computers and people

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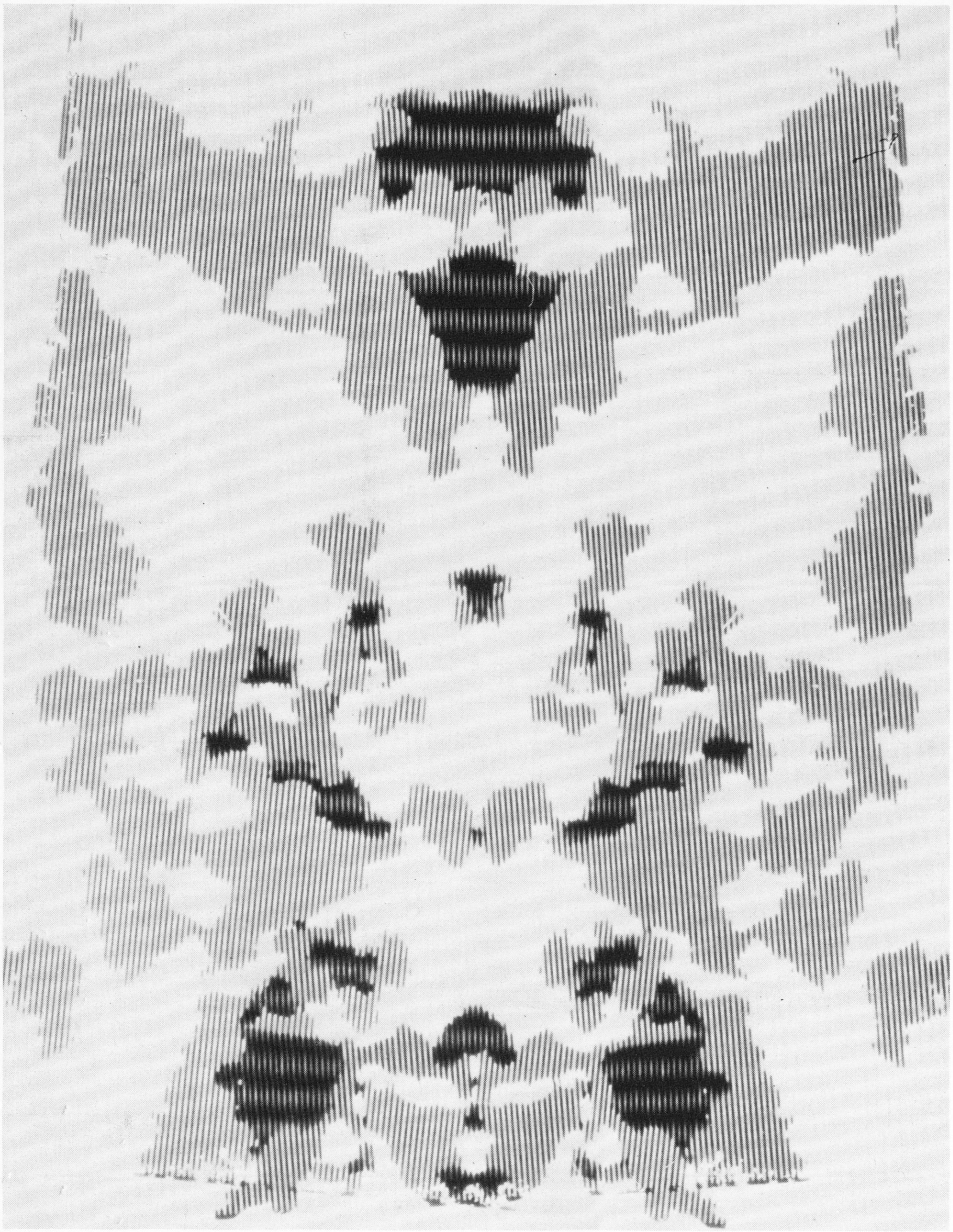

TOTEM, FROM BAVARIA

The Future Role of Engineering
– S. Ramo

Computer Control and Audit: A Necessity
– W. Mair, D. Wood, and K. Davis

The Division of Labor in the Computer Field
– J. Greenbaum

Computerized Tomography: Scanning with Moving X-Rays and Interpreting with Computer
– P. Gempel

"RIDE THE EAST WIND: Parables of Yesterday and Today"

by Edmund C. Berkeley, Author and Anthologist

Published by Quadrangle/The New York Times Book Co., 1974, 224 pp, $6.95

The Fly, the Spider, and the Hornet

Once a Fly, a Spider, and a Hornet were trapped inside a window screen in an attic. For several hours they walked up and down, left and right, here and there, all over the screen. They could look through the screen at the summer woods, feel the summer breezes, and smell the summer smells; but they could not find any hole to pass through the screen to the woods and fields so tantalizingly close, yet so far away.

Finally they decided to hold a conference on the problem of getting through the screen. The Fly spoke first, and said, "My Colleagues, ...

The Fox of Mt. Etna and the Grapes

Once there was a Fox who lived on the lower slopes of Mt. Etna, the great volcano in Sicily. These slopes are extremely fertile; the grapes that grow there may well be the most delicious in the world; and of all the farmers there, Farmer Mario was probably the best. And this Fox longed and longed for some of Farmer Mario's grapes. But they grew very high on arbors, and all the arbors were inside a vineyard with high walls, and the Fox had a problem. Of course, the Fox of Mt. Etna had utterly no use for his famous ancestor, who leaping for grapes that he could not reach, called them sour, and went away.

The Fox decided that what he needed was Engineering Technology. So he went to a retired Engineer who lived on the slopes of Mt. Etna, because he liked the balmy climate and the view of the Mediterranean Sea and the excitement of watching his instruments that measured the degree of sleeping or waking of Mt. Etna. The Fox put his problem before the Engineer . . . .

The Fire Squirrels

Scene: Two squirrels, a young one named Quo, and an older one named Cra-Cra, are sitting by a small campfire in a field at the edge of a wood. Behind them hung on a low branch of a tree are two squirrel-size hammocks. Over each of the hammocks is a small canopy that can be lowered to keep out biting insects. It is a pleasant summer evening; the sun has just recently set, and the stars are coming out: ——

Quo: Cra-Cra, you know I don't believe the old myths any more. Tell me again how it really happened.

Cra-Cra: Just this: we received our chance because they dropped theirs. It is as simple as that.

Quo: In other words, they were the first animals to use tools, and we are the second?

Cra-Cra: Yes. There is a mode of surviving in the world . . . .

Missile Alarm from Grunelandt

Once upon a time there were two very large and strong countries called Bazunia and Vossnia. There were many great, important, and powerful leaders of Bazunia who carefully cultivated an enormous fear of Vossnia. Over and over again these important and powerful leaders of Bazunia would say to their fellow countrymen, "You can't trust the Vossnians." And in Vossnia there was a group of great, important, and powerful leaders who pointed out what dangerous military activities the Bazunians were carrying on, and how Vossnia had to be militarily strong to counteract them. The Bazunian leaders persuaded their countrymen to vote to give them enormous sums of money to construct something called the Ballistic Missile Early Warning System, and one of its stations was installed in a land called Grunelandt far to the north of Bazunia.

Now of course ballistic missiles with nuclear explosives can fly any kind of a path all around a spherical world, and they do not have to fly over northern regions. But this kind of reasoning had no influence on the leaders of Bazunia who wanted the money for building BMEWS. Nor did it have influence on their countrymen, who were always busy, trying to make money — in fact often too busy to think clearly . . . .

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52 parables (including fables, anecdotes, allegories)
23 never published before
27 authors
18 full-page illustrations
330 quotations and maxims

7 Parts: The Condition of Man / On Flattery and Persuasion / On Perseverance and Resourcefulness / Behavior — Moral and Otherwise / The Problem of Truth / On Common Sense / Problem Solving

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MULTI-ACCESS FORUM

THE UNPROJECT REGISTER

From: C. J. Holley, Administrative Vice President
The Unproject Register
305 South Pennsylvania Ave.
Greensburg, PA 15601

We are offering a new and unusual service, called "Unproject Register." We are a research and development center which accepts the listing of all proposals that have been unfunded by government agencies. The listing will provide a protection of all research ideas against subsequent plagiarism. It also constitutes a more comprehensive repository of scientific and technical information than the federally sponsored counterpart, the Science Information Exchange (SIE).

Since current awarding of contracts and grants by federal agencies averages less than 10% of the proposals submitted, the Unproject Register has a potential resource over ten times greater than the SIE.

