 percent participated in sports, 22 percent held school offices, and 17 percent worked on either the school yearbook, newspaper, or humor magazine. There is no readily accessible way of comparing G-E REVIEW engineers' participation in school affairs with liberal arts graduates. But a comparison was made between engineers and liberal arts graduates in the previously mentioned survey of General Electric college-graduate employees: engineers participated in more extracurricular activities than did the liberal arts graduates, 93 and 88 percent respectively. From this evidence, certainly a good proportion of engineers cannot be characterized as the antisocial bookworm.

Interviewers also inquired into the engineers' current interest in liberal arts and nontechnical subjects. Seventy-nine percent said that they had maintained an interest in a nontechnical or liberal arts subject since leaving college. The most frequently mentioned liberal arts subjects were fine arts (48 percent), history and western culture (36 percent), literature (35 percent), economics (33 percent), psychology and sociology (25 percent). Interest in other subjects, not related to their professional work, was in photography, public affairs and political science, sound recording, and language.

Training Programs

Company training courses were evaluated very low in educational worth as compared with college technical courses and actual job experience. The respondents were asked to estimate the relative contribution of each to their present job activities, using 100 as the total value. Eighty-six percent of the sample estimated that they learned *less* than one quarter of their present job activities in company training programs. This compares with 48 percent who estimated that they learned from one quarter to one half of their present job activities in college technical courses, 21 percent who estimated the value of college technical courses from one half to three quarters, and 4 percent who estimated their value at more than three quarters.

They rated actual work experience somewhat higher than college courses, with 42 percent estimating they learned from one quarter to one half from this source; 17 percent, from one half to three quarters; and 15 percent, more than three quarters.

Post-1942 graduates favored college technical courses more than those who had graduated prior to 1942. But the two groups differed little in their estimated low value of training courses and high value of work experience. The estimated value of company training programs was surprisingly low; but caution should be exercised in evaluating these data. It should be remembered that generalizations from this survey are limited to the population of G-E REVIEW readers and that no generalizations can be made to the total population of engineers. In addition, further investigation is required before the programs could be properly evaluated. Nevertheless, since most of the sample was employed by industry and presumably a large proportion of the more recent graduates did attend some form of training program, the findings indicate serious shortcomings.

From the foregoing information, it is possible, with some reservations, to draw a composite of the G-E REVIEW reader. He believes in devoting a good proportion of engineering curriculums to the humanities and social sciences; and the longer he is out of school, the more he realizes the value of these subjects. His career advancement has been greatly aided by his knowledge and use of English. He spends part of his leisure time keeping up with cultural, social, political, and economic subjects. Moreover, any thought that he is antisocial is contradicted by his past performance in extracurricular activities.

Our average G-E REVIEW reader may not qualify as the "complete man," but he does possess the essentials for the well-educated man. Besides a background in his major area of study, he has knowledge of the humanities and the physical and social sciences. The same may not be said of many of the nonscience majors of liberal arts colleges. Their avoidance of physical science subjects has left them with a more limited education than that of the average G-E REVIEW reader, if not that of engineers in general. Ω

SAMPLING PROCEDURE AND RESEARCH DESIGN

The findings were obtained from a randomly selected quota sample of 110 G-E REVIEW readers, and the survey was conducted by McGraw-Hill Research during June 1958. Distribution of the G-E REVIEW by section of the country and by industry determined the quotas assigned to interviewers. No General Electric employees were interviewed. The sample is not representative of all engineers, and the results can only be generalized to readers of the G-E REVIEW. The sample of G-E REVIEW readers consists of electrical engineers (46 percent), mechanical engineers (20 percent), engineering professors (10 percent), chemical engineers (4 percent), and all other types of engineers (20 percent). More than a third of the sample are registered professional engineers. The educational background of the sample ranged from 21 percent who held advance degrees to 22 percent who had not received an undergraduate degree.

All members of the sample were asked identical questions by professional interviewers. The respondents were asked a series of questions on the May 1958 issue of the G-E REVIEW followed by several general questions related to engineering education.

The General Electric survey of college-graduate employees was conducted by the Company's Educational Relations and Corporate Support Service. The survey technique was a mail questionnaire sent to all General Electric employees holding degrees from accredited colleges and universities as of October 1, 1955. A total of 13,586 questionnaires was completed, giving a return of approximately 57 percent. Of the 13,586 respondents, 47 percent were classified as nonengineering graduates and 53 percent as engineering graduates. The questions relating to evaluation of subjects and extracurricular activities differed in wording from those employed in the McGraw-Hill survey but were similar in purpose and content.

Bearing and height-finder radar symbolizes vigilance. Yet many defense products have far-reaching benefits beyond the military. Voltage-tunable magnetrons, no larger than a thimble, promise benefits ranging from aircraft collision warning devices to radio-frequency medical therapy.

Voltage-Tunable Magnetron, Heart of Radar, Heralds New Benefits for Mankind

By R. I. REED

Mention "electron tube" to the typical layman, and he immediately conjures up a mental image of the mysterious devices in the back of his home TV receiver. Little known to him, naturally, are the many special-purpose tubes that engineers utilize in myriad electronic equipments for industry and defense.

Still lesser known among these special-purpose electron devices is a small but highly versatile tube called the voltage-tunable magnetron (VTM). Developed before 1950 (see July 1958 REVIEW, page 34), it belongs to the famous magnetron family of tubes. By merely varying its input voltage, you can vary the frequency output of a VTM—a most important feature in military detection and countermeasures (photo), and in many nondefense applications as well.

Prior to World War II, the magnetron itself was looked upon as merely a laboratory curiosity. But then on the eve of the war, important inventions made it ideally suited for a new radio echo-detection device—subsequently to be known as radar.

Now, several years later, the voltage-tunable magnetron is carrying on in the tradition of its famous wartime cousin.

Radar Countermeasures

Early radar systems utilized a simple principle. In fact, this principle has been used by mariners for many years: blowing the ship's whistle or ringing a bell and listening for the echo. With sound traveling through air about 1100 feet per second at sea level, the mariner could reckon distance between his ship and a nearby mass, by noting the time for the echo to return.

