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IEEE spectrum

features

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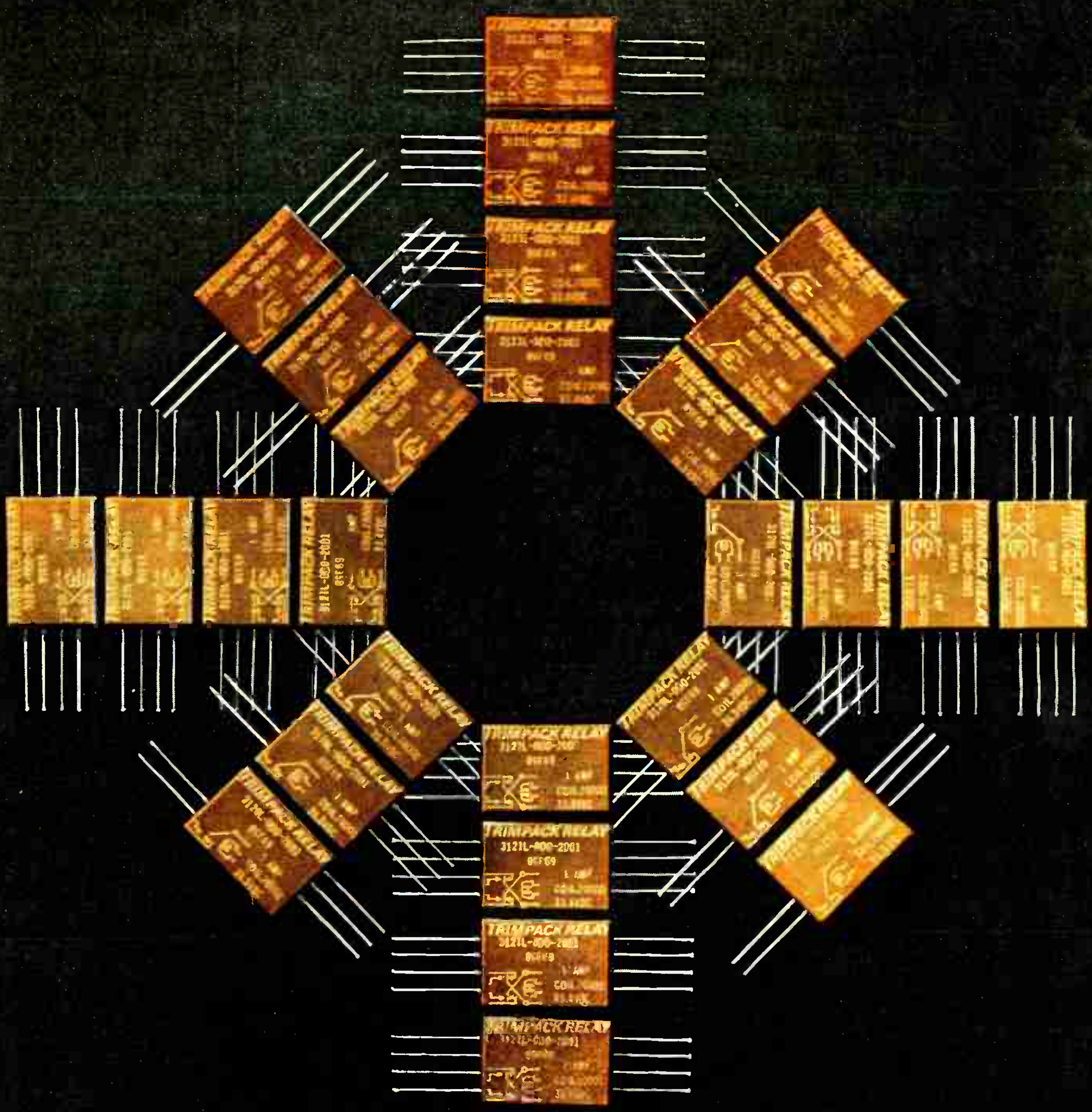

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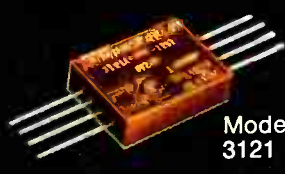

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the cover

This map of the Tokaido, the most highly traveled road in Japan, appears in "The Fifty-Three Stages of the Tokaido by Hiroshige" (Heibonsha Ltd., 1960), an album of the artist's woodblocks based on his trip down the Eastern Sea Route around 1832. A look at a more modern route—the microwave network now encompassing all Japan—begins on page 48.

departments

the

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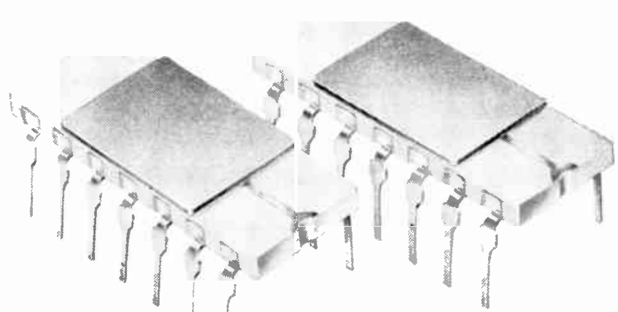

with the 4-bit byte

Forum

Readers are invited to comment in this department on material previously published in IEEE SPECTRUM; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession.

White House Fellowships

Once again, The President's Commission on White House Fellows is beginning a new search for outstanding young leaders of our society who want to come to Washington for a year as White House Fellows. The success of our search depends upon many people and organizations, and we are counting on the Institute of Electrical and Electronics Engineers for assistance.

The White House Fellows program was inaugurated in 1964. Nonpartisan in nature, it provides those selected as Fellows an opportunity for observation and involvement at the highest levels of our national government. Specifically, Fellows serve as Special Assistants to members of the President's staff and Cabinet, and with the Vice President. The age range is 23 to 35, and those who have demonstrated extraordinary ability in any field, a capacity for leadership, and a deep interest in community and societal affairs, are eligible to apply. Applications for the 1970–71 White House Fellows year must be filed by December 24, 1969. Final selection of the new Fellows will occur in May, and their year in Washington will begin in September 1970.

Applications may be filed immediately. For those who are interested in applying for the program, additional information and application forms will gladly be supplied.

Arthur S. Flemming
Chairman, Commission on White House Fellows
The White House
Washington, D.C.

Corrections and complaints

The article, "Human Experience in Artificial Intelligence," by Carl V. Page in IEEE SPECTRUM for September 1969, contains what I believe to be a misstatement of fact.

The chess-playing machine, known as the Maelzel Chess Automaton, was very briefly mentioned in an article by Claude E. Shannon, which appeared in the February 1950 issue of *Scientific American*. Shannon's article later appeared in Volume 4 of *The World of Mathematics*, which Page lists as his Ref. 1. Page explains in his IEEE article that the Chess Automaton was operated by "a small man, made smaller by amputations," hidden inside the Automaton. The reader gets the impression that Page derived his information about the "small man with amputated legs" from Shannon's article, but a reading of both the *Scientific American* and *World of Mathematics* articles shows that Shannon does not discuss the operation of the Automaton. It must be therefore assumed that Page himself reached the erroneous conclusion about a man having amputated legs being used as the Automaton operator. The reader is even treated to the additional detail that the amputations were received during a European war, although no reference source for this particular piece of information is given.

Actually, the Automaton was large enough to contain a normal man; the leg amputations were not necessary. The ingenious method used by the owner, Kempelen, in showing the interior of the Automaton to the spectators, created the illusion that it was not possible for a man to hide inside the Automaton. Of course, the operator inside the Automaton avoided detection by moving himself, both legs included, to various different parts of the interior via the opening and closing of internal panels. The internal movements were so well organized and synchronized with the operation of the external doors by Kempelen that the operator was continually hidden from the view of the spectators.

A complete description of the circumstances concerning the Chess Automaton was presented in *Chess Review* by Kenneth Harkness and J. S. Battell in a series of nine articles published around 1947. The first three of these articles, posing and solving the problems of the Automaton, are reprinted in *The Treasury of Chess Lore*, a book edited by Fred Reinfeld and published by Dover Publications, New York City. Diagrams showing the various operator positions are provided.

Edward E. Wetherhold
Annapolis, Md.

Mr. Wetherhold has indeed caught me depending on folklore rather than the facts to explain how a man could be hidden effectively inside the Maelzel Chess Automaton. Shannon's article does not explain how this was done. I am not sure where I first heard the amputation story and I hope that Mr. Wetherhold, as a better historian than I, has effectively laid it to rest. However, it appears that Mr. Wetherhold has heard a different version of the folklore than I, namely, that the legs of the operator were amputated, whereas my article claimed only unspecified amputations.

There is another error in my article that requires correction. On page 74, research with mechanical hands that actually occurred at Stanford University was incorrectly attributed to Stanford Research Institute. Major robot projects at Stanford Research Institute deal with exploration of and representation of an environment. A recent account of some of the work done at SRI can be found in the article, "A Mobile Automaton: An Application of Artificial Intelligence Techniques" by Nils J. Nilsson, *Proceedings of the International Joint Conference on Artificial Intelligence*, May 7–9, 1969, Washington, D.C. (edited by Donald E. Walker and Lewis M. Norton).

Carl V. Page
Michigan State University
East Lansing, Mich.

The authors of the paper, "An Introduction to Synthetic-Aperture Radar" (IEEE SPECTRUM, September 1969), wish to disclaim any credit for certain periph-

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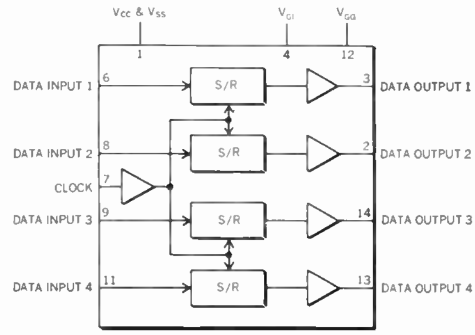
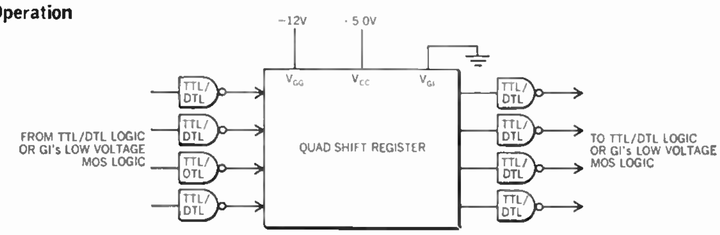
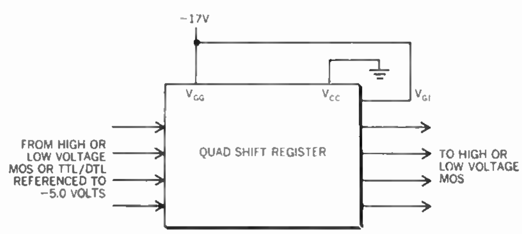


TTL/DTL Operation



MOS Operation



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eral statements that appeared with this paper. Specifically, the boldface and italicized paragraphs at the top of page 52 are the work of a junior editor, published over our objections; the comments in the table of contents are an editorial product that appeared with no forewarning. We sympathize with those readers whose esthetic and technical tastes may be offended.

William M. Brown
Leonard J. Porcello
Institute of Science and Technology
The University of Michigan
Ann Arbor, Mich.

The Editor shares deeply the regret of the authors at the abnormal treatment of their excellent manuscript.

J. J. G. McCue

The Special Staff Report by Paul Hersch in the October SPECTRUM incorrectly chastises both U.S. hospitals and medical instrument companies with respect to the use of isotope scanners.

Nuclear image organ scanning was developed in the United States after World War II by much hard work of a few companies, the AEC, and many university hospitals. I estimate that U.S. companies have developed and sold over 3000 isotope scanners and camera image systems throughout the world, and still are, by far, the dominant factor in the market and in new development.

These systems sell from about $15 000 to $80 000, depending on the type of diagnosis to be performed and the sophistication of the medical personnel involved in this new field. Lower-cost units that study flow of isotopes through various organs, but do not form an image, are available for smaller hospitals that cannot justify or afford the more versatile scanners and gamma cameras, or desire dynamic studies only.

As for hospital techniques in the United States, they most certainly have established the need for standardization of isotope scanning. Most medical schools train students in some nuclear techniques, and in most large hospitals, any suspicion of brain, liver, or lung tumors immediately brings forth a call for a scan from the internist or surgeon. Smaller hospitals, of course, refer patients to the medical centers, where the equipment and the facilities to handle radio pharmaceuticals are already in existence.

Samuel C. Goldman
Chief Engineer
Picker Nuclear
North Haven, Conn.

A controverted rejection

IEEE SPECTRUM is to be commended for the excellent article[1] in the September issue in which the authors relate synthetic-aperture radars to holograms (p. 60: "The radar is an analog . . . of the holographic technique," and on p. 61: "When this collection of one-dimensional holograms . . . " etc.).

The purpose of this letter is to emphasize the importance of this relationship and to point out that until recently this concept has been rather controversial. Thus, the editors will recall that an article on this subject[2] by the undersigned submitted to SPECTRUM in September 1967 was returned with the comment: "Our reviewers . . . do not feel that anything worthwhile is gained by relating synthetic antennas to holograms, nor by relating holograms to synthetic antennas." Shortly after publication of a short form of that paper,[3] synthetic antenna pioneers Leith and Ingalls also published on this relationship[4] saying (p. 539): "The holographic viewpoint appears to be more flexible than the communications theory or cross-correlation viewpoint, and has led to designs which are not easily explicable from the latter viewpoint."

The greater flexibility of the holographic viewpoint is evident when Doppler effects are considered. The SPECTRUM article notes that a side-looking radar was originally referred to as a "Doppler beam-sharpening concept." Doppler effects, however, are absent in holography, and hence stationary (Doppler-free) coherent radars and sonars are obviously quite feasible.[3] The unbelievable focusing performance in the near field exhibited by holograms and synthetic antennas as compared with ordinary optical systems and ordinary radar or sonar systems[3,5,6] has been the basis for several suggested extensions for coherent radar and sonar.[7-9]

Winston E. Kock
The Bendix Corp.
Southfield, Mich.

1. Brown, W. M., and Porcello, L. J., "An introduction to synthetic-aperture radar," *IEEE Spectrum*, vol. 6, pp. 52–62, Sept. 1969.

2. Paper presented on Oct. 5 at the Tokyo Holography Seminar, sponsored by the National Science Foundation. (See report of this seminar in *Appl. Opt.*, vol. 7, p. 622, Apr. 1968.

3. Kock, W. E., "Side-looking radar, holography, and Doppler-free coherent radar," *Proc. IEEE*, vol. 56, pp. 238–239, Feb. 1968. (The abstract said: "This letter calls attention to a similarity between side-looking radar and holography.")

4. Leith, E. N., and Ingalls, A. L., "Synthetic antenna data processing by wavefront reconstruction," *Appl. Opt.*, vol. 7, pp. 539–544, Mar. 1968. (The abstract said: "A side-looking radar system employing an optical correlation is analyzed on a holographic basis.")

5. Kock, W. E., "Microwave holography," *Microwaves*, vol. 7, pp. 46–54, Nov. 1968.

6. Kock, W. E., in *Lasers and Holography*. New York: Doubleday, Sept. 1969, pp. 92–94.

7. Kock, W. E., "Stationary coherent (hologram) radar and sonar," *Proc. IEEE*, vol. 56, pp. 2180–2181, Dec. 1968.

8. Kock, W. E., "A hologram form of bistatic radar or sonar," *Proc. IEEE*, vol. 57, p. 100, Jan. 1969.

9. Nalimov, I. P., "Applications of holography," reprinted in Stroke, G., *An Introduction to Coherent Optical Holography*, 2nd ed. New York: Academic Press, 1969, pp. 193–194.

Last words on Wald

I was very interested in the two articles published recently in SPECTRUM dealing with student unrest (June) and the ABM issue (August).

Such articles provide a real service to the membership in providing some insight into major issues of our day. The rapid advances in technology over the past two decades have created problems that can only be solved in social and economic terms.

Ours is a technical society but its members have a responsibility to the overall society in which we live. We are living in a global village that is becoming smaller day by day.

A membership of Dr. Strangeloves may be able to conquer outer space but they will be poorly equipped to solve the social and economic problems of both wealthy and poor nations.

H. H. Wood
Mont. St. Hilaire, Que., Canada

In his pacifistic speech to protesting students (June SPECTRUM) Prof. George Wald, when trying to explain the generation gap as caused by a difference in the military environments, says:

"How many of you realize that just before World War II the entire American army including the Air Force numbered 139 000 men? Then World War II started. . . ."

At that time, in the twenties and thirties, the official policy of the western nations was just that same pacifism that Professor Wald is advocating. This policy led straight to World War II. Had the Nazis been stopped when they remilitarized the Rhine Zone, in violation of a treaty signed by Germany, Hitler and his gang would have vanished from the scene. For the West it would have been a weekend promenade to stop him at that time. But the word then was: Never use arms.

As a non-U.S. citizen I have no say in what the U.S. should or should not do. I can only express my admiration for a nation that has learned the harsh lesson from that epoch. As long as there are powerful totalitarian regimes lacking a democratic mechanism for selecting the leaders, the democracies cannot secure peace just by being peaceful. The decision on war or peace is not ours. Had not the U.S., and to some extent Britain and France, had the determination and the preparedness to stop aggression in Berlin, Malaysia, Korea, and Cuba, to mention only a few cases, we would now certainly be much nearer the catastrophe of a World War III than we seem to be today.

Surely, the Vietnam intervention is no weekend promenade for the United States. As this tragic venture has developed it is understandable that, today, Americans differ in their opinions. Professor Wald's words, however, as they were cited above, reveal how far away he is from even being aware of the fundamental motive for U.S. military preparedness in general, and its presence in Vietnam in particular.

It is natural for very young people to ignore the causal connection between the outbreak of World War II and the pacifistic policies preceding it—it was always the privilege of the young to ignore past experience (and no enthusiasm is as great as that based on partial ignorance!). But in a mature man and a great scientist that same unawareness is amazing.

"Then World War II started." In fact, it did.

Uno Lamm
Hillsborough, Calif.

If the letters published in the August issue of SPECTRUM on the subject of the Wald talk are at all representative of those received, they are in themselves an excellent reason for seeking out and publishing relevant socially oriented material. My reason for this conclusion is that the content of these letters reveals a great need among our membership to do more thinking about the social consequences of the work that we do, to discuss these matters among ourselves, and to begin to originate some ideas as to how we can employ the special talents that we possess to help find better answers for dealing with urgent national problems.

Those letters that commented favorably had little to say about the content of Wald's talk. They merely applauded the idea of opening the pages of SPECTRUM to material of this sort. On the other hand, the unfavorable comment not only condemned publication of this material; those writers also took rather violent issue with the content. Apparently these readers failed completely to grasp the point that Wald tried to make. They grossly distorted what he did say, and attributed to him things that he did not say.

All of this reveals a lack of experience in dealing with social problems and in discussing them in an objective and constructive manner. It is simply not acceptable to dismiss this on the ground that engineers are too engrossed in technical matters to have time for thought or concern about public and, more specifically, social questions. If our work as engineers involved nothing but tinkering with unimportant and harmless gadgets, there might be some foundation for such a point of view. The fact is that without engineers there would be no hydrogen bomb, no ABM, no Apollo 11.

Even the least of us is not engaged in playing harmless games. To quote an eminent authority, Alfred Douglas Flinn, writing for the *Encyclopaedia Brittannica* under "Engineer, Professional":

"Having been endowed more or less completely with qualifications and capacities requisite for a professional engineer and having developed them with the aid of educational and other institutions and contacts provided by civilized communities, the engineer is under obligation to consider the sociological, economic, and spiritual effects of engineering operations and to aid his fellowmen to adjust wisely their modes of living, their industrial, commercial, and governmental procedures, and their educational processes so as to enjoy the greatest possible benefit from the progress achieved through our accumulating knowledge of the universe and ourselves as applied by engineering. The engineer's principal work is to discover and conserve natural resources of materials and forces, including the human, and to create means for utilizing these resources with minimal cost and waste and with maximal useful results."

That just about says it all. Engineering is not, as some of our members would have us believe, an "ivory tower," a refuge that relieves us from concern over social problems, that excuses us from becoming involved, from trying to find solutions—yes, even from discussing or reading about the issues! We are "*under obligation* to consider the sociological, economic, and spiritual effects of engineering operations and to aid our fellowmen to adjust wisely. . . ." One of the very best ways to encourage our members to live up to their responsibilities as engineers is to print controversial and provocative material in our journals that bears upon the sociological, economic, and spiritual impact of engineering works. Perhaps the reason for some of the acrimony in the comment on Wald's talk is that someone's ox has been gored. This can usually be counted upon to produce responses that are based more upon emotion than upon reason.

Upon rereading Wald's talk I failed to find that he was espousing any theory other than his theory as to what is troubling so many of our young people today. And that theory must be shared by anyone who has bothered at all to listen to what so many of these people are saying. After all, they ask us, what else matters when the very existence of humanity is threatened by prospects of nuclear war on one hand and the world population explosion on the other?

In his talk, Wald provided no answers. That obviously was not his objective. Let's be clear as to his objective. There should be no mystery about it, because he stated it clearly enough:

"I think that this whole generation of students is beset with a profound uneasiness. I don't think that they have yet defined its source. I think I understand their uneasiness even better than they do. What is more, I share their uneasiness."

The balance of the talk deals with Wald's evaluation of the causes of this uneasiness. He does not provide the answers, because neither he nor anyone else has the answers. That is precisely the trouble. All of our thoughtful young people are concerned because they fail to see sufficient effort going into finding the answers. And some of these young people, being young, idealistic, and impatient, are so disturbed over what they regard as our callous attitudes toward these vital issues that they are going berserk.

True, Wald did say, "We have to get rid of those atomic weapons, here and everywhere. We cannot live with them." He did not say that the United States must unilaterally throw away all of its nuclear weapons. Instead, he is pointing out the obvious fact that so long as atomic weapons are deployed anywhere on earth they pose an imminent threat to the existence of the human race. And he points out the equally obvious fact that adding to the store of such weapons, for whatever purpose, adds to that threat.

The consensus of opinion among the nation's leaders is that we have no alternative at present but to strengthen our deterrent forces, and that in turn requires an increase of nuclear weaponry. But none of the advocates of this course of action pretends that it will eliminate the threat of an ultimate nuclear war. If hard-pressed, they would all have to admit that if nuclear war does come, the resulting devastation will be in proportion to the amount of nuclear weaponry deployed at the time. So, what this policy achieves, if anything, is to buy time—to stave off the day when the holocaust will break upon us. But the price is a certainty that that war, when it does come, will have more devastating effect than would be the case if there were less nuclear weapons.

It is difficult to quarrel with this logic. Thus, when our young people, and citizens of all ages, for that matter, demand that something else be done—something that has the objective not merely of buying time, but of getting rid of the threat of nuclear war altogether, how is it possible to condemn them? We do not have the answers they want to hear. We may need all the time that we are able to buy by one means or another, and then some, to find the right answers. But this does not justify our abusing those who insist on reminding us that we don't have a satisfactory answer, and who insist on prodding us to find one. One must suspect that the irrational behavior of at least some of the young protesters stems in part from their realization that they have no good answers either, and that they just may live long enough to find themselves in the situation where a new generation of youth demands answers of them.

Alexander H. Kuhnel, P.E.
Cleveland Heights, Ohio

The letters published in the August issue were thoroughly representative of those that had been received at the date of going to press, and they were also representative of those that arrived later.

Mr. Kuhnel is quite right in saying that Wald was not advocating unilateral nuclear disarmament. In fact, in a different public talk given at about the same time, he specifically repudiated unilateral nuclear disarmament.

The Editor

Professionalism

IEEE SPECTRUM has been debating the issue of engineering recognition in the United States for the past few months and many members have expressed their opinion. After reading Clarence L. Ahlgren's letter in the October issue concerning the use of some kind of a title to identify the engineer, I decided that I could not keep silent any longer.

Why do we get involved in all these arguments when the solution is right in front of our noses? All we have to do is look at other countries that have solved this problem of professional recognition a long time ago.

In Europe and Latin America, engineers have been regarded for a long time as at the same level as doctors and lawyers. People respect and recognize them for what they are worth in the professional community. In South America, for example, every engineer signs his name, or is referred to as. "Ing. John Smith." ("Ing." stands for "Ingeniero.") The "Ing." abbreviation gives him the same status a doctor or a lawyer receives when using his respective abbreviated title.

Why not start a program for engineers to use some kind of abbreviation to denote their status, such as: John Smith, E.E., for electrical engineer, or John Smith, M.E., for mechanical engineer, etc.

It may also be that what is wrong with the title "engineer" is that the word is a derivative of "engine," and is used in many other trades, such as operating engineers and locomotive engineers—and very soon the title "sanitation engineer" may be used to designate garbage collectors. In Spanish this fallacy does not occur. The title "Ingeniero" is a derivative of "ingenio," which means "ingenuity." This is a far better explanation of what an engineer is—an ingenious man.

Finally, I would like to say that another approach may be to change the title "engineer," and start calling ourselves some other name that will give more merit to our profession, such as "ingenuer," "technologer," or some other more meaningful name to truly express our status to the man on the street.

Jorge O. Svoboda
Baldwin Park, Calif.

As a member of the engineering profession I feel there is a real need for an AMA or Bar Association type of group to represent engineers. An organization like those described in the letters by D. T. Hooper and Henry J. Ochs, Jr., (October) would go a long way toward creating the public image that is missing.

Ask your wife how many times she told someone you were an electrical engineer and found out they thought that meant you were an electrician.

Such an organization could eliminate the numerous problems of registration of electrical engineers between states. It could establish suggested salary standards like the AMA fee schedule.

It would be an organization that could speak to the public for engineers. As the AMA is speaking out on smoking, engineering should have spoken on auto safety or television radiation.

I suggest that the IEEE poll its members with the aim of working toward an AMA-type organization. The mechanical engineers I have talked with also feel the need for such an organization. Perhaps combined efforts from the engineering societies is called for.

E. F. Holtmann
Concord, Calif.

Please continue to be involved in the great and necessary "professionalism" debate. Rather than say in my own words what Messrs. D. T. Hooper, Clarence L. Ahlgren, and Henry J. Ochs, Jr., have already said, allow me to concur—especially with some rather interesting ideas proposed by Mr. Ochs.

I intend to obtain my Professional Engineer's license next spring, not because the company I work for requires it, but because I feel that we must be considered professionals and our organization must be our spokesman in all aspects of our professional lives.

The idea of forming another professional (?) group of "Technician Engineers" does not appeal to me at all. The misuse of the term engineer has reached ridiculous proportions, as everyone well knows! My wife is typing her high school reunion notes and one of her classmates, who installs air conditioners, describes himself as a "thermal dynamics engineer"!

Why can't the IEEE promote legislation to restrict the usage of the term "engineer" to qualified, degree-holding individuals?

You may argue that such efforts are now being conducted by State Boards of Registration, but I hasten to remind you that none have the national and international scope of IEEE.

Michael F. Wilson
Seaford, Del.

I have been very interested in the comments that have been made with regard to engineers and professionalism. I would like to address myself to a slightly different aspect of our situation.

Many have suggested, or implied, that IEEE should take a more active role in the (I hate to use the word) bargaining position of the engineer. Some have even advocated unionism for engineers. I feel that we could strengthen our position more by becoming more active in politics.

I have learned through private correspondence with the President of IEEE that we are not allowed to lobby or otherwise influence the legislatures and Congress because of our tax-exempt position.

How many times have we asked ourselves why the guy who empties our trash has the same title as us? The answer is that there is nobody representing us in the legislatures on a state or national level.

We would do well to consider the possibility of foregoing the tax-exempt status we now hold and use our "professional'" society to place pressure on our congressmen for the benefit of the society members.