Today, scientists, engineers, and other researchers are spending untold sums of money and hours in developing projects which are not funded, and this massive scientific effort becomes lost with respect to its contribution to science and technology. The main purpose of the Unproject Register is to make a first step toward salvaging this scientific and technical effort.

We also anticipate that selected lists of the unfunded proposals will be made available to prospective or potential buyers since the primary interest of the authors of unfunded projects is to get them funded by someone.

The registry of proposals will also be a benefit to individual researchers and firms whose ideas often become plagiarized by other researchers either consciously or unconsciously. In the process of evaluating a proposal, agencies utilize many persons both inside and outside of the government. Until the formation of Unproject Register, there was no formal machinery to safeguard proprietary ideas, no check on the subsequent re-appearance of the original ideas in a proposal submitted later or even the incorporation of the idea as a refinement to a current contract. Now there will be a protection against "leaking" leads. The Unproject Register will maintain a record and research mechanism by which ideas can be traced to the original authors.

The Unproject Register is utilizing a format somewhat similar to that used by the registry of projects in the Science Information Exchange and is compatible with other federal project lists such as the Engineering Index, National Technical Information Service and others. Further information and format sheets are available by writing to us.

TRANSLATION FROM ONE NATURAL LANGUAGE TO ANOTHER

From: Phyllis R. Eakin
7569 Herschel Ave.
La Jolla, Calif. 92037

To the Editor:

It may be that "translation from one natural language to another has been largely given up by the computer programming profession" as you stated in the July issue of "Computers and People", but it has not been given up by LATSEC, Inc.

By one of those delicious coincidences which occur from time to time, I read your editorial "Ambiguity and Computers - II" during the same week in which Dr. Peter Toma spoke to members of the San Diego Chapter of ACM at its monthly meeting. I'm happy to report to you that machine translation from one natural language to another is not extinct; it is alive and well and operational as SYSTRAN.

Dr. Toma explained that the major problems of automatic language translation are linguistic ones ... finding analyses of usage which cope with idioms, with figures of speech and other subtleties. After all, even human speakers of the same language may be mutually misunderstood if meaning is clouded by ambiguity and metaphor, as it often is in the language of poetry, of international diplomacy and of marital conflict.

SYSTRAN's greatest capability at present is in Russian to English and English to Russian, both successfully used for the Apollo-Soyuz space project. However, the basic in-depth linguistic analysis system, the control and utility programs, can all be easily adapted to any other natural language pair thus making SYSTRAN a truly universal automatic translator.

The Air Force currently uses SYSTRAN to translate some 15 million words of Russian text per year using specialized dictionaries in such areas as physics, geology and metallurgy. Translation times average only 18 seconds of computer processor time per 1000 words.

For straight-forward scientific and technical papers, computerized translation is no longer in its

(please turn to page 26)

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computers and people

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Computers and Society

7 The Future Role of Engineering [A]

by Dr. Simon Ramo, Chairman of the Executive Committee, TRW Inc., Cleveland, Ohio

To meet the challenges and needs of our rapidly changing civilization, new methods of research and new utilizations of existing ideas and materials must be implemented. A new science and technology ("polylogy"?) will be necessary to meet these new demands, and present-day engineering may be the seed for this new discipline.

6 The Future of Engineering, and Polylogy [E]

by Edmund C. Berkeley, Editor

"Polylogy," an innovative idea advanced by Dr. Simon Ramo, proposes that a new science, incorporating principles from many different scientific disciplines into a workable technology , must be founded to solve the problems created by a progressive world. *Computers and People* will strive to draw attention to this bright new idea, and to advance its cause in any way possible.

Computers and Business

18 Computer Control and Audit: a Necessity [A]

by William Mair, Don Wood, and Keagle Davis, Touche Ross & Co., New York, New York

With inexperienced or naive management computers can lose great amounts of time and money. To use computers successfully and effectively their mechanics and environment must be understood and sensibly assessed.

3 The Unproject Register [F]

by C. J. Holley, Administrative Vice President, The Unproject Register Service, Greensburg, PA

Computers and Labor

22 The Division of Labor in the Computer Field — Part I [A]

by Joan Greenbaum, Instructor in Data Processing, LaGuardia Community College, Bronx, New York

The use of computers in business and industry has evolved into highly specialized operations; broad jobs requiring complicated skills have subdivided into narrow ones, to the advantage of management and stockholders and to the disadvantage of labor and society.

The magazine of the design, applications, and implications of information processing systems – and the pursuit of truth in input, output, and processing, for the benefit of people.

Computer Applications

3 **Translation from One Natural Language to Another** [F]
by Phyllis R. Eakin, La Jolla, California

26 **Computer Terminals Help Congressmen Stay Informed** [N]
by Richard Weisman, "The Boston Globe", Boston, Mass.

25 **Computerized Tomography: Scanning with Moving X-Rays and Interpreting with Computer** [A]
by Patricia Gempel, A. A. Little, Inc., Cambridge, Mass.
This exciting new development is advancing medical diagnosis immeasurably; it has many advantages over conventional x-ray examinations; and new uses for this invention are being discovered frequently.

Computers, Games, and Puzzles

Games and Puzzles for Nimble Minds – and Computers [C]
by Neil Macdonald, Assistant Editor

27 MAXIMDIJ – Guessing a maxim expressed in digits.
27 NAYMANDIJ – A systematic pattern among randomness?
27 NUMBLES – Deciphering unknown digits from arithmetical relations.
26 GIZZMO – Some cryptanalytic Jabberwocky: solution for 769.

Announcements

2 *RIDE THE EAST WIND: Parables of Yesterday and Today* [R]

5 *101 Maximdijes* [R]
A new Berkeley Enterprises, Inc. publication.

28 *COMPUTER GRAPHICS and ART* [R]
A new international quarterly magazine of interdisciplinary graphics for graphics people and computer artists.

Front Cover Picture

Totem, from Bavaria by Dr. Herbert Franke, Puppling, West Germany. According to the artist, this illustration is from the series *Bavaria* "in which the output of images is from a microfilm plotter. The final graphic series was manipulated in a photographic way."

Key

[A]	–	**Article**
[C]	–	**Monthly Column**
[E]	–	**Editorial**
[F]	–	**Forum**
[N]	–	**Newsletter**
[R]	–	**Reference**

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EDITORIAL

The Future of Engineering, and Polylogy

In this issue of "Computers and People" we are fortunate to be able to publish (see page 7) a profoundly important talk by Dr. Simon Ramo, one of the great men and distinguished scientists of recent years. In this talk, given at the National Bureau of Standards in April, he discusses one of the most important problems currently facing the people of the world.

This problem is arranging an organized and systematic way to solve prodigious problems that lie across many different disciplines and branches of knowledge: economics, business, industry, government, law, environment, social behavior, technology, and so on.

To organize a way to solve the prodigious problems, Dr. Ramo proposes the recognition of a new field of knowledge, a new study or subject, like engineering, but much broader. He suggests a name for this subject, "polylogy." It is a reasonable name and may be translated into "many knowledges," or even "interdisciplinarianism." He appeals for recognition by universities of this field, and for work in this field by capable and concerned persons.

Readers of "Computers and People" know well the concern this magazine has expressed for many years in the use of computers for the benefit of society (as in management information systems) and not for the harm of society (as in weapon systems). The same sort of concern is evident in the address by Dr. Ramo. But he goes further: he describes a number of problems which are close to insoluble under existing social arrangements; and he focuses on a practical way for going forward technically, a procedure which changes them from insoluble to soluble. Progress in this direction can be made if enough people understand his proposal and devote time and effort to making his proposal of "polylogy" come into existence.

I read Dr. Ramo's address for the first time in September; I could not put it down until I finished because it was so interesting to me. Then I inquired if any progress had been made in five months towards an association for polylogy, or a medium of publication for polylogy. I was told nothing at all had happened to carry this proposal any further. Here is a typical reception for a bright new idea: since it does not fit into an existing, established box, forget it!

"Computers and People" will not go along with the forgetting philosophy. We shall continue to do our utmost to draw attention to this idea, and to invite and publish articles related to polylogy.

Is this another excursion outside of the computer field? No. Computers are now as omnipresent as books, as omnipresent as mathematics, logic, probability, statistics, files, tables, and pencil and paper. Almost all subjects bear on computers, and computers bear on almost all subjects.