Of course, radar differs basically from the mariner's distance reckoning system: it uses radio waves which travel at a speed of 186,000 miles per second. Extremely sensitive electronic devices detect the echo while accurately measuring the time elapsed.

In wartime, the use of radar is like a game of chess wherein the opponent always tries to block your moves and vice versa. And so, countermeasure systems were developed that caused the radar echo from a target to be lost. This process was relatively simple: you broadcast a great deal of radio noise to obliterate the returning echo. All you had to do was listen for the incoming radar signal and then send out a radio signal of your own on that same frequency, thus blanketing, or "jamming," your opponent's entire radar system for measuring the echo's return time.

When you are on the "sending" end, you try to outwit your opponent—again, as in the game of chess—by making it difficult for the enemy to jam, or block, your own radar echo signal.

A system for doing this is to send out a signal and listen for its return on the same frequency. But then, when you send the next signal, you shift to an entirely different frequency and listen for its return. Thus, by switching back and forth over a wide band of frequen-

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COMPLEX IN STRUCTURE, voltage-tunable magnetrons are supplied as package equipment, complete with permanent magnet and electron circuitry. Three VTM packages comprise (left to right) a low-power low-noise unit with a milliwatt output in the 2350 to 3100 mc range; a high-power narrow-band unit with a 10-watt output between 2900 and 3100 mc; and a general-purpose unit with minimum output of 2 watts in the 2200 to 3850 mc range. Pencil locates the VTM.

cies, you obtain some radar information on the target despite the enemy's attempt to jam you—unless, of course, his radar system shifts in the same random frequency.

Such shifting in frequency is easily accomplished with a voltage-tunable magnetron. You merely shift the tube's voltage in some random fashion.

Although the VTM works in radar, it can also perform as nicely in radar countermeasures. In this instance, it could be made to automatically scan the appropriate frequency bands on which radar signals are being transmitted.

You can develop many types of operation for such automatic equipment. On a cathode-ray picture tube, it could present a spectrum of all the radar frequencies received. Or it could pick out and stay tuned to a particular signal. Receivers of this type could automatically set radar-jamming equipment to a proper frequency.

Doppler Radar

Recent air disasters—the midair collision of two commercial airliners over the Grand Canyon in 1956, the crash of a DC-7 and military jet plane over Los Angeles in 1957, and the crash of an airliner and military jet in 1958, along with minor collisions and near misses—have greatly emphasized pilots' need for collision-warning equipment.

For such use, Doppler radar can serve simply and well. Though similar to regular radar, it differs in this manner: distance is measured by the difference in frequency between outgoing signal and return rather than by time lapse between outgoing signal and return.

The principle underlying this type of radar was first enunciated by Austrian physicist and mathematician Christian Doppler (1803–1853): the pitch of a sound heard differs from the frequency of the vibrating source from which it originates whenever the observer or the source moves. This principle applies to *all* wave motion.

Radio waves travel at the speed of light, an extremely high velocity much greater than that of any present flight vehicles. Thus the slight difference in frequency of the returned radar signal, or echo, would normally be difficult to measure. However, by means of the simple expedient of constantly changing frequency of the outgoing signal, you can readily measure frequency shift in the returning radar echo.

As an example, assume that the target you want to detect is at some distance requiring time T for the signal to leave the transmitter, arrive at the target, and be returned. During this time interval, frequency of the transmitted signal is changing so that when the target echo returns, it will be at some higher frequency than the signal sent out. This difference in frequency you can detect and measure to obtain the target's distance.

Next, let's consider an example where the radar transmitter is not stationary but moving, and it and the target maintain the same relative positions. Difference in time T will again be constant; likewise, the difference in frequency of the outgoing signal and its echo will remain constant. You can see that even though the radio frequency is changing, the frequency-difference signal will remain the same—provided distance between the transmitter and target does not change.

The voltage-tunable magnetron is ideally suited to this application. In addition to its linear tuning characteristic, you can easily and rapidly tune the tube. Quite obviously, then, the VTM will play an important part in any Doppler radar system.

TV Flicker a Clue

Thus far we've confined the discussion of Doppler radar to only one measurement—that of distance between transmitter and target. By a simple addition to the radar's detection circuit, you can easily measure the velocity of the target, too.

Ensconced in a living room chair, watching your favorite TV show, no doubt you've noticed a peculiar flicker of the television picture when an airplane flies overhead. This flicker results because radio waves from the TV station's transmitter bounce off the airplane and down to your television antenna. There, they combine with radio waves that have traveled directly—that is, in a straight line—from the station transmitter to your antenna. (For an explanation of how this can occur, see July 1954 REVIEW, page 12.)

Because the aircraft from which these radio waves are reflected is moving, the length of their path changes, causing a corresponding change in the number of wavelengths. Sometimes the reflected waves are in phase with the direct waves and add to one another, making a stronger signal. At other times they are out of phase and subtract from one another, to make a weaker signal. This change in signal strength causes your TV receiver picture to flicker.

This same phenomenon, applied to a Doppler radar system installed in an airplane, would give the pilot a convenient measure of relative velocity of approaching aircraft. Should another aircraft come within a preset range from any direction, the pilot could be warned by a flashing light, ringing bells, or any other type of warning device. And he could instantly maneuver away from an impending crash.

Aircraft Navigation

But Doppler radar isn't limited to collision warning devices alone. It can also be used to inform the pilot of his altitude above ground—not just above sea level, as his aneroid barometer-type altimeter does. (This would be especially helpful when flying over mountainous terrain and making instrument landings in bad weather.)

In determining the plane's drift angle, Doppler radar can also assist the pilot. Drift angle is the difference between the direction an aircraft is heading and the path it should be traveling over the earth's surface (see March 1957 REVIEW, page 44). In other words, to fly a direct route between two points on the earth's surface when a wind is blowing across the path of travel, the pilot must head his plane into the wind sufficiently to compensate for its effects; otherwise he would be blown off course.

How much he would head his plane into the wind depends on the wind's velocity, which the pilot presently gets from weather reports. During a prolonged flight, however, wind velocity constantly changes as the plane moves over the earth's surface. And unless the pilot has a means to constantly check these changes, his flight path would be erratic, taking the plane longer to travel from one point to another.