We will never raise our status by forming a union. Nor will we gain it by collective bargaining with our employers for higher wages. That must still be an individual effort on individual merits. We can only gain status by having laws passed that will be favorable to our situation.

John Pritchett
Altec Lansing
Anaheim, Calif.

As an old-timer, I have been interested in recent letters to IEEE SPECTRUM regarding the proper concern of the Institute for the economic well-being of its individual members. Thinking back to the now (happily?) forgotten early 30s, I can well remember the sense of isolation and lack of communication with AIEE when it came to this matter. (Lofty considerations of such subjects as proper temperatures at which to operate class "B" insulations seemed very distant and irrelevant!)

If, by some miracle, a job opportunity did arise, no channels existed through which an individual member could obtain informed advice as to the adequacy of salary, working conditions, future, etc., etc. We were strictly babes in the woods!

I did then, and still do, believe that there is a real need for a Job Evaluation Committee within the Institute, composed of knowledgeable and dedicated members, whose function it would be to recommend minimum qualifications and remuneration for individual jobs, giving due consideration to such factors as geographical location, responsibilities demanded, scope and nature of the work, and a host of others. In my estimation this could well be one of the major activities of the Institute, ranking right up there with those of the Standards Committee, etc.

This approach would give a sense of economic solidarity to all members, while still avoiding the "leveling off" of individuals into arbitrary classes. Any member, armed with the best information and advice, would be in a position to choose intelligently the opportunity that best suited his particular qualifications, inclinations, and ambitions. Perhaps we can "exalt individual merit" and "exalt the welfare of the hive" at the same time.

I also believe that some form of Mutual Benefit Association should be set up and guided by the Institute; participation by the members, however, should be on a voluntary basis only. It seems to me that the Institute would be uniquely qualified to implement such an organization equitably, and would be sensitive to a member's individual problems in regard to his economic interface with the electrical industry. The present Institute insurance plan seems to set a precedent for such an endeavor.

Undoubtedly such activities on the part of the Institute would raise many questions, including tax status, but what makes tax status so sacrosanct? Surely, if an otherwise desirable expansion of the scope of the Institute does make it subject to additional equitable taxes, no one should object!

In short, I can see no valid reason why an individual member of the Institute should be expected to join another organization in order to obtain either professional status or adequate economic protection.

C. T. Hesselmeyer
Chicago, Ill.

Concerning the question of tax status, see the Robbins letter that follows. In *Civil Engineering* for April 1969 (page 35), the secretary of the American Society of Civil Engineers declared: "Although ASCE values its exemption from income taxes as an educational and scientific non-profit organization, it does not intend to let this hinder the fulfillment of its responsibilities to the public and to its members as a professional society. Should the acceptance of these responsibilities ever be held to exceed the limitations of Section (c) (3) of the Internal Revenue Code, it is expected that the Board of Direction will decide then whether or not to curtail programs or to accept exemption as a non-profit 'Business League' under the more liberal provisions of Section 501 (c) (6) of the IRS Code."

The Editor

The highly interesting article by Messrs. Alger and Holt in the August issue, "The Responsibility of the Engineer," graciously suggests that engineers, in addition to joining their technical society, should join a professional society, such as NSPE. We appreciate this comment.

However, one point needs clarification. The authors state that because of differences in concept the technical societies have a tax exemption and NSPE does not. In fact, both the technical societies and NSPE have a tax-exempt status under the Internal Revenue Code. The only difference is that the exemption is under different sections of the Code. The technical societies, such as IEEE, have their exemption under Section 501 (c) (3) as "scientific" organizations, whereas NSPE has its exemption under Section 501 (c) (6) as a "business league." The major difference is that contributions to a 501 (c) (3) organization are deductible by the donor, but such organizations may not engage in any "substantial" activities to influence legislation. Under Section 501 (c) (6) contributions are not deductible by the donor, but there is no restriction on activities to influence legislation, which is one of the major activities of NSPE and its affiliated state societies.

Paul H. Robbins, P.E.
Executive Director
National Society of Professional Engineers
Washington, D.C.

I have read the thought-provoking editorials on professionalism in electrical engineering in the July and August "Spectral lines" with great interest and hope that members of IEEE are inspired into action.

IEEE and other technical societies have ignored the professional aspects of engineering for too long, and I am hopeful that the officers of IEEE will implement a program to assist other organizations devoted to the engineer's social and economic welfare and recognition of the engineering profession.

The problem is complex, and the first approach might well be a meeting of the presidents of all the technical societies together with the presidents of the National Society of Professional Engineers, Engineers Council for Professional Development, National Council for Engineering Examiners, Engineers Joint Council, and other national engineering organizations. The primary purpose of the meeting would be to clear the air of all past misconceptions and to define the problems involved.

This should be the easy part, since this is the type of challenge for which engineers are trained.

For those engineers who have not been exposed to all the facets involved in the road to recognition as a professional, I would like to enumerate a few.

Each state in the United States today has a law governing the licensing of engineers. These laws include a General Provision, definitions, sections relating to the Board of Examiners, general requirements for registration, general requirements relating to the examination, plus disciplinary action, appeals, violation and penalties, and an exemption clause.

Although in general all states' laws covering engineering registration contain all of the above provisions, the requirements contained in the provisions differ. Many states have bills before their legislative bodies to update their registration laws, introduced by the state professional engineering societies. These efforts, often unsuccessful, are the work of many dedicated engineers.

As a point of interest, the National Society of Professional Engineers and the member state societies have been so incorporated and chartered as to make it legal to lobby for these changes in legislation, as well as against legislation detrimental to the profession. Few if any of the technical societies have this right in their incorporation charter.

Most states, if not all, exempt the engineers in industry (including public utilities) from being registered. Although some states do not require an examination for registration, these states do require a degree from an accredited college of engineering.

For those proponents of registration without examination, statistics do not indicate this as a sufficient inducement to registration. Statistics also point out that only 55 percent of those taking the exam receive a passing grade.

The National Society of Professional Engineers is generally opposed to collective bargaining for professional engineers. Recognizing that circumstances may require participation in a collective bargaining group, NSPE has promoted legislation to permit the professional engineers to hold a separate election if they so desire.

Today there is no one national organization having as its primary objective the promotion of the social and economic welfare of the engineer that can, under its constitution, accept as members all engineers. Although NSPE attempted to open its requirements for membership in 1966, it narrowly failed to obtain the necessary vote. This issue is not dead, however.

Through its Practice Section of Professional Engineers in Industry, NSPE is being made aware of the impact of defense cutbacks on engineers in defense industries, trying to improve the engineer–management relationships by establishing guidelines, evaluating the need and preparing guidelines for portable pensions, and generally taking on the position of watchdog and mentor of the welfare of the industrially employed engineer.

In summary, the problem is one of apathy on the part of too many engineers; it is lack of a concerted and unified approach to the basic problem by all engineering societies; it is a lack on the part of our engineering educators to instill professionalism in our universities; and it is a lack of support for the legislation required to update our registration laws to meet today's technological explosion.

The status of Professional Engineer in any branch of technology is not only desirable but necessary, and the rewards can only be achieved through the same degree of effort that was required to achieve today's technology. We've asked for and received the moon! Can there be any limit to what we can achieve through a united effort?!

Robert G. Holfelder, P.E.
Clarence, N.Y.

While reading the recent round of discussion in "Forum" concerning the question of engineering "professionals," it occurred to me that the debate is an internal one and that perhaps some comments by an "outsider" would be appropriate.

I was first introduced to the term "professional engineer" about five years ago, during my last year in engineering school. The occasion was a meeting of the graduating EE class at which the speaker was a representative of the state registration board. His mission was to invite us to take the examinations that would be offered in the spring prior to graduation.

It seems that the strongest motivation offered for seeking professional registration was that it was the "thing to do." At that time, that was all I needed to hear; I would take another exam if it would make a few bucks difference in my first paycheck. Besides, if everybody else was doing it, I certainly did not want to be left out.

I took the examination and earned the vague distinction of "Engineer-in-Training." My first job offer was attractive and I launched my engineering career with a salary that was above the school average that year. However, my career was cut short very soon by military service.

As an engineer, I was naturally put in one of the military engineering corps, where I joined the Society of Military Engineers. Since I always took my duties seriously, I was reluctant to recognize that I was not really doing engineering work, nor was I an engineer in any sense of the word.

While I was pondering my engineering status, I saw a growing emphasis on professional registration as "desirable" for all military engineers. Before I left the "corps," registration had become an announced prerequisite for promotion to the higher ranks.

As this parody became clearer to me, I started to follow the discussion of professional status in the civilian society with greater interest. The conclusions that I came to had a lot to do with my later decision to leave my engineering career behind.

As for the military "professional" engineers, there is little doubt in my mind that emphasis on professional registration represented an effort to maintain *status* with the civilian contractors who did most of the engineering required. If there were other objectives that justified this push, they have eluded my honest search.

With this status seeking on my mind, I began to recall my reading of Vance Packard and discovered symptoms of status seeking in the civilian professional engineers' campaign as well. As the status of the engineer decreased in the company, and the population of engineers increased in society, along with the trend toward migratory employment, it is quite understandable that the engineering groups should fight back.

Oversimplified, it appears that engineers want an accredited title "P.E." to wear after their names to invoke respect and *status* equal to the highest of the other professionals in our society. All the rhetoric about codes of ethics and duties to the community are but pecksniffery.

I am not going to try to justify my own conclusions to the engineering societies. Rather, I offer to you an opinion from an "outsider" to be considered as you read your journals and other publications in which this question is being discussed. I think the outside point of view is important to keep in mind, because, if you recall the difficulty that engineers have had over the years in agreeing upon whether engineers are professionals, you can get some idea of the magnitude of the task you will have when finally you set out to convince the public.

Carlos Williams
Boston, Mass.

The following are some observations about the October issue. The outstanding difference between doctors/lawyers and engineers is that doctors/lawyers are more directly involved in a person's personal life and troubles. This involvement directly affects the patient/client, especially with a serious illness/criminal or civil suit. The engineer, by nature of his work, is more concerned with inanimate objects performing service functions. This is not to say that doctors and lawyers should or should not have titles but the relationship with those they serve is completely different from that of engineer and employer.

What is the engineer after? If it is status, then you need a title. But today the status is being sought by the phonies to cover up their shortcomings. Respect? From whom and for what reason? If you know your job you'll get it without the title. Recognition? Ralph Nader has that and more, but no title. Money? Do your job better, faster, cheaper, then toot your own horn, to the boss. And by the way, Ralph Nader is a lawyer. Where's Ralph Nader, engineer? He's out looking for status, respect, recognition, and money. He's writing reports for symposiums and technical meetings. He's keeping abreast of his field, working free overtime, and bringing home his work. He's an ostrich as far as the rest of the world is concerned.

If engineers want those things then they better wake the hell up. Get involved with the problems of today.

Know what's going on in the world. Read history. Write letters. Talk to your friends about the country's problems and the world's problems, but logically and precisely. Not like our Senior Member who wants our editor tried for treason. A professional? Who can't even reason properly? Not in my organization.

Z. M. Wisniewski
King of Prussia, Pa.

Sociologists writing on professionalism as a phenomenon have remarked that traditionally the term "profession" has usually referred to work, not with things, but with the concerns of people.

The Editor

There has been considerable comment in the recent technical press concerning engineering unions or associations. It behooves IEEE to take cognizance of this fact—that salaried engineers will eventually organize as nearly all other professional groups have done.

IEEE's attempt at being all things to all men is laudable but the majority of its members is clamoring for a voice in events that are now outside their collective control. IEEE should at least start to make some initial and tentative moves in the direction of engineering representation. If they don't some other body surely will, and this will inevitably lead to a loss in membership. This will of course lead to a diminution in the present excellent service rendered by IEEE—then we will all be the losers.

The inner councils of the Institute should not deny the winds of change that are there for all to see.

P. Longrigg
Dallas, Tex.

Pollution

The July 1969 issue of SPECTRUM contained an article, "Air Pollution and Electric Power," which includes useful information but also conveys a message of resignation to the existence of air pollution. The author, Mr. Netschert, I am sorry to observe, presents an echo from recent events when control of automotive-generated air pollutants was considered in California. For those completely unfamiliar with those proceedings, a description follows:

1. California announces maximum pollutant emission levels to apply after a certain date.

2. The automobile manufacturers protest that they cannot develop control devices within the time frame and that it would cost too much.

3. Independent entrepreneurs demonstrate feasible modifications and/or devices for the purpose of meeting the state's criterion.

4. The automobile manufacturers find that both time and cost goals can be met.

(Add one year and repeat steps 1 through 4.) Statement 2 is a reasonable representation of the article. Automotive pollution is under attack. Why can't IEEE aid in establishing guidelines for power generation plants? Simultaneously, the aid of the ASChE should be enlisted for two reasons:

1. The ASChE can verify the feasibility of emission control goals.

2. The ASChE can recommend guidelines for reducing pollution generated by the chemical industries.

The "Canon of Ethics for Engineers" states, "The Engineer will have proper regard for the safety, health and welfare of the public in the performance of his professional duties."

Since air pollution, as carried by wind, respects no boundaries, it is fitting that the engineering organizations attack the problem. (After this comes water pollution.) A suggested approach to the problem appears as follows:

1. The IEEE and ASChE will set up a committee to attack the air pollution problem.

2. The committee will prepare recommendations with respect to:

(a) Pollutant levels.
(b) Timetable.
(c) Tax write-off and/or rate change.
(d) Other considerations they deem advisable.

3. The committee will present the recommendations to Congress and will lobby diligently for enactment of legislation penalizing pollution and promoting cleaner air.

Personally, I don't care whether the suggested approach is used or not, but I do care that the professional societies should avoid both procrastination and extreme sensitivity to the objections by polluters. Mr. Netschert's paper provides background information that would be very useful to such a committee.

Joseph R. Herr
Los Altos Hills, Calif.

Certainly not all of Mr. Herr's proposal can be carried out under the present charter and tax-exemption status of the IEEE.

The Editor

Morality and engineering

Disagree with the morals of various engineers if you wish, but please give us credit for having some! My fellow engineers and I are not "amoral technicians," as we were recently called in IEEE SPECTRUM.

In the August 1969 issue, SPECTRUM presented a group of three articles on the antiballistic missile controversy. I believe that this represents a welcome usage of SPECTRUM to assist its engineering readership in seeing the opposing political and technical views concerning one engineering creation. However, in establishing the frame of reference for the articles that constituted the debate, defense industry engineers were referred to as "amoral technicians," and as having "moral neutrality" (pp. 26 and 50). It is a minor point that Mr. Tilson, a staff writer for SPECTRUM, does not appear to know the differences between scientists, engineers, and technicians, nor to know which of the three constitutes the large majority of IEEE membership. My major disagreement is with his assumption of a lack of moral values associated with engineering work.

In a discussion of moral codes or positions, I can only speak positively for myself. However, since I believe that this general position is widely held by defense industry engineers, I shall use the term "we" in the following discussion.

Undoubtedly all informed citizens of this planet are aware of, and concerned about, mankind's problem of war. We, the U.S. defense industry's engineers, are especially aware of this since our daily work involves the design of weapons and related equipment of warfare. We believe that a strong United States is the best insurance the world has that these, and the weapons of warfare owned by other nations, will not be used. Similarly, we believe that a weak United States will greatly increase the probability of major warfare. Therefore, a major part of our moral position regarding our work is that strengthening the United States is good, since it increases the chances for peace and freedom, and that weakening the United States is bad, since that increases the chances for war.

Another moral position is that technological advances are good in themselves, even though the far-ranging consequences cannot be foreseen. For example, Eli Whitney undoubtedly did not appreciate the tremendous material good that would be accomplished by his development of interchangeable parts for the production of muskets. In other words, we consider that technology advances generally result in advances to man's material well being and are therefore good regardless of the immediate application.

These positions can be criticized for lack of a "fine structure," i.e., a project-by-project moral evaluation. That this lack of individual determination is not unique can be seen by examining other professions. A physician is dedicated to the general cause of healing and does not evaluate whether each patient is worthy of help. A clergyman is dedicated to the service of God and helps man based on need, not the worth of each recipient. A lawyer is dedicated to justice through the legal process and provides counsel to the guilty as well as the innocent.

In summary, I believe that we defense industry engineers do have a moral code pertaining to our work—one that is based on seeking peace through a strong United States, and in seeking material gains through technology advances.

Richard E. Wells
Hughes Aircraft Co.
Fullerton, Calif.

Blinking in the glare of unaccustomed controversy, SPECTRUM has emerged into the real world. Welcome! The new "Forum" may turn out to be SPECTRUM'S biggest service to the profession yet, simply by proving that, under a thin layer of graph paper, engineers are *people*—given to irrational emotions and even stupid prejudices.

The ABM discussion (which for many of us is a matter of life and bread) is superbly suited to prove the point. In 27 pages not a single graph, or even a table—no facts, no figures to injure anybody's preconceived notions, nothing on which one could form an opinion with any semblance of objectivity. No wonder the issue is so emotional! Worse yet—the public *cannot* be informed without violating national security, as we now understand it.

Because in order to form an honest opinion, one would not only have to know who has how many missiles of what kind, but answers to such unpleasant questions as: What will be our response when that ABM superradar reports the approach of 1000 missiles? Immediate retaliation, or second strike only? What if there are only 100 missiles, or ten? What if it's only one? With MIRV that may be all that's needed to wipe out those soft radar eyes, and render us virtually defenseless. How can we distinguish a peaceful space vehicle from an orbiting MIRV-bus, whose missiles can descend on us from *any* direction? These are the kind of nitty-gritty details on which engineering thrives.

However, things will get worse. Right now we know where these hypothetical missiles come from, and there goes Moscow. But in ten years, how will the ABM super computer tell whether the UFOs are Russian or Chinese? Will we, in response, wipe out Moscow or Peking or—just in case—both? And another decade later—if we live that long—we may have the choice among all major capitals, and a few minor ones. What then?

Depending on the answers to these questions, an ABM system may well be a senseless waste of billions, or even encouragement to the enemy. It is, on the other hand, true that during recorded history turning the other cheek has never worked among nations, while balance of power has, after a fashion. And while we argue over this, mankind crazily piles up more and more supertinder, praying all the while that the spark will never come. This is so irrational that observations in zoology appear scientifically significant by comparison. Enter Professor Wald. When the underdog realizes that he has had it he rolls over on his back, and the overdog leaves him alone. Well, mostly anyhow. I think I would rather stake my life on this than on the next two generations of time-shared computers.

Mr. Brennan favors ABMs because he would rather save American lives than destroy Russians. That is laudable. But if it is really people the Administration wants to save (rather than factories or manpower) it should urge Congress to embark on an all-out shelter program for the 160 to 180 million survivors because, when all the ABMs have gone off, only the salt mines will be fit for homo sapiens to live in. Furthermore, we do know how to dig holes—the more I think about it, the better I like the idea. In fact, I must excuse myself, I'm getting my shovel. To witness the extinction of the human race, I wouldn't miss for the world.

Max J. Schindler
Boonton, N.J.

Space exploration

In regard to Heinz Trauboth's article on "Space Exploration—Wisdom or Folly?" in October, I would like to make some observations. This article involves several defects in reasoning, which is understandable for one immersed in a discipline. On the other hand, such prejudices are very misleading to the general public, as well as to the scientist.

First, Dr. Trauboth has missed the point of establishing criterions for the merit of investigations, whether scientific or otherwise. The purpose of science is not solely to advance the scope of knowledge, but also to help society and people. The government, or any institution that must allocate funds, should have proper criterions for defining the value of the funds with respect to society in general.

Almost any endeavor can be rationalized in terms of pure teleology. Something more is required. In contrast, what would happen if the same funds that we spent on moon exploration were spent on such other areas as medicine, human relations, or political, economical, or sociological problems? Maybe the spinoffs here would be much greater.

Let's bring the discussion to a domain more familiar to Dr. Trauboth. Suppose the same money had been spent in a technological area such as development of a supersonic transport. Would not the total project have aided society more? Wouldn't the spinoff have been just as great, or greater, in the development of propellants, alloys, etc.? His teacher's conjectures, taken for whatever they're worth, would also have been disproved.

I'm not suggesting that pure science be abandoned; it is supported by research facilities in both education and government, and should be encouraged. But, where large sums of money are to be spent with a specific aim, that aim must be evaluated in terms of the public good by concrete criterions, and not with the hopes of eventual spinoffs that will always take place.

I am not about to investigate what criterions should be applied, since I feel this is an important project that should receive ample funding from the proper agencies. Subjective criterions will not suffice.

Ivan Flores
Flores Associates
Brooklyn, N.Y.

Engineering as an art

There is something especially reassuring about the future of the engineering profession when we are given the opportunity through IEEE SPECTRUM to read the article by Dr. Robert A. Frosch on

Forum

"A New Look at Systems Engineering" (September 1969).

Dr. Frosch has rendered a notable service to the engineering profession by taking time from his heavy duties to alert us to the terrifying influences of "computerized engineering." Since this is something new, the daily press journalists seem to be enamored with their discovery of a new technique of problem-solving and decision-making, and to them nothing is authoritative unless it has been run through a computer.

Of particular importance are the words of Dr. Frosch: "We have lost sight of the fact that engineering is an art, not a technique. . . . We must bring the sense of art and excitement back into engineering. Talent, competence, and enthusiasm are qualities of people who can use tools; the lack of these characteristics usually results in people who cannot even be helped by techniques and tools. . . . The only thing I know that works is to obtain a competent man and his assistants, and make sure they understand the problem. . ."

Adolph J. Ackerman
Consulting Engineer
Madison, Wis.

This discussion is a very relevant one to all engineers, especially to those working in the aerospace and electronics industries. It points to a general acute problem: to what extent can an engineer be a professional; to what extent can he use creativity, apply judgment? The "systems approach" too often seems to relegate the "peon engineer" to a position of a poor substitute for automatic information processing as a tool for management. I could supply many illustrations of the kind of fallacies and failures generated by the "systems approach," which sound unbelievable even though they are case histories.

Erik Unt
South Gate, Calif.

Are you an AFIT alumnus?

During this 50th anniversary year of the Resident School of Engineering, a group of faculty and alumni of the Air Force Institute of Technology are exploring the possibility of reactivating the AFIT Alumni Association. A number of us believe that such an organization can be an effective instrument for graduates to contribute to the unique educational mission of AFIT and aid in shaping its future programs. Equally important, we believe, it can also be the basis of continuing ties of friendship and mutual interest among the alumni. In this regard, we have discussed the possibility of an annual directory that would allow graduates to keep track of "who's where," as well as a quarterly or semiannual newsletter.

However, before we make any organizational commitment, we want to know the feelings of our former graduates toward this project. Because many of our graduates are active in electronics research and are members of IEEE, I am asking for the aid of your publication, to publicize this endeavor and to request prior graduates to drop us a line concerning their views on this subject. In the replies, which should be sent to AFITSE-P (Major Ericson), the class and present address and position should be included.

Any assistance you could give us in this venture would be deeply appreciated.

David M. Ericson, Jr.
Major, USAF
Department of the Air Force
Air Force Institute of Technology (AU)
Wright-Patterson Air Force Base, Ohio 45433

IEEE style for plurals

Every sizable publishing organization has a "style," a list of rules for composition. The new IEEE style for plurals* forms them by adding *-s* (or when appropriate *-es*) in all cases where the irregular form, usually derived from Greek or Latin, is frequently misused by engineering writers. The purpose is to avoid ambiguity by forestalling the loss of the singular form, which has already happened to *data*. The following word list, compiled at the request of the Publications Board, gives examples.

addendum	addendums
agenda	agendas
agendum	agendums
antenna	antennas
appendix	appendixes
auditorium	auditoriums
aurora	auroras
cello	cellos
cherub	cherubs
chorus	choruses
compendium	compendiums
concerto	concertos
continuum	continuums
corrigendum	corrigendums
cortex	cortexes
criterion	criterions
curriculum	curriculums
dogma	dogmas
erratum	erratums
formula	formulas
gnomon	gnomons
index	indexes
larva	larvas
matrix	matrixes
maximum	maximums
medium	mediums
metropolis	metropolises
minimum	minimums
modulus	moduluses
moritorium	moritoriums
nebula	nebulas
nova	novas
octopus	octopuses
optimum	optimums
opus	opuses
pendulum	pendulums
phenomenon	phenomenons
quantum	quantums
radius	radiuses
seraph	seraphs
spectrum	spectrums
spurious	spuriouses
stapes	stapes
status	statuses
stimulus	stimuluses
stratum	stratums
supernova	supernovas
symposium	symposiums
torus	toruses
trauma	traumas
vertebra	vertebras
vertex	vertexes

Some of these forms are already in use by IEEE, and most are either recommended or countenanced by at least some American and English dictionaries. On *agenda*, a comment may not be superfluous; *agenda* in Latin means "things to be acted on" (singular, *agendum*). In English, however, *agenda* means a list of things to be done, and it is singular. Individual items on the list are *agendums*.

The Madison Avenue word *media* has no plural. It is a Latin plural ushered into use as a singular by people not noted for scholarship, nor for promoting clarity of thought; ultimately, it will need a plural form, and the likely candidate is *medias*.

In IEEE publications, the criterion for continued use of irregular plurals will be that they are almost always used correctly by engineers. Examples are the plurals of *axis*, *thesis*, *woman;* the list will diminish as time goes on, but it is safe to predict that *woman* will long remain a special case.

The Editor

* Spectral lines, November 1969

New... a career guidance film

"ENGINEERING... THE CHALLENGE OF THE FUTURE"

THE ENGINEER — Who is he? What is he? Where does he come from? What does he do?

"Engineering — The Challenge of the Future," A new 16-mm film in color, examines the engineer from three perspectives: the potential engineer, the engineering student, the professional engineer.

High school students describe the personal feelings which have led to their choosing engineering. The testimonies are all direct and unscripted.

High school counsellors in their words (not ours) tell about the personal qualities they believe necessary for a career in engineering. The necessary high school preparation is covered.

Engineering students describe engineering school — what they study, why, what they're going to do after they leave school.

Engineering professors cover various aspects of engineering which are responsive to society and people in general.

In a series of closing testimonies, practicing engineers tell what they're doing. Starting with young engineers just out of school, the film moves to those on an intermediate level and concludes with engineers functioning in executive capacities.

Addressed to the individual youngster in high school, the film is designed to answer his personal questions as: What is an Engineer? Should I consider engineering? Would I qualify? How can I find out more about engineering? What happens in Engineering school? What does an engineer do to help people? What are my chances of getting through engineering school? What happens after I graduate? What does the engineer do in his workaday world?

The answers all come from real people in actual situations.

THE FILM, sponsored by Eta Kappa Nu and the Institute of Electrical and Electronics Engineers, is being distributed by the movie committee of Eta Kappa Nu. Industry assisted in this project. The showing time of this 16-mm optical sound color film is 23 minutes.

TO OBTAIN A COPY

A. Inquiries regarding the purchase of the film "Engineering — The Challenge of the Future" may be made to the Eta Kappa Nu Movie Committee whose chairman is J. E. Farley, Illinois Bell Telephone Company, Room 19G, 225 W. Randolph St., Chicago, Illinois 60606.

B. Any high school wishing to show the film can contact their local Engineer's Council for Professional Development, State Guidance Coordinator or Mr. David R. Reyes-Guerra, ECPD Guidance Director, 345 East 47th Street, New York, New York 10017 for a copy.

ETA KAPPA NU

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THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

345 East 47th Street, New York, New York

Spectral lines

A failure of education? C. P. Snow lectured ten years ago on the cleavage between the literary intellectuals and the natural scientists, calling their worlds "the two cultures." It seemed to me even then that a much more disastrous cleavage separates the universities from the world of industry and business.