Edmund C. Berkeley

Edmund C. Berkeley

Editor

The Future Role Of Engineering

Dr. Simon Ramo
Chairman of the Executive Committee
TRW Inc.
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Cleveland, Ohio 44117

"The art of mixing together harmoniously public value judgements, technical analyses, creativity, and pragmatic actions surmounts the established expertise of any recognized profession."

[An address delivered at the National Bureau of Standards, Washington, D.C., April 2, 1976]

A common and short definition of engineering describes it as the application of science and technology for the intended benefit of mankind. On this 75th anniversary of the National Bureau of Standards, an institution which has contributed so much to the nation through its engineering expertise, it is pertinent to ask: Is the U.S. employing science and technology to the fullest on behalf of our society? This is not the same as inquiring: Are we following up every clue to nature's undiscovered secrets and are we building every machine it is technically possible to build? These latter are very different (and partly foolish) questions. We seek here to know rather whether our scientific and technological know-how is being applied avidly where strong potential exists for a net, high social reward for the effort.

Science and Technology Key

To this serious question I submit the answer is "no." While our nation today has more capability in science and technology than ever before, we are using it less — less as a fraction of the realizable, beneficial possibilities. Science and technology, fully employed, could improve the value of our resources, natural and human. These tools could be put to work to develop more products so economically and socially advantageous as to warrant the investment of the required resources and whose production could create new jobs to reduce unemployment. Further research could lead us to methods for increasing supply and lowering costs as a counter to inflation, to substitutes for materials in short supply, and to ways of acquiring raw materials and manufacturing what we need with less harm to the environment. But we have become slower, more timid and less innovative in applying science and technology toward such possible ends.

Lethargy and negativism regarding research and development are especially penalizing to the U.S. society because our values and habits are so strongly based on a generous availability of the fruits of advancing science and technology. Our high standard of living is rooted in many decades of such advance. While some may prefer our shifting to a culture less dependent on high production of goods and services, political experts assure us that no approach to our social and economic problems is politically viable if it contemplates the average citizen's accepting a substantially reduced personal supply. It is equally unrealistic politically to expect those living in sub-standard conditions to give up aspirations for a better life. If these are political truths, then as a practical corollary, the tools of science and technology must be used vigorously, because such application is indispensible for a feasible approach to national problems.

Of course, when we speak here of employing technology, we specifically do not mean the unthinking application of it, the mis-use of technology on projects and products the public does not in the end really want and that bring us more harm than good. A high rate of technology advance we recognize as not automatically synonymous with happiness. Also, we know that even if all implemented technological programs were selected to please the great majority of citizens, we still would not be guaranteed a healthy economy and happy society. If the government and the public handle badly numerous other (non-technology related) decisions, we can have inflation, recession, unemployment, high pollution, urban problems, and numerous other ills all at once. However, without a strong engineering foundation, our needs will not be satisfied. Science and technology are not sufficient. But they are necessary.

They are essential to the U.S. for more than domestic tranquility. The U.S.'s international economic competitiveness and our contribution to world stability and progress are both dependent on the status of our science and technology. If world social and economic health is fostered by each nation doing for the world what it can do well and freely trading with the other nations for their best suppliable items in return, then continuing U.S. advances in science and technology are fundamental to our doing our part. In this regard the situation is again disappointing. In those high technology areas where we are close to unique in our capabilities and opportunities we are moving painfully slowly.

The Anti-technology Wave

Now, why are we not doing better to reap the potential rewards of scientific research and technological effort? One reason is the growing "anti-technology wave." A substantial fraction of our nation's citizens equate technology with the devil. In attaining our high production of goods and services, as they perceive it, we have lost much and gained too little: we have been forced to crowd into the cities, this before we have learned to live together. TV offers vapid programs, loaded with violence, that mis-educate our children. The automobile kills 50,000 people a year and fouls the air, and we drive in worsening traffic congestion. We go to the moon but we do not care for our senior citizens. The atom bomb may destroy civilization. The nuclear reactor may poison our environment. We make our soil more productive, but insecticides may do us in.

It can be argued that the folks who believe these things are failing to distinguish between the tools of man and his use — his mis-use, rather — of those tools, and we need only to explain the difference to them. Unfortunately, however, there indeed has been misapplication of technology. Our national mechanism for choice and decision — for matching potential to needs and balancing gains and losses when assigning resources to technological advance — is not yet adequately developed. After all, we find it hard to articulate what kind of a society we want. Thus, it is not surprising that it is difficult to pinpoint the most effective application of science and technology as tools to help us build that society. However, a broad anti-technology bias is a handicap, as is all prejudice. It stands in the way of our arriving at meaningful value judgments and impairs our overall ability to reach objective, sound, non-emotional decisions on the use of technology.

Roles for Government and Free Enterprise

An even more serious limitation to our wise employment of science and technology is the public confusion as to the right roles for free, private enterprise, on the one hand, and government sponsorship and control, on the other. Many people are convinced "business" is socially irresponsible. Whenever any kind of a problem surfaces, they are certain private enterprise can be counted on only to exploit it, seeking "unconscionable" profits and monopolies at the expense of the consumer. They thus look to government alone to provide solutions. They vote for those politicians who blame business most vehemently. Technological advance is often identified with big business, and the anti-business zealots reason that such "advance" really means injected but unneeded product changes, or withheld though needed product improvements, with resulting unemployment and higher prices.

Another large fraction of the voters are equally fed up with government spending and big government generally. They rate the government as a huge and increasingly incompetent and inefficient bureaucracy. As to government-sponsored scientific research and technological advance, they see the government as engaging in wasting dollars into the billions, probably in response to numerous selfish-interest constituencies.

As a capping indication of the confusion, it seems much of the population holds both of these extreme views at once. They distrust both the free enterprise sector's and the government's involvement with technology and can be counted on for a totally negative stance.

Mismatch of Technological and Social Progress

We see in the U.S. today a severe mismatch between the high potential of technological advance and the slow pace of the country's social-political progress. We are simply not organized to use science and technology to the fullest. The problem of wise, full use of science and technology lies not in any lack of availability or promise of science and technology per se. It is the interface of technological with political, organizational and other non-technological factors that is critical and controlling. The whole is a "systems" problem. For instance, in choosing where and how to apply science and technology it would be helpful to have clearer national goals. For a "systems approach" it is required that we know what we are after before we expect to get very far. We cannot make satisfactory decisions on what to do without an understanding of trade-offs and options. We need to be in a position to compare the "good" that can come from technological advance against the "bad" and the cost. As to our employment of technological change, we can be likened to a bunch of carpenters, sawing and hammering away, often getting fingers in the saws and hitting our own thumbs and each other's heads as we swing our hammers, who don't know quite what we are trying to build, who sense an unsatisfactory situation, and who meanwhile blame the saws and hammers.

Limitations of Free Enterprise

We have two mechanisms for getting things done in the U.S.: free enterprise and government. These approaches are not mutually exclusive. In fact, we have always had a hybrid system and the need for a balance as we go about allocating assignments to private or government initiatives. One of the two routes for progress, the free enterprise system — private capital at risk seeking a return — has served well for two centuries to connect many of the needs and desires of the citizens with the capabilities of science and technology. This wedding has blessed us with an immense stream of products and services. Why is this free market, free enterprise mechanism not still the practical answer to the challenge of putting science and technology to work sensibly and completely?

One important reason is that technological businesses producing goods and services, large and small, are not earning enough now on the average to provide adequate funds for investment in scientific research and new technology. After the typically small difference between selling price and costs is used to pay taxes, the interest on borrowed money, dividends to the shareholder, and the inflated costs of replacing depreciating facilities, too little is left to improve methods and develop new products. So dislocating has been the effect of inflation and recession that most corporations have overborrowed. They now find themselves with too high a debt in relation to their equity capital and their net earnings. Since this condition has been paralleled by high interest rates, their debt expenses are extraordinary. Many technological corporations' stock are selling on the market at less than the book value of assets, even though those assets, because of inflation, could not be bought or replaced now at the stated book value. This means new equity capital is as hard to come by as are earnings for reinvestment.

There are a number of further limitations of the free enterprise sector in helping us realize today the full promise of advanced technology. An increasing proportion of potentially beneficial technological projects now involve too great a business risk. More specifically, the "risk-to-return" ratio is too great. The clearly forseeable start-up costs are too high, the time to "turnaround" to an eventual profit phase too long, and the dependence of success on political decisions forbiddingly severe. The market is far from being a free one determined by the public, the ultimate consumers. Instead, it is a chaotic cacophony of semi-autonomous, conflicting private and government actions.