A Doppler radar system aboard, continuously informing the pilot of the plane's drift angle, will go a long way toward improving navigation.

Things Yet to Come

VTM's are already finding their way into equipments for aircraft navigation, altimeters, warning devices, missile guidance, radar, and radar countermeasure equipments. Engineers even use them to test the frequency response of such electronic equipment as antennas and amplifiers. However, you can be sure the future uses of these tubes will extend far beyond the military.

Medical scientists know of physiological radio-frequency effects that apparently benefit man. Their information about these effects is spotty, however, because of technical limitations of the radio-frequency power sources presently available. But by use of a changing frequency power source, such as the voltage-tunable magnetron, medical scientists may find that radio waves have new and wonderful therapeutic value. Without question, study of the effect of various radio frequencies upon animal and plant tissue would greatly add to the fund of mankind's knowledge.

In the field of chemistry, scientists can use the VTM to detect otherwise undetectable chemical reactions by noting changes in dielectric constant. Similarly, dielectric constants of chemical elements or compounds can be measured. By classifying susceptances of materials to radio frequencies, chemists would be able to ascertain when to stop a chemical reaction at some critical point.

Another application is in the treatment of organic materials by fermentation. Here the fermentation process itself could be controlled by exposure to certain bands of radio-frequency power.

Agriculture, too, could benefit from the VTM. It's possible to build airplane altimeters capable of measuring altitude within an accuracy of a few feet. Accordingly, it should also be possible to make equipments that would detect the amount of snow covering a particular region so that aerial surveys could determine the watershed potentials for the annual snow run-off used in irrigating arid regions.

Even foolproof and tamperproof burglar alarms could be built utilizing the principles underlying the voltage-tunable magnetron. These devices would protect warehouses, department stores, and similar large areas. With their principal function to detect motion, these devices would utilize a Doppler radar type of system.

Servant of Mankind

These are only an indication of the services you'll see performed as voltage-tunable magnetron "packages" become available commercially. Because of technical difficulties in circuit design and construction, the VTM is supplied as part of a complete package containing the necessary circuitry and permanent magnet (photos).

At present, the VTM packages you can obtain on the market are capable of operation from 2200 to 3850 megacycles, with a minimum power output of two watts. But already under development is a new line of VTM's capable of operating from 350 to 4600 megacycles. And research indicates the feasibility of producing a family of tubes operating from 50 to 6000 megacycles. With still further research, it may even be possible to extend their range to 10,000 megacycles.

Because of its light weight and small size, the voltage-tunable magetron is ideally suited for use in airborne applications. And like many another development from the field of defense products, its beneficial effects will be far-reaching.

Not only a tool in itself, the VTM will also assist the world's scientists and engineers to develop other new and even better tools for the service of mankind. Ω

CREDITS

10	Pix Incorporated New York City
13, 15	Arthur D. Little, Inc. Cambridge, Mass.
36 (right)	Bell Telephone Laboratories
37 (left)	The Martin Co., Baltimore

CORRECTION

The photo caption on page 10 of our September issue should have stated . . .

"The power applied to this jet reaches 15,000 kw—enough power to serve more than 13,000 average homes."

General Electric High technical and mathematical content of Advanced Engineering Program challenges participants.

Bell Three-year communication development program at Bell Telephone Laboratories stresses basic sciences plus communications and electronic technology.

NEW DIMENSIONS OF AMERICA'S ECONOMY—4

Industry's Increasingly Bigger Stake in Developing

***Review* STAFF REPORT**

Not long ago, an experienced Russian engineer who had recently become an American citizen addressed a luncheon meeting of engineers and scientists. His topic: education in the Soviet Union.

With lines horizontally chalked on a blackboard, he indicated a Russian child's lead in learning over his American counterpart—the gap ever-widening as the two youths progressed through their respective elementary and secondary schools and on to graduation from technical institutions. From the diagram it appeared that the Russian graduate about to enter industry was advanced in *specialized* knowledge.

"If this is so," inquired an agitated voice from the rear, "then how do you account for the achievements of American engineers and scientists? And of American industry in general?"

The speaker smiled. "The answer to that is quite simple," he replied. "Upon entering industry, the Russian engineer is considerably advanced over the American, true; but after a few years in industry, the more broadly educated American reaches the same level of specialized knowledge." Gesturing symbolically, he continued, "After that, the American engineer begins to lead, and from then on continues to move ahead. "Opportunities for individual development and education in American industry are without parallel in the Soviet Union—or any other country, for that matter."

The speaker had accurately assessed industry's position. Though perhaps little known to the American public, progressive corporations have long since become institutions of learning. Estimates on the large amounts of money they spend yearly are difficult to obtain. But as a yardstick, General Electric figured that in 1956 it was spending $35 to $40 million a year on personnel development. When you multiply this estimate by the number of other large companies in America, the investment looms monumental. And it will continue to grow.

Something Better

Why has industry assumed this role?

J. Douglas Brown, dean of the faculty at Princeton University, has stated that America's rapid rise in productivity from 1915 onward is largely the result of high talent—educated manpower—in science, engineering, and managerial capacity. So, for one thing, industry realizes that to function effectively today—to operate profitably—its personnel must be developed to their fullest potentialities, in all ranks. This they consider their most precious asset, whether the employee is an engineer, an applied physicist, a manager, an advertising copywriter, a secretary, or a lathe operator.

Consider another factor, the ever-changing character of the American economy. In our unique economic system, increasingly referred to as "people's capitalism," we believe in high wages, high productivity, and high purchasing power. All together, they spell dynamic *growth*. We believe in scrapping the obsolete, whether it's a tool or a technique, whenever we can substitute something better for it.