Education is the process by which a community preserves its cultural pattern, and perhaps provides for criticism and improvement of that pattern. The community consisting primarily of Japan, North America, Great Britain, and Western Europe is oriented toward industrial production of goods and their distribution to as large a fraction of the citizenry as possible. To what degree have educators functioned, during the past 20 years, to orient the young toward this goal? To what degree have industrialists, engineers, and businessmen helped the educators to comprehend the social mechanisms that in one lifetime have converted the U.S. from an underdeveloped nation dependent on foreign capital to the richest nation on earth?

If the function of education is to provide continuity of culture between the generations (continuity, not stagnation!) and if the educators are ignorant of—and despise—the culture, then education collapses.

The ideal that made the dominant college pattern seem rational to the past two or three generations was the Educated Man. In the name of that ideal, professors persuaded U.S. undergraduates to read the dramas of Racine and Grillparzer in the authors' languages, to learn the causes and consequences of the War of the Austrian Succession, and to compare the worldview of Kant with that of Parmenides. The students applied themselves to such tasks with varying degrees of effectiveness; in normally successful cases, the result was a graduate accustomed to disciplined mental effort, able to convey the result of that effort in accurate speech or writing, ready to become an active participant in the productive life of the community, and perhaps eventually a leader in its improvement.

At least two things have disrupted the pattern. One is that the human outlook has been drastically reshaped by science. Increasingly, the great books of the past speak to us in terms to which we do not respond, because science has altered man's picture of what man is. The other change is the death—at the hands of the teachers themselves—of Educated Man, the ideal that coupled the college of liberal arts to the outside world. As research management has displaced teaching as the way to academic prestige, interest of academic people has turned toward transmission of their own subculture, research. Undergraduate courses beyond the first year are designed as preparation for graduate school; as preparation for the world outside the university, they have diminished in value.

Just over a century ago, the Morrill Act (1862) established the land-grant colleges for those in the U.S. who doubted the Educated Man theory. The guiding idea was to offer education beyond high school but to focus on practical knowledge: agriculture, mining, engineering, home economics. These colleges were regarded by many of their graduates as highly satisfactory. However, in recent times they have succumbed, in large numbers, to the prestige values established by the Publish or Perish movement in the older universities.

These changes have occurred during decades when the draft and other social pressures have made college seem almost inescapable to millions of young people who have little zeal for research. The result may well be a breakdown in the system.

There is at least one area in which the death of Educated Man and the glorification of research have not caused great strain. It is engineering. Prospective engineers have operated in the land-grant tradition. They never expected to become Educated Man; they wanted to become engineers. They still do, and the courses that they take are still moving them in the desired direction. The teachers maintain a coupling to the world of the Gross National Product, and often enough their research increases that coupling. Most of them do not feel obliged, at every opportunity, to speak disparagingly of private enterprise. Few feel betrayed by a promising student who leaves off university work and enters industry.

Engineering faculty and students certainly have more concern for the social results of engineering projects than they had a decade ago, but still not very much. Social scientists and their students have developed a burning anxiety about the results of engineering activities, and are determined to regulate them. It is therefore a good bet that near-term, much engineering action will be controlled by people who are out of sympathy with industrial enterprise and ignorant of engineering.

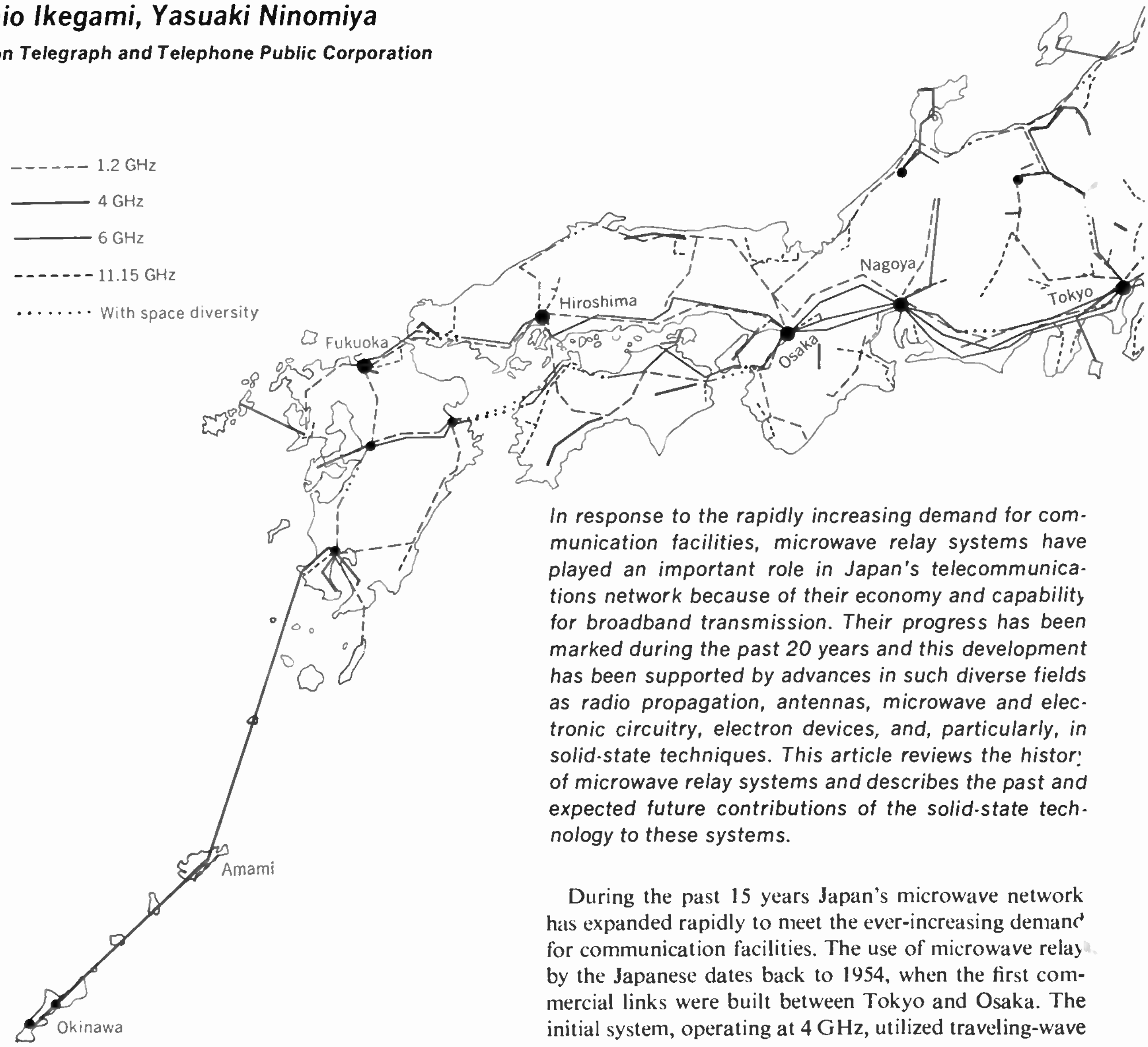
J. J. G. McCue

Note: To forestall a blizzard of letters, it should be said that "culture" is here used as Snow used it, not as anthropologists use it.

Solid-state microwave relay systems in Japan

Since the first link was introduced a decade and a half ago, Japan's microwave relay network has expanded until it now spans the entire country. And the rapid progress in the development of solid-state techniques should accelerate this growth even further

Fumio Ikegami, Yasuaki Ninomiya
Nippon Telegraph and Telephone Public Corporation



In response to the rapidly increasing demand for communication facilities, microwave relay systems have played an important role in Japan's telecommunications network because of their economy and capability for broadband transmission. Their progress has been marked during the past 20 years and this development has been supported by advances in such diverse fields as radio propagation, antennas, microwave and electronic circuitry, electron devices, and, particularly, in solid-state techniques. This article reviews the history of microwave relay systems and describes the past and expected future contributions of the solid-state technology to these systems.

During the past 15 years Japan's microwave network has expanded rapidly to meet the ever-increasing demand for communication facilities. The use of microwave relays by the Japanese dates back to 1954, when the first commercial links were built between Tokyo and Osaka. The initial system, operating at 4 GHz, utilized traveling-wave

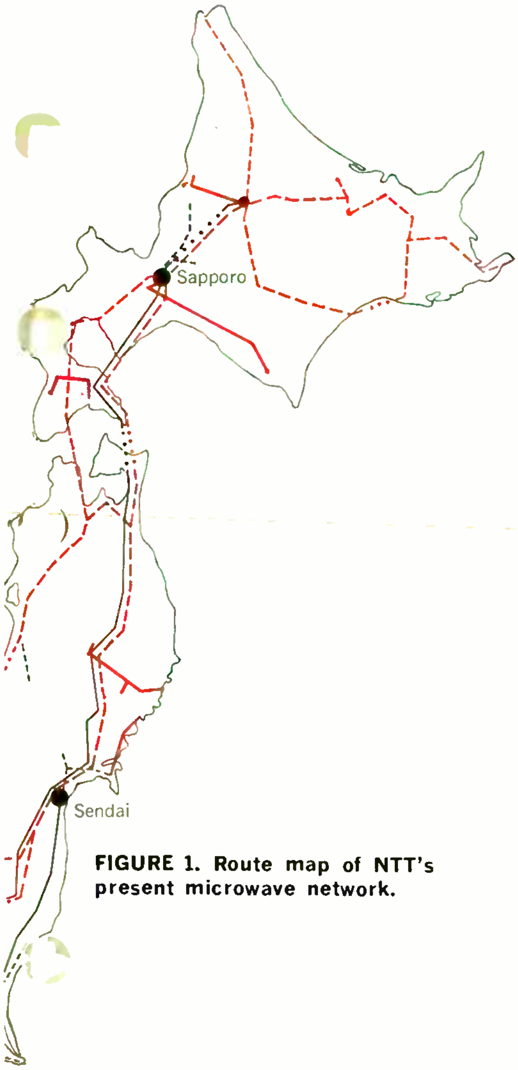


FIGURE 1. Route map of NTT's present microwave network.

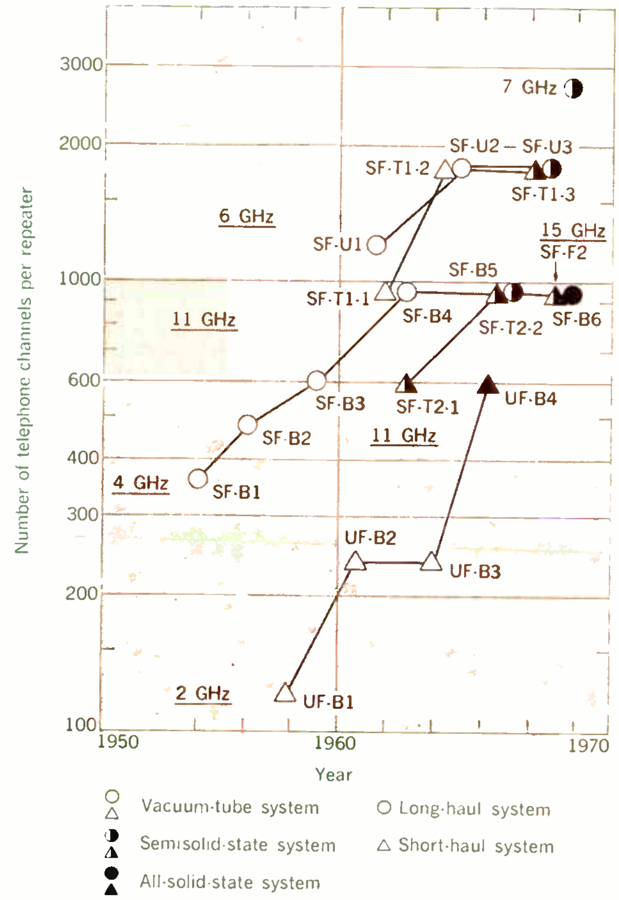


FIGURE 2. History of line-of-sight microwave systems as adopted by NTT.

tubes as microwave amplifiers and could transmit 360 telephone channels. Today, a single system carries as many as 1800 channels and the radio frequency covers the 2-, 4-, 6-, 11-, and 15-GHz bands.

Figure 1 shows a route map of the Nippon Telegraph and Telephone Public Corporation (NTT) network; the history of NTT's microwave system is summarized in Fig. 2 for both long-haul and short-haul links. The latter illustration indicates the increase in the number of channels, the employment of new frequency bands, and the application of solid-state techniques.

Japan's first microwave system has now been improved to carry 960 channels or one color television signal. Another frequency band for long-distance links, the 6-GHz band, was put into operation in 1958 to carry 1200 telephone channels initially; this was increased to 1800 channels in 1964. Recently, a system that can transmit 2700 telephone channels was developed in the upper 6-GHz band (for convenience, to be referred to here as the 7-GHz band), and is now ready for commercial use.

As the need for microwave systems increased, it became expedient to explore a higher frequency—11 GHz. This band is used for short-haul links as the radiowave attenuation caused by rainfall is significant. Because of the heavy traffic between the large cities and their surrounding suburbs, 11-GHz systems are now being used throughout the country. In response to the growing demand for short-haul systems, a 15-GHz system was also developed, in 1966, and is scheduled to be put into commercial use in the near future.

Microwave pulse code modulation (PCM) has been under study at ECL since 1963. In addition to its advantages of high transmission quality and economy as compared with FDM, PCM is expected to resist the effects of radio interference. An all-solid-state 2-GHz PCM system is also considered a promising medium for the transmission of various data signals.

The first application of solid-state devices was to a short-haul 11-GHz system in which, except for the microwave sources (klystrons), the electron tubes were replaced by semiconductor elements. The technique was then extended to 6-GHz 1800-channel and 4-GHz 960-channel systems, with the exception of the traveling-wave tubes. Now, recent advances in these techniques have made possible a 4-GHz 960-channel system composed exclusively of solid-state devices. Figure 2 illustrates the progress from vacuum-tube to semisolid-state to all-solid-state systems.

Together with the above, various fields of microwave technology have supported the development of microwave systems. Radio-propagation studies have enabled us to predict statistically the magnitude of fading and thus have made possible an optimum design for an economical and high-quality system meeting the particular conditions and requirements of the country.

In addition to the conventional microwave relay systems, special techniques were also developed. Space diversity reception has been applied to improve the degradation of transmission performance due to the severe fading that may occur on unfavorable transmission paths or due to meteorological conditions. A special passive repeating device—a diffractor grating—has also proved effective in reducing the transmission loss and fading that might be encountered on a path obstructed by a mountain ridge. The use of mountain obstacle gain can provide a more economical and more reliable long-distance mountain-diffraction link than the usual tropospheric scatter link.

With the integration of these techniques, NTT now has a microwave network that serves all of Japan, from its northernmost point to its southern tip.

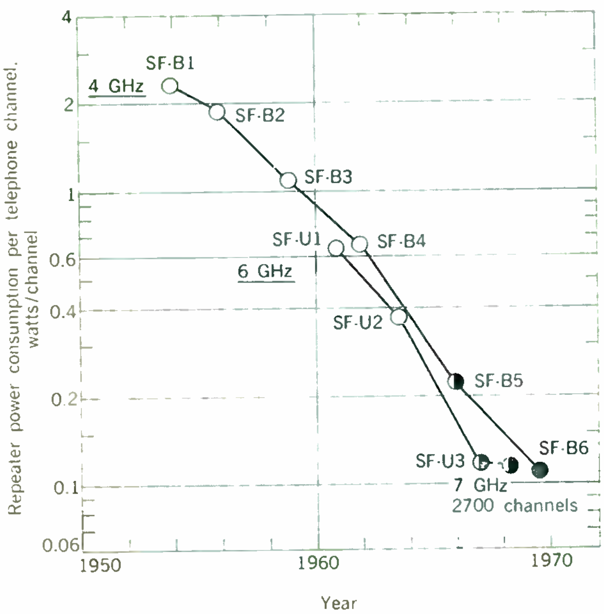
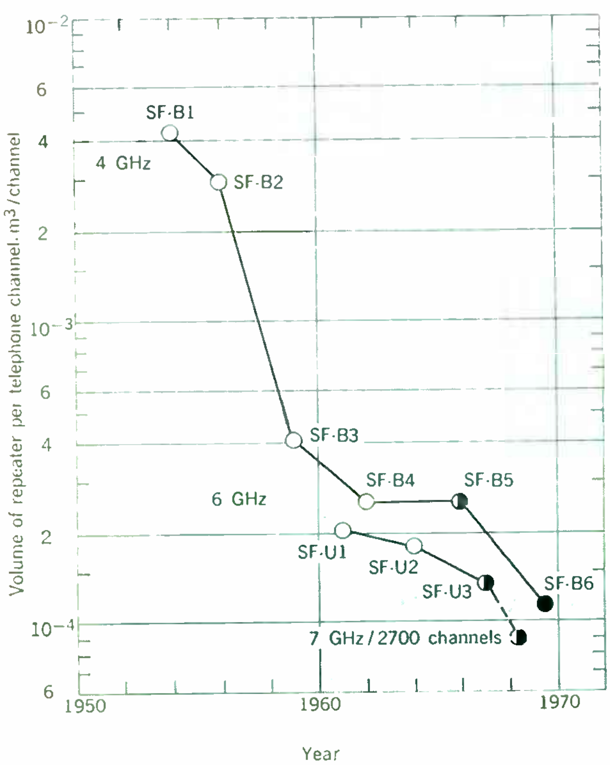


FIGURE 3. Reduction in power consumption of repeaters.

FIGURE 4. Reduction in size of repeaters.



The role of solid-state techniques

How can solid-state techniques contribute to microwave relay systems? The answer is simple—by improving transmission performance and reducing system cost. Or we could say that solid-state techniques result in systems that are more economical for a given quality of performance.

The application of solid-state techniques can provide improved equipment reliability, reduced power consumption, and a decrease in equipment size. In what follows, we shall examine the role played by solid-state techniques in the advancement of microwave relay systems.

Equipment reliability. It is well known that solid-state elements—transistors and diodes—inherently have unlimited life when operated under ideal conditions. Compare this with electron tubes, which have the intrinsic limitation of cathode emission. For example, the life of an ordinary electron tube is of the order of 10 000 hours; in comparison, the reliability of a typical transistor or diode operating as an active element is approximately 100 FIT [100 failures per 10^9 device (operating) hours], which corresponds to a mean time between failures (MTBF) of some 10^7 hours.

Thus, the use of solid-state devices greatly reduces the failure rate of microwave equipment and consequently the maintenance cost that would be required for the necessarily more frequent checks of vacuum-tube equipment, particularly at unattended relay stations.

Power consumption. One of the most important contributions of solid-state techniques is in the efficiency of active devices; in other words, the power consumption of the relay equipment is greatly reduced. Figure 3 illustrates the reduction in equipment power consumption for long-haul systems.

Moreover, reduced power consumption can simplify the power supply facilities. For vacuum-tube equipment, a three-unit standby generator is provided as an emergency power supply in order to maintain uninterrupted, continuous operation. For solid-state equipment, a floating battery and solid-state power system are utilized in lieu of the three-unit generator, which can be a source of power trouble. Thus, with solid-state devices, the frequency of power system failure is greatly reduced, as is the cost of the system.

Equipment size. Repeater equipment is growing progressively smaller as microwave techniques advance. An example is shown in Fig. 4, which indicates the variation in volume per channel with time for long-haul repeaters. Figure 5 compares vacuum-tube, semisolid-state, and all-solid-state repeaters. Also, the size of frequency modulators has been markedly reduced by the use of diode modulator circuits in place of vacuum-tube circuits.

Smaller-size and lighter-weight equipment is effective in

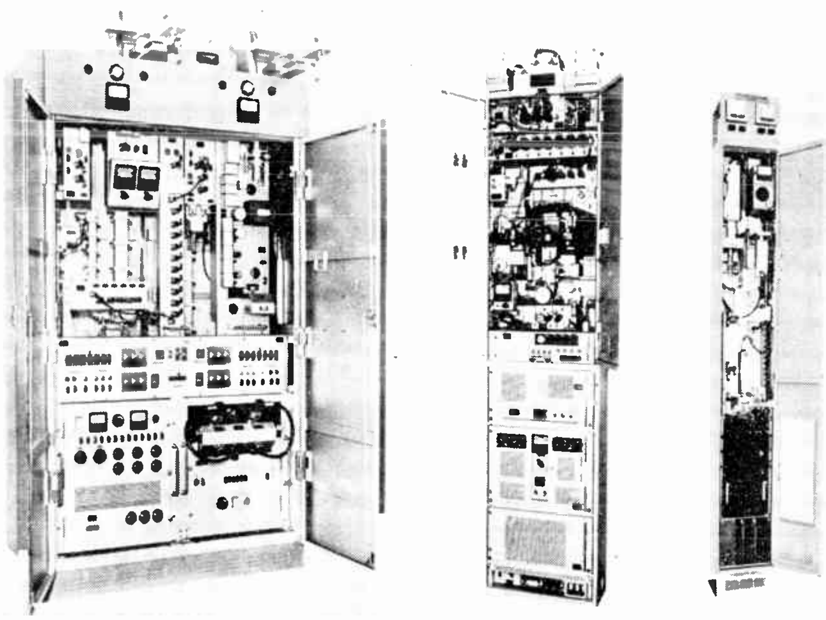


FIGURE 5. Reduction in size of the 4-GHz repeater. At left is the first vacuum-tube model (SF-B1), in the middle is the latest vacuum-tube model (SF-B4), and at right is the all-solid-state model (SF-B6).

turn in reducing the repeater station size and the installation cost.

As stated in the foregoing, solid-state techniques contribute to the economy of microwave relay systems in various ways. The actual improvement of equipment by the application of solid-state techniques results as a combination of the above factors. Let us review some examples of our experience with existing microwave systems.

System cost. A typical example of a reduced-cost microwave repeater system is seen in the 11-GHz short-haul system (SF-T2), which reflects our first application of solid-state techniques. Here, all tubes were replaced by transistors and diodes, except for the klystrons used as microwave sources. As a result of the reduced power consumption and equipment size, the power supply and the station building can be simplified. A small shed can be used as a station instead of the conventional large building. This shed, with its equipment, is transportable. Figure 6 shows such a station; Fig. 7 compares the initial cost with that for a similar system using tubes (SF-T1). If one includes the reduced cost of the repeater, the power supply, and the building housing the equipment, the total cost is less than half of that of a vacuum-tube system.

System reliability. The reliability of microwave systems depends mainly on the equipment and on propagation conditions. Although unexpected severe fading can cause degradation of reliability, this factor has been improved by use of space diversity reception. Figure 8(A) shows the failure rate for vacuum-tube systems as based on the maintenance data of the NTT microwave network. As seen from this illustration, failures on such equipment as repeaters, modulators, demodulators, and generators account for most of the total failures.

Efforts have been made to reduce equipment failure by means of solid-state techniques. The actual failures of semisolid-state systems on the NTT network have been reduced to about a third of those of vacuum-tube systems, as shown in Fig. 8(B), with far fewer failures of radio equipment and power plant.

Even in semisolid-state equipment the reliability depends mainly on the solid-state elements. Particular care was taken to keep the failure rate of the transistors and diodes within 100 FIT in normal operation and less than 1000 FIT under the severest operating conditions.

Practical failure data collected by the NTT Maintenance Department on different types of repeaters are given in Fig. 9. Here, "total failure" covers all types of failures, including those cases where the equipment was found to be below the specified standard before it actually failed. Many circuit interruptions can be avoided by switching from a failed channel to a spare channel.

As seen from this figure, in any frequency band the total failure rate of the vacuum-tube-type repeater is several times that of the solid-state repeaters, and the ratio of failure in operation to total failure is high for tube-type equipment and low for solid-state equipment. The latter fact indicates that vacuum-tube equipment requires more careful checking and higher-level maintenance techniques for the same order of reliability as the solid-state type.

Present status of solid-state devices

Solid-state techniques are now being used in various devices in microwave systems. For devices of lower power-handling ability, the replacement of electron tubes by solid-state elements is relatively simple, but it is difficult to accomplish in high-power active devices. The difficulty has been overcome for medium-power generation at the lower microwave frequencies but it is not anticipated that the transition will be made in the foreseeable future for all electronic devices.

Generally, electronic components must be smaller for use at higher frequencies. In solid-state elements the interaction between the electron current and the crystal lattice takes place in the same region in which heat is generated; hence, heat dissipation poses a serious problem in high-power operation at the higher frequencies. However, in an electron tube the generated heat can easily be dissipated through a metal electrode that is separate from the active region of the electron beam.

The foregoing restriction should be considered in designing solid-state microwave relay repeaters. Figure 10 shows three examples of microwave heterodyne repeater construction. It has been concluded that, at the present state of the art, type 1—solid-state equipment with a traveling-wave tube—is most favorable for frequencies above about 6 GHz as far as economy and maintenance are concerned. At present, the TWT provides an excellent active element for use with power outputs of more than several watts.

The 6-GHz 1800-channel and the 7-GHz 2700-channel systems are of type 1 because of the high power output required for broadband transmission. The former system necessitates an output of several watts and the latter an output of some 20 watts with a receiver noise figure of 8.5 dB, making use of a Schottky barrier diode. As a 4-GHz 960-channel system requires a power output of about one watt with a receiver noise figure of 6 dB, the all-solid-state configuration, type 3, without a parametric amplifier has been realized with a power consumption of 100 watts and MTBF of 30 000 hours.

The principal applications of solid-state techniques to microwave devices include the following.

Low-noise amplifier. In 1954 ECL experimented with a parametric amplifier utilizing the nonlinear capacitance characteristics of a diode, and later parametric amplifiers were studied as low-noise amplifiers with improved varactor diodes. As a result of these studies,

FIGURE 6. Example of an 11-GHz relay station housed in a small, transportable shed.

FIGURE 7. Comparison of initial costs of an 11-GHz repeater station.

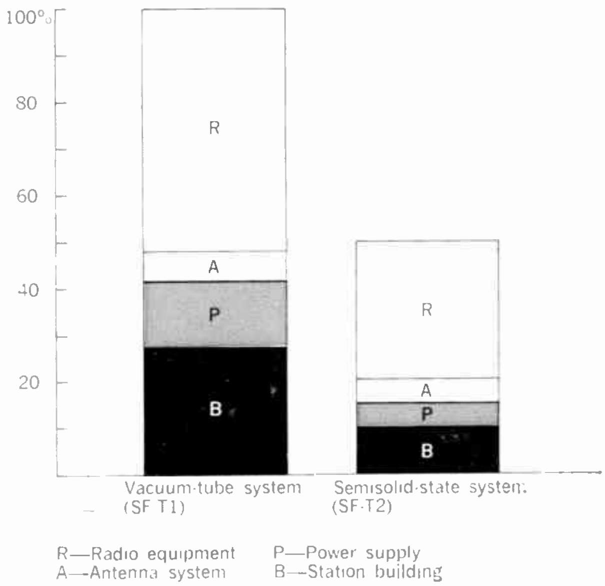
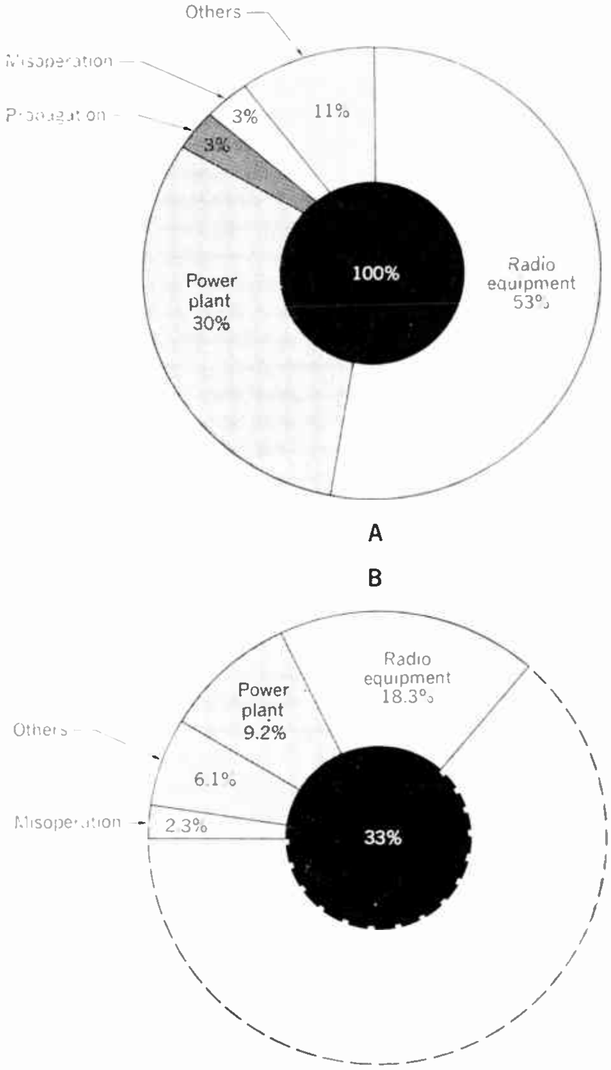


FIGURE 8. Field data on operating failures. A—Vacuum-tube system. B—Semisolid-state system.



in 1962 a reflection-type parametric amplifier was adopted for the 1-GHz and 2-GHz mountain diffraction network between Kyushu and Amami Island. Studies have been continued on amplifiers for 4-GHz, 7-GHz, and 11-GHz systems but these amplifiers have not been adopted for line-of-sight systems because of maintenance difficulties and their relatively high cost.