Government Involvement Inevitable

To ensure the proper application of science and technology in the interests of the public, the government must be in the act. It must regulate against impairment of the public welfare that might arise from some technological applications, particularly if performed for the narrow benefit of a private group. Moreover, to advance some aspects of science and technology for the general society's benefit, the government must be relied upon for a strong and essential if not solitary contribution. This is perhaps most obvious in the development of military weapons systems, for sending a man to the moon, and for similar large projects considered as vital to the national interest but where there is no consumer product, no free market involving the general public. On the whole, scientific and technological advance realistically involves the government either as the doer, sponsor, regulator or partner. Additionally, a host of indirect impacts from necessary and unnecessary government actions set the environment and shape decisions on areas of investment and on the mode and pace of activities in the private sector.

The necessity, and yet the complexity of combined government and private involvement in science and technology advances means that the pace of the advance depends on organization and cooperation. We are weak in both functions.

Limitations of "Engineering"

In listing factors highly influential in determining whether science and technology are used to the fullest for the public benefit, we must now mention one second to none, namely, the profession that is concerned with this issue. "Engineering" has meant to most, both in theory and in implementation, the utilization of resources to design and build machines and systems. We are in transition to a new, more highly technological society for which this definition of engineering, and the profession and activities it describes, falls far short of meeting society's requirements. The proper use of science — its timely and wise application to help man with his problems, enchance his opportunities, provide him with acceptable options, and satisfy his social and economic requirements — now is seen to constitute an endeavor of vast proportions. It is this broad endeavor, the overall matching of scientific and technological advance to social needs and progress that must constitute "engineering." The profession should include, but does not today, everything from recognition of need, articulating options for filling it, analysis of technical-economic-social tradeoffs, to the planning, arranging and actual implementation of the most sensible response — this whenever science and technology are expected to play a major part in the accomplishment. If this new profession is not to be developed from present engineering as a beginning base, if engineering cannot rise to this needed "greater engineering" plateau, this failure does not decrease the requirement. We simply then have a missing profession.

We wish now to discuss the many changes in education, image, motivation, practice and organization required to develop this necessary but presently non-existent profession. This can best be done if we first look at some examples of technological advances which the society could attain with benefit if we were to go about it correctly, but where the pace, quality and clarity of effort today is unsatisfactory.

Food and Nutrition

In the coming decades the world problem of food and nutrition will probably move to the top as a critical issue. With very few exceptions the nations of the world, developed or underdeveloped, face the certainty of food insufficiency problems. The United States is close to unique in possessing the combination of natural and technological resources such as to yield us a permanent large food surplus. The production we are capable of could enable us to make a dominant contribution to the world's supply problem. If we organize our research and technology in relationship to the market requirements properly, and, of course, have the right political-social-economic policies, we can improve the economic health and stability of the world, exert world leadership tending towards peaceful, cooperative world trade (and enjoy a favorable trade balance rather similar to the OPEC nation's petroleum based income).

Our land, soil, weather, topology and size of terrain are outstanding, our capacity for high mechanization is great, and our technological know-how on growing, processing, storing, and distributing food is ahead of the rest of the world. Yet we have hardly scratched the surface. Very basic research questions are unanswered (what are the real nutritional requirements of a human being?). Detailed technology of the entire process from seed to mouth remains skimpy. For a maximum effort both the government's and the private sector's roles are not yet fully developed and defined. Water, energy and environmental factors involve the government. Policies for sale of products to other countries certainly do. The private sector can be motivated by the right national policies to a much greater level of investment, innovation and accomplishment.

Many billions of dollars per year of added income to the U.S., millions of people saved from starvation and under-nourishment, and greater world stability depend on our having the skill and desire to organize agricultural science and technology advance, on our putting to work the know-how and entrepreneurial ability of Americans and our physical resources. It is not a project to be finished in a year or two by a small group of government policy makers. The task involves instead a spectrum of interacting programs including many disciplines and many government and private interests. Food is an area full of challenge for the full utilization of science and technology. But if we are to move rapidly and optimize benefits in relationship to costs, the field needs and deserves a thoroughly professional effort.

Transportation

Another example where science and technology advances are not being matched well to the national need is in the area of transportation, whether mass public transport in cities, or railroads, airlines or automobiles. In each of these and other segments something is wrong. We are not getting the transportation that we should be capable of. Too large a fraction of the operating entities are barely avoiding bankruptcy or have achieved it, or it is not possible to obtain financing for needed improvements, or too much of the traveler's time is dissipated, or the accident rate is too high, or the overall costs are soaring, or the system uses up too much energy, or it pollutes the air too severely — all this beyond what would be the situation if we could organize to create a superior match of technology to real requirement.

Specifically, surely almost every large city could gain by installing a first-class public transportation system — not just any system, but the right system. The approach has to be carefully selected and suited to each city's layout, industry pattern, employment, health care, education — i.e. to that city's total economy and life-style. The social and economic gains, assuming a sound application of the correct technology to the city's needs, could be prodigious. In Los Angeles, where I happen to live, the average person resides, say, 10 miles from work — such is the city's "design" — and completes this 10 miles through the heavy traffic at something closer to 10 miles an hour than the 100 miles per hour his automobile can do. A combination of private and urban transportation harmonized with the needs of the people would use less energy, cut air pollution, decrease accident rates and require less total investment (most of the latter now left all day in the parking lot contributing nothing). If workers could save hours each week compared with present means for getting to and from work, that would be the equivalent of a major increase in productivity.

Let us assume I am right about there being a need for a public mass transit system in Los Angeles, a potential for large gain in economic and social terms. Would it be intelligent for even the largest of American technological corporations to invest private resources with the objective of developing, then selling, and thus finally earning a return from, a mass transit system for Los Angeles? Hundreds of separate (and generally quarrelling, apathetic, self-seeking and uncooperative) groups, both private and governmental, are involved in the creation of the "market." Critically important and potentially beneficial as the application of the right transportation technology might be to Los Angeles, that market is not yet formed. The "risk-to-return" ratio for the private corporation going after this field is absurdly high and the start-up cost is huge. Even assuming success in the vague future, the time to pay off is too long and the government's policy on transportation fares — and hence, the promise of return on the private investment — is too unpredictable.

Environmental Protection

Consider next an environmental example. Done with a mixture of creativity and common sense, a major program for selective depolluting of the principal waterways of the nation stands to yield a high return on the investment through improved health, quality of life and long-term economic gain from preservation of human and natural resources. To accomplish this on more than a small scale would require much more scientific research and technology effort than we have so far expended. Understanding pollution phenomena in detail, developing superior nonpolluting approaches to the use of the waters, and inventing and producing a myriad of specialized equipment would require the assignment of expensive technological and scientific resources for many years. Of course, such specific technical work would be meaningless without attention to complex interface problems, such as severity of cleanliness standards versus short-term unemployment consequences, or puzzling out the long term value to the society of cleaner water (how clean?). The decision-makers, in the end the public, must be able to see the options and compare the benefits against the price to be paid.

The technical problems in this area of engineering and the trade-off questions of a social and economic nature are admittedly difficult, but the organizational problem is even more so. Take a specific example — cleaning up Lake Erie. If a combine could be created of, say, five large corporations, including amongst their staffs and their subcontractors all the technical expertise required, how could they even presume to design and then go about installing a system that might depollute the Lake but would also affect the economy and hence the social make up of industrial communities of millions of citizens bordering it? The private combine might offer proposals to install superior waste disposal equipment to a typical city contributing sewage to the Lake but why should that city pay to pollute the Lake less unless all other polluters do their part in an agreed-upon, balanced program. Government initiative and sponsorship, at least in part, and rather complete government regulation of standards are essential to create a market. Of course, a syndicate of large private corporations would not even be allowed to form under present interpretations of anti-trust laws, even though such an arrangement might be necessary to achieve the required breadth of attack on the whole system.

We are today approaching the various problems of environmental control, whether it be land, water or air, through a highly fragmented system of sponsorship, planning and control. We have arranged nothing near to the degree of cooperation required between the private sector, where much of the science and technology know-how is to be found, and the government agencies, local through national, who are necessary participants.