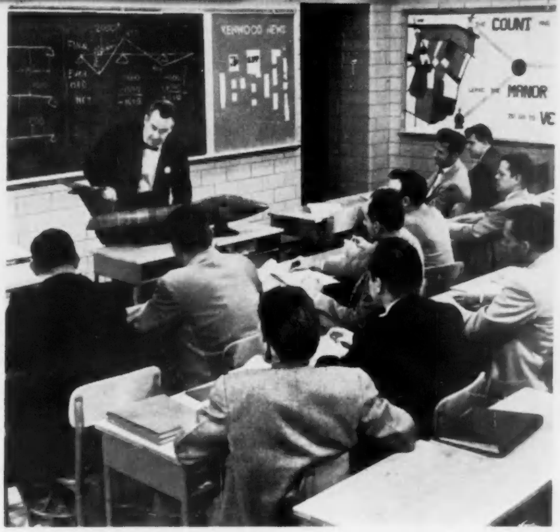
Industry's capable employees also apply this principle to themselves. They who are ambitious realize their on-the-job development (Box, page 34) can keep them on top of this perpetual progress.

Personnel development in industry falls into three broad categories . . .

- General development
- Technical, scientific, and other professional development
- Manager development

General development may range from secretarial courses for women to complete programs in drafting, machining, patternmaking, and metal founding for young men entering industry.

Young people, particularly those with two-year technical-school backgrounds, also have the opportunity to advance toward careers as laboratory or engineering technicians.



Martin At a local school in Baltimore, The Martin Company's employees, led by a design specialist, study statically indeterminate structures.

INDUSTRY-ORIENTED COURSES hone managerial skills . . .

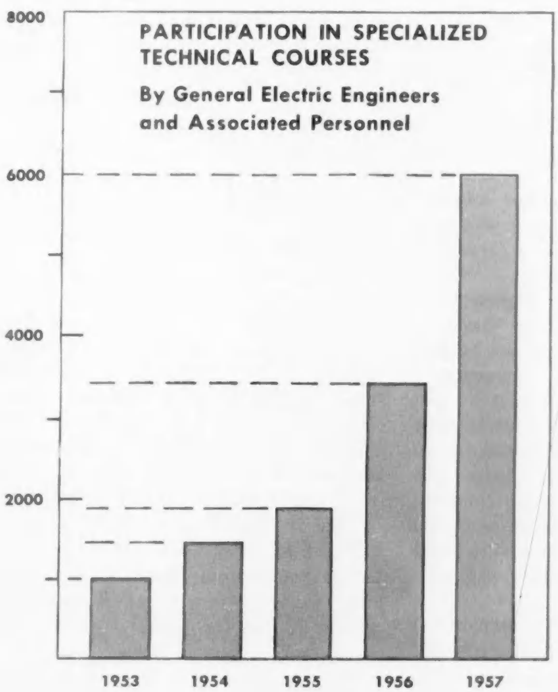
. . . teach secretaries greater efficiency . . .

. . . increase technicians' knowledge . . .

. . . and give ambitious employees the opportunity to learn the latest techniques in welding.

Its Personnel

Each year more employees take advantage of industry's role as an educator. With courses from management and engineering to secretarial efficiency and manufacturing skills, industry encourages all employees to achieve their full capabilities, with increased personal satisfaction.



ONE DEPARTMENT'S PERSONNEL DEVELOPMENT COURSES

Over-all, in 1957, one out of every eight General Electric employees participated in self-development programs. The programs themselves are administered on a decentralized basis. That is, each department has the responsibility for the continued development of its own personnel.

Here for example is a listing of courses offered by just one of the Company's 112 operating departments, the Medium Alternating Current Motor and Generator Department (MAC) in Schenectady.

GENERAL DEVELOPMENT
- Crane school
- Operation of industrial vehicles
- Round table conferences
- Safety
- First aid
- Better business women
- Shorthand refresher
- Job instruction training
- Job methods improvement
- Securities and investing

TECHNICAL AND SPECIALIST DEVELOPMENT
- Electronic computations
- Principles of stored program computers
- Numerical methods and mathematical analysis
- Statistical analysis
- Creative approach seminar
- Principles of servomechanisms
- Automatic control systems
- Engineering analysis
- Vibrations
- Heat transfer
- Fluid dynamics
- Electronic circuits
- Principles and applications of transistors
- Electromagnetic fields
- Magnetic materials and applications
- High polymer materials
- Plastic engineering
- Insulation seminar
- Engineering design
- Computer
- Applied creativity
- Measuring instruments
- Principles of mechanical engineering

TECHNICAL AND SPECIALIST DEVELOPMENT (CONT'D)
- Principles of electrical engineering
- Product design
- Materials and processes
- Electrical properties of motors
- Slide rule
- Value analysis
- Motion-time study
- Methods analysis and improvement
- Time standards
- Standard time tables
- Methods engineering
- Principles of mathematics

MANAGER DEVELOPMENT
- Effective presentation
- Fundamentals of supervision
- Better business operations and relations
- Professional business management
- Appraisal techniques and salary plan
- Effective human relations
- Rapid reading
- Motor sales
- Motor marketing
- Applied citizenship
- Fundamentals of purchasing
- Financial analysis
- Oral communications
- Conference leadership
- Union relations
- Principles of manufacturing engineering
- Job payment and wage-rate application
- Supervisor movie program
- Reprint club
- Business creativity

The college graduate reigns in the area of what Princeton's Dean Brown calls "seed-corn talent." These are the people who constantly replenish and expand industry's ranks, from which comes the professional and managerial leadership of tomorrow.

Development of these professionals falls into many fields, each with still smaller subdivisions. Some of the more common categories include research, engineering, sales, marketing, finance, public and employee relations, accounting, and advertising.

Technical Personnel . . .

Many of the nation's larger companies have intensive development programs for professional, technical employees.

As an example, Bell Telephone Laboratories—a subsidiary of American Telephone and Telegraph—offers the recent college graduate a three-year program of graduate study and industrial education in communications engineering.

In Baltimore, The Martin Company has an extensive program of engineering and scientific development for its employees. Martin's objective: to assure that their engineering capacity is maintained at a level ready to meet any demands placed upon it.

At General Electric, further development of engineers who have recently completed their college education is supplied by the Creative and Advanced Engineering programs. These programs, the first year of which is called the Advanced Technical Course, require keen understanding of physics and mathematics, plus the ability to apply it.

Specialized technical courses are also provided in individual departments to supply more detailed knowledge and comprehension of engineering subjects. In 1957 alone, 5998 experienced engineering and scientific employees were enrolled in them (illustration, page 37).