In 1957 Esaki invented a diode with a simple structure and the possibility of application up to microwave frequencies; it was adopted by NTT for the first-stage amplifiers of their 2-GHz and 11-GHz systems in 1966 and 1967 respectively. These amplifiers could be connected to repeaters for use on links subject to unfavorable propagation conditions, such as severe atmospheric fading or rainfall attenuation at 11 GHz.

Frequency converter. With advanced techniques, the noise figures of conventional receiving converters are being reduced to values just a little higher than those for low-noise amplifiers operating at normal temperatures. This could be accomplished by the development of Schottky barrier diodes and a converter circuit with a reactivity terminated image. A low-noise converter of this type, being simple in structure, easy to maintain, and inexpensive, has been adopted widely for line-of-sight systems such as the 7-GHz 2700-channel semisolid-state system and the 4-GHz 960-channel all-solid-state system. The overall noise figures are 8.5 and 6.0 dB respectively.

For a transmitting frequency converter, nonlinear resistance diodes have been in use since the first microwave systems. For higher conversion efficiency and transmitting power, the application of varactor diodes has made possible a conversion loss of 4 dB and transmitting power of one watt at 4 GHz. This type of converter is used with NTT's 2-, 4-, and 7-GHz systems.

IF amplifiers. The intermediate-frequency amplifiers of a microwave repeater are wide-band multistage transistor amplifiers with a mid-frequency of 70 or 140 MHz. A wide-band impedance transformer is used for interstage coupling and the terminating condition of each amplifying stage is designed to give stable amplification in order to obtain broadband transmission characteristics with high stability.

An effort has been made to control the amplifier gain automatically without degradation of the wide-band transmission characteristics. Previously, automatic gain control was effected by controlling the emitter current of a transistor, as shown in Table I. More recently, a method of varying the interstage transformer ratio by means of a varactor diode (or using a transistor variolosser) has been introduced, as shown in the table.

Local oscillator. In microwave regions, microwave sources composed of a transistor amplifier or oscillator and a varactor diode frequency multiplier chain are most practical and are widely used. The varactor chain frequency multiplier sources can provide power efficiency, output power, and noise performance equivalent to those of a klystron. A high-power varactor chain microwave source, developed by ECL, has been adopted for the all-solid-state 4-GHz 960-channel system. An output power of 3.5 watts and MTBF of 100 000 hours are obtained as shown in Fig. 11.

Modulator. The hyperabrupt junction diode has contributed a great deal to the solid-state frequency modulator. It has been successfully applied to FM modulators in microwave repeater systems as a resonance element in the oscillator circuit. Modulators of this type are now in practical use for 1800-telephone-signal modulation in the 70-MHz band and for 2700-telephone-signal modulation in the 140-MHz band.

Solid-state elements. The advances in solid-state de-

FIGURE 9. Failure rate for repeaters.

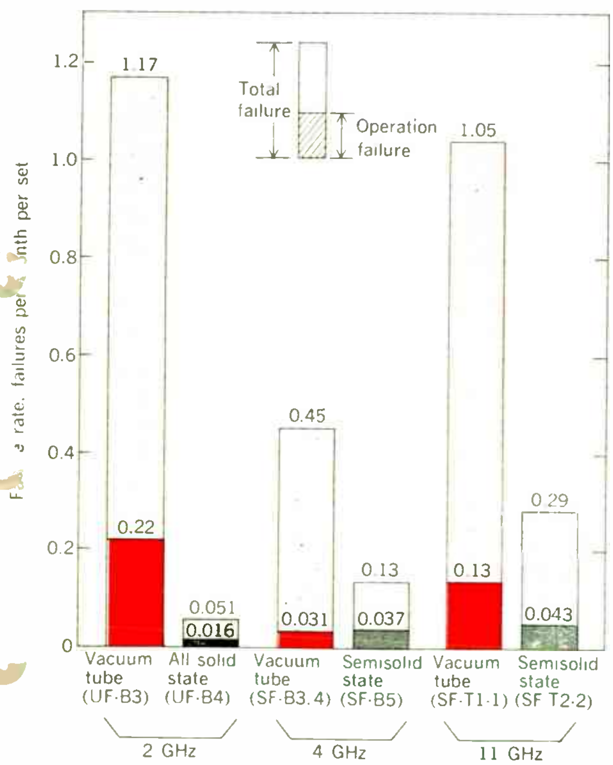
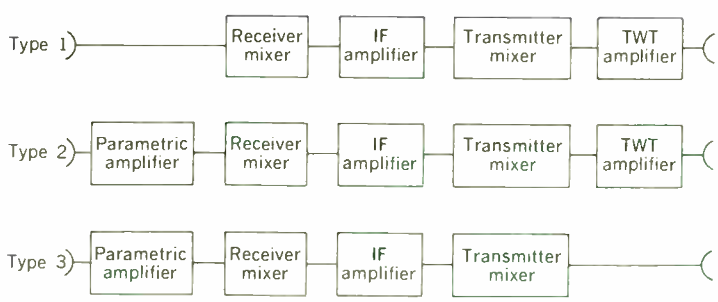


FIGURE 10. Repeater construction of a 6-GHz 1800-channel system. A—Types of solid-state repeater construction. B—Comparison of power consumption for various types of repeater.

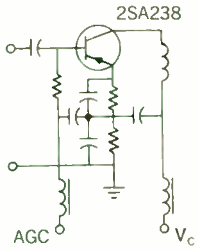
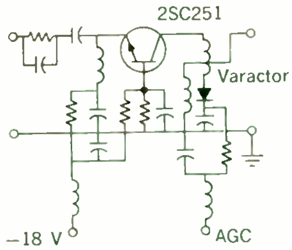
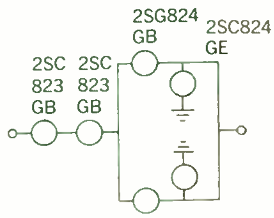


A

B

Characteristics \ Type	Type 1	Type 2	Type 3	Present Vacuum-Tube Repeater
Noise figure, dB	7	4.8	4.8	12.5
Transmitting power, watts	3.7	2	2	14
Multiplier-type local-oscillator output, watts	0.1	0.7	8.1	0.2
Total power consumption, watts	100	80	300	600

I. Progress of transistorized IF amplifier circuits

Year	1961	1964	1967
System	SF-T2-1 11 GHz/600 channels	SF-U3 6 GHz/1800 channels	7 GHz/2700 channels
Intermediate frequency, MHz	70	70	140
Unit main IF amplifier circuit			
AGC	Emitter current control	Varactor bias control	Transistor variolosser

vices described have been supported by the development of various solid-state components.

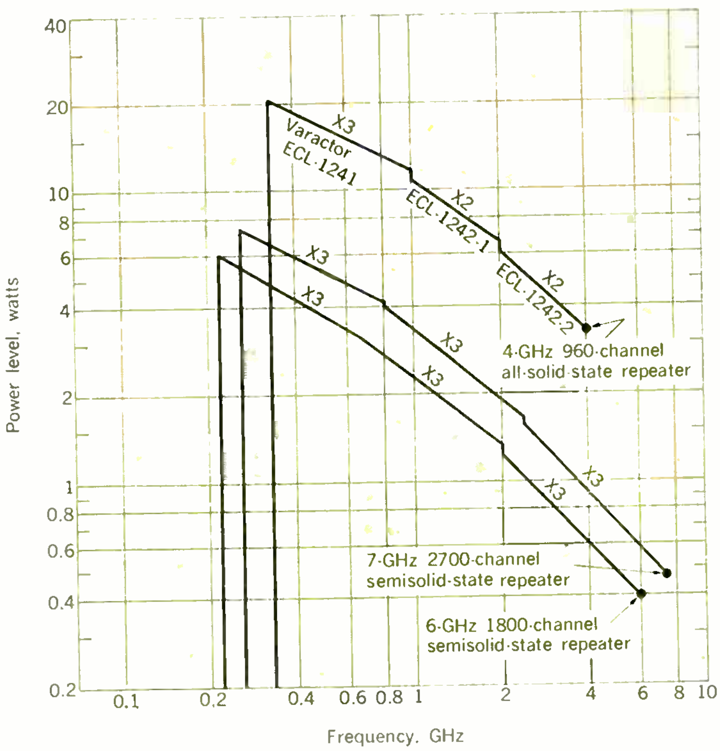
In 1958 the Kita diode was invented at the NTT Electrical Communication Laboratory as a nonlinear capacitance diode for a parametric amplifier. Now, GaAs epitaxial-type diodes with a cutoff frequency of up to 400 GHz are available. A tunnel diode with a cutoff frequency of 30 GHz has also been developed and is being used for amplifiers operating in the 11-GHz band.

In addition, a Schottky barrier diode for a receiving mixer in the microwave region is now available with a noise figure of 4.5 dB (the noise figure at the input of an IF amplifier is 1.5 dB). For low-noise amplifiers in the 70- or 140-MHz band, a silicon-planar-type transistor with a noise figure of 1.5 dB has been developed.

Varactors have also been developed for high-power microwave generators. Various chains of frequency multipliers presently in use are shown in Fig. 11. They operate at junction temperatures lower than 120°C with sufficient reliability. Varactors are also used for high-power transmitting converters.

Furthermore, a silicon-epitaxial-type hyperabrupt junction diode has been developed as a nonlinear capacitance diode and is being utilized for intermediate-frequency modulators in microwave systems of up to 2700-channel capacity. Figure 12 shows the various diodes and transistors now in use.

FIGURE 11. Power-level-frequency diagram for varactor-chain local oscillator.



The future

So far we have discussed the past and present of solid-state techniques as applied to Japanese microwave relay systems. What can we expect in the future? It is not easy to make predictions as solid-state techniques are advancing daily. However, it is interesting to consider what today's engineers are thinking about for tomorrow.

New solid-state devices. As mentioned previously, the TWT is presently regarded as a superior element for the transmission of more than 1800 channels. However, in view of equipment reliability and maintenance considerations, future microwave systems could go to solid state, thus challenging the TWT's superiority in this field. Here, improved solid-state elements, such as Gunn, IMPATT, or other new diodes, show promise.

Gunn and IMPATT diodes are rapidly progressing with regard to their electrical characteristics and their methods of manufacture. They are also being tested as system components; for example, the ECL has demonstrated the possibility of applying a Gunn diode to frequency modulation (coupling a Gunn diode to a varactor-loaded resonan' circuit). Figure 13 illustrates a prototype Gunn diode modulator. At present, its electrical performance is considered adequate for modulation of a 960-channel telephone signal. The IMPATT diode is more suitable for use with a high-power microwave generator but has a disadvantage in that its thermal noise is greater than that of a Gunn diode. In an effort to overcome this, the phase-loc' technique is now being studied as a prospective remedy.

Recently, still another approach to semiconductor devices has been considered. An n-type GaAs diode, in-

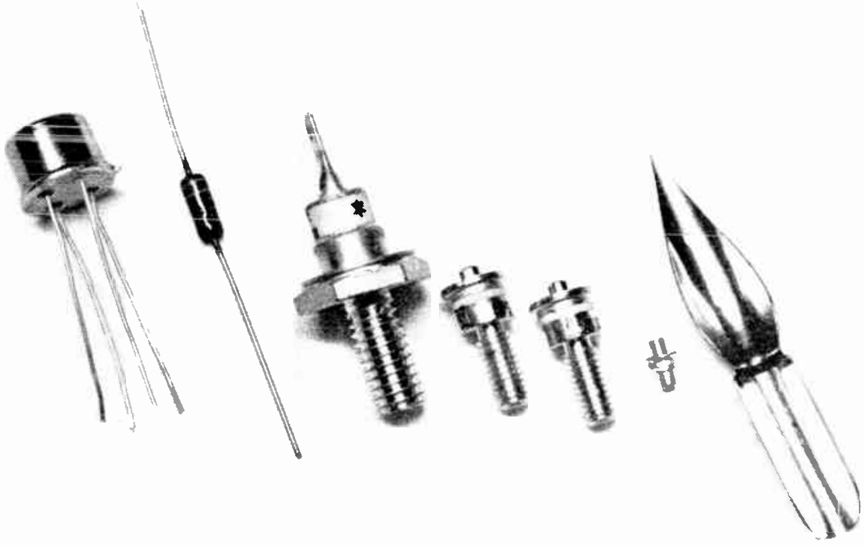


FIGURE 12. Solid-state elements currently in use for microwave repeaters. From left to right: transistor for a low-noise IFA (2SC823); hyperabrupt junction diode for frequency modulator (1S1617); two varactors for a high-power frequency multiplier (ECL-1241A, ECL-1242-2A); varactor for a high-power transmitting mixer (ECL-1305); Schottky barrier diode for a low-noise receiving mixer (SM-153).

FIGURE 13. Prototype of Gunn diode frequency modulator for the 11-GHz band.

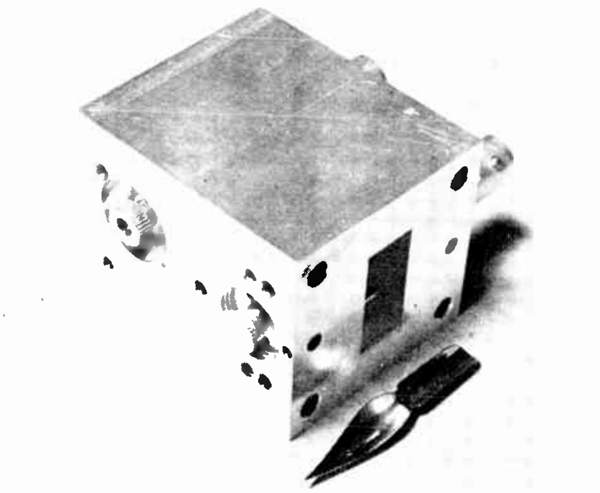
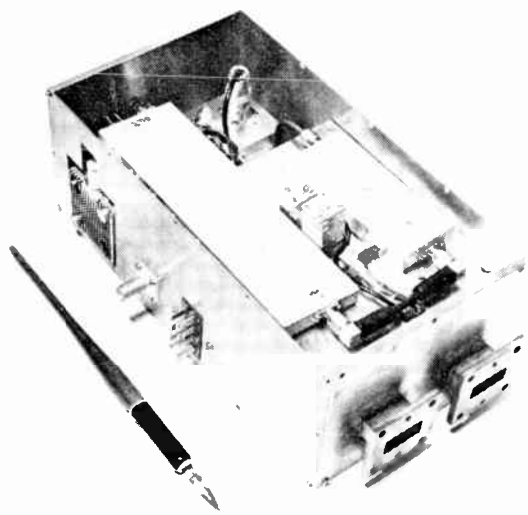


FIGURE 14. Prototype model of 11-GHz short-haul repeater using ICs.



jected with a high electric field exceeding 3.5 kV/cm, generates Gunn oscillation. If the oscillation is suppressed in any way, an increasing space charge wave travels along the electron beam. A new amplifier based on this principle is under study at ECL and Stanford University.

In an ECL experiment a maximum gain of 30 dB and saturation power of 3 dBm were obtained at 1.5 GHz with microsecond pulse insertion. An improvement in heat dissipation would lead to continuous-wave amplification and an increase in saturation power, which would make this a promising microwave amplifier element for the future.

Integrated circuits also should provide one of tomorrow's significant technologies. Such circuits are now available for frequencies below about 100 MHz and for maximum handling power of about one watt. For such frequency and power levels, integrated circuits are presently in commercial use in portable radio equipment. The application of integrated circuits to microwave repeaters will also be possible for lower-frequency components, with the exception of inductors and transformers. As for microwave circuits, the miniature elements could be effective in obtaining the broadband characteristics that would be required in future microwave systems. The ECL is currently experimenting with an 11-GHz short-haul repeater using integrated circuits, as shown in Fig. 14. The use of these circuits should contribute greatly to the development of reliable, small-size, low-cost microwave equipment.

Tomorrow's systems. In viewing the future trend of microwave systems, it is necessary to consider why these systems are used to such a great extent. The main reasons are economy and the capability for broadband transmission that is gained by wave propagation in free space. However, there are disadvantages in that the transmission characteristics may be variable due to the effect of atmospheric variations and that the RF utility may be limited by mutual interference between links because of the transmission through open space. A great deal of effort has been expended to make best use of the advantages and to overcome the disadvantages.

Today's all-solid-state equipment can carry 960 telephone channels at most. Traveling-wave tubes are used to transmit 1800 or more telephone channels because a combination of solid-state devices and the TWT is more advantageous than all-solid-state equipment with regard to economy and power consumption. If new devices such as high-efficiency high-power transistors or bulk amplifier elements are developed, the existing semisolid-state system could be replaced by all-solid-state equipment by taking advantage of the merits of solid-state techniques.

As for broadband capability, which is now attaining as many as 2700 channels, we may ask: "In our future transmission network, how many channels will be required and will be technically available?" Present techniques, including radio and wired communication, can provide sufficient transmission capacity to meet the future demands of telephone, telegraph, and data services. However, the trend of information innovation certainly will require expanded visual services, which necessitate much broader transmission bandwidth. For example, future transmission mediums for a trunk line should provide information capacity equivalent to a million telephone channels. In meeting this requirement, microwave systems may encounter difficulties. The first of these arises from the limitation on radiation power by CCIR recommendation, which requires that radio frequencies be shared between terrestrial and satellite communication systems. The second difficulty results from the restriction on economy and frequency utility as far as existing system design is concerned. The third lies in the limitation on frequency bandwidth due to the propagation distortion that would occur under ordinary conditions.

A solution that has been proposed many times over the years is the use of millimeter-waveguide or laser-beam-waveguide transmission. The ECL has studied millimeter-waveguide transmission systems for more than 15 years. Combining the techniques developed on waveguide transmission lines, millimeter-wave filters, TWTs, high-speed pulse techniques, and millimeter-wave circuitry and components, a transmission test was carried out successfully in the spring of 1968 on an experimental 8-km waveguide line. The PCM bit rate was 225 Mb/s, which corresponds to 3000 or more telephone channels. The repeaters used were all-solid-state prototypes. Further development is anticipated by the extension of solid-state techniques to future systems capable of transmitting several hundred thousand telephone channels on a single waveguide line.

In considering the future trend of radio systems utilizing open space as a propagation medium, two approaches may be anticipated: PCM relay systems using higher microwave frequency ranges, and application of radio systems to lower stages of the communication network.

As the existing microwave systems would be limited as to the maximum number of channels, it is necessary to utilize higher frequencies and new system configurations. At frequencies higher than about 10 GHz, the repeater spacing must be decreased because of the large attenuation due to rainfall; the subsequent increase in the number of repeaters causes difficulties in system design because of the accumulation of transmission distortion. A PCM radio system with regenerative repeaters is considered more favorable for this use, as in this system distortion does not accumulate with relaying. Thus, as the shorter relay span results in an increase in system cost and difficulty of maintenance, such a system requires maintenance-free, small-size, low-cost repeaters. In this respect, the value of highly reliable solid-state equipment, perhaps making use of integrated circuits, should be recognized in the coming years.

The second approach would be found in that broadband transmission lines will be required not only for trunk lines but also for links to subscriber lines to meet the demand for broadband video signals. Because of the radio system's transmission capability, the utilization of microwave might become necessary for links between switching offices and between an end office and a subscriber. In this approach, solid-state techniques would be indispensable for mass production of maintenance-free low-cost microwave systems.

With either approach, and for any other application of microwave systems, the future trend will be to advanced techniques that can meet the requirements of low cost and freedom from maintenance. The solid-state techniques, including new elements, devices, and integrated circuits, will do much to promote the coming age of information innovation.

Fumio Ikegami (M) was born in Manchuria in 1926. He received the B.S. degree in electrical engineering in 1947 and the D.Sc. degree in engineering in 1956, both from Kyoto University, Japan. From 1947 to 1949 he worked at the Ministry of Telecommunication Radio Wave Bureau, in the field of VHF propagation. Since the reorganization of the ministry in 1949 he has been with the Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation, Tokyo. For 15 years he worked on tropospheric radio propagation and antennas and related problems.

In recent years Dr. Ikegami has been involved in the development of microwave solid-state repeater systems, including a super-broadband relay system, and research on future radio communication systems. At present he is deputy director of ECL's Research Division. He has been an instructor in antennas and radio propagation at Seikei University, Tokyo, since 1965. He is a member of the Institute of Electronics and Communication Engineers of Japan.

Yasuaki Ninomiya was born in Sendai, Japan, in 1926. He received the B.S. degree in communication engineering from Tohoku University, Sendai, in 1951. Since 1951 he has been associated with the Electrical Communication Laboratory of the Nippon Telegraph and Telephone Public Corporation, Tokyo, and was engaged in R&D work on microwave measuring equipment until 1959. He received the Ph.D. degree from Tohoku University in 1962.

From 1959 to early 1969 he worked on the development of solid-state microwave circuits and equipment, specializing in high-power, high-efficiency microwave frequency multiplexer circuits. He contributed to the development of 6-GHz and 11-GHz 1800-channel relay systems, a 7-GHz 2700-channel system, and a 4-GHz 960-channel all-solid-state system. During 1968 and early 1969 he served as director of the Radio Transmission Section. He is now director of the Electronic Circuits Section.

Dr. Ninomiya is a member of the Institute of Electronics and Communication Engineers of Japan.

Market trends in the electronics industry

Although the economic pace of U.S. electronic industries has slackened in recent years, sales of products to industry are on the rise. These trends have important implications for the future technological base of the industry

Donald G. Fink General Manager, IEEE

The statistical survey of the electronics industry in the United States, published annually by the Electronic Industries Association, for several years has shown a trend of importance to all IEEE members whose employment and job assignments depend on the markets for electronic systems, equipment, and components. That trend is a decrease in the year-to-year growth of factory sales in two major components of the industry: products sold to the government and to the consuming public. The other major component, sales of industrial products, has shared this trend of arrested growth, but there is an encouraging turnaround that is evident in the projected figures for 1969. Although product sales are by no means the only significant economic factor in these industries, this indicator has a fundamental influence on future product design and development. The statistics reviewed in this article are taken by permission from the recently published "EIA Yearbook — 1969." This 94-page document[1] contains detailed data on sales of individual product lines, funding, employment, and related industry statistics. It is recommended highly to IEEE members, in the U.S. and elsewhere, who have an interest in the economic underpinning of our profession.

The record of the past

The statistics of Table I show factory sales of the four major classes of electronic equipment over the years from 1914 to 1968. The data in the early years are scattered and approximate, but a clear indication of the record growth can be obtained in two categories since 1935, and in four categories since 1950. Figure 1 displays the trend lines graphically, with the projection for 1969 added.

Observers of industrial growth concur that the record over these years is matched by no other industry of comparable scope. Consider the 35-year span from 1935 to 1969. Total sales over these 35 years increased more than

I. Industry summary of factory sales by selected years, 1914–1968 (in millions of dollars)[1]

Year	Consumer Products	Industrial Products	Government Products	Replacement Components	Total
1914					1
1919					8
1921					11
1923	13				54
1925	92				180
1926	94				187
1927	95				200
1929	275				465
1931	125				220
1933	73				135
1935	135		20		240
1937	182		28		350
1939	186		37		340
1947	810		680		1 750
1950	1 500	350	655	200	2 705
1951	1 400	450	1 193	270	3 313
1952	1 300	500	3 100	310	5 210
1953	1 400	600	3 230	370	5 600
1954	1 400	650	3 100	470	5 620
1955	1 500	750	3 332	525	6 107
1956	1 600	950	3 595	570	6 715
1957	1 805	1 300	4 130	610	7 845
1958	1 660	1 405	4 725	475	8 265
1959	2 002	1 676	5 373	530	9 581
1960	2 018	1 980	6 124	555	10 677
1961	2 020	2 585	7 190	580	12 375
1962	2 435	3 025	8 080	620	14 160
1963	2 604	3 610	8 841	590	15 645
1964	2 940	4 268	8 775	620	16 603
1965	3 641	5 222	8 969	630	18 462
1966	4 528	5 842	10 330	640	21 340
1967	4 378	6 373	11 720	650	23 121
1968	4 619	6 693	12 504	675	24 491

Sources: Electronics Division, Business and Defense Services Administration, Bureau of the Census, and EIA Marketing Services Department.

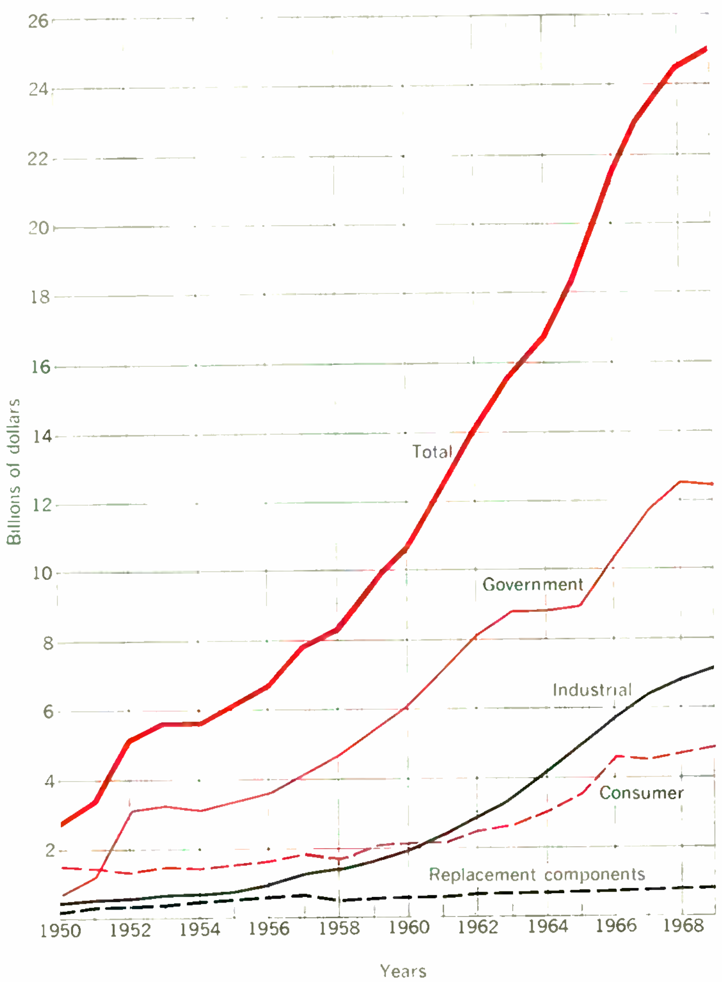


FIGURE 1. Graph of factory sales of electronics by markets (1950–1969). Note that the long-term growth of sales has been steadily upward for 20 years, but in recent years the curves are flattening.