Electronics Information Technology

A quite different example of the relationship between science and technology advance and the filling of national needs is to be found in electronic information technology. Electronic data systems are now possible that can absorb, store, categorize, process, ponder, move and present information in vastly higher quantities, yet with greater speed, radically reduced cost and increased reliability and accuracy, than has ever before been conceivable. This electronic "synthetic brain power" can make each human being smarter at his job. Information makes man's spinning world of activities go around, and we all spend much of our time doing something with information. By a new man-technology partnership in information handling the potential for increasing the value of every hour of a person's time and hence the nation's productivity is tremendous — in business and industry, banks, the professions, airlines, hospitals, educational institutions, and all levels of government.

We know that, compared with almost every developed nation, the productivity growth in the United States is lagging. If it continues, this lag will increasingly hurt our international competitiveness and stand in the way of growth of standard of living for the many millions in the U.S. whose situation is well below average. Electronic information technology looms as the solution to the increasing costs in the service sectors of our economy. The counter to inflation and the potential for new jobs which this new technology offers makes it especially regrettable if we cannot use science and technology to the fullest in this area.

As with the telephone then the automobile and later TV, such electronic information handling advances become economical only if the users are numbered in the many millions. The U.S. is close to unique in the world in possessing the combination of characteristics needed for implementation of this information-technology advance: technological lead; a single integrated large market; a clear need; opportunity for high return on invested resources. Almost everyone's output could be enhanced in value by the equivalent of, say, $1,000 a year by the application of innovative electronic technology that would cost about $1,000 for hardware and software per person using it, that is, if the implementation were done on a mass, national scale. But this would sum up to some hundreds of billions of dollars of initial implementation costs, too big for any one corporation.

This effort is progressing now in a steady fashion but not nearly at as high a rate possible if one counts only technological bottlenecks. Many corporations are involved already in producing the ideas, systems concepts, apparatus, and the information in electronic form required for the applications to operate. Thus, tellers in many banks now are using electronic information aids to enable them to service each customer more accurately, rapidly and efficiently. A credit purchase at a department store, a reservation at an airline counter, a purchase of securities through a broker — these and numerous other applications of advanced information technology are becoming familiar to us as we observe the human partners in the activity relying on a network of intelligent electronic terminals, computers, electronic information files and communications systems.

Full implementation of electronic information systems would radically change the way in which we communicate with each other, altering our present dependence on the transmittal of billions of pieces of paper in motion each day across the nation, would substitute electronic fund transfer for most checks and most cash transactions, would alter the role of the Post Office, and would lead to better concepts for purchasing, scheduling, manufacture, arriving at decisions of a professional-financial kind, and even for the ways medical care is dispensed and schools educate our children. However, the broadest use of electronic information technology includes the setting and evaluation of standards for performance, privacy, and interconnection. It requires cooperation between government and private groups. It adds up to a system problem far more complex than, let us say, the telephone system or the TV network system of the nation. In electronic information handling as in many other frontier areas the application of advanced technology is not set by the technology itself but rather by the complexity of the arrangement-making problem.

An Example in Space

Space satellites represent startling additional examples of the potential of further beneficial technological advance. For instance, if we want to send telephone messages to Europe we now no longer have to put hundreds of thousands of pounds of copper beneath the Atlantic Ocean in the form of a cable. We can instead put a few pounds of copper in a communications satellite and enjoy increased channel capacity. Or consider a space system to advance agricultural technology in which we plot and examine the earth's resources by satellites working with a network of communication equipment, computers and data analyzers on earth. Such a project could enhance weather prediction and hasten mineral and water prospecting as well as disclosing yield potentials and warn of problems for improved agricultural planning. However, a private entity could not scan the terrain of our nation and that of others and then offer the information for sale to realize income without a government sanctioned position to carry out such a task. This means not only government decision-making and sponsorship but also government regulation. Earth resources scanning by satellites is an example of an embryonic, unsettled area where arrangement-making, the setting of goals and functions and the organizing of a team of private and government participants, sets the limit on speed of useful application.

Coal Technology

Some aspects of coal technology constitute excellent examples of the problem of advancing technology occuring when the size and risk of the project and the number of independent players become too great. We know we can obtain gas and liquid fuel from coal, that coal can be mined more safely by using new concepts in mining machinery, and that it can be desulfurized and burned more cleanly. However, the complete system needed for a much greater utilization of coal by the U.S. involves a host of private and public organizations that are rather autonomous and not readily directed from any one point: land owners, mine operators, labor unions, railroads, pipeline companies, power generating and water supply utilities, numerous specialized engineering and manufacturing organizations and many agencies in the federal government and state governments that deal with prices, environmental controls, labor and transport, to name only a few. So far no free enterprise group has risen to make a major new entry into new coal technology, that is, development then production and distribution on a scale such as to bring coal up to petroleum as a source of energy. Such ambition would require billions of dollars and many years of start-up time before fulfillment and a realized return on the investment. Indeed that return might never come, so great are the unpredictable risks associated with independent decisions made on related critical activities not subject to the investor's control.

Need for a New Profession

The foregoing examples help illustrate that applying science and technology for the benefit of society is an enormously complex task transcending the science and technology ingredients thereof. Combining knowledge and ideas on so many technical, economic, social and political fronts is an intellectual challenge. The art of mixing together in a harmonious ensemble public value judgments, technical analyses, and creativity with the right content of pragmatic actions surmounts the established expertise of any recognized profession. Yet the potentials match the difficulties. Also, the detriments to society of inadequacy of attack and execution are so great that professionalism in applying science and technology is a vital world need. Amateurism — everybody in the act in a helter skelter free-for-all — is in some respects inevitable as part of the operations of a democracy. But we are far from an optimum balance. It does not have to be as bad as it is.

Engineering, as the profession is today, does not fill the need. The simple definition that engineering deals with applying science and technology for the benefit of society is misleading and, presumptuously, though innocently, overstated. Today's engineering deals with only a part of the task, so it is only a part of the missing but required profession. Surely those practicing engineering today cannot on the average be claimed to have a professional knowledge of the society greater than that of many other professionals, such as lawyers, physicians, educators, businessmen, politicians or those selling insurance. Of course, it should be stated that in no way can any of these other professions be regarded as engaged primarily in the matching of science and technology to society's wants and needs.

Engineering may be closer than other conventional professions to what we must have, but neither in substance nor image does it cover the intellectual disciplines, know-how and interests embracing the whole subject of the wedding of science and technology with economic and social requirements.

Most engineering educational institutions have for many years required that a typical engineering student include courses in the humanities and social sciences. But this practice has been largely to supply a veneer, a cultural coating to make the engineering graduate a fuller man. It has not been out of a recognition that understanding the way our society operates is as important as understanding physics for the profession the student expects to enter. A number of universities offer "hybrid" courses of study — physics and economics, engineering and political science, biology and electronics — and, of course, some engineering graduates go on to take an additional degree in business, economics or even medicine. Such multiple education equips these graduates for careers that are different from what would be open to them with an engineering degree alone. But the image is not that of creating a force of young people who will comprise the new, presently absent, profession, one to be looked to by the public as the source of leadership to cover the science to society relationship. That relationship is being covered instead by accidental, strained, contesting forces powered by people from all walks of life.

Notice how different in some pertinent respects the situation is as regards law and medicine. If we trained our physicians the way we do our engineers we first would define medicine narrowly as involving (if the reader will forgive a slight exaggeration) the application of drugs and knives to the human body. Then we would proceed to train him in drugs and knives also giving him a few short courses on anatomy — as a cultural bonus, but not with the imperative claim that knowledge of the body is vital to his professional work. One would think that if engineering is the profession of applying science and technology to society then engineers in sum would have to spend about as much time learning about, and in their professional work dealing with, the society as with the tools they plan to apply to that society.

Public health, whether it involves treatment of individuals, regulation of manufacture and sale of drugs, or organization of government efforts, involves physicians in leadership positions. Physicians are not the only actors in the professional effort of handling the nation's medical and health problems, but they furnish the backbone for it.

In a similar way we certainly look to lawyers on anything that has to do with the law. Attorneys provide the professional foundation for such activities whether they be by government or individuals, businesses or families, and whether in lawmaking, law enforcement or the interpretation of the Constitution. We are not surprised that a majority of national and state senators and representatives and Executive Department office holders have a legal background. The substance and image of the legal profession are both pervasive on all matters of life that relate to the law, even though individual practitioners may spend their lives narrowly on divorces, business contracts, criminal cases or numerous other specialties.

What If . . .