. . . and Manager Development

In the third category of industry's personnel development you find the professional managers. These are the men who combine ideas, technology, capital, and manpower into a productive and profitable relationship.

Management attitudes and skills are subject to rapid obsolescence in this age of change. Ralph J. Cordiner, General Electric's Chief Executive Officer and Chairman of the Board, writing in the January 18th issue of the *Saturday Review*, said that the manager who doesn't keep up with the times—or rather, keep up with the future—will soon find himself as obsolete as yesterday's newspaper.

In modern business, then, the day of the successful manager who runs his operation by the seat of his pants is definitely a thing of the past.

Who Benefits?

There's no mystery surrounding the reasons why industry is increasingly interested in its employees' self development.

Since Thomas Edison experimented with the incandescent lamp almost three-quarters of a century ago, the United States has progressed from an agrarian economy to the most advanced industrial nation in the world. Similarly, the corporation has grown in stature to become one of the great institutional forces in our competitive society.

Progressive companies realize this. And they realize also that accomplishments are built on the work of people—largely on their education, training, skill, experience, and intelligence. This sort of "raw material" will always be in great demand. Anything that increases the supply, therefore, definitely is to the long-range benefit of both industry and the individuals concerned.

There's another way of looking at it, too. While a person stops growing in physical stature, the human mind is such that there's no reason why it shouldn't continue to grow. This growth is all to the individual's advantage: in prestige, contentment, and, invariably, in wages or salary. On the other hand, if a person stops developing "from the neck up," there's a twofold loss. He himself becomes frustrated, and not putting forth his best effort, he isn't as satisfied an individual as industry would like to have.

Today's technology is one of exploding technological advancements. As a young manager of personnel development—quoting from *Alice in Wonderland*—puts it, "In this world you have to run as fast as you can to stay where you are."

—JJR

Heating-cable installation, wider at the end of the driveway for easier entry, promises to end time-consuming, laborious shoveling chores.

Melt the Snow Off Your Driveway—Electrically

How often was your car stuck in the driveway last winter? Heating cable prevents this frustration and menace by melting the snow before it accumulates.

By JAMES R. MAHER

Last spring, a resident of Westchester County, NY, analyzing his electric bills for the winter months, found that it had cost him approximately $20 in electric power to get rid of a bothersome chore—shoveling snow from his 45-foot driveway.

Westchester County, in common with so many areas of the country, was plagued with snow and ice storms, particularly from January through March. This man works in New York City and commutes daily. He went through last winter without once getting stuck in his driveway.

In Columbus, Ohio, a home owner pays $32 for the electricity needed to keep his 70-foot driveway open all winter; and a Connecticut man living in the northern part of the State found that one particularly bad storm, with a recorded 10-inch snowfall, cost him about $3 in electric power to melt the snow in his 70-foot driveway. This was about the going rate for boy shovelers in the neighborhood.

Like so many of us, these three men depend on their automobiles to get them into the city on time each day. Snow may turn the landscape into a "winter wonderland" for some; but for most of us, it is more a frustration than a thing of beauty. Though snow is generally removed from streets and highways by various Departments of Public Works, the individual home owner must shovel out his own driveway. And a driveway covered with snow looks twice as long to the man who must get his car out of the garage and into the street. To some people—doctors, for instance—snow becomes even more than a nuisance; it is actually a menace.

The trend toward the use of more and more electric servants in the home has made the installation of snow-melting systems increasingly popular. The average home owner is taking a second look at industrial plants and commercial establishments—department stores, banks, office buildings, hotels, restaurants—that have found it good business to have safe, cleared sidewalks around their buildings. Its success for them, he reasons, assures its success for him.

Design Considerations

Are you one of the many who have been mulling over the question of electric "snow shoveling" for your driveway or walk? In designing an electric heating-cable system, there are four factors that should be considered: rate of snowfall, temperature, wind velocity, and humidity.

Mr. Maher is an Application Engineer in General Electric's Wire and Cable Marketing, Bridgeport, Connecticut. He began his career with the Company in this capacity in 1956.

These factors vary considerably over the country; even within a given locality, surfaces having a severe wind exposure, for example, will require more heat than those that are relatively shielded by adjacent buildings, shrubs, and other forms of protection.

Rather than deal with weather variations on a purely theoretical basis, let's consider the *average* requirements for specific locations in the United States. You should remember that slight differences in performance within a given locality may exist in some instances. The magnitude of this difference seldom warrants a change in the design rate.

While you can design a system so that each snowflake will melt as it hits the driveway, even during the most severe storms, the operating cost of such a system, in most instances, would be prohibitive. Rather than design for the worst conditions, the usual home driveway requires approximately 80 percent effectiveness.

For example, suppose your city has an average of 100 hours of snowfall per year. Your system should provide enough heat to melt *all* of the snow as it falls for 80 out of the 100 hours. This does not mean that the system fails to operate for the remaining 20 hours. Part of the snow that falls during the 20 hours of severe storms will still melt as it falls.

When the weather moderates (usually within a few hours) the remainder will be cleared. In other words, the inadequacy of the system, if we must call it that, is only temporary.

With this concept in mind, we can illustrate the effectiveness of three design rates—30, 40, and 50 watts per square foot for a number of cities throughout the country (Table I). The data are based on years of weather statistics, forming the most important factor in design consideration. Let's consider the specific cases of New York City and Columbus, Ohio.

In New York City . . .

In New York City we can expect an average of 76 hours of snowfall per year. Snowfalls of "trace" amounts (so slight as to be immeasurable) are not included, for they will not prevent the use of the driveway.

We find next that 30 watts per square foot will keep an area clear for 55 out of the total of 76 hours but that there will be 21 hours during which only part of the snow will melt as it falls. While in many instances this may not be too objectionable, the results of 40 watts per square foot are more desirable. The higher wattage reduces the hours of partial snow melting from 21 hours to 11 hours per year.