100 times, from $240 million in 1935 to an estimated $25 billion in 1969. Consumer product sales increased about 36 times. The big factor was government products, which have posted a 35-year increase of over 600 times.

The growth over the postwar period, 1950–1969, is significant because it has been achieved *after* the substantial base established during and immediately after World War II. During these 20 postwar years, the growth of sales of consumer products and replacement components has been modest, about three times. Government sales are still the major factor, accounting for a *postwar* increase of nearly 20 times. Equally important, the record of industrial product sales shows an impressive 20-times increase, reaching estimated sales in 1969 of $7.15 billion.

Is there a plateau in the making?

These long-term records are just cause for establishing pride for every engineer and technical worker who researched, developed, and produced the products, and for the sales engineers and other marketing people who served the markets for them. But, as often happens when congratulations on past accomplishments are in order, someone is bound to ask: "What have you done for me lately?" The recent record, over the years 1966–1969 inclusively, gives cause for concern, because there has been a definite flattening out of the products sales curves. These trends are clearly shown in Fig. 1. Although there has been continued growth in sales, the slope of the curves has been flattening, particularly in the last two years. In the largest component of all, government products, a slight *decrease* is projected for 1969 relative to 1968.

Figure 2 has been prepared to illustrate these year-to-year trends in more specific form. As the upper chart of this illustration demonstrates, 1965 was a good year by any standard; total sales exceeded those of 1964 by a healthy 11 percent. The year 1966 can only be classed as a boom year; in that year, the increase over the prior year was nearly 16 percent. Since then the year-to-year growth in sales has steadily declined: 8.4 percent in 1967, 5.9 percent in 1968, and estimated to be less than 3 percent in 1969. If we take account of inflationary price increases, which have affected electronics no less than other industries, it appears that in 1969 the sales growth has in fact stopped altogether, if measured in the preinflation value of the products. The lower four charts of Fig. 2 show the year-to-year percentage growth in the four categories.

Only time will tell whether this slowdown is a temporary phenomenon or a reflection of conditions faced by industry at large, or whether it arises from a significant,

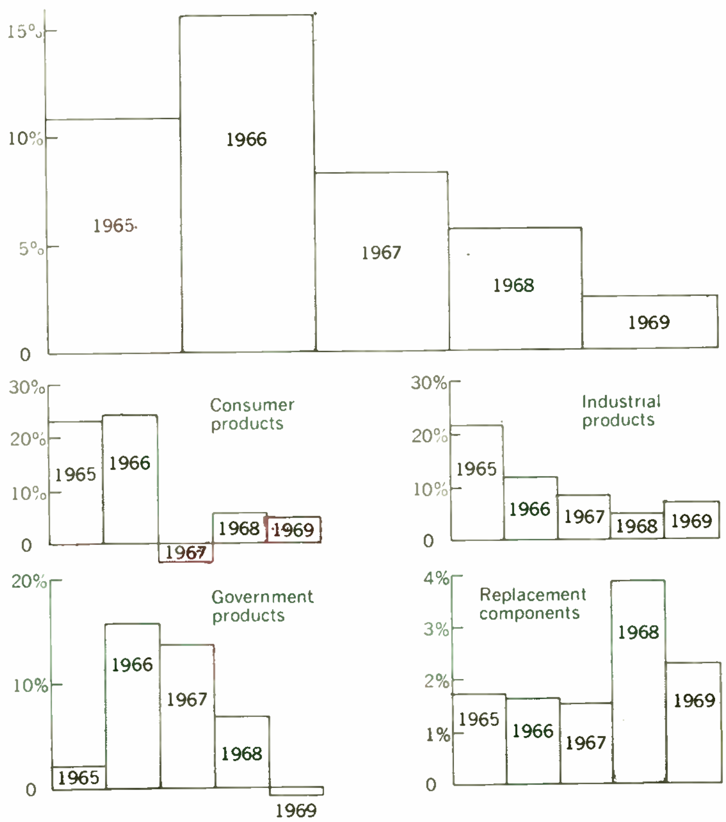


FIGURE 2. Total and individual year-to-year comparisons of factory sales (1969 data are estimated). These results compare the year indicated with the year before.

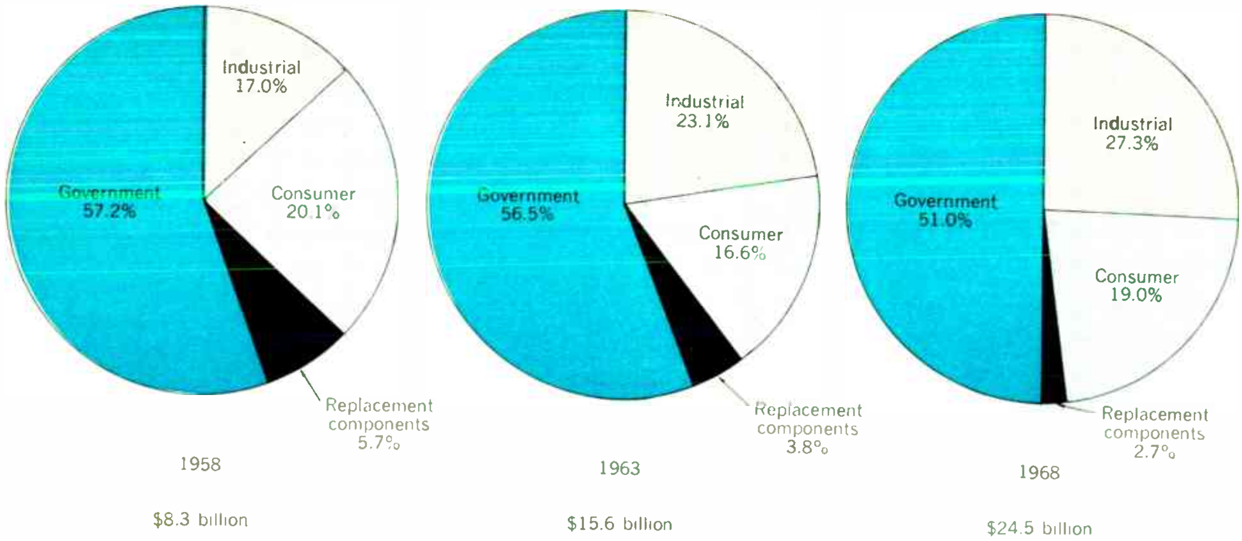


FIGURE 3. Distribution of factory sales among major product categories (1958–1968). Note the increase in industrial sales percentage and decrease in government percentage.

long-term shift in the market for certain classes of electronic products. Prudence dictates that this last possibility be carefully studied.

The growing percentage of industrial products

Further evidence provided by the *EIA Yearbook*[1] shows that the mix of product types has undergone consistent shifts over the past ten years in the two largest categories—government and industrial products.

The pie charts in Fig. 3 show the relative percentage of sales in the four categories over a ten-year span. Total sales trebled from $8.3 billion to $24.5 billion in that time, and nearly doubled in the first five years. But the relative emphasis on types of products has significantly changed. Most impressive is the increase in percent of the total accounted for by industrial products, from 17 percent in 1958 to over 27 percent in 1968. A further increase to about 28.5 percent is forecast for 1969. The cause of this shift is not hard to find: the electronic computer and its accessories are industrial products.

Conversely, Fig. 3 shows a steadily decreasing percentage attributable to government products, from just above 57 percent in 1958 to 51 percent in 1968, with a particularly sharp percentage drop in the last five years. The 1969 estimates show a further decline to 50 percent.

There are many reasons that can be given for the relative decrease in the importance of the government market; among them are an economy-minded U.S. Congress and Administration, deep public concern over the cost and efficacy of new weapons systems, and the uncertain future of the space-exploration program. These issues are being resolved amid so many conflicting political and ideological forces that the end points are impossible to predict. The future trend of government support of the electronics industry, therefore, may depart radically, up or down, from the trends here reviewed.

In recent talks with marketing managers, this writer has observed an increasing sentiment that the long-term future of electronics marketing lies in improved penetration of the industrial market, with less reliance on defense-oriented and space-exploration government business. However, other categories of government support, those associated with civil aviation, ground transportation, health, education, housing, and urban development, are expected to increase in importance. They may, in fact, be considered the government market for industrial electronics.

The segment of the charts in Fig. 3 relating to consumer products deserves close attention. It is a large factor, approaching $5 billion annually, and has important long-term support from population growth and the trend of the standard of living. The consumer-goods slice of the pie has slightly decreased over the ten-year span, with an increase since 1963 traceable primarily to the advent of color television.

Here the future clearly depends on a deeper penetration of a wider range of electronic technology into the home. Today, consumer electronics is essentially synonymous with electronic entertainment. It is significant that (with the exception of new methods of producing low-cost recorded and prerecorded programs for television receivers) no major innovation in electronic entertainment is in sight. What does appear to be in prospect, however, is an increasing number of *wide-band* circuit connections to homes, through the growth of CATV and Picturephone service. Such wide-band circuits are capable of extending the existing data information services, now available to industry and commerce, to the domestic scene. In a sense, this might be considered the ultimate penetration level of the market for industrial and commercial electronic services. But, in the opinion of many observers (including the participants in the Highlight Session of the 1969 IEEE International Convention in March),[2] the cost/utility ratio of such domestic information services is high, so that a long development period must be anticipated.

What impact on engineers?

If, as the foregoing review of the trend lines suggests, industrial applications of electronics are to dominate the market in future decades, whether the end use is by private industry, government, or the consuming public, there are important implications that engineers should face now, not later. Four changes in outlook seem worthy of particular attention.

First, there is the need for an interdisciplinary competence, a retreat from the present emphasis on specialized competence. The industrial markets of greatest potential for electronics are those offered by major industries whose technical base is not primarily electrical or electronic. Penetration has already started in two of the largest industries—automobiles and petrochemicals—which are served mainly by mechanical and chemical engineers, not electrical engineers. Application of electronics to such industries requires a broad, interdisciplinary knowledge of the industries themselves and their technical problems—and these are as diverse and rooted in as many different technologies as the products and processes they sell and employ. Thus the electronics application engineer, who keeps in constant touch with the needs of his target industry, must be a key member of the industrial electronic design and development team. He must interpret and pose the questions for which the research, design, and production engineers provide the answers.

Second, there is the need for a modular concept of design for industrial electronic technology. If each application is treated as a separate project, with piecemeal development of every subsystem from scratch, the per-job cost may price industrial electronics out of the market altogether. To avoid this, industrial electronic jobs must be selected, not only because they serve an important need, but also because they can be assembled from a "bank" of proved techniques. In other words, specific end products for industrial purposes should be synthesized wherever possible from existing methods, rather than being built from the ground up.

Third, the technical content of industrial electronics may approach the high level already set by the sophisticated tasks of defense and space projects, and the pressure to shorten the lead time from initial concept to production will not be relaxed. An example of very close coupling between basic science and industrial application is the unlikely, but real, application of laser technology to the garment industry. Less than a decade has elapsed between the early demonstrations of stimulated emission from inverted population of energy states to the commercial development of fabric cutters using laser beams.

Fourth, the cost-price constraints on the design and manufacture of industrial electronic products are very stringent compared with those appropriate for defense and space projects. Thus, as job assignments shift from government projects to industrial electronic systems for industry and the home, many comfortable habits of design will have to change. The success of the Apollo Project certainly depended on the adoption of the best technical answers, almost without regard to cost. But no such luxury can be afforded under the competitive conditions of an industrial market.

To meet these changing requirements, the engineer must certainly broaden his horizons. He must spend more time becoming familiar with techniques in areas adjacent to, and possibly a few far removed from, his present assignments. He must give more attention to the synthesis of subsystems, not known to him but familiar to others, into his overall design. He must be aware of the significance of new discoveries, outside his field, that have useful application in his assigned area. And he must bring (as those engaged in consumer electronics have had to do) cost-price thinking into engineering from the earliest design stages through testing and production.

The information flow that permits this broadening of outlook starts within the engineer's lab, office, or plant, through direct exchange with co-workers. But this is not enough! Knowledge of what is going on *outside* the plant is essential to successful engineering practice in the highly competitive scene of industrial electronics. Accurate, dependable information from technical meetings and exhibitions, technical journals, abstracting services, and active participation in professional committees and associations (and for us, all these read "IEEE") is available and must be acted upon to meet the future challenge.

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Donald G. Fink (F), General Manager of IEEE since its inception, received the B.S. degree in electrical communications from M.I.T. in 1933, and the M.S. degree in electrical engineering from Columbia University in 1942. After a brief period on the staff of the Geology and Electrical Engineering Departments at M.I.T., he joined the staff of the journal *Electronics* in 1934, serving as its director-in-chief from 1946 to 1952. Obtaining a leave of absence from his editorial duties in 1941, Mr. Fink became a member of M.I.T.'s Radiation Laboratory, becoming head of the Loran Division in 1943, and then transferring to the Office of the Secretary of War as an expert consultant on radio, navigation, and radar. His war service included traveling over 80 000 miles throughout the world both siting and arranging for the use of loran systems by the Allied forces. In 1946, he participated in the atom bomb tests at Bikini as a civilian consultant on the staff of Admiral Blandy.

A chairman or member of many IRE, U.S. Senate, and national committees, Mr. Fink became the Editor of the *Proceedings of the IRE* in 1956 and 1957, and served as President of the IRE in 1958. In 1952, he joined the research staff of the Philco Corporation, and in March 1961 was appointed vice president for research. He later became director of the Philco Scientific Laboratory. Since 1957, Mr. Fink has been an active member and consultant of the U.S. Army Scientific Advisory Panel, which advises the Secretary of the Army "in the field of science and matters related thereto." From 1965 to 1967, he was chairman of the electronics advisory group of the U.S. Army Electronics Command. The author of numerous books, which have become standard references and texts in many areas of electronics engineering, Mr. Fink is currently editor-in-chief of *The Standard Handbook for Electrical Engineers*, for which he recently received special commendation. A fellow of the IEE and SMPTE, Mr. Fink is a member of the honorary societies Tau Beta Pi, Sigma Xi, and Eta Kappa Nu, being selected an Eminent Member of the last in 1965. A recipient of many awards and honors, he was elected a member of the National Academy of Engineering in April 1969. He holds two patents on stereophonic systems.

Research and the changing campus environment

Today's students, reared in affluence, have had time to concentrate on social and political problems. The result is rebellion on the campus—and industry may well be the next target. We must recognize that these are changing times, and that it is up to us to adapt to them

Charles A. Anderson Stanford Research Institute

Everyone who is exposed to the realities of daily life in the U.S. is aware of the fact that dissenting students are not hesitating to make their dissatisfaction with the establishment known, and, in fact, are taking direct action to implement their various causes. In a number of instances their target has been defense-oriented research on the campus; an example of this was the pressure in recent months to achieve control of research programs at SRI. As this article points out, the militants need not be victorious—their actions in themselves are enough to affect the climate within which the researcher must work. Furthermore, as these "new" students leave the university to enter industry, they take their attitudes with them. As a result, a whole new philosophy of management is becoming necessary.

During recent months the actions of militant and dissident students in virtually every part of the United States have made their many causes known to all. Their stated causes for demonstration and disruption have covered a wide range of concerns, in many cases concerns shared by people everywhere—war, poverty, health.

In a number of cases, the object of their displeasure has been defense-oriented research, particularly classified research, on the campus. The furor created by these students and the controversy now surrounding this type of research is of great importance to the electronics industry, for if there is any industry that realizes the value of research—including research on the college campus—it is this one. This large but comparatively young industry was virtually born and developed in university research laboratories. Even today the industry is deeply concerned about the research being done, or not being done, on campus, for it could have considerable impact on the future of electronics.

The kinds of research the dissidents consider objectionable is sometimes surprising, yet the fact remains that they have succeeded in changing research policies on a number of campuses and in creating doubt about the propriety of much of the research on many others. In short, the atmosphere in which research is being conducted on campus today may call for adjustments in the electronics industry's plans for the future.

The SRI experience

An example of the pressure placed on research by these groups occurred at Stanford Research Institute during recent months. Although not a part of Stanford University, SRI has been affiliated with it for many years, an affiliation now being terminated. Stanford Research Institute does research related to national security—in electronics as well as in many other fields—and this attracted the intense interest of the campus radical groups. The experience with these groups was lively and instructive if not very pleasant.

Stanford Research Institute was harassed on the basis that some of its research is in support of national security. Both students and faculty members were active in efforts to achieve control of SRI's research programs so as to concentrate on areas that these groups felt would be morally acceptable to them. Research cannot be conducted very well under the scrutiny of a morality review board and SRI's professional and scientific staff flatly rejected such a suggestion. In the midst of the uproar, the Stanford Board of Trustees decided to terminate the formal ties between SRI and the university, a decision fully supported by SRI.

When the dissidents saw their opportunity to achieve control of SRI's research policies fading, they turned to violence and lawlessness. This led to a rather serious confrontation with considerable damage to one of SRI's buildings before police could restore order. More than 100 participants in that violence were arrested and are now coming to trial.

The experience of SRI underscores the intensity of this movement—and the movement is not going to disappear. It is more likely to expand into different areas and to different targets and it may further influence where and how some of the research important to the electronics industry is going to be conducted.

Obviously, there are no easy solutions to the problem of campus rebellion. Students today are not like students of yesterday, and campus administrators are having a tough time coping with their demands that they be full participants in running things. And many of the faculty are aggressively in the act as well.

A survey made by *Fortune* magazine discovered that 42 percent of a representative sample of college students view college not so much as a means to practical gain but as an opportunity to make changes in society rather than to go along within the existing system. The tactics they use are often alien to the campus community and it remains to be seen whether they can be countered through means that do not destroy the essence of the university.

Today's students were reared in affluence and they do not worry much about economic security; they see it as a right. Rather, they have had time to concentrate on social and political problems and on introspection. Dr. Joseph Katz, executive director of the Institute of Human Problems at Stanford, in a recent talk to an SRI conference made this comment: "There is an increasing erosion of respect for president, faculty member, political leader, or the corporation president. There is no erosion if that authority is based on a competence, particularly if the competence is relevant to the lives of the young. The rejection is not of authority, but rather there is an attempt to participate in it." He pointed out further that "as former students enter professional and business life, they are apt to try to continue their ways in their new environments." That point will be elaborated on later.

This new wave—this great desire to be heard, to influence, to change the existing structure—is not confined to the students; they get much support from some of the faculty. Recently, a professor of engineering at Stanford, commenting on his past years, pointed out that he had always felt free to project his own views and actions into the outside community as an individual and that the university had provided the base that made such actions possible. But now, he explains, we seem to be entering "a period of consensus in which the university itself is urged to adopt a position on issues moral and political, and those within who do not naturally subscribe to the consensus view must conform or be quiet."

He continued: "My alarm is heightened by the apparent ability of any hyperactive group, perhaps a group small in numbers, to gain enormous strength from the tacit enlistment through this process of the force of the total university community. It is dangerous to the university and, through extrapolation, to the outside community."

In short, this professor points out, it is now considered by many on campus, both students and teachers, to be appropriate—even desirable—for the university to use its influence to effect change, to be a unit of pressure on political bodies or on business and industry to bring about changes that they want in our society and in our national priorities.

Those who wanted to end SRI's practice of accepting research projects in support of national security were completely unmoved by the argument that the work is fully in keeping with national priorities set by a government duly elected by the majority of the people. They simply disagree with the majority and feel it their role, and the role of the university, to bring about change. And quite clearly, one of their primary targets is the kind of research to be conducted on the campus.

In that regard, it is important to note another factor.

The movements against certain types of research have been headed primarily by individuals concerned with the social sciences rather than by those in engineering and business. At Berkeley in 1964 and 1965, business and engineering students tended to be almost completely absent from the demonstrations. At Stanford last spring, in fact, it was the engineering research that was the victim of the longest sit-in.

The unhappy conclusion, therefore, is that the militant activist, the person who is most dedicated to having a say in campus research policies, is also apt to be a person who knows very little about and is generally unsympathetic with the kinds of research that are important to the members of the electronics industry.

If these people have their way, or even if they succeed only partially in having their way, it can mean a steady shift of classified and applied research away from university laboratories and into private industry and independent research institutions. It is not necessary that these militants achieve tangible victories or that they always force changes in policy. They are affecting the climate within which the researcher must work and live, the climate that lets him enjoy the respect and friendship of his peers in the community—or the climate that criticizes or ostracizes him for engaging in classified research. He may just feel uncertain about the future and decide that, for his own peace of mind, he will leave the campus.

In today's climate for on-campus research, *all* research projects are being questioned by many students as well as by many members of the faculty. The most vocal of these persons applaud research projects on such social problems as poverty, urban crowding, and hunger, and attack projects with which they are not sympathetic. Their efforts can range from letters to the college newspaper to harassment to violent physical assaults.

The shift of research

All in all, with the continuing need for classified or applied research, it is likely that there will be a trend toward the shifting of applied research from the universities to private industry and to institutions such as SRI. Applied research financed by the Department of Defense probably will be the first to shift, for this research will find the environment most uncomfortable. Some research people are already leaving the campus to continue their work in the more protected seclusion of private industry or private research institutions. As this happens, it is likely that some of the unclassified and basic research may also leave the universities, because research projects will go where the researchers are.

These militant and dissident groups who are so vocal in their opposition to classified and applied research in the universities are just as opposed to it in industry. For example: SRI is physically separated from the Stanford University campus by several miles. The Board of Trustees of Stanford University has announced that it will sever relations between the university and SRI. Nonetheless, these student militants have waged a continuing assault against Stanford and SRI in an attempt to deter it from conducting classified research for the Department of Defense, as well as certain unclassified research.

These people consider universities more vulnerable to pressure, so universities have had most of the pressure so far. But, when federal research funds come into plants and facilities, management might be well advised to see if there are militants close behind. Just as the projects follow the researchers, so the militant students and their tactics will follow. In short, industry—particularly those companies with a technology base—could well be the next targets. In fact, militant students, at their rallies and meetings, have targeted a number of electronics firms and have conducted preliminary forays against these to test the defense.

Management of such firms might be well advised to prepare for possible encounters with such groups. There are a number of basic steps that could be taken:

1. Through actions and public posture make it quite clear to those who might be planning harassment that

violence will not be condoned and disruption of work will not be tolerated. Make it clear that when laws are broken the civil authorities will be asked to take appropriate and swift action so business can go on as usual.

2. Condition employees to the fact that harassing tactics from small, well-organized, and tenacious groups could be forthcoming in plants and offices.

3. Communicate with the communities in which plants are operated and seek the understanding and support of groups and individuals in these communities.

Attacks by militant groups are grueling; however, if management is prepared, the experience is less of an ordeal and their efforts are more readily thwarted. It is likely that some employees, especially the younger ones, may have a certain amount of sympathy for the demonstrators. Many companies have dealt with such harassment successfully; others can deal with it too, but it would help to lay plans in advance.

As former students enter business they will take some of their ways into the new environment. This is particularly true in industries with a high technical orientation, such as the electronics industry.

A new type of management

It is the belief of many professional managers that a whole new philosophy of management is becoming necessary as a result of the kinds of forces just discussed. For example, in a recent book Peter Drucker points out that most of the major industries of today developed from experience, whereas many of the new and growing industries are based on brand-new knowledge, and past experience isn't too important. The electronics industry would fall into the knowledge-based rather than the experience-based category.

Mr. Drucker goes on to point out that the employees in these new industries are valued for their new knowledge, not for long years of experience. This is true of creative professional scientists as well as of laboratory technicians and computer programmers. This increased emphasis on knowledge as distinct from experience will require—in fact, requires right now—a different kind of management. The traditional, experience-based management styles just might not work so well in the new environment.

The differences between running a business and SRI, for example, relate to the people involved, and the people at SRI—with their aspirations, their expectations, their needs, their values—are the types of people that the electronics industry relies on to provide the manpower and brainpower to run its companies. Briefly, some of their traits and characteristics are as follows:

- They tend to be young. This figures; it is knowledge that is more important than experience.
- They are highly trained and highly specialized.
- Their views as to authority, supervision, and discipline tend to be quite different from the traditional concepts. They don't "dig" the "organization men"; they are likely to have more loyalty to their profession or academic discipline than to the organization with which they happen to be associated.
- They feel a commitment to do something about our society. They want to see their professional capabilities used to this end and this may be more important to them than contributing to earnings per share. Indeed, because management's job *is* concerned with earnings per share there tends to be mistrust of management. This is a manifestation of the differences in the value systems.

In short, they will come more and more to resemble the campus groups just discussed, and the management process required to coordinate the efforts and energies of such groups is clearly different from the traditional management process. These new students—not the radicals, but the vast majority of today's students—and today's young employees are going materially and significantly to alter society and influence the economy. And the style of management processes will certainly change.

Obviously, the rewards will be great for those organizations able to develop a management style that will accommodate to the needs of the knowledge professional and, at the same time, benefit economically and commercially from his efforts.

This changing world

In short, a cliché says it: "It's a world of rapid change and we'd better adapt to it." The campus already has changed vastly and is changing even more. Attitudes and values of the younger generations are not the values of the square, over-30 set, and these brash young people are changing things of importance—like where the research our nation requires will be conducted.

They are changing the companies of the U.S.; they have new ideas about incentives for working, about rewards, about the social responsibilities of the business world, and about their right to sound off on management's role—especially when they think management has made a mistake.

Management must adapt to these changes—by becoming more imaginative, more flexible, more creative. And management might have to get used to an awful lot of noise. As that great philosopher, Charlie Brown of the Peanuts comic strip, says: "The world is filled with people anxious to function in an advisory capacity."

It seems as though there are more of them every day.

This article is based on an address at WESCON, San Francisco, Calif., August 19–22.

Charles A. Anderson, president and chief executive officer of Stanford Research Institute, Menlo Park, Calif., and a member of SRI's board of directors, was born in Columbus, Ohio. After receiving the A.B. degree from the University of California, Berkeley, in 1938 and the M.B.A. degree from Harvard University in 1940, he became a research assistant at Harvard's Graduate School of Business. During World War II, Mr. Anderson served with the U.S. Navy, being discharged in 1945 with the rank of lieutenant commander. He then returned to Harvard as assistant professor of business administration, leaving in 1948 to become vice president of the Magna Power Tool Corporation in Menlo Park. He was a member of the faculty of the Graduate School of Business at Stanford University from 1958 until 1961, when he joined the Kern County Land Company as vice president, finance. In 1964 he became president of Walker Manufacturing Company, a Kern subsidiary, and in 1966–67 was president of J. I. Case Company, another Kern subsidiary. He was elected president of SRI in 1968. Among his many activities, Mr. Anderson is a director of the Stanford Bank, Palo Alto, and the National Cash Register Company, Dayton, and is on the board of directors of Cutler-Hammer, Inc. He has been a recipient of the U.S. Air Force's Exceptional Service Award.

A step-by-step active-filter design

A new approach to active-filter design uses as its basis a rudimentary knowledge of conventional, relatively simple passive filters, thus providing the nonspecialist with a valuable design tool

J. Tow Bell Telephone Laboratories, Inc.

This article presents, in a simplified manner, a design method for active filters intended for those who are not filter specialists. By following the described five-step approach, a circuit designer who has some knowledge of passive filters will (without having to learn a whole new technology) be able to design active filters just as easily as he now handles conventional passive filters. Starting with the filter specification, it is shown sequentially how to realize a network that meets the prescribed requirements. Configurations and element values are given for the low-pass (LP), bandpass (BP), high-pass (HP), all-pass (AP), and band-elimination (BE), second-order active filter building blocks.

Passive-filter design vs. active-filter design

Analogies between the procedures used in the design of passive and active filters are given in this section. In conventional passive-filter design, the circuit designer usually follows these steps:

1. The specified high-pass, (geometrically) symmetrical bandpass, or (geometrically) symmetrical band-elimination requirements are converted into equivalent requirements in the normalized low-pass case.