What if there did exist for application of science and technology to society a fully developed, totally adequate professional group with the necessary quality and quantity of practitioners? How would things be different? What would we notice about the way science and technology are applied to the society? In reply, many things can be mentioned. One broad-brush example is that since ours is a highly technological society, one in which science and technology figure into almost every aspect of our lives — the economic strength and security of the nation, the way we move about and communicate, and the way we educate ourselves and provide for our material comfort and maintain our health and happiness — a substantial fraction of the leadership of the nation, private and government, would be expected to come from members of that new profession. Their influence would be felt as the nation goes about reaching decisions. Alternatives would be made clearer to us. Facts, theories, proposals for action, and value judgments would be articulated more clearly. The public would be in the habit of listening and trying to understand what we might get in the way of benefits and have to pay in the way of costs or detriments if we decided on various courses of action. We would expect our railroads, airlines, medical care plans, military weapons systems programs, investments for technological advance and further scientific research projects to be better run or better chosen.

A good many potential changes in the society resulting from technological advance would be anticipated. There would exist no perfect prediction process, naturally, and the public would not have to lose any freedom of choice as a consequence of overplanning. However, we would work less from crises and more by following through based upon an easier and wider participation by the public in choosing directions and emphases as increasing scientific advance and technological developments alter our society. If the people want more time to walk barefoot in the sand rather than to own more pairs of shoes, that would show itself more readily in the motivations and controls the government would set up for environmental conservation or incentives for productivity improvement. The average person would have increased awareness that science and technology can be used to realize more the life he wants or, if he does not participate, might be improperly employed to alter society in a way he does not want. The relationship between goals and operating and decision mechanisms would be clearer, this as a result of a steady flow of analyses and data. A national pattern and habit would develop of expecting a new plateau of quality and quantity through the increased utilization of professional effort now highly inadequately supplied.

How do we get there?

Now, if this new level of professional activity is not available today, and if we want it in the future, how do we get there from here? If neither engineering nor any other profession is "it," how do we plant the new seed and make it grow? I submit that engineering is not ineligible even as it exists today as the starting point, although I am not sure that the new profession needs to be called "engineering." Perhaps it is "techno-sociology" or "socio-technology." But those two names are not good enough because they suggest a teaming of only two existing areas of endeavor, engineering and sociology. Perhaps it is better to call it polysocio-econo-politico-techno-logy or, for short, "polylogy." What we call it is not the most important factor.

Engineering is a sensible beginning point because of two considerations. First, the already existing base of science and technology in the profession and in the education for it is a basic piece of the substance and image of the required broadened activity. Even more important, engineering is a "do it" profession and the new profession is as well. To digress only slightly, to pursue pure research, we have need for the kind of individual exemplified at the highest by Einstein. These are people who professionally apply themselves to understand better the laws of nature. This applies not only to physical science but to all other aspects of the universe including trying to understand the behavior of man as an individual and in groups. For the new broadened profession we are describing, in the long run it is indispensible to have a steady flow of the contributions of such fundamental philosophers and researchers. We should not expect to create the missing profession by merging an engineer with, let us say, an academic researcher in sociology. The latter is permanently essential in just what he is doing, at which he is presumably expert and for which he presumably has natural talent and aptitude. The expanded profession we seek to define and create will be concerned, as is today's engineering, with getting things done. Again, like engineering, it is distinct from pure research. It is not concerned with attempting to enhance our understanding of the laws of nature but it will profit and grow as that understanding grows.

University Requirements

University training for this "greater engineering" profession would inevitably have to include three main dimensions: (1) science and technology; (2) the society — the nature of man and his institutions and practical, social-political-economic disciplines related to making the society work; (3) interdisciplinary techniques, or "systems engineering in the large," for attacking problems through recognizing and handling interactions, multidimensional aspects, interfaces, compromises, alternatives, balances and optimizations. The fullest use of science and technology for the nation requires understanding both science and the nation and this thought would dominate the curriculum. In addition, since most real-life problems involve synthesis as well as analysis, methods would be found to bring out the creative as well as the analytical talents of the student.

To assemble a faculty that might be expected to turn out "polylogists" clearly requires a merging of talents and specialties to create a new kind of teacher as well. Obviously "greater engineering," like law or medicine or any major pursuit, will continue to have its highly detailed specialized aspects. Many professionals, probably most of them in fact and most of the graduates, might be expected to pursue specialties as a life's work. The same will apply to faculty members. But there must be an overall concept that all of these specialties are somehow part of an integrated whole which is interdisciplinary. This certainly requires that in the university part of the creation of the new profession there be a strong contribution from individuals whose zeal and capability apply well to the generalization of the whole and the integration of all the parts.

Certainly for the profession itself, if it is to develop as quickly as possible, we shall have to create mergers from various professions. There are now people in business, government, law, medicine, sociology, (and even engineering) who agree on the points being expressed here and who, in making their individual contributions, could properly be labeled "school of hard knocks" polylogists. When an engineer becomes a businessman or even conceivably a senator, or a physician becomes a university president, this does not necessarily mean he has become a polylogist, a member of the new profession we have been describing. He may have simply changed from one specialized, existing profession to another, neither of which is the new and presently missing profession. In mentioning existing polylogists, I refer rather to individuals whose interests and contributions are in the broadest sense actually in the application of science and technology to the meeting of society's needs. The individuals who are in such situations today are engaged in their interactive, interdisciplinary activities more or less fortuitously. They have not been deliberately trying to create a pattern for a new profession.

If we want to do precisely that, the professional societies could be helpful. Leaders in engineering should be interested in broadening engineering to meet a societal need. Those concerned, even though they are not engineers, with the operation of major science and technology centers also should be interested. So should leaders of the academies and the major philosophical societies, as should university presidents, and heads of technological corporations and of those large government organizations that have a heavy dependence on science and technology.

All engineers might encourage the bringing of people into our fraternity who are not normally thought of as engineers, this if they are engaged in a distinguished way in contributing to the fullest use of science and technology for the benefit of the world. Many consulting engineers come closer in certain respects to having a beginning foundation for "greater engineering" than do, say, computer engineers or aerodynamists. However, in general all engineers tend to have been organized and categorized by technical specialties rather than through the route of interdisciplinary activities and seldom through the merging and matching of nontechnological with technological aspects.

Payoff Warrants Attention

As these paragraphs are recited as to what might be done to bring the new profession into being, and even as the case is made that present day engineering in substance and image is one candidate for a base for expansion and growth into the new needed profession, I am conscious of how little I have really said about how to get there from here. But I think we should be earnestly trying to make the step because the payoff could be so great.

Perhaps it is inevitable that the new profession will arrive only when it is ready to arrive as a result of eventual supply-demand pressures of the real world. More and more it may become apparent to thinking people that we are inadequately using, or in many instances actually mis-using, these remarkable tools of man, science and technology. It may be seen we are missing too much. Meanwhile, a steady flow of evidence will follow of what we might gain in rewards by improved vision and performance. The surfacing of the potential will attract outstanding brains. Organizational patterns will begin to improve and intellectual disciplines will be developed. The new profession will evolve. It may still be called "engineering." Whatever it is called, it will be different, challenging, creative and beneficial to the world, well beyond today's engineering.

Greenbaum – *Continued from page 24*

of systems analyst became the highest level in prestige and salary, as systems analysts were separated from programmers. Although both job descriptions still required technical expertise and thought processes, the systems analyst was to develop procedures to process information and determine the method and solution to business problems, while the programmer was to translate these solutions into a language the machine could understand.

The process of sorting out the repetitious tasks from those that might still require thought has been evolving during the last ten years. Programmers have been divided and subdivided into single-skill categories, and simplified programming lanquages have been developed as a means to concentrate skill into as few hands as possible.

Four Levels of Programming Languages

A noteworthy movement in the codification of programmer tasks was the development over the last fifteen years of four levels of programming languages. Initially, programs had to be written in a detailed format called machine language. This required a great deal of skill and knowledge of the machine, and was replaced by assembly language coding which simplified the instructions process by allowing the programmer to code fewer and less complicated instructions. By 1965 general purpose computers like IBM's 360 could use more generalized instruction sequences; and easier-to-use languages like COBOL, a language for business processing, came into widespread use. These languages removed the programmer from the technical detail of the equipment and required only the ability to transcribe a given solution into an English-like series of instructions. The last development has been the introduction of pre-planned application languages, where programmers need only insert a prearranged series of codes. The development of pre-planned applications has resulted in the total removal of technical skill from some of the tasks of programming. Starting in the late 1960s, more and more applications which would have previously been done by a data-processing worker have shifted out of the field. Accountants and bookkeepers, for example, code financial information directly into data terminals for transmission to the central computer center. These workers require minimal computer training compared to the programmer specialists of the early sixties.