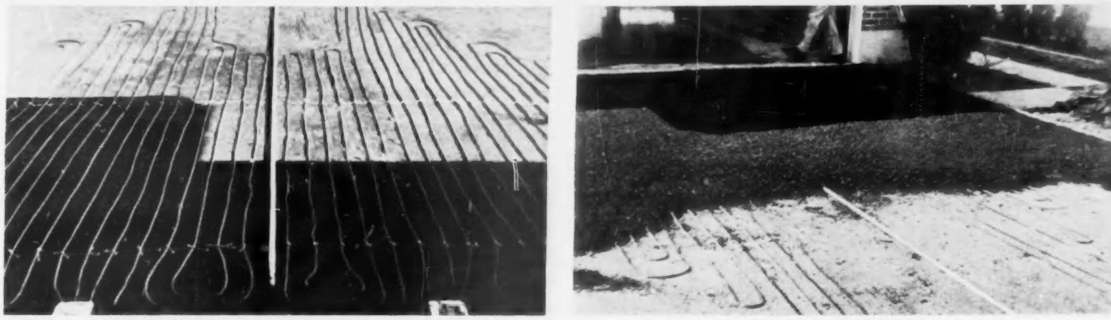
Economics enters into the final decision of which system to choose. The ultimate consumer must weigh the system costs against the time that he will have to wait for the snow to melt *after* it has fallen. Either system will, of course, melt all of the snow; they

TABLE I—SNOW-MELTING SYSTEM EFFECTIVENESS*

Location	Average Annual Snowfall (Inches)	Average Annual Snowfall (Hours)	30 Watts/Sq. Ft. System Snowfall Removal (Hours)		40 Watts/Sq. Ft. System Snowfall Removal (Hours)		50 Watts/Sq. Ft. System Snowfall Removal (Hours)	
			Complete	Partial**	Complete	Partial**	Complete	Partial**
Boston, Mass.	43	145	101	44	119	26	130	15
Buffalo, NY	74	240	173	67	202	38	218	22
Burlington, Vt.	65	236	170	66	201	35	219	17
Caribou, Me.	102	290	174	116	220	70	249	41
Cheyenne, Wyo.	56	138	44	94	61	77	76	62
Chicago, Ill.	34	134	91	43	112	22	123	11
Columbus, Ohio	22	105	84	21	93	12	99	6
Denver, Colo.	24	76	37	39	49	27	58	18
Detroit, Mich.	40	134	104	30	119	15	127	7
Duluth, Minn.	55	250	110	140	145	105	175	75
Great Falls, Mont.	54	174	75	99	96	78	113	61
Hartford, Conn.	41	171	120	51	144	27	156	15
Lincoln, Neb.	26	91	44	47	55	36	65	26
Minneapolis, Minn.	42	203	96	107	124	79	150	53
New York, NY	31	76	55	21	65	11	70	6
Ogden, Utah	89	160	133	27	150	10	157	3
Philadelphia, Pa.	22	58	45	13	50	8	54	4
Pittsburgh, Pa.	35	182	133	49	155	27	164	18
Portland, Ore.	13	36	32	4	34	2	35	1
Rapid City, SD	33	116	54	62	70	46	80	36
Reno, Nev.	28	87	81	6	85	2	86	1
St. Louis, Mo.	17	33	21	12	25	8	28	5
Salina, Kan.	18	54	35	19	42	12	46	8
Sault Ste. Marie, Mich.	84	345	228	117	272	73	307	38
Seattle-Tacoma, Wash.	12	44	42	2	43	1	44	0
Spokane, Wash.	38	196	157	39	180	16	190	6
Washington, DC	20	33	25	8	30	3	32	1

* Some of the heat supplied by the system will be dissipated downward and will not be effective in melting the snow. These data are based on an assumed downward loss of 25 percent.

**During these hours part of the snowfall will be melted and part will accumulate. When the severe conditions subside, the accumulation will be melted.



BLACKTOP INSTALLATION has 8-foot deep apron-wide cable arrangement tapering to $1\frac{1}{2}$ feet for wheel tracks.

INSTALLING THE HEATING CABLE

Typical layouts for systems in New York and Columbus utilize 100-foot lengths of cable operating at 230 volts (illustrations). The usual procedure is to clear tire tracks only, because the tracks will be snow free and the excess heat will tend to appreciably lower the snow blanket between the tracks and on either side. Some installations also cover the entire garage apron.

In these two wiring layouts a spacing of 4 inches center-to-center provides 30 watts per square foot (Columbus) and a 3-inch spacing provides 40 watts (New York). (A 2.4-inch spacing gives 50 watts per square foot.) Excess cable length may be used by spreading it around the area in front of the garage doors or at either side of the street entrance of the driveway where the car tracks curve when entering or leaving the driveway. Do not vary the lengths given in Table II; too long a length will not provide enough heat and too short a length will cause overheating and subsequent cable damage.

Usually, concrete installations require two pours. The first pour of the mix covers to the depth required by structural design. After the cable is laid maintain the proper spacing by loosely tying the cable to reinforcing wire mesh. Temporary pegs, which are removed as the second pour progresses, may also be used to achieve the same results. The second pour, usually 2 or 3 inches in depth, covers the cable and completes the installation.

In blacktop installations (photo, left), the surface on which the cable is laid must be smooth and free of sharp rocks and projections. The normal procedure is to roll the base rock and then cover with a finer crushed stone. Re-roll to a good, compact, smooth finish filling up all depressions. Again the spacing may be maintained by temporary pegs or by any other method that prevents the cables from moving during the spreading operation (photo, right).

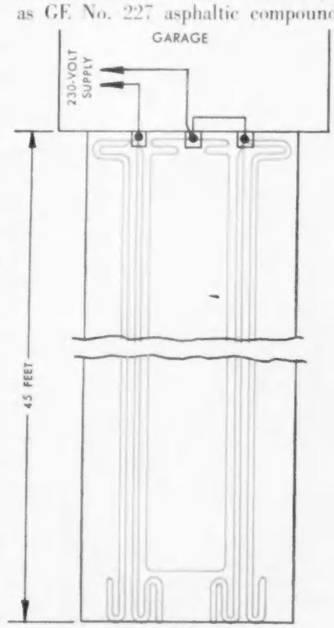
Cables should not be laid closer than 12 inches from the edge of blacktop surfaces unless provision is made to prevent collapse of the edge portion. It is good practice to retain a minimum spacing of 6 inches from the edge, even with permanent side boards in place. The blacktop itself should be a fine mix to prevent damage from large or sharp stones during the final rolling operation.