2. A low-pass prototype configuration and its element values are obtained by consulting the many excellent tables, catalogs, etc., that are available.[1]

3. By suitable transformations on the L and C elements (for example, LP-to-BP transformation and denormalization of the element values), the final passive configuration for the HP, BP, or BE filter is obtained.

4. The complete passive circuit is put together.

5. High-precision filter performance is obtained by resonating the appropriate L and C elements.

Active filter design calls for essentially the same five-step approach:

1. As in passive-filter design, the equivalent normalized low-pass requirements are first obtained.

2. An appropriate set of normalized transfer poles and zeros for the low-pass case can also readily be obtained from the many available sources (e.g., Ref. 2).

3. By suitable frequency and denormalizing transformations on the poles and zeros, the complete transfer function that meets the filter requirements is obtained.

4. The transfer function is factored into a produc second-order functions, and each of these functions is realized by a standard building block. In this article, a building block consists of RC and operational amplifiers.

5. The building blocks may be tuned separately and then cascaded directly to form the final active filter.

This five-step active filter design can be divided into two phases: obtaining the transfer function from the requirements and implementing this transfer function.

Phase 1—Obtaining the transfer function

The first three steps just outlined form the basis of the technique used to obtain the transfer function.

Step 1 is assumed to be a familiar procedure and no discussion is necessary here. For convenience, the

FIGURE 1. A normalized LP filter characteristic.

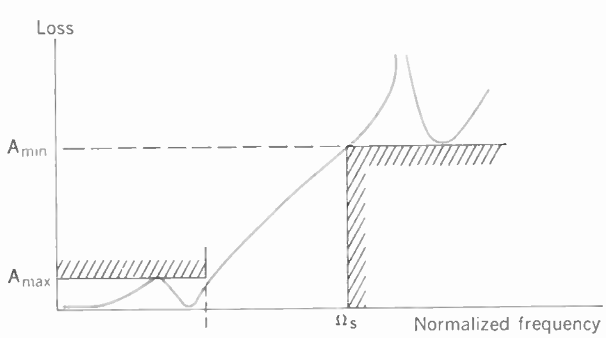
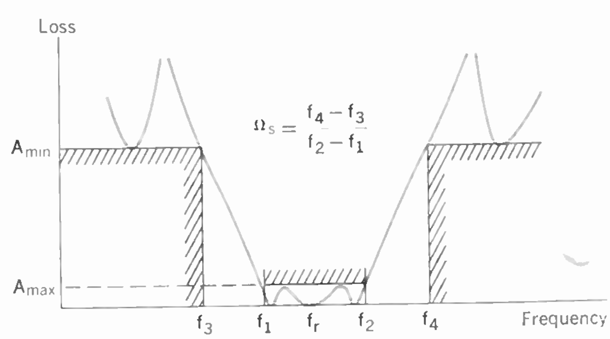


FIGURE 2. A bandpass filter characteristic.



characteristics of a normalized LP and the equivalent BP and BE characteristics are shown, respectively, in Figs. 1, 2, and 3. (The figures illustrate degree-3 Cauer filters.)

In Step 2, the degree (or order) and the type of filter (e.g., Butterworth, Chebyshev, Cauer) to be used in the active-filter design are obtained exactly as in the design of its passive counterpart. Once these are decided upon, the active design requires the computation of the transfer poles and zeros instead of obtaining the element values for a given configuration in the passive design. Tabulations of these poles and zeros are also available.[2]

Example 1. Transfer function of an LP filter. Throughout this article, filter designations—for example, C 03 25 30—are the same as those given in Ref. 1. The transfer function $T(p)$ of a normalized low-pass Cauer filter with degree 3, 25 percent reflection coefficient (this corresponds to a 0.29-dB in-band ripple), and a stopband edge frequency Ω_s equal to 2 [that is, $\theta = \sin^{-1}(1/\Omega_s) = 30°$] given in Ref. 2 (page 51) as follows:

$$T(p) = K\frac{N(p)}{D(p)}$$

where

$$K = 1/4.791\,901\,5$$

$$N(p) = p^2 + (2.270\,066\,959\,6)^2$$

$$D(p) = (p + 0.831\,246\,722\,6)$$
$$\cdot(p + 0.311\,280\,648\,9 + j1.093\,993\,610\,1)$$
$$\cdot(p + 0.311\,280\,648\,9 - j1.093\,993\,610\,1)$$

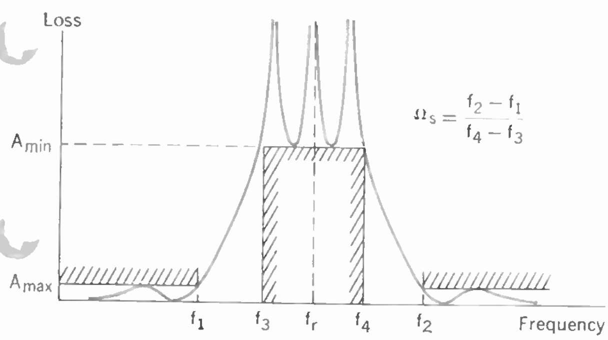
The normalized filter characteristic is as shown in Fig. 1, with A_{min} = 28.57 dB and A_{max} = 0.29 dB. The normalized poles and zeros are shown in Fig. 4.

Step 3 in the active design requires the transformation of the normalized LP poles and zeros into the actual poles and zeros. In practice, each pair of the normalized complex poles or zeros should be transformed separately, as should the single real pole. The product of all the resulting poles and zeros forms the final transfer function. A procedure based on the reactance transformation is given below for the transformations from normalized LP to BP and from normalized LP to BE. This easily programmable procedure computes the transformed poles and zeros directly in a few algebraic steps and without the need for finding the roots of a polynomial.

Let the normalized LP complex root (that is, a normalized LP pole or zero) be given by

$$p_0 = -\sigma_0 \pm j\omega_0$$

FIGURE 3. A band-elimination filter characteristic.



With reference to Figs. 2 and 3,

$$\omega_r = 2\pi f_r = 2\pi(\sqrt{f_1 f_2})$$
$$BW = f_2 - f_1$$
$$x = BW/f_r$$

s = complex frequency in the actual transfer function

Then the LP-to-BP root transformation is as follows:

$$(p + \sigma_0 - j\omega_0)(p + \sigma_0 + j\omega_0) \xrightarrow{\text{LP to BP}} \frac{(s - s_1)(s - s_1^*)(s - s_2)(s - s_2^*)}{K^2 s^2}$$

where the asterisk (*) denotes the complex conjugate and the transformed roots s_1, s_1^*, s_2, s_2^* are given by

$$s_1 = -\tfrac{1}{2}(\sigma + v)\omega_r + j\tfrac{1}{2}(\omega + u)\omega_r \quad (1)$$

$$s_2 = -\tfrac{1}{2}(\sigma - v)\omega_r + j\tfrac{1}{2}(\omega - u)\omega_r \quad (2)$$

$$K^2 = 4\pi^2(f_2 - f_1)^2 \quad (3)$$

and

$$\sigma = \sigma_0 \cdot x \qquad \omega = \omega_0 \cdot x \quad (4)$$

$$u = \left[\frac{1}{2}(4 - \sigma^2 + \omega^2) + \sqrt{\left(\frac{4 - \sigma^2 + \omega^2}{2}\right)^2 + \sigma^2\omega^2}\,\right]^{1/2} \quad (5)$$

$$v = \sigma\omega/u \quad (6)$$

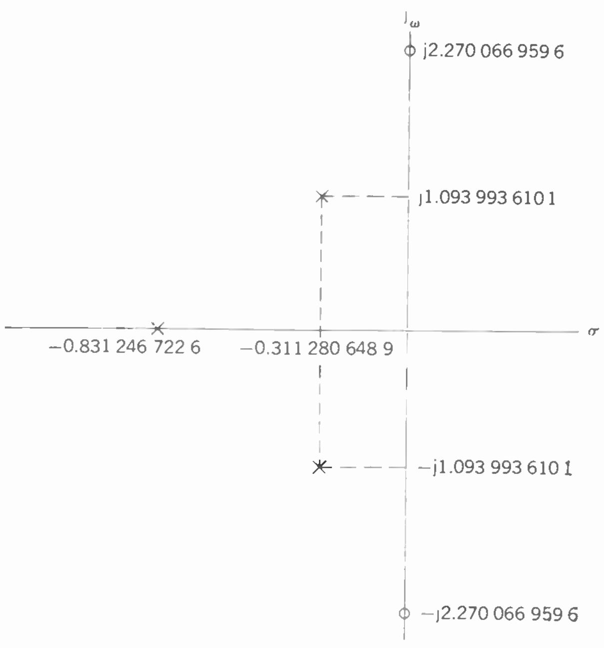
The LP-to-BE root transformation is as follows:

$$(p + \sigma_0 - j\omega_0)(p + \sigma_0 + j\omega_0) \xrightarrow{\text{LP to BE}} \frac{(s - s_1)(s - s_1^*)(s - s_2)(s - s_2^*)}{(s^2 + \omega_r^2)^2}$$

where s_1, s_2, u, and v are as given in Eqs. (1), (2), (5), and (6), respectively, and

$$\sigma = \frac{\sigma_0 x}{\sigma_0^2 + \omega_0^2} \qquad \omega = \frac{\omega_0 x}{\sigma_0^2 + \omega_0^2} \quad (7)$$

FIGURE 4. A normalized LP pole-zero pattern.



Example 2. Transfer function of a BP filter. We wish to obtain the actual transfer function of a bandpass filter with a resonant (center) frequency at 2600 Hz, a bandwidth of 20 Hz, and a prototype transfer characteristic that is equivalent to the LP Cauer filter (C 03 25 30). The normalized LP poles and zeros were already given in Example 1. The corresponding LP-to-BP transformations [Eqs. (1) to (6)] are

$$p^2 + (2.270\,066\,959\,6)^2 \rightarrow \frac{[s^2 + 2.715\,751\,38\,(10^8)][s^2 + 2.622\,544\,43\,(10^8)]}{(125.663\,706)^2 s^2}$$

$$(p + 0.831\,246\,722\,6) \rightarrow \frac{s^2 + 104.457\,544 s + 2.668\,741\,03\,(10^8)}{125.663\,706 s}$$

$$ab \rightarrow cd/e$$

where

$a = p + 0.311\,280\,648\,9 + j1.093\,993\,610\,1$
$b = p + 0.311\,280\,648\,9 - j1.093\,993\,610\,1$
$c = s^2 + 39.281\,268\,6s + 2.691\,294\,09\,(10^8)$
$d = s^2 + 38.952\,091\,3s + 2.646\,376\,96\,(10^8)$
$e = (125.663\,706)^2 s^2$

The actual BP transfer function is then given by

$$T(s) = \frac{125.663\,706}{4.791\,901\,5} \cdot \frac{s}{s^2 + 104.457\,544s + 2.668\,741\,03\,(10^8)} \cdot \frac{s^2 + 2.715\,751\,38\,(10^8)}{s^2 + 39.281\,268\,6s + 2.691\,294\,09\,(10^8)} \cdot \frac{s^2 + 2.622\,544\,43\,(10^8)}{s^2 + 38.952\,091\,3s + 2.646\,376\,96\,(10^8)}$$

Phase 2—Realization of the active filter

The foregoing discussion centers on how to obtain a transfer function that meets the desired filter requirements. We now show how this transfer function can be implemented to realize the actual active filter. On the basis of sensitivity studies, economic necessity, and practical considerations (for example, ease of tuning, troubleshooting), it is concluded that hybrid integrated active filters should be implemented in a cascaded manner, with each section capable of realizing a general second-order (biquadratic) transfer function or, equivalently, a pair of poles and zeros. Furthermore, a standard configuration should be used in each section.

Step 4 of the active-filter design requires an implementation of the second-order building blocks. Among the variety of techniques and configurations available, one will be discussed in some detail. Let the general biquadratic transfer function ("biquad") be given by

$$\frac{V_{out}}{V_{in}}(s) = \frac{ms^2 + cs + d}{s^2 + as + b} \qquad (8)$$

In Ref. 3, a single configuration, together with its element values expressed in terms of the biquad coefficients (m, c, d, a, and b), is given for the realization of (8). This method—referred to as the operational amplifier biquad realization—uses resistors, capacitors, and operational amplifiers as its network elements. It is particularly suited for realizing high-precision active filters in a standard form. The various second-order cases (LP, BP, HP, AP,

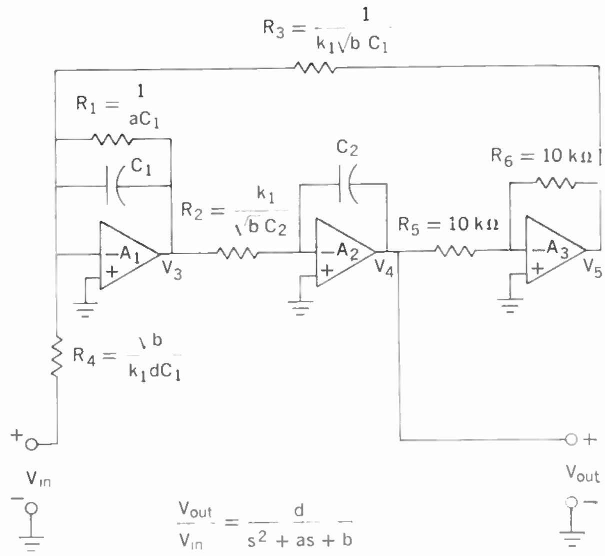


FIGURE 5. Biquad realization of an LP building block.

FIGURE 6. Biquad realization of a BP building block.

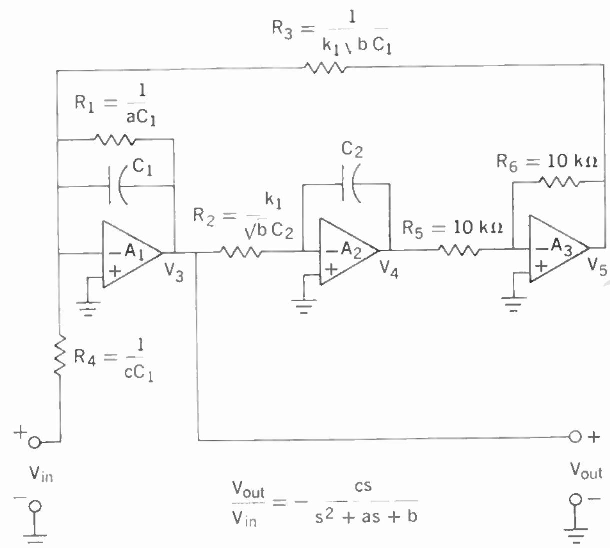
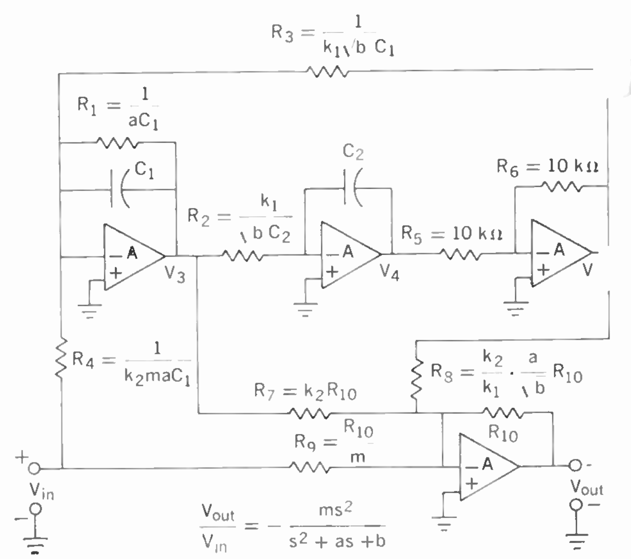


FIGURE 7. Biquad realization of an HP building block.



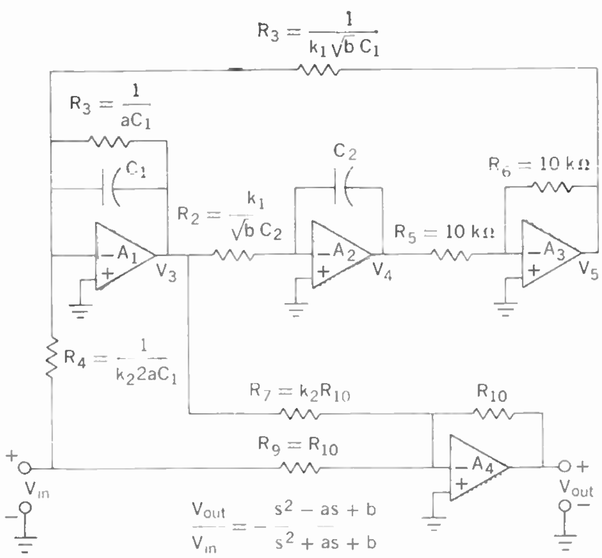
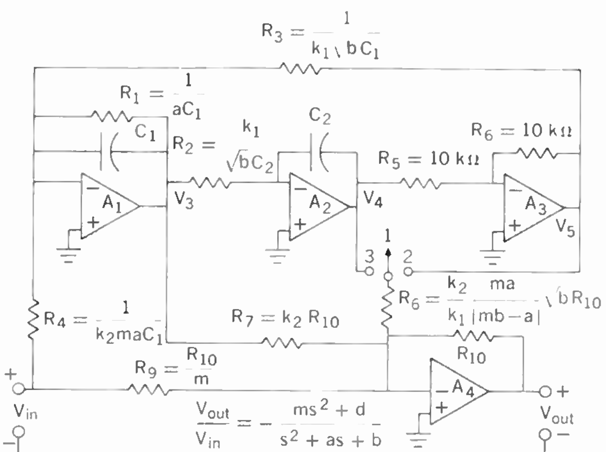


FIGURE 8. Biquad realization of an AP building block.

FIGURE 9. Biquad realization of a BE building block.



Condition	Switch Position
mb ≥ d	1 to 2
mb < d	1 to 3

and BE) are but special forms of (8). Their biquad realizations can easily be obtained from the standard configuration given in Ref. 3. They are, respectively, shown here in Figs. 5 through 9. Values of C_1, C_2, R_{10}, k_1, and k_2 can be conveniently chosen; e.g., $C_1 = C_2 = 0.01\ \mu F$, $R_{10} = 10\ k\Omega$, and $k_1 = k_2 = 1$.

Step 5 of the active-filter design involves tuning of the building blocks. After the transfer function is obtained and factored into biquadratic factors, and each factor is implemented by a biquad building block, the building blocks can then be cascaded to form the final active filter. However, in applications in which high-precision performance is desired, adjustments on the filter sections must be made before cascading. The biquad realization is extremely easy to tune. The poles and zeros can be tuned independently. To demonstrate this, let us write the voltages at the output of the operational amplifiers in each of Figs. 5 through 9 as follows:

$$\frac{V_3}{V_{in}} = -\frac{1}{R_4C_1}\cdot\frac{s}{s^2+\dfrac{1}{R_1C_1}s+\dfrac{1}{R_2R_3C_1C_2}\cdot\dfrac{R_6}{R_5}} \tag{9}$$

$$\frac{V_4}{V_{in}} = \frac{1}{R_2R_4C_1C_2}\cdot\frac{1}{s^2+\dfrac{1}{R_1C_1}s+\dfrac{1}{R_2R_3C_1C_2}\cdot\dfrac{R_6}{R_5}} \tag{10}$$

$$\frac{V_5}{V_{in}} = -\frac{R_6}{R_5}\cdot\frac{1}{R_2R_4C_1C_2}\cdot\frac{1}{s^2+\dfrac{1}{R_1C_1}s+\dfrac{1}{R_2R_3C_1C_2}\cdot\dfrac{R_6}{R_5}} \tag{11}$$

Furthermore, in Figs. 7 to 9, for cases when $mb \geq d$,

$$\frac{V_{out}}{V_{in}} = -\frac{R_{10}}{R_9}\cdot\frac{s^2+\dfrac{1}{R_1C_1}\left(1-\dfrac{R_1R_9}{R_4R_7}\right)s+\dfrac{1}{R_2R_3C_1C_2}\left(1-\dfrac{R_3R_9}{R_4R_8}\right)\cdot\dfrac{R_6}{R_5}}{s^2+\dfrac{1}{R_1C_1}s+\dfrac{1}{R_2R_3C_1C_2}\cdot\dfrac{R_6}{R_5}} \tag{12}$$

and for cases when $mb < d$,

$$\frac{V_{out}}{V_{in}} = -\frac{R_{10}}{R_9}\cdot\frac{s^2+\dfrac{1}{R_1C_1}\left(1-\dfrac{R_1R_9}{R_4R_7}\right)s+\dfrac{1}{R_2R_3C_1C_2}\left(\dfrac{R_6}{R_5}+\dfrac{R_3R_9}{R_4R_8}\right)}{s^2+\dfrac{1}{R_1C_1}s+\dfrac{1}{R_2R_3C_1C_2}\cdot\dfrac{R_6}{R_5}} \tag{13}$$

Alternatively, for those cases where amplifier A_4 is presented, the output voltages can also be written as

$$\frac{V_3}{V_{in}} = -k_2\frac{(ma-c)s}{s^2+as+b} \tag{14}$$

$$\frac{V_4}{V_{in}} = -\frac{V_5}{V_{in}} = \frac{k_2}{k_1}\cdot\frac{\sqrt{b}\,(ma-c)}{s^2+as+b} \tag{15}$$

$$\frac{V_{out}}{V_{in}} = \frac{ms^2+cs+d}{s^2+as+b} \tag{16}$$

Comparing Eqs. (9) through (13) with the biquadratic transfer function,

$$\frac{V_{out}}{V_{in}}(s) = \frac{ms^2+cs+d}{s^2+as+b} = m\cdot\frac{s^2+\dfrac{\omega_N}{Q_N}s+\omega_N^2}{s^2+\dfrac{\omega_0}{Q}s+\omega_0^2} \tag{17}$$

Tuning can be achieved as follows:

- Resonant frequency ω_0 by R_3
- Selectivity factor Q by R_1
- "Notch" frequency ω_N by R_8
- "Notch attenuation factor" Q_N by R_7
- Overall gain by R_{10}

The first two tuning steps are monitored at V_3 and the remaining steps at V_{out}. These tuning steps, when carried out in the above sequence, are mutually independent. One or more of the steps can, of course, be omitted.

I. Maximum voltage levels at amplifier outputs

Amplifier	Maximum Output Level, dB	Frequency at Maximum Level, Hz
V_3/V_{in}	0	2589.083
$V_4(\text{or } V_5)/V_{in}$	$6.22(10^{-9})$	2589.079
V_{out}/V_{in}	11.8	2589.904

Example 3. Realization of a BE building block. Let us realize one of the sections from Example 2. Specifically, let the biquadratic transfer function be

$$\frac{V_{out}}{V_{in}}(s) = \frac{s^2 + 2.622\,544\,43\,(10^9)}{s^2 + 38.952\,091\,3s + 2.646\,376\,96\,(10^9)}$$

The realization is in the form given in Fig. 9, with point 1 connected to point 2. If the typical values $C_1 = C_2 = 0.01\ \mu F$, $R_{10} = 10\ k\Omega$, and $k_1 = k_2 = 1$ are used, then

$$C_1 = 0.01\ \mu F \qquad C_2 = 0.01\ \mu F$$
$$R_1 = 2.567\ M\Omega \qquad R_2 = 6.147\ k\Omega \qquad R_3 = 6.147\ k\Omega$$
$$R_4 = 2.567\ M\Omega \qquad R_7 = 10\ k\Omega \qquad R_8 = 2.659\ k\Omega$$
$$R_9 = 10\ k\Omega \qquad R_{10} = 10\ k\Omega$$

The maximum voltage levels at the output of the amplifiers are listed in Table I.

The values of R_1, R_3, and R_4 can be lowered by increasing C_1. Since output levels at V_3, V_4, and V_5 are proportional to k_2, the maximum output levels at the amplifiers can be made identical if k_2 is chosen to be 3.890 451 38. The final values are

$$C_1 = 0.03\ \mu F \qquad C_2 = 0.01\ \mu F$$
$$k_1 = 1 \qquad k_2 = 3.890\,451\,38$$
$$R_1 = 855.8\ k\Omega \qquad R_2 = 6.147\ k\Omega \qquad R_3 = 2.049\ k\Omega$$
$$R_4 = 220.0\ k\Omega \qquad R_7 = 38.9\ k\Omega \qquad R_8 = 10.34\ k\Omega$$
$$R_9 = 10\ k\Omega \qquad R_{10} = 10\ k\Omega$$

The maximum output levels of the amplifiers are now all the same and equal to 11.8 dB. Improvement in the dynamic range of the filter section is obtained.

Example 4. A switchable BP building block. A single-section BP filter is specified to have a constant 3-dB bandwidth of 212.058 radians, a midband gain of 50, and a resonant frequency that can be switched between the two frequencies 2025 Hz and 2225 Hz. The corresponding transfer functions are as follows:

$$\frac{V_{out}}{V_{in}}(s) = \frac{50\,(212.058)s}{s^2 + 212.058s + [2\pi(2025)]^2} \qquad (f_0 = 2025)$$

$$\frac{V_{out}}{V_{in}}(s) = \frac{50\,(212.058)s}{s^2 + 212.058s + [2\pi(2225)]^2} \qquad (f_0 = 2225)$$

The realization is in the form given in Fig. 6. Let us choose, for the 2025-Hz case, the typical values for C_2 and k_1, and also let $C_1 = 0.03\ \mu F$. The element values are

$$C_1 = 0.03\ \mu F \qquad C_2 = 0.01\ \mu F \qquad k_1 = 1$$
$$R_1 = 157.2\ k\Omega \qquad R_2 = 7.86\ k\Omega$$
$$R_3 = 2.62\ k\Omega \qquad R_4 = 3.144\ k\Omega$$

For the 2225-Hz case, we further let

$$k_1 = 2225/2025 = 1.098\,765\,43$$

Then the element values are

$$C_1 = 0.03\ \mu F \qquad C_2 = 0.01\ \mu F \qquad k_1 = 1.098\,765\,43$$
$$R_1 = 157.2\ k\Omega \qquad R_2 = 7.86\ k\Omega$$
$$R_3 = 2.17\ k\Omega \qquad R_4 = 3.144\ k\Omega$$

If we compare the two foregoing sets of element values, we see that the switchable BP filter is realizable with one set of element values, except for R_3, which requires two values corresponding to the two resonant frequencies.

Realization of a first-order building block. When the filter transfer function contains also a real pole, then this first-order pole can be implemented as shown in Fig. 10. Specifically, let the transfer function be

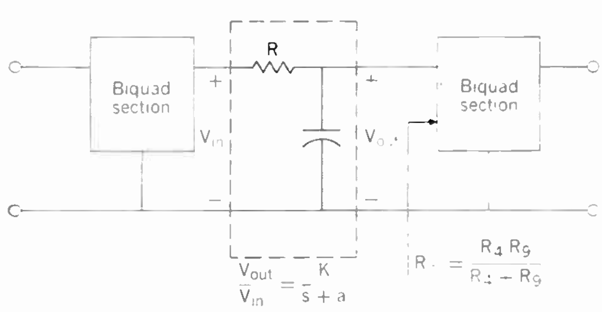
$$\frac{V_{out}}{V_{in}}(s) = \frac{K}{s + a} \tag{18}$$

If ideal operational amplifiers are assumed,

$$\frac{V_{out}}{V_{in}}(s) = \frac{1/RC}{s + \dfrac{R + R_{in}}{RR_{in}} \cdot \dfrac{1}{C}} \tag{19}$$

R and C values can be obtained from (18) and (19).

FIGURE 10. Implementation of first-order pole. (Dotted section shows realization of a real pole.)