(To be continued in next issue)

Computer Control And Audit: A Necessity

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"Although computers are highly reliable at what they do, they only do that which is programmed and, then, only with information that is provided from humans. Errors and inaccuracies in these inputs may be the source of millions of dollars of losses.

Strong Computer Controls

The Equity Funding fraud, for all of the millions of dollars that it cost investors, is somewhat facetiously credited for providing the greatest contribution in recent years to the goal of strong computer controls. The authors' accounting firm was engaged by the bankruptcy court to produce more realistic financial statements after the discovery of the fraud. Although the press credited the success of the fraud to the sophisticated use of computers, we found, rather, that only 1% of the fictitious assets claimed by Equity Funding had any relation to the use of computers. In fact, most of the assets were wholly without any type of support by computer or anything else. The only role that a computer actually played was to create some rather weak support for certain fictitious insurance policies that Equity Funding was selling to legitimate insurance companies. /1/ If Equity Funding were all we had to worry about regarding computer fraud, we wouldn't really have much to worry about.

The Puppet = The Computer

The opportunity for computer fraud that should cause greater concern is the programmer's ability to manipulate the computer as though it were a puppet. He does not need to have direct access to the actual computer equipment. By submitting programs with subtly imbedded routines to perpetrate a fraud or evade existing controls, he may gain control of huge quantities of assets.

A Little "Extra" Maintenance

A case of programmed computer fraud occurred in a revolving-credit-card system. A programmer provided a little "extra" maintenance along with some routine program changes. Thereafter, on the tenth day of each month, the first $100 payment processed was credited to the programmer's own account. The second $100 payment was credited to the account of the first payment, and so on. A complaint resulting from the eventual shortage in the last account could never be traced to the programmer. The programmer never came near the computer room.

In spite of these examples, relatively few cases of computer fraud or embezzlement are uncovered — particularly when one considers the number of opportunities that exist. Based upon our observations, relatively few companies have sufficient internal controls to reliably prevent or detect acts of computer fraud and embezzlement. Apparently, the only reason computer fraud and embezzlement are not more common is that data processing personnel are generally honest. In comparison to the other problems that exist, the exposures to computer fraud and embezzlement seem to be relatively minor. This is not to say that they are negligible, but rather, that other and more substantial problems should command the greater concern and attention.

The "Information Assets" of the Organization

The business records maintained today on a computer may constitute virtual "information assets" of the organization. Although not negotiable, these assets may even be more critical to the successful operation of the business. If they are damaged or destroyed, they may threaten the very existence of the business enterprise.

Probably the greatest threat to these assets, like their more tangible cousins, is fire. The computer equipment and machine-readable records can be damaged by temperatures as low as 120 degrees F. While fire seldom occurs within computer equipment, fire in an adjacent area may easily spread.

Fire and Water Damage

A computer manufacturer experienced a serious fire in a computer center used to distribute software products. The fire started in the basement used to store packing materials for the shipment of the software products. The intensity of the heat structurally damaged the computer room floor on the level above and entered the computer room via conduits provided for electrical cables. Water used to extinguish the fire added to the destruction. Millions of dollars of computer hardware and information assets were destroyed.

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The Danger of Concentration in Just One Place

What makes the risk from catastrophes greater with computers is the totally new level of concentration of information assets that they promote. The comparison of information assets between a paper environment and a computerized one is like comparing a cash register to a bank vault. The consequent effects on risk management may be compared to an insurance company having all of its policies on buildings within a single block. Although the probability of destruction is not increased, the potential consequences certainly are.

The risks provided by the concentration of assets do not involve only the catastrophic destruction. Daily operating errors may also have massive consequences.

Forgetting the "Protect Ring": Erase Record of $500,000 Cash Receipts

The computer operator in a medical institution forgot to remove the "protective ring" on a magnetic tape that constituted the sole record of approximately $.5 million in cash receipts. He accidentally mounted the tape on the wrong tape drive, and it was erased. As a result, past-due receivables could not be identified and pursued. To assist the reconstruction, additional labor had to be hired. About the time that the reconstruction was finally complete, the same accident happened again.

"Organization Amnesia": Bankruptcy

Computer records often play an essential role in the business information systems. A serious deficiency in the quality of these records or their complete loss can cause "organizational amnesia." This occurs when the business information system fails to provide accurate and timely information regarding the activities of the organization. As businesses grow and must deal with an increasingly complex society, the effects of organizational amnesia become of greater concern. Businessmen must take positive steps to assure that their survival is not threatened.

A small aerospace manufacturing company developed a high-technology consumer product having great appeal. Within two years it grew from a business that served only 20 customers to a household name selling directly to more than 15,000 retail establishments. However, its information system for the collection of receivables was completely inadequate to control the growth. Three years after its successful product introduction, the company declared bankruptcy — a victim of organizational amnesia.

While serious threats, catastrophe and organizational amnesia are still not the primary reason for concern with modern computer systems. Fires do not occur every day; and many businesses can continue to exist, even though their internal information is limited or inaccurate.

Greatest Source of Losses = Innocent Errors

Based on our experience, the greatest sources of computer losses are innocent errors and omissions. Users may be excluded from development and operation of computer applications and, therefore, never really understand the meaning of the information they receive nor the role they play in controlling it.

A receivables application included excellent controls: starting when the data entered the computer room and ending when the reports left it. Since a computer produced the reports, they were regarded as infallible. Auditors soon discovered, rather, that customer payments were so hopelessly misapplied that they could only request that the customers inform the company of the amounts owed per their records. The company eventually went out of business.

Although computers are highly reliable at what they do, they only do that which is programmed and, then, only with information that is provided from humans. Errors and inaccuracies in these inputs may be the source of millions of dollars of losses.

Error Suspense File: 120,000 Items

A medical institution developed a sophisticated computer system to gain better control over patient billings and collections. One major feature of this system was an error suspense file that controlled follow-up on items submitted with apparently erroneous information. The system provided capacity to control 100,000 error items in suspense at any time. Within three months after inauguration of the system, this file contained 120,000 items and was completely out of control. No one had ever dreamt that the volume of erroneous information being submitted could be so massive. Auditors had to be called in to institute computer-assisted auditing techniques to resolve most of the exception items.

The Wrong "New Price List"

Even one error in certain types of inputs can have a persistent, recurring effect.

A large wholesaler was forced to raise prices in order to recover inflationary increases in costs. However, the "new" price list that was fed into the invoicing system was actually the list of six months previous. Incorrect billings were issued for two months for a total loss of $80,000. Recovery efforts cost another $20,000 for a total of $100,000.

Clerks Often Recognize Ridiculous Errors... But Not Computers

Computers lack the tolerance for erroneous inputs that manual systems previously could handle. Clerks who operated manual information systems would often recognize ridiculous situations and correct them without hesitation.

A manufacturing company converted its inventory control system from a manual system to a computerized one. They were pleasantly surprised but somewhat perplexed when the reported inventory increased by approximately $1 million. Subsequent investigation eventually disclosed that the instruction manuals for their product were classified under the same part number as the machine they described. The 50 manuals in stock were treated by the computer as also being worth $20,000 apiece.

Absurd Results from Proper Inputs

Even when proper inputs are provided to computers, they can still produce absurd results.

Depreciation calculations of an aerospace company contained assets with a negative net book value. Although the programming staff was instructed regarding the various acceptable depreciation methods, none of the finance people had ever informed them that depreciation calculations stop when the net book value reaches zero.

Lack of Communication: Cause of Error

Logic problems in computer processing do not simply evolve from any natural process. They are caused! The vast majority of the cases are caused by poor or nonexistent communications between the data processing personnel and the other members of the business organization. However, even perfect communications will not eliminate all problems.

31 Day Months: $100,000 Loss

In a financial institution, the interest calculation on savings accounts was erroneously programmed as if there were 31 days in every month. In the five months before it was discovered, over $100,000 in excess interest was paid out.

Subtle Defects that Persist for Years

The error rate in programmed functions is intolerably high. Even "tried-and-true" applications may contain subtle defects that exist for years.

A large retail establishment computed its aging of receivables incorrectly for three years before it was detected. It was impossible to determine what effect this had on its collections of receivables.

Programming Errors in 30% of Computer Applications

Experienced EDP auditors may expect to encounter programmed errors in 30% of applications they test. This percentage is lower among financial institutions and higher in manufacturing and service organizations. Rates of as high as 60% have been observed. Fortunately, the majority of the errors that are detected do not have material financial consequences. On the other hand, some of them amount to millions of dollars.