All connections from the supply leads to the heating cable should be made in junction boxes which may also be embedded in the concrete or blacktop. Not more than two lengths of heating cable should be terminated in a junction box, to prevent overheating of the supply leads. For the same reason, the lengths of heating cable brought into each junction box should be kept to a minimum, preferably 3 inches or less.

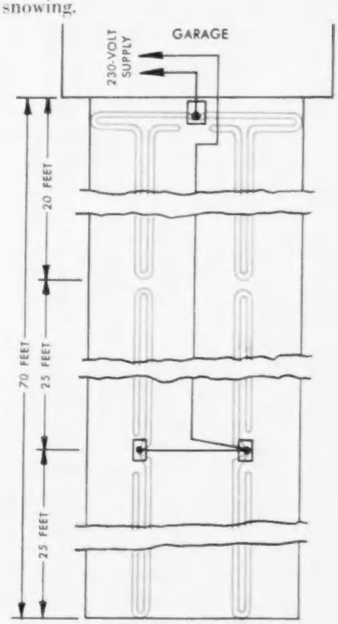
The supply leads should be suitable for direct burial, such as Type UF cable. They should be buried in the soil a few inches below the level at which the heating cables are installed. Use a two-conductor cable with a ground wire so that the lead sheath of the heating cable can be grounded in the junction box, eliminating any shock hazards. After the connections are made and properly taped, the boxes should be filled with a sealer, such as GE No. 227 asphaltic compound, to prevent the entrance of moisture.

Each length of cable will draw approximately $4\frac{1}{2}$ amp. Because two cables are generally brought into each junction box, the total of 9 amp can be handled by No. 14 supply leads. If it is more convenient to supply two boxes from the same lead, the total current will be 18 amp requiring a No. 12 cable. Each supply circuit should be protected by fuses or circuit breakers, preferably by circuit breakers, as they also provide a means for turning the circuits ON and OFF. If fuses are used, you'll need separate switch controls. No. 14 cable should be protected (or fused) at 15 amp and No. 12 at 20 amp.

Manual switch control of the heating cable system is recommended. Mount a red light in a conspicuous location to serve as a reminder to shut off the system when the snow has melted. Automatic control of the system by thermostat is not recommended, because it will actuate the system whenever the temperature drops below a certain point whether or not it is snowing.



3 INCH CENTER-TO-CENTER SPACING



4 INCH CENTER-TO-CENTER SPACING

differ only in how rapidly they are able to remove the accumulation.

. . . and Columbus

Let's assume that we decide on 40 watts per square foot for New York and

TABLE II

Volts	Length (Feet)	Total Watts
115	50	500
230	100	1000
460	200	2000

Rating—10 watts per foot; resistance—0.53 ohms per foot.

move on to Columbus, which averages 105 annual hours of snowfall. Because 30 watts per square foot clears the surface as the snow falls for all but 21 out of the 105 hours, this would seem to be adequate. We should mention that even with 50 watts per square foot, there would still be 6 hours when a portion of the snowfall would accumulate before being melted. This indicates that a design rate based on the most severe storm is seldom economically justifiable. In other words, a rate of more than 50 watts per square foot would be necessary for 100 percent effectiveness, but for most of the snowfall hours this excess wattage would be wasted.

Having arrived at 40 watts per square foot for New York and 30 watts per square foot for Columbus, in the next step we'll examine how the wattage (or heat) will be supplied.

The Heat Source

Heating cable has a long record of successful industrial, commercial, farm, and home applications dating back to the early 1930's. This includes pipe heating, soil heating, and roof, gutter, and downspout de-icing. It is only natural that its applications would eventually include snow melting.

The type of cable most frequently used in driveways is designated as SI-12314 with a rating of 10 watts per foot. Sturdily designed, the cable may be embedded directly in concrete or blacktop for light traffic use without the need for metallic conduit. The over-all Flamenol (registered trademark of the General Electric Co.) jacket gives the necessary protection to the lead sheath against the corrosive elements generally found in concrete.

To obtain the rating of 10 watts per foot of cable, it is important that it be used in proper lengths as specified in Table II.

For installation procedure, refer to the Box on page 41.

Operating Costs

Because it is not always feasible to turn the system On at the exact time the snow begins to fall or to turn it Off exactly the moment all snow has melted, the yearly operating time is not equivalent to the annual hours of snowfall given in Table I. To be conservative make the assumption that the system will operate twice the time indicated for the yearly snowfall. In the examples of annual hours of operation for the two systems described, New York should be calculated as 2 × 76 or 152 hours and Columbus as 2 × 105 or 210 hours.

The total wattage of the two systems is 5 kw for the New York driveway and 6 kw for the Columbus driveway. Total current is 22 and 26 amps., respectively. If the total wattage is multiplied by the annual hours of operation, we can find the annual consumption of electric energy in kilowatt-hours. Thus, 760 and 1260 kw-hr per season are used for New York and Columbus respectively.

The cost of electric energy varies considerably in different localities. A figure of 2½ cents per kilowatt-hour is considered fairly average for homes that are all-electric. On this cost basis, $19 per year clears the New York driveway and $31.50 covers the longer Columbus driveway.

Future developments are almost certain to include satisfactory automatic control of snow melting as well as other improvements. Our mode of living, away from cities and places of employment, and our dependence on the automobile for transportation have helped to create a desire for and an actual need for an easy way to remove snow. With the present marked trend to all-electric living, heating cable answers the requirement, and the snow shovel may soon become obsolete. Ω

ANNUAL INDEX VOLUME 61 1958 — Authors and Titles

Annual Index (continued)

Subjects

Appraising Research

(Continued from page 30)

efficient methods of production; it shows up too in critical and irreplaceable loss of lead-time.

Profit Incentives

Additionally, the profit incentives for producing new weapons and systems for defense are usually inadequate compared with the incentives for producing a major innovation for the civilian sector of the economy. Companies participating in defense projects today frequently find high proportions of their skilled manpower and material resources assigned to work that yields only a small government-administered profit. For example, General Electric has nearly 50 percent of its technical manpower assigned to defense product departments accounting for only 20 percent of the Company's total business. Profit yield falls substantially below those realized in commercial business. Yet the Company continuously makes significant contributions to national defense.