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James Tow (M) was born in Canton, China. He received the B.S., M.S., and Ph.D. degrees in electrical engineering from the University of California, Berkeley, in 1960, 1962, and 1966, respectively. From 1960 to 1966 he served as a teaching assistant in the Department of Electrical Engineering and was also a research assistant in the University's Electronics Research Laboratory at Berkeley. In 1966 he joined the Bell Telephone Laboratories, Inc., Holmdel, N.J., where he has been a member of the technical staff in the Network Analysis and Synthesis Department.

His present interests include computer-aided network analysis and design and active-filter realization. Dr. Tow is a member of Eta Kappa Nu and Phi Beta Kappa.

The 1969 Popov Society Meeting:

Some impressions from U.S. delegates

Introduction *Howard E. Tompkins*

Every year now a delegation from the IEEE visits the Soviet Union at the time of the annual Popov Society meeting in May or June. The Popov Society (Scientific-Engineering Society of Radio Engineering, Electronics, and Communication honoring the name of A. S. Popov) is the major Soviet counterpart of the IEEE. Reciprocity between the U.S.A. and the U.S.S.R. brings a Soviet delegation to the United States at the time of the IEEE International Convention in March.

In 1969 the IEEE delegation to the Popov Meeting* included 12 representatives, and the wives of nine of them. The delegation stopped at Leningrad, Moscow, and Akadem Gorodok (the "Academic City" near Novosibirsk), visiting factories, laboratories, and institutes, and meeting people and sampling the Soviet culture made available to foreign visitors. Brief descriptions of specific visits follow this introduction; they were selected by the Editor of SPECTRUM from a more extensive set edited by me from reports prepared by the individual delegates. If factual errors have crept in, I take the blame.

Now here are some personal impressions, somewhat influenced by views expressed by others in the delegation. (For another view, see the article by Herbert Sherman, starting on page 75 of this issue.)

First of all, the Soviet Union had an impact—even on those who had been there before, who said they received significant new impressions, facts, and insights. The view of the U.S.S.R. one gets from newspapers, magazines, and books in the U.S.A. is so varied in content that one does not know what to believe. A visit helps immensely to put the facts in perspective, and to provide a coherent view of at least that part of Soviet society one has seen.

Second, the best of science, engineering, and applied technology in the Soviet Union seems very good indeed—on a level the United States would be proud to have as its own; however, the level of performance seems to drop far more rapidly in the U.S.S.R. than in the U.S.A. as one moves from the best down to the commonly available technology. This could be a temporary phenomenon associated with the relatively young stage of Soviet eco-

PRESIDENTS F. K. Willenbrock and V. I. Siforov of the IEEE and the Popov Society speak at the Meeting banquet, ably assisted by interpreter Valerie Nadeyeva.

*The 12 IEEE representatives included IEEE President F. Karl Willenbrock, State University of New York University Center, Buffalo, N.Y.; Robert Adler, Zenith Radio Corp., Chicago, Ill.; George Berkin, IBM Corp., Rochester, Minn.; Harold Chestnut, General Electric Co., Schenectady, N.Y.; Edward E. David, Bell Telephone Laboratories, Inc., Murray Hill, N.J.; Michael L. Dertouzos, Dept. of Electrical Engineering, M.I.T., Cambridge, Mass.; Jan A. Narud, Motorola Inc., Phoenix, Ariz.; Raymond C. Sangster, National Bureau of Standards, Boulder, Colo.; Herbert Sherman, Lincoln Laboratory, M.I.T., Lexington, Mass.; Daniel L. Slotnick, Dept. of Computer Science, University of Illinois, Urbana, Ill.; Howard E. Tompkins, IEEE, New York, N.Y.; and Vladimir K. Zworykin, RCA Laboratories, Princeton, N.J.

nomic development, or it could be more intrinsic.

Third, the "system" under which the Soviet society and economy work involves an immensely complex, frustrating bureaucracy. Even the most loyal and proud Soviet citizen has trouble concealing his annoyance at those functionaries who, in applying the system, cause errors and delays and create difficulties for him and for visitors.

Lack of knowledge as to what is going to happen (and when) until after it actually has happened is a major characteristic of the system. In dealing with Intourist, the arm of the bureaucracy that arranges travel and accommodations for foreigners, have faith. You'll not be told much in advance, but everything usually will work out pretty well. When something *has* gone wrong, protest loudly and vigorously, but to the point, and keep justice on your side. It seems to work. But don't expect any preventive protest to affect how tomorrow's events will work out; the system usually does not provide the representative with whom you are dealing with adequate tools to affect the future.

Fourth, the human and natural resources of the Soviet Union are impressive, and there seems little doubt that in the long run their goals and ours can be made to coincide: a "good life" as a major nation in a world where power is shared with other major nations whose societies are playing out their own version of the "good life."

Returning now to more immediate considerations, the year 1970 is a very important one to the Popov Society, since it is the 75th anniversary of the early work on radio by A. S. Popov, and the 25th anniversary of the founding of the Society (and hence the 1970 meeting will be the 26th). Delegations will be exchanged once again, in the continuing effort to seek greater understanding and a sufficient consonance of goals.

The Popov Society

F. K. Willenbrock

The organization and activities of the Popov Society were discussed with its president, Prof. V. I. Siforov, and its secretary, Professor Gabrilov. The Popov Society was organized in 1945 and at present has more than 160 000 members from all 15 republics of the U.S.S.R. There are 123 local sections, which serve to develop activities in conjunction with local universities and industrial plants. The Society is governed by a board of 59 members, who are elected for four-year terms, and is one of more than 20 societies whose activities are coordinated by the All-Union Council of Scientific and Engineering Societies, of which Professor Siforov is a member.*

The membership fee for students and pensioners is very low, 30 kopecks (33 cents); full members pay one ruble and 20 kopecks ($1.32). There is also support for the Society from organizations needing help with their educational programs.

The major activities of the Society include publication of periodicals and books, sponsorship of meetings and tours, educational programs, and the recognition of individuals who make outstanding technical contributions. In the last category, the Society advises on the awarding of Lenin and State Prizes; for example, the constructors of the Ostankino television tower and the acoustic designers of the Palace of Congresses in the Kremlin (a theater seating over 5000) were recently recommended for awards.

The publishing activities (in conjunction with the State Publishing House) include *Radiotekhnika* (*Radio Engineering*), which has a circulation of approximately 17 000—and which is translated by the IEEE—as well as *Elektrosvyaz* (*Electrotechnical Communications*). A series of 30 books on radio electronics is in the process of being published, designed to be a comprehensive "library" for professional radio engineers. Typically, these books are 120 pages in length and as of this date two have been completed. Sales have been quite rapid. Professor Siforov is chairman of the editorial board of this project, which is a joint activity of a publishing house, the U.S.S.R. Council of Higher Education, and the Popov Society.

The educational program of the Society is quite extensive. More than 70 two-year programs in radio technology are carried on jointly with the technical universities. Much of the teaching is done voluntarily by members of the Society, and those taking the courses do not have to pay.

* The other societies under the All-Union Council cover agriculture, chemistry, mining, metallurgy, and specific areas of industry, such as water transport, power (energetics), instrument building, printing and publishing, oil and gas, etc. There are also literally hundreds of scientific and technical councils, commissions, and committees, as well as additional societies, that are attached to the Academy of Sciences of the U.S.S.R. For a detailed list, see *The World of Learning* (Europa Publications, London, 1968–69 edition, pp. 1184–1215).

The Popov Society's 25th Annual Meeting

G. M. Berkin

The 25th all-Union scientific session of the Popov Society opened with a plenary meeting at 10 o'clock, June 3, 1969, in the Red Army recreation building (Central House of the Soviet Army honoring the name of M. V. Frunze). From behind a wide red-draped table on stage, with a white bust of Lenin in the background, the opening remarks were made by Prof. V. I. Siforov, president of the Popov Society and a corresponding member of the Academy of Sciences.

The first speaker, S. E. Kataev, gave a eulogy on Prof. Boris L. Rosing (1869–1933), alleged to be the first scientist to describe the fundamentals of television. Dr. Valdimir Zworykin of our delegation had studied in Petrograd (as Leningrad was then known) under Professor Rosing. On this special occasion, Dr. Zworykin had been asked to address the plenary session. He spoke fluently in Russian of the increasing importance of medical electronics. He was enthusiastically applauded.

The third and final address at the opening plenary meeting was by R. A. Nielander, who wore on his civilian suit a gold star medal, which identified him as recipient of the award of Hero of Socialist Labor. He described the growing use and importance of kinescopes and the state of the art of television camera tubes in the Soviet Union.

The regular Popov Society technical sessions were crowded between the opening and closing plenary meetings into two and one-half days. A total of 309 papers in 19 categories were scheduled on a range of topics similar to that of the "IRE" part of IEEE. (Power is under the Energetics Society in the U.S.S.R.) Each of the 12 members of the IEEE delegation was invited to present a paper in the section appropriate to his subject. Examples of the IEEE presentations were: F. Karl Willenbrock, IEEE President, described the prime purpose of the IEEE as providing a medium for the exchange of technical information. At the same session Howard E. Tompkins, Director of Information Services at IEEE, spoke of the Institute's plans for technical information dissemination. Most of the audience in the session on information dissemination was able to understand carefully spoken English. In other sessions, George Berkin presented an overview of optical character recognition as data-processing input and Jan Narud described integrated-circuit manufacture in the United States.

The closing sessions were held on June 6. Speakers described progress in radio and television network transmission and studio apparatus, and the new Ostankino television center and tower. Closing remarks were made by the president, V. I. Siforov. Since no translation facilities were available, a knowledge of Russian was essential to an understanding of the papers.

THE DELEGATION, from left to right: Jan Narud, F. Karl Willenbrock, Daniel Slotnick, Howard and Betsy Tompkins, Michael and Hadwig Dertouzos, Mary Adler, Vladimir Zworykin, Erma Ruth Chestnut, Natasha Berkin, Mildred Willenbrock, Harold Chestnut, and George Berkin. Not shown are Robert Adler, Edward and Ann David, Raymond Sangster, Herbert and Esther Sherman, and Katiusha Zworykin.

The Ostankino Television Center and Tower

V. K. Zworykin

The giant building of the Union Telecenter in the U.S.S.R., not quite completed, is in Ostankino, a suburb of Moscow. It is claimed to be the biggest building on the continent, with a volume of about 1.1 million cubic meters. Near the Telecenter is the "Ostankino Tower" for the antennas and transmitters, with a height of 543 meters, providing reliable television reception over a radius of 160–170 km. This is the tallest inhabited man-made structure in the world. (The Empire State Building is 450 meters tall, to the top of its television antennas. Several uninhabited nonself-supporting guyed television towers are taller, the tallest, to the editor's knowledge, being 630 meters, KTHI-TV, Fargo, N.Dak.)

The Ostankino television tower was completed in 1968. The tower is in two parts, a lower trunk of prestressed concrete 385 meters tall, and the top part of steel 157 meters tall. The tower has three promenades; the uppermost, at a height of 340 meters, is capable of holding 500 people. Immediately below it is a slowly rotating restaurant seating 300. There are two high-speed elevators.

The concrete trunk of the Ostankino tower is stressed with 150 steel cables about 3 cm thick, stretched vertically along the inside shell, like a line of piano strings running from bottom to top, providing a total stress of about 10 800 tonnes. Each cable is visible to maintenance personnel and can be tautened, repaired, or replaced. It is said that repairs should not be necessary for a hundred years.

The tower's stability is even greater than its resistance. To knock it over would be three times more difficult than to break it, and the maximum expected wind velocity should disturb the antenna beam less than 2 degrees. Because of the enormous weight of the lower part, the center of gravity of the building is fairly low. Dozens of solid binding strips are fixed into the circular foundations, so that the tower's 45 000 tonnes are spread out uniformly. After being built it only sank 35 mm—half as much as the engineers had foreseen.

The method of construction was as original as its design. The hoisting of the framework, installing of scaffolding, and casting of concrete, at all heights, was not done in the open air, but in temporarily enclosed heated premises. After the cementing of each stage (or ring) of the tower, the machine would lean on the hardened side of the tower with its powerful triple claw and hoist itself farther up. The other, lower claw would dig into specially arranged bays and the cementing would begin again.

The problem of making such an immense building absolutely vertical was an arduous one, and the calculations took into account even the daily rotation of the earth. Panels bearing the equipment were fixed above and below the cement machine and 1500 meters away from the tower an invisible plumb line was detected at the intersections of light beams. The departure of the axis of the tower from the planned axis is five or six times less than the tolerance—to wit, only about 0.1 meter for a height of over 500 meters.

The nearby Telecenter building is equipped to provide up to six series of television programs with a total time of up to 50 hours a day; it contains facilities for radio broadcasting, and for film and magnetic tape recording of television programs as well as intercity cables. The total output will include up to 200 hours of artistic films and up to 1000 hours of reporting films a year. Major projects of the Telecenter are

1. Creation of the first all-Union program of television in the U.S.S.R.
2. The program "Orbit," transmitted by satellite to the outlying regions of the U.S.S.R.
3. Creation of three local programs for Moscow and adjacent areas.
4. Preparation of recorded programs for small telecenters.

At the present time the first program serves a population of 135 million directly, with an additional 20 million reached by satellite transmission. These numbers are rapidly increasing with the construction of new cables, microrelay facilities, and centers for reception from satellites. This first program also provides for the transmission of color television for approximately 1.5 hours a day. In 1970, this will be increased to three to four hours a day, and in five years all programs are planned to be in color.

The Telecenter building is equipped with large studios with up to 1500 seats, and many rooms for the actors and administration. The newest high-quality television, audio, and cine-recording equipment made in the U.S.S.R. is used. The studios are equipped with transistorized KT-87 cameras with 4½-inch (15-cm) image iconoscopes, new KT-90 camera equipment with 40-mm vidicons, and with film projectors for 35-, 16-, and 8-mm films, flying-spot scanners, and magnetic tape recorders (Electron-2) with wide-band recording. There is also provision for the recording of television programs to the American standard of 525 lines and 60 Hz.

For the recording of television programs and films on 16- and 35-mm cinefilm, 12 installations are expected to be available for direct recording and for recording from the screen of kinescopes, a process important for long-time storage. The center is provided with all necessary equipment for an annual production of more than 33 million meters of 35-mm film, with 28 well-equipped viewing centers, etc. Studio illumination utilizes new economical sources of light, with a color temperature of

THE OSTANKINO TV tower reaches for the sky, sprouting antennas, observation decks, and a restaurant.

3200°K (including iodine-vapor tungsten lamps) and automatic control of illumination, by means of a prerecorded program on perforated cards. This permits shortening of the time of preparation of the studio for transmission and better utilization of studio area.

The electric power supply for the Telecenter is 25 000 kW, of which the lighting equipment consumes from 600 to 900 kW; 100 kW of dc power are supplied to the studios for electric-arc illumination. The studios and rooms of the telecenter are served by 14 high-power air-conditioning installations.

The general impression of the ensemble is a grandiose scale of construction, very elaborate, up-to-date, expensive equipment, and lavish decoration, indicating the importance the Soviet government has attached to televisio broadcasting.

The Svetlana plant, Leningrad *G. M. Berkin*

Svetlana is the firm name of an industrial complex in Leningrad employing 30 000 people. Its original output was electric light bulbs assembled from imported parts. Today it produces electronic hardware, such as amplifiers, receiving and transmitting tubes, X-ray tubes, orthicons, and many semiconductor devices, specializing in low-power high-frequency devices. All the automation equipment used in manufacturing at Svetlana is made there.

The plant was organized in 1913 and converted to military use for World War I. Subsequently, it was reconverted to civilian production. In 1928 a radio laboratory was added. Up to 1941 it was the chief source of electronic components for the entire U.S.S.R. It was largely self-sufficient, making it own glass, equipment, and tools.

During World War II, men and equipment moved eas Before returning to Leningrad, they seeded the establishment of several new plants throughout the country. Semiconductors were introduced in 1958. In 1962 a reorganization united six enterprises into one firm adopting the Svetlana name.

In recent years the profit motive has been introduced. Perhaps as a result of this and more local management freedom, a 12 to 18 percent annual growth in production is reported. The management is highly concerned with output quality and claims that product testing represents 20 to 40 percent of product cost. Tubes are guaranteed for a life of greater than 5000 hours. Transistors are 100 percent tested, and a 10-hour aging cycle is included.

Considerable attention is given to empoyee motivation, including large illuminated displays indicating the present day's performance with respect to quota. Prizes and medals for outstanding production are awarded.

Institute of Radio Electronics, Moscow *R. Adler*

There is a substantial program at the Institute of Radio Electronics in the field of acoustoelectric effects and acoustic amplification, with particular emphasis on surface waves. Layered structures, in which the functions of carrier transport and acoustoelectric energy conversion are performed by separate materials, were first proposed at this Institute, and experimental as well as theoretical investigations are in progress.

A large fraction of the effort is devoted to semiconductors. Using the far-infrared region of the spectrum, a technique has been developed for analyzing small impurity concentrations of donors and acceptors. The technique makes use of the absorption caused by the impurities, a series of lines in the far-infrared region (for example, 160 μm). The presence of very small quantities of material, such as 10^{10} atoms per cm^3 of boron, can be determined by this method.

Capture cross sections of traps and other levels are being studied in films of CdS and GaAs as part of a study of defects. Optical properties are under study; recent work showed that the exciton line absorption disappears when electric fields of 5×10^5 V/cm are applied.

When long-wavelength radiation is absorbed near the surface in a thick sample of InSb, a gradient in the electron temperature, observed as a photothermal effect, is set up. In the presence of a magnetic field, a transverse voltage appears—a photothermomagnetic effect—which is very much larger than the voltage generated by the photothermal effect. Use of the transverse photothermomagnetic effect is being considered for a radiation detector in the 100- to 2000-μm range. Work is also being conducted on ferrites, nonlinear magnetic resonance, spin waves and their coupling to elastic waves, and on related phenomenons.

Academic City *H. Chestnut*

Akadem Gorodok (Academic City) was established in 1958 as a project of the Siberian Branch of the U.S.S.R. Academy of Sciences. Located 30 km from Novosibirsk, the metropolis of central Siberia (population 1.3 million, location 3400 km due east of Moscow and 180 degrees due east or west of Wichita, but at the latitude of Ketchikan), Academic City has grown to a population of over 45 thousand, and contains about 16 research and development institutes and a university, plus the homes, stores, and other living facilities required to house and care for the people who staff them. Academician G. I. Marchuk, deputy director of Academic City and director of its Computing Center, described the program to us with a vigor and enthusiasm characteristic of the frontier that Academic City represents.

About 80 percent of the activity of the Siberian Branch of the Academy centers in the Norosibirsk area; but now that Academic City is so well established, new centers of similar (or complementary) nature are to be opened, some as additional suburbs of Novosibirsk and others elsewhere in Siberia. Particularly needed are applied technological institutes that will bridge the gap between new research and factory production. This problem seems quite international.

A major goal of Academic City has been to find and educate the best young scientific talent in Siberia. The University at Academic City runs a competition each year, which starts out by having each of the 14- to 17-year-old students throughout Siberia (which amounts to some one million or so) take part in two math contests, from which 10 000 winners are chosen. Scientists are then sent out to centers to conduct second tests (a part of which includes oral exams, which are really conversations) in an

MODERN APARTMENTS rise from the birch forest in Academic City, near Novosibirsk in Siberia, and traffic is not yet a problem.

attempt to determine who the more creative youngsters are. One thousand young people are chosen, and on August 1 they come to Novosibirsk for four weeks of summer school. Prominent speakers visit the institutes and direct contact is obtained between scientists and students. After four weeks of extensive tests and evaluations, 250 students are chosen for an up-to-three-year enriched program to prepare them for superior performance at the university in the physical or mathematical curriculum. Initial results from the program are so encouraging that similar programs are being established in Moscow, Kiev, Leningrad, and Atta. Although it is a frontier city, Novosibirsk expects to become an innovator and leader in Soviet science; it certainly appears able to do exactly that.

Computer Science Education in the Soviet Union

M. L. Dertouzos

The U.S.S.R. is facing just about the same problems as the United States when it comes to educating the computer scientist of tomorrow. After all, conditions are largely similar: new, faster, and better machines, such as the BESM computer, are rapidly emerging; large time-sharing systems such as the AIST (Automated Informational Stations) project at Novosibirsk are currently under development; research in languages, compilers, parallel programming, system architecture, automation, and the like is mounting; and the requirements of noncomputer disciplines that need computers, such as meteorology, are continuously increasing. These trends place a heavy demand on the computer professional and raise among educators the familiar and difficult questions concerning the autonomy of computer science, its relationship to other disciplines, and the desirable structure of a computer-science curriculum.

As in the United States, today's computer professional in the Soviet Union was trained as the mathematician, engineer, or physicist of yesterday. Today, in contrast to the U.S.A., where every university is more or less developing its own brand of computer science, the U.S.S.R. strives to develop the new discipline through a central planning committee encompassing geographically and academically diversified experts, under the auspices of the U.S.S.R. Academy of Sciences. A recent output of this committee is the following computer science curriculum, which will be used in Kiev, Kazan, Leningrad, Minsk, Moscow, Novosibirsk, and Yerevan, starting next September; it was described to us by Dr. A. P. Yershov, a computer scientist of international reputation, who participated in its evolution.

1st year: Calculus; analytic geometry; linear algebra; programming (this includes such topics as the use of a simple Algol-like language, IBM-360 language, methods of programming and coding); foreign languages; social disciplines.

2nd year: Calculus, theory of complex variables, ordinary differential equations, theoretical mechanics, programming languages (description and study of languages such as Fortran, Algol, Cobol, Lisp: methods of description and compiling algorithms); profiling course (an elective course from a list including principles of numerical methods, mechanics, cybernetics, mathematical economics, and finite mathematics, the purpose of which is to give a profile or specialty to the student); foreign languages; social disciplines. During the second year all students practice heavily with computer equipment such as punches and printers, each student solving about ten trivial problems per year in order to become familiar with computer equipment.

3rd year: Partial differential equations; functional analysis; system architecture (systems software and hardware organization); profiling course; project (during the third and fourth year, all students split up in small teams, undertaking a complete self-contained project, such as the construction of a conversational compiler); foreign languages; social disciplines.

4th year: Probability, heuristics, and information theory; numerical methods (the fundamentals of which are also scattered in other courses such as calculus, linear algebra, and differential equations, as need dictates); project (continued); profiling course; social disciplines.

5th year: Diploma work. Although students may take some optional courses, they are expected to concentrate five days per week on a current, important, and relatively new problem—for example, design and implementation of a sophisticated text editor. This is generally a more difficult project than the type undertaken by the third- and fourth-year teams.

Comparing this curriculum with that of M.I.T., we find that (1) the Soviet curriculum has a more concentrated coverage of classical mathematics and theoretical physics, and less extensive coverage of modern mathematics; (2) the Soviet curriculum concentrates heavily and in a planned way on the practical use of computers and in team projects, whereas the M.I.T. curriculum achieves similar results through a more decentralized and informal approach—that is, the natural use of computers by elective subjects and thesis students, according to need; (3) programming linguistics is introduced in the Soviet curriculum through the practical study of existing languages, with no attempt being made to develop a fundamental theoretical approach, such as M.I.T.'s use of the lambda calculus; (4) the U.S.S.R. five-year diploma corresponds to our master of science degree; (5) a striking similarity between the two independently developed curriculums is the Soviet provision for profiling courses, which coincides with M.I.T.'s intentionally flexible elective structure and with the philosophy that a curriculum in computer science must be augmented with a cohesive program in another discipline (such as electronics, biology, mathematics, physics, and so forth) in order to be effective.

Russian computer scientists publish their results in *Kibernetika*, in the *Journal of Numerical Mathematics and Physics*, and at international conferences. There is no professional computer association comparable to ACM, but there are user groups for software interchange.

Student–faculty relations seem quite informal and comparable to ours. There appears to be a dedicated student–faculty group eager to exchange information, and anxious to get on with the many challenging tasks ahead.

The Soviet engineer—his life and living

Although a cursory comparison of salary scales between the average Russian and Western engineer may give the West a decided edge, the greater prestige and social distinction afforded the Russian engineer does much to offset any differences

Herbert Sherman M.I.T. Lincoln Laboratory

Knowledge of the values, traditions, and habits that influence personal behavior can be a vital bridge between cultures. The IEEE–Popov Society exchange delegations that have crossed the Atlantic Ocean in both directions since 1957 have been invaluable for increasing the exchange of such knowledge. Much has been published about the technical facets of this exchange, but less has been written about the more personal matters. This article considers the personal budget of the Soviet engineer: How much does he earn? How will his salary change with responsibility, education, and age? How can he augment this salary? What will his wife contribute to the family coffers? Where will the money go? How does his budget compare with that of his Western peers? Answers to these questions give some clue to the societal values and pressures in the U.S.S.R., help erase some of the mysteries about Soviet life, and contribute to better mutual understanding. United States information and statistics are used as a point of Western reference.

Not intended to be a deep and scholarly treatise, this article is based on very-small-sample statistics obtained as a member of the U.S. delegations to Popov Society meetings in May 1966 and June 1969, in entertaining a variety of Russian delegates to the U.S., and in correspondence with Soviet counterparts during that interval. Some of the data were obtained from other engineers who visited the U.S.S.R.

Some of the Soviet data were cross-checked with up to a dozen Soviet engineers and the answers were acceptably in agreement. The reader should be cautioned, however, that some vital parameters may have been omitted. I look forward to receiving inquiries and comments to refine this material, especially from Russian readers who may see a translated version of this article in the U.S.S.R.

The reader should also be cautioned against making simple conversions based on the official rate of exchange ($1.11 = 1 ruble), because the disposable income differs so widely between the systems as a result of tax differences and state-provided or state-subsidized services.

The young engineer

Ivan Stepanovich Smirnov* has just been graduated from a five-year university course in engineering and is ready for his first job. There are no formal recruiting teams, despite a great demand for his services. He knows that his starting salary will be 120 rubles per month unless he goes to special areas such as Novosibirsk, where he can receive a 15-percent bonus. Starting salaries are rumored to be more flexible recently.

Usually, Smirnov will be assigned to a position where he must serve for three years, although the demand for engineers is sufficiently high that if he is extremely unhappy he can probably change position, since many managers recognize that his output will be jeopardized by such unhappiness. The plant to which he is assigned had applied to a government ministry for an allocation of engineers; most assignments, in the words of one manager, "are made by the method of Monte Carlo." The more aggressive employers will go to faculty members for the names of promising students; these will be sought out, interviewed, and encouraged to apply to the appropriate government agency for specific positions.

The plant manager had six months to evaluate Ivan Stepanovich and could dismiss him during this probationary period; after six months the engineers' union made it virtually impossible to dismiss an inadequate engineer.

* The names used here are all imaginary, of course. Roughly, this name is the equivalent of John Smith, son of Stephen. Ivan Stepanovich will marry Natalya, daughter of Nikolai. Thanks to her strong personality, their first son will be named after *her* father; he will be called Nikolai Ivanovich (Nicholas, son of Ivan) by his acquaintances and Nikolai Smirnov under more formal circumstances.

Since June, the Soviet government made discharge possible, but unlikely in a tight labor market. If he does stay on, he can expect a 10-percent raise after three years, although this can vary with the quality of his work.

The mature engineer

Ivan Stepanovich can improve his financial status by means other than longevity. For instance, he can add to his salary if he passes a foreign-language examination. If he is a programmer and learns a new programming language (e.g., Cobol), his salary goes up by ten rubles per month.

Ivan Stepanovich, with high probability, will marry Natalya Nikoleyvna, who sat beside him in class for five years at the university and is herself an engineer. They will probably have one child, or possibly two if grandmother is resident in the household. Without grandmother, Natalya Nikoleyvna must remain at home to take care of little Nikolai Ivanovich until he reaches the age of two or three, when he can attend nursery school. Such babysitting involves an interruption of her professional career, on which she places great value.