Truncations of Figures: $500,000 Loss

Another financial institution was making discounted installment loans. Upon receiving the information of the amount of discount, the computer would calculate the effective yield on the loan and store that yield for use in subsequent interest-earned calculations. Unfortunately, the programmers did not allow the system to accept any discount values of $2,000 or more so that, when such amounts were occasionally submitted, they would be truncated and produced a lower apparent yield than the actual loan. By the time this was discovered by the auditors, misstatements in earnings had already accumulated to $1.5 million; and more than $.5 million had already been allowed in excess rebates to individuals who repaid loans early.

"Minor" Error in Logic: $10 Million Overstatement

Approximately five percent of the items carried by a company in the distribution industry were so-called "catalog items" whose unit cost was based upon the volume purchased in a year. The company's rule was that inventory items would be valued at the lowest amount of such sliding-scale prices representing the highest possible purchase volume. Prices paid in excess of the minimum would be expensed as variances from standard. A minor error in the logic of valuing inventory reversed this rule, however, and valued these items at the maximum price or minimum quantity. The effect was to increase the reported value of inventory by approximately $10 million.

Cost Overruns in Computer Applications: 250%

Not only do the applications being developed contain numerous subtle and not-so-subtle errors, but they also cost far more to develop than ever intended. One popular seminar on EDP controls presents materials stating that cost overruns in the development of computer applications of 250% are "typical."

Systems Analysts Should Be Trained To Design Controls Also

There is a tremendous need for better controls designed more economically and reliably. Systems design personnel may be trained in "systems analysis" but rarely are trained in the design of controls. Many controls that they institute are not even recognized as controls. They are just the way things are done...sometimes. Auditors, who are supposed to be the control experts, will list off numerous controls that they think should be provided but rarely provide any explanation as to how they reach their conclusions. As a result, the systems designers repeat the same errors and omissions with the next system.

The data processing personnel of a large mail-order house designed a "perfect system." It would only operate if everything else worked perfectly. After implementation, the auditors discovered that errors were occurring at the rate of almost 50 percent. The system swiftly collapsed and had to be abandoned after investment of approximately a quarter of a million dollars.

In spite of the absurd results they occasionally produce, computers have come to be considered an essential part of the business environment. At the end of 1973, 133,000 computers valued at almost $30 billion were in use. The number of installed computers will grow to 500,000 by 1978 with a projected value of over $50 billion. The reason for the increase in value being less than proportionate to the number of units is because the heaviest growth is taking place in the very small units, although a heavier rate of growth is also noted in the very large machines. /2/ Given this phenomenal growth, we must ask what need are these machines satisfying?

A medium-sized company in a service industry installed a medium-sized computer for which the rent was approximately $100,000 per year. When their utilization was evaluated, it was found that the machine was being used only 22 hours per month. The equipment had obviously been installed based upon the management's desire to appear progressive and modern rather than any economic evaluation of the actual needs.

Some Systems Function Properly

In spite of the horror stories on things that go wrong with computers, some systems are designed and function properly.

A service organization designed a "cradle-to-grave" automated accounting system. Their design methodology followed a textbook approach precisely and was performed by trained and expert systems personnel. After careful design for more than seven man-years, the system was implemented and has now been operating for five years with an almost perfect record for reliability and accuracy.

Strong, well-directed management is what makes the difference. Data processing management is a very new profession. Business applications of computers only reached a wide scale in the early 1960's. Current standards for effective EDP management may be quite unfamiliar to individuals who entered the electronic data processing profession only a few years ago. Such persons must not allow themselves to become obsolete.

Why Learn by Bitter Experience?

The great waste is that so many organizations seem to have to learn the hard way rather than by the experience of others. So often professional data processors complain that integrity controls "cost too much." They are sadly unaware that many techniques to improve record integrity pay for themselves by also improving productivity.

A perpetual inventory system contained inaccuracies in 70% of its on-hand balances. By expanding cycle-count efforts, the rate was reduced to 30%. This then permitted a reduction of 15% in the levels of inventory carried to protect against stockouts. The reduced carrying costs saved from four times the cost of the additional controls.

Creative Use of a Computer System: 25% Reduction of Inventory

Fortunately, some organizations eventually reach a state where they start to use computers creatively rather than merely extending payrolls...and even doing that wrong. Just as the maturation of humans is accompanied by an increasing concern for distant future events, this same phenomenon is noted in business organizations that achieve a mature level of comprehension of this invaluable tool.

A distribution company now projects anticipated future sales of each product by dividing its inventory into hundreds of demand classifications and comparing recent sales with historical sales trends for products of each type. Using this approach, they have managed to reduce inventory levels by 25% while improving the level of service.

Computer Potential

We absolutely must learn to control and audit computers in a more reliable and efficient manner. Even the sophisticated applications of today barely hint at the potential of what computers will be used to do tomorrow.

One of the fundamental concepts of computers is the "stored-program" concept. This recognizes that stored programs are identical in form to stored data; therefore, programs may be modified by programs just as data can. From this recognition, we already have computer programs that appear to "learn" to play chess or to perform other advanced logic. While these applications appear to constitute "artificial intelligence," they are still merely sets of computer instructions designed by men. However, the program can modify its own instructions according to its "experience." The actual instructions that are being performed may change dynamically and be unrecognizable when compared to the original set. If we can't even design a receivables-aging program that operates correctly by using the same logic rule for years, how are we ever going to control or audit a program that changes itself each second?

The Computer Revolution Requires Control

What we are really witnessing is a "computer revolution" that has potentially greater consequences than the Industrial Revolution. While the Industrial Revolution harnessed machines to multiply the power or man's muscles, computers can be harnessed to multiply the power of his mind. The successful and effective use of this power demands control. The people who can provide this control will be able to guide the future.

/1/ "Report of the Trustee of Equity Funding Corporation of America Pursuant to Section 167(3) of the Bankruptcy Act (11 U.S.C. §567(3))" by Robert M. Loeffler. Trustee United States District Court Central District of California, February 22, 1974, p. 38 and October 31, 1974, pp. 137-139.

/2/ "EDP Industry Report," James Peacock, editor, International Data Corp., quoted in "Computer World," August 7, 1974, p. 29.

□

GEMPEL – *continued from page 25*

out-patient basis. Certain other neurologic diagnostic procedures (electroencephalography and skull x-ray for example) will be unaffected since they provide different information. The impact on neurologic diagnosis is expected to be measurable within the next two to four years. It is too soon to estimate the impact of whole-body scanners on other areas of diagnostic medicine.

New Models

Fifteen companies now offer CT equipment, and new models with improved resolution of the images and reduced scan time are coming along rapidly. Some units use multiple detectors; one unit being developed has 600 detectors that remain stationary while only the x-ray source rotates about the patient. Some companies offer equipment including computer systems that are capable of processing data from more than one scanner, a development that should reduce equipment costs.

Long Waiting Periods at Present

Because manufacturers cannot keep up with demand there are now long waiting periods for CT examination at most institutions. Presently available instruments can scan one or two patients in an hour. Newer and faster-scanning equipment will not significantly increase patient throughput, however, since patient handling imposes a practical limitation. Many institutions are operating their equipment 12 to 16 hours a day, six days a week to meet the demand.

Exciting New Approach to Imaging

CT may well be the most important diagnostic medical advance since x-ray was introduced in the late 1800's. There is no doubt that this exciting new approach to imaging will have a dramatic, long lasting effect on medical practice.

□

The Division of Labor in the Computer Field —Part 1

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"Marx's analysis (of capitalism) is no less applicable to an occupation that could not have been conceived of in his day. In a short twenty-year span, work in the computer field has been transformed by capitalism to suit its needs, through carefully planned division of labor."

Labor on Computers

Throughout the 1960s there was intense academic debate about the effects of automation, particularly as represented by the computer, on the labor process. Bourgeois economists and sociologists, while admitting that automation frequently reduced skills among many kinds of workers, pointed to the growing employment in the computer industry itself as a bright spot for labor. Many of the new jobs in this growing field were categorized as technical and professional and were considered illustrative of labor-force upgrading.

Indeed, computer jobs were glorified in the early period. Salaries were high, and qualified computer technicians had a great deal of freedom and mobility. I entered the data-processing field almost 15 years ago in the heyday of its craft, and like many of my fellow workers rode the