In spite of inadequate profits derived from the work, responsible companies and individuals will, of course, continue to serve the national defense with skill and ingenuity. But industry's acceptance does not indicate that this is the most effective or most desirable basis for building a strong, continuing defense industry, integrated into the corporate economy of companies large and small, and capable of meeting the long-range requirements of a Cold War.

In spite of our apparent weaknesses, we are enormously strong technologically. We possess tremendous assets in capital productivity, technical skills, and scientific resources. As experience emphatically shows, the American system of competition and incentives and individual initiative and freedom is a most dynamically effective producer of technical goods and services. There is no question of our system's over-all superiority in the production of automobiles, refrigerators, electric generating equipment, and the like, to meet the needs of the civilian economy. If used to anywhere near the same potential, with the same freedom and incentives, American industry's ability can unquestionably provide the same superiority in weapons and weapons systems for defense.

Lack of Understanding

Though we have known better than any other people how to practice innovation, we have paid relatively little attention to the principles. The actual process by which we obtain both our weapons of defense and our civilian goods has been too little understood by the public as well as by some of those who must administer and control the process itself. This lack of understanding can be particularly dangerous if the errors it propagates become built into the economy, for their effects will multiply over the probable duration of the Cold War.

Soviet Russia has demonstrated the capacity to mount a serious challenge to us in certain areas of advanced and advancing technology. The answer to the Soviet challenge is not duplication, of course. We need bold and daring technological leaps that bring us out ahead, not in just one line of development, but in many. This is the moment to reappraise the problem of technical training; to reduce the restrictive practices that impede the translation of new technology into everyday life; and to launch vigorous new assaults on a whole range of obstacles to the nation's technical and economic advance.

These things won't be done tomorrow because someone has thrown down a gauntlet and challenged us to do them. They will be done because they need to be done.

Responsibility: Dual Role

In accomplishing this engineers have a dual role to play: first, in adequately developing themselves to carry out the technological advances of today and tomorrow; and second, in helping to bring to their associates and the public a better understanding of the principles that underlie technological advance.

Because in matters of defense and national security our clients are truly, in Woodrow Wilson's phrase, "the future generations," we must provide training and education for those clients to make their own maximum contribution. This problem of today was summed up by Alfred North Whitehead when in 1917 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 of 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

Cryogenics

(Continued from page 15)

basic control element is also useful in the cryotron flip-flop circuit, whose output loop is either all normal or all superconducting. Because of its simplicity, low power requirements, and advantages inherent in input-output isolation, this device is a leading prospect for logical networks, memories, and computers in general.

Other applications include a memory device for computers, using superconductivity to achieve improved compactness and power drain; a superconducting heat switch, in which application of a magnetic field to a metal increases its heat conduction 10 to 100 times; and a new microwave amplifier, the "maser" (microwave amplification by stimulated emission of radiation) capable of virtually noise-free amplification that will be immensely important in such instruments as the radio telescope.

. . .And In Outer Space

Much half-truth has been written about the "cold" of outer space, suggesting that we may soon have convenient access to temperatures near absolute zero. But space has no temperature—we can consider only the temperature of a body placed in empty space.

A black body orbiting around the sun at the earth's distance receives radiation from the sun and reradiates it to space. If it is a good heat conductor, or if it rotates rapidly, exposing all sides to the sun, it will assume a temperature of about 300 K. If it is a perfect insulator and one side faces the sun continuously, that side will reach a maximum temperature of about 400 K. The other side, though, would continuously radiate its heat store without replenishment, asymptotically approaching absolute zero. Stellar radiation and interplanetary gas would probably maintain the dark side temperature at a few degrees absolute.

In practice, then, a space ship or an artificial satellite would have very low temperatures available only if the cold zone were carefully shielded from "seeing" the sun, the earth, and any of its own supporting structure. We calculate that great care would be required to attain even 20 K by radiative cooling. A fair conclusion: if a need develops in outer space for temperatures in the liquid helium range, that need will be met as here on earth with a helium liquefier. Ω

Everyone has a stake in a better business climate

The photograph above shows some of the people whose products or services are used by a typical employee in industry and his family. This is an example of the chain reaction of benefits set off by just one job in a community.

Further dramatic proof of the importance of jobs is provided by a recent survey* which shows that 100 industrial jobs in a community can create:

74 additional jobs
112 more households
4 more retail stores
296 more residents in the community
$590,000 more income per year
$360,000 more in retail sales per year

The jobs that bring widespread benefits like these to a community depend on healthy and profitable businesses. And business, in order to grow and prosper, looks to the community for a healthy business climate.

What are some of the conditions which make an ideal business climate? They are the same things that thoughtful people in a community want for themselves:

Honest and efficient government, supported by a strong majority of alert and well-informed voters who have the balanced best interests of the community at heart.

Fair taxes for both business and individuals, without restrictive regulations or discriminatory financial burdens.

Conscientious law enforcement which protects the rights of all citizens, corporate and private.

Equitable pay and benefits which reward employees for applying their full effort and skill to the job.

*"What Industrial Jobs Mean To A Community," U.S. Chamber of Commerce

Responsible union leadership and freedom from unwarranted strikes and slowdowns where collective bargaining is in effect.

Qualified people to fill employment needs, with educational facilities to prepare people for a wide range of jobs.

Adequate community facilities such as stores, banks, utilities, transportation, hospitals, and commercial services.

A social and cultural atmosphere in which people will enjoy living and working, including schools, churches, libraries, theaters, a responsible press, and healthful recreational facilities.

Throughout America, businesses, municipal and state governments, and individual citizens are taking an increased interest in gaining these good business climate conditions for their communities.

There is still much to be done, however, on local, state, and national levels. You can help by asserting your views on the need for a good business climate —as a member of community organizations, in civic planning activities, and at the polls. You'll be helping achieve the conditions that will enable your local businesses to operate successfully—with the greatest benefit to you.

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To find out more about how you can help appraise and improve the business climate in your community, write to Business Climate, Dept. A, Box 2490, Grand Central Station, New York 17, N. Y.

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