Over the years, Ivan Stepanovich may do well for himself. On each patent (which usually takes three to four months to be processed, although delays of two years have occurred), he gets 60 rubles. If the patent is used in production he may obtain more, depending on a committee's evaluation of the patent's utility.

In time, he may be designated as "senior constructor" at 158 rubles per month. If he leads a group, he can reach a peak of 186 rubles per month. One can go above this level, competing with the Candidat's salary (equivalent to the Ph.D. in the U.S.), but this requires a special and personal exception that, though possible, is rare.

A bonus may be an important addition to his income. In one research institute, the completion of an important project or paper enabled half the staff each year to secure a bonus of up to 33 percent of annual salary. This bonus was given to everyone on the project.

The young scientist

Ivan Stepanovich might decide to go on for his Candidat degree. He would have to pass professional qualifying examinations, with about a 25-percent chance of survival; language examinations, with a higher chance of survival; and an examination in politics and history (Marxism and Leninism), with a very-high survival rate. If he passes these barriers, he is then an Aspirant and will probably live on an 80–100-ruble-per-month grant in addition to his wife's salary.

Alternatively, he might choose to continue taking courses while an engineer or "scientist" at the polytechnic institute as a member of a contract research staff. Here he might make up to 170 rubles per month working on a multiple-person research contract, negotiated by the professor holding the chair in which Ivan was majoring. This contract typically would be for 25 000 rubles per year over a two-year term. It would be negotiated between the institute and an industrial firm and would include research and development done under a specific contract. The contract would encompass delivery schedules, report deadlines, and a specification on the kinds of equipment, components, and services to be supplied by the company to the institute. Of course, Ivan's thesis research would be related to the goals of the contract.

The Aspirant normally takes three years to become a Candidat and the contract may last two years, but no more than three years. This makes for some instability, which can be alleviated by the prominence of his professor and by the quality of the delivered product.

If Ivan Stepanovich selects this route, he might defer his qualifying examinations until convinced of his potentialities as an Aspirant. The personal investment in time and effort can be large, but the rewards in pay, in better living quarters, and in social status are also high. Having obtained his degree, he will be regarded as a "scientist" rather than an engineer, no matter how applied his research may be. Ivan Stepanovich is not questioning his "social relevancy" or his material aspirations as some of his U.S. counterparts are doing.

When his dissertation is complete, it must survive a five-part defense, four of which are extremely rigorous, requiring written critiques by referees who may be on the faculty of other universities. If the thesis is done at a school outside of Moscow, it will be important to have at least one Muscovite opinion.

The mature scientist

If he achieves the Candidat degree, Smirnov enters a new social stratum. With this degree, he can expect his income to grow to 300 rubles per month and, if he becomes a group leader or laboratory chief, as much as 400 rubles per month.

If he is a teacher, he may obtain consulting jobs and earn up to 50 percent above his regular salary. If he publishes papers or books, he will receive 200 rubles per signature (16 printed pages). Thus, for a reasonably sized book, he can receive the equivalent of one year's salary. To avoid "a snow job" ("watering" in the Soviet vernacular), the publishing house depends on a review committee.

If his book is translated abroad in a hard-currency country, he may receive a percentage of the royalties in scrip usable in the "Berioska" shops, which sell foreign and scarce domestic goods for foreign currency.

As his reputation spreads and his research improves, the opportunity to consult increases. He may then publish a major work at the age of 35, or more likely a later age, and be adjudged qualified as a doctor of technical science. He may be appointed as a full professor at 500 rubles per month or as director of an institute and make 600 rubles per month. He is then near the pinnacle of the Soviet engineering and science hierarchy. There is no U.S. degree directly comparable to the Soviet "doctor of technical science"; the closest approximation is an honorary doctorate. Even at the level of vice director, the higher degree is worth 100 more rubles per month.

The very pinnacle is to be designated as an Academician of the Academy of Sciences, with an added 500-ruble-per-month stipend. Second best is to be a Corresponding Member of the Academy with an added 250-ruble-per-month stipend. With consulting, his income may now total 1400 rubles per month. He will have a villa (the equivalent of a suburban home in the U.S.) and can conceive of taking his wife with him on trips abroad.

The range of salaries from junior engineer to director of a research laboratory spans more than a 10:1 ratio; in comparable U.S. laboratories, this range would be about 5:1 (before taxes).

The outgo

One cannot evaluate a standard of living from income alone. What do the essentials of life cost? What goes into fixed expense? What do some of the simpler pleasures require?

There are certain large expenditures incurred by the U.S. engineer that in effect do not seem to exist for Ivan Stepanovich.

1. **Medical expense.** Out-patient medical care costs Ivan Stepanovich virtually nothing. The doctor's fee per visit is one ruble or less; medications must be purchased, but my Russian acquaintances uniformly agree that medical costs are not significant in their budget. No information was gathered on hospital costs.* By comparison, the average American (according to government surveys) is spending slightly in excess of $200 per person per year, including insurance and dental care, or about $800 for a family of four.

2. **College.** The State takes care of Nikolai Ivanovich's tuition and provides him a living allowance if he passes the entrance examination. Across the ocean, the U.S. engineer putting children through the better private schools may spend about $15 000 per child, although this expense is spread across his working years. Of course, Johnny Junior can, in the United States, go to a state university at substantially lower costs than those that prevail at Ivy League schools.

3. **Retirement.** Saving for old age is not necessary for Ivan Stepanovich. The U.S. engineer, on the other hand, is probably putting 5 percent of his earnings into the retirement fund at his plant, in addition to contributing to Social Security benefits.

The remaining expenditures, before "disposable" income, are for housing, transportation, taxes, and food.

Housing

The average U.S. engineer is probably putting 20–25 percent of his income into rentals or a house, especially starting incomes. That portion of his mortgage payment representing equity is a form of savings. By comparison, Ivan Stepanovich, once he is past his probationary period, is likely to be assigned an apartment in a block controlled by his employer.

Apartments are easier to come by than they were in 1966. The norm of 9 square meters per family member is being achieved, and explains why Ivan Stepanovich is reluctant to invite Western friends to his home. If Ivan Stepanovich has received a Candidat degree, he may apply for an apartment with a 20-square-meter area over his normal allowance. If he and his wife follow the pattern of one child per professional family, the added 20 square meters in Ivan's apartment give him nearly twice the floor area per person that nondegree-holders can achieve.

Below the professorial level, and aside from the

*Abortions are formally discouraged but are available for five rubles.

FIGURE 1. The prices of these women's shoes are shown in rubles (the 38 is not related to price). Imported and much sought after, these Italian shoes are not purported to represent "average" prices, but show styles in a "non-Fifth-Avenue" department store in Moscow.

FIGURE 2. The same department store as that of Fig. 1 also displays washing machines selling for 75 and 98 rubles.

Candidat allowance, the quality of housing seems to be fairly uniform, and more a function of personal history than of rank. At the full professor and institute director level, however, there is a marked improvement in housing. In Novosibirsk, some of the Academicians live in villas with detached garages and large plots of ground. In Moscow, the equivalent ranks live in roomy apartments.

Rentals are cheap, of the order of 10–12 rubles per month. Gas and electricity average 2–3 rubles per month, going up to 5 rubles by midwinter.

If apartments are hard to acquire, Ivan Stepanovich can purchase one at about 100 rubles per square meter with a 20–30-percent down payment and the remainder at nominal interest.

One area that was explored by later visitors involved summer quarters called the "dacha." At the professional level of Candidat and higher, the dacha seemed to be universal. In early June, when the IEEE delegation arrived in the U.S.S.R., school was over and many families had already moved children to their dacha. No dacha economics were uncovered, however—whether they were leased or sold, or what the purchase and running costs came to. The dacha was the frequent motive for owning a car, although availability of public transportation was a factor in selecting the dacha.

Transportation

In Moscow, Ivan Stepanovich can buy a pass that allows him to use public transportation as often as he likes. The six-ruble monthly fee is a close approximation to the summed four kopecks per bus ride and five kopecks per subway ride if he paid for these individually. Buses and subway trains run very frequently; peak hour headway is two minutes on the subway and four minutes with the tram, with off-peak runs acceptably frequent. Bus fare is collected on the honor system. All mass public transportation ceases at 12:30 A.M., but taxis are available and not inordinately expensive. The taxis are supplemented by "capitalists" who are reputed to use either government cars or personal cars to "moonlight."

Subways are impeccably clean, the windows gleam, and each station stop in Leningrad and Moscow is a fresh adventure in decorative art. At least one station has doors between the platform and the train, thus cutting down platform draft and noise and increasing platform safety. The subway depths require escalators.

Notwithstanding the quality of public transportation, the private car is increasingly in evidence. The Moskvich, the cheapest car available, costs about 3000 rubles or about 2.1 annual incomes of the starting engineer. He can go to 5600 rubles for a four-door Volga, but the waiting time is reputed to be up to four years.* Insurance is available, but maintenance is a problem. One friend said that purchasing a car is entirely possible (although delivery time was not specified), but begrudges the time he would have to spend *under* the car. The taxis were observed to be equipped with hand crank and crank hole for manual starting. One crank was seen in use even though it was mid-June and far above the winter temperatures.

**New York Times*, July 1, 1969, reporting an article in *Voprosi Filosofi*.

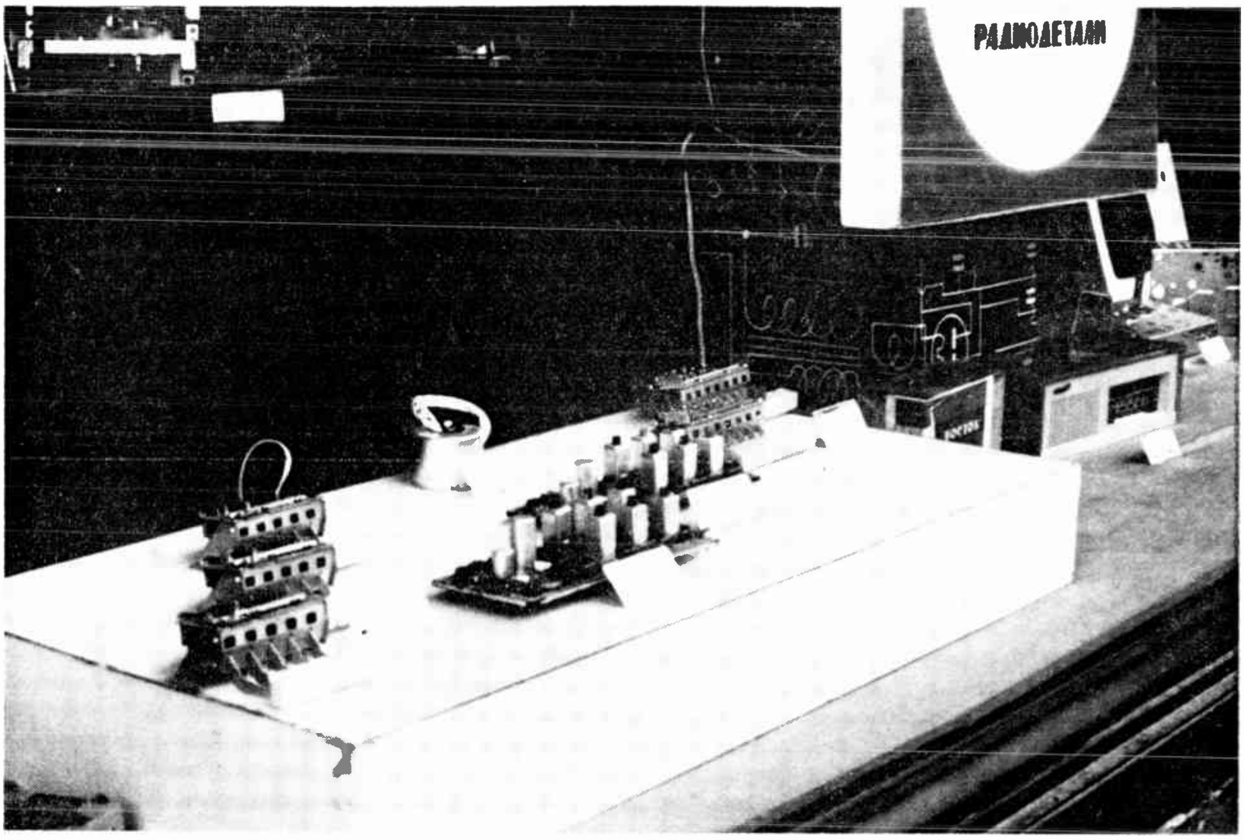

FIGURE 3. The vacuum-tube IF strips and tuners shown here are bought by nonprofessionals for assembly into complete units. The components in the center sell for 16 rubles; tape decks are also available for such assembly. The store at which these items were on display is in the midst of an apartment complex far from the downtown area.

that necessitate using a hand crank. It will be interesting to see how the Soviet Union solves the maintenance, legal, insurance, and orthopedic problems raised by increasing car ownership.

The average U.S. citizen is spending $1448* per 10 000-mile year, of which fixed costs are $1053 for insurance, depreciation, licensing, and registration.

Taxes†

The difference in economic systems between the U.S.S.R. and Western nations makes the "tax" problem ambiguous. With a little reflection, it will be evident that in the West the tax is largely visible as a deduction from income, but in the U.S.S.R. the tax is "hidden," having been removed by the state and dispensed as pensions, medical care, and subsidies to education or public utilities such as subways. A direct Soviet tax is, therefore, only the top of a submerged iceberg.

The fraction of Ivan Stepanovich's income going directly to taxes is dependent on income and it is difficult to reconcile information gleaned from private conversation with published information. Ivan Stepanovich seems to pay 13–15 percent of his received income directly in tax. However, he pays no local real-estate or automobile excise taxes.

Food, clothing, and household costs

Food prices in the Soviet are state controlled. Some prices were sampled in the food stores. A pound of butter costs about 1 ruble 70 kopecks. A quart of Cyprus orange juice costs about one ruble (but is used less frequently than in U.S. households). Ground meat costs about 90 kopecks per pound, the better beef cuts are about 1½ rubles per pound, and cucumbers in season were about ½ ruble per pound. The price of bread was not sampled.

Ivan Stepanovich usually has a more demanding palate than can be satisfied by the normally marketed food and will purchase food on the open market, which is officially limited to twice the government-controlled prices. Ivan Stepanovich's haircut costs 30 kopecks (and no tip!). Natalya Nikoleyvna's hairdo is also about one fourth to one fifth the comparable U.S. cost.

One of Ivan Stepanovich and Natalya Nikoleyvna's biggest complaints is related to clothing and shoes. There are shoes available at 8 rubles, but general agreement conceded that durable shoes cost 35 rubles and up (see Fig. 1). These are Italian shoes admired by the ladies for style, comfort, and durability. Ladies' boots, adequate enough to survive a Siberian winter, are reputed to be worth 50 rubles or more.

Natalya Nikoleyvna could purchase material and have it made into a dress at the atelier at prices in the range of

* AAA study cited in the *Boston Evening Globe* of June 23, 1969.

† I am indebted to Prof. F. D. Holtzman, Tufts University, for suggesting these references on income tax: F. D. Holtzman, "Income Taxation in the Soviet Union: A Comparative View," *National Tax Journal*, vol. 11, pp. 99–113, June 1958; and M. B. Bogachevski, "Finansiy Kredit," SSSR, Moscow, 1964.

20 rubles. Ivan Stepanovich's suit made this way seems to cost nearer 200 rubles, but both of these figures are based on a sample of one.

Nylon shirts are available at about twice the Western prices and are much sought after from tourists. Natalya Nikoleyvna's panty hose cost about three times the Western price and are markedly inferior, but miniskirts are much less in vogue and mitigate the demand.

Household goods

Ivan Stepanovich and Natalya Nikoleyvna's new apartment comes with a two-burner gas range and no other appliances. They need a refrigerator; the 5-cubic-foot unit with freezer and ice-cube trays costs between 280 and 300 rubles. A radio and stereo phonograph costs about 150 rubles and the black-and-white television about 250. Washing machines (Fig. 2) are on sale for between 75 and 98 rubles complete with wringer, but there really isn't any room for one in the kitchen. A sewing machine in a cabinet is 110 rubles, and folding couches range from 72½ to 121½ rubles. There is no sales tax.

At the Candidat level, it is fashionable to design one's furniture specifically for the apartment and to have it custom-built. Candidat Ivan Stepanovich may spend about 1000 rubles to furnish the apartment in this style, drawing the money from his account at the local savings bank, which pays 3-percent simple interest. Credit is available for certain items, but, according to one informant, not for the most desirable items. The finish details on the furniture that I saw were well done, particularly in comparison with the finish on construction inside many apartments.

In quoting prices, one must be prepared to ignore second-order effects. To a Continental European family who have been accustomed to shopping for fresh food every day, a 5-cubic-foot refrigerator with freezer compartment and ice-cube maker may be a greater leap forward than going from the 5-cubic-foot refrigerator to the 12-cubic-foot unit that is so common in the average U.S. home.

Leisure time

The cheapest outlets for leisure time are books and records. Records are typically 70 kopecks per disk and the quality is pretty good. By U.S. standards, books are very cheap. The easiest comparison is between translated technical books and their U.S. originals. It is quite common to have translated U.S. books reprinted in larger numbers in the Russian than in the U.S. edition—and at one fourth the U.S. price! (Royalties are paid U.S. authors in nonexportable rubles.)

If Ivan Stepanovich's tastes run to the countryside, he may buy a light motorcycle for 540 rubles. If he prefers to hike or hunt, camping goods and guns are available at reasonable prices; and if his professional and hobby interests coincide he can construct his own tape recorders and other electronic gear (Fig. 3). He will probably own a 35-mm camera costing between 100 and 150 rubles. He can get a Brussels Fair prize-winning 500-mm Cassegrainian optical lens for his camera for 100 rubles; the same lens is being exported to the U.S. and sold for $250, although it is available in the Berioska stores in the U.S.S.R. for $88. Bicycles are 47 to 57 rubles; a scuba gun costs 30 rubles.

Ivan Stepanovich's best leisure-time buy, however, are tickets to the theater, opera, ballet, and music presentations. The best seat at the ballet is 2 rubles 50 kopecks, with the productions all well-staged and usually first rate. "My Fair Lady" translated into Russian was a sell-out in June 1969.

Travel is relatively cheap in Russia. Ivan Stepanovich can get a one-way ticket to Moscow from Novosibirsk (approximately New York to California) for only 49 rubles. His hotel costs in Moscow are 2 rubles 50 kopecks per day, so that taking a vacation in Moscow is not unusual. There is a step function at the border; a trip to the U.S. costs about 2000 rubles, 1000 for travel expense and 1000 for hotels. It is much more likely that Ivan Stepanovich will get to the West by delivering a technical paper or visiting a plant on business rather than as a tourist, and if he is not an Academician, taking Natalya Nikoleyvna remains but a dream.

Epilogue

Did Ivan Stepanovich make a "good" choice in electing engineering as his vocation? By all the material standards associated with salary and choice of assignment, he did very well. By Western standards, some of Ivan Stepanovich's rewards in relation to others are almost startling. The pay of one Soviet gynecologist (six years beyond secondary school) having an additional specialty of surgery (acquired with three years of additional training) is 100 rubles per month compared with Ivan Stepanovich's starting salary of 120 rubles per month. The social rewards are also high, as measured by the esteem of others and as evidenced by the wide sale of popularized scientific books. The distinction between the engineer and scientist is "blurred" and, in fact, may not be differentiated by the Soviet citizen on the street.*

Finally, there is the provocative evidence that the new emphasis on efficiency and "profit" in Soviet industry may even lead to larger roles and rewards for the engineer. It will be interesting to review Ivan Stepanovich's status several years from now.

* This, however, is also true in the West. How many Western laymen understand whether Apollo 11 was built by scientists or engineers?

Herbert Sherman (SM), born and educated in New York City, received the doctorate in electrical engineering at the Polytechnic Institute of Brooklyn. He was with various agencies of the U.S. Government. Since 1952, he has been with M.I.T.'s Lincoln Laboratory as a staff member later becoming a group leader in communications and most recently responsible for the design and orbital testing of the Lincoln Experimental Satellite series. He is the author of a number of papers on signal design, optical signaling, communication satellites, pattern recognition, data transmission, and channel characterization. A consultant on the associate staff of the Peter Bent Brigham Hospital since 1958, Dr. Sherman also became a staff member of the Beth Israel Hospital in 1969. Until this year, his medical interests were in instrumentation for and mathematical modeling of physiological systems, which have resulted in several papers published in the medical journals. Two patents issued for devices that assist in processing cardiac catheterization data are now, or shortly will be, in production.

Annual Index

IEEE spectrum

Volume 6, 1969

This section contains complete multientry indexes covering the contents of IEEE Spectrum for the calendar year 1969. The Author and Subject Indexes include feature articles and Book Reviews. The News Index includes items from the Focal Points and News of the IEEE sections, except for People and Obituary items, which are listed separately.

In the Subject Index, there are several entries for each published item, under descriptive subject headings that establish a context. The item is referenced only in abbreviated form in the Subject Index. Always refer to the Author Index for full details.

Author Index

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Adams, G. E., *see* Lee, T. H., *1968*
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Review by F. J. Tischer, *SPEC 69 Sep* 106

A combined index of all IEEE 1969 periodicals and conference papers will be published early in 1970. A magnetic tape of all these indexes, suitable for computer use, is being prepared. Address inquiries as to its availability to Information Services Department, IEEE, 345 East 74 St., New York, N.Y. 10017.

Alger, Philip L., and E. Howard Holt; The new responsibility of the engineer; *SPEC 69 Aug* 63–65
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Bachynski, M. P.; *SPEC 69 Jul* 110. *Review of* Delcroix, J. L.; Plasma Physics—Vol. 2, Weakly Ionized Gases. *John Wiley & Sons (New York, N. Y.) 1969*
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Beauchamp, J. W. (Ed.), *see* Von Foerster, H. (Ed.), *1969*
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Bell, W. E., *see* Sinclair, D. C., *1969*
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Berkin, G. M., *see* Tompkins, Howard E., *SPEC 69 Dec* 69–74
Blakemore, John S.; Solid State Physics. *W. B. Saunders Co. (Philadelphia, Pa.) 1969*
Review by W. Murray Bullis, *SPEC 69 Nov* 114–115
Blewitt, Bert J.; *SPEC 69 Nov* 116. *Review of* Turvey, Ralph; Optimal Pricing and Investment in Electricity Demand: An Essay in Welfare Economics. *MIT Press (Cambridge, Mass.) 1969*
Bloom, Arnold L.; Gas Lasers. *John Wiley & Sons (New York, N. Y.) 1968*
Review by Kalus D. Mielenz, *SPEC 69 Jul* 108–109

T. W. Jarmie (SM) has been named division manager of Telonic Instruments, a division of Telonic Industries, Inc. Mr. Jarmie participated in the formation of Electronic Associates, Inc., in 1946. In 1950 he joined the Electronics Engineering Company of California as a division engineer. From 1957 to 1969 he served as president and treasurer of the Components Division.

H. Fred Koehler (SM) is the new chief engineer, core memory products, of Ampex Corporation. He was formerly in charge of the core manufacturing plant and magnetics manufacturing group of the corporation's Computer Products Division. Prior to joining Ampex, Mr. Koehler was with the IBM Corporation.

Morton L. Long (SM) has been named division vice president of Special Projects for RCA Defense Electronic Products. He will be responsible for special space and defense programs, specializing in data and microwave communications systems. Mr. Long came to RCA from the Philco-Ford Corporation, where he was corporate vice president and general manager of the Educational and Technical Services Division.

Donald L. Oestreicher (M) has been named president and general manager of Lynch Communications Systems, Inc. Mr. Oestreicher joined Lynch in 1959 as assistant to the general manager, and subsequently held the positions of manager of engineering, assistant general manager, and vice president. He was named to the board of directors in 1969.

Alfons A. Tuszynski (SM) has joined the Electronics Division of Union Carbide Corporation as a staff engineer in MOS research and development. He had been consultant in microelectronics and digital filters to General Precision, Inc., and Sylvania Microelectronics Group. Dr. Tuszynski, a native of Poland, received the B.S. degree from the University of London, and the M.S.E.E. and Ph.D. degrees from Newark College of Engineering, Newark, N.J.

Maynard C. Waltz (SM) has been promoted to head of the Components and Materials Information Department at Bell Telephone Laboratories, Murray Hill, N.J. Mr. Waltz joined Bell in 1946, and has most recently supervised studies of the proper application of transistors and integrated circuits.

Obituaries

Zvi Prihar, communications specialist

Zvi Prihar (SM '51, F '64), who had received his IEEE Fellow award "for contributions to communications systems, and for applications of operations analysis to communications networks," died August 28. He was 62 years old.

Dr. Prihar was born in Austria and received the Dipl.Ing. degree in 1928 from the University of Caen in France. He then joined the Bell Telephone Manufacturing Company in Antwerp, Belgium, where he was assigned to the long distance transmission laboratory.

In 1933 he joined the Iraq Petroleum Company as communications engineer, where, for 15 years, he was responsible for the planning, design, and operation of the company's extensive pipeline communications systems in the Middle East. In 1948, he was invited to become the first director-general (postmaster general) of the State of Israel, responsible for the planning, organization, and operation of the postal, telephone, telegraph, and radio services of the new state.

Dr. Prihar resigned this position and came to the United States in 1952. In 1953, while pursuing doctoral work at Columbia University, he joined the RCA International Division as consultant, and later became administrator of special studies and communications. He received the Eng.Sc.D. degree from Columbia in 1954.

He then taught at City College, New York, N.Y., and at the University of Wichita in Kansas. In 1963 he joined the Philco Corporation, and in 1966 became scientific advisor to the president of Operations Research, Inc.

Dr. Prihar was a member of the Operations Research Society of America and the French Society of Radio and Electronic Engineers.

Kilburn Miller Smith (M '25, SM '33, F '53, L) of Fort Lauderdale, Fla., died recently. He had received his Fellow award "for contributions to the field of power system engineering, particularly in the pioneering of high-voltage transmission of bulk power in densely loaded areas." Mr. Smith was born May 18, 1902, in Hingham, Mass. He received the B.S.E.E. degree in 1923 from M.I.T.

William W. Barr (M '57, SM '60) of Dallas, Tex., died August 16.

James Warren Beisel (M '60) of St. Paul, Minn., October 4.

Donald Carter Crowell (M '32) of Berkeley, Calif.

Warren E. Dahl (S '50, A '52, M '57) of Scottsdale, Ariz., August 1.

Franklin Fey Elliott (M '52, SM '58) of Nashville, Tenn., September 30.

John Erstad (A '30, M '55, L) of Palma de Mallorca, Spain.

Walter Wolf Fleming (SM '35, L) of Yonkers, N.Y., September 27.

Antonio C. Gamboa, Jr. (A '56, M '56) of Manila, Philippines, September 12.

John L. Harthorn (S '58, M '61) of Lenox, Mass.

Carmi Alvin Leibold (M '17, SM '56, L) of Reading, Pa., July 24.

Eldon James Montoure (M '48) of Honolulu, Hawaii, August 15.

Gordon A. Neilsen (M '63) of Newport Beach, Calif., August 17.

Madhukar S. Patkar (M '69) of New York, N.Y., in September.

E. Everett Perkins, Jr. (M '20, SM '35, L) of Berkeley, Calif.

Lawrence T. Phelan (M '36, L) of Berwyn, Pa., August 9.

Edward Frank Rendell (M' 13, SM '27, L) of Transvaal, South Africa, August 5.

Walter Edward Smithen, Jr. (M '44, SM '61) of Lafayette, Calif., August 20.

Larry A. Stark (S '65, M '67) of Syracuse, Neb.

Robert H. Walker (M '44, SM '49) of South Hadley, Mass., June 30.

Robert H. Wheeler (M '56) of Colorado Springs, Colo., October 3.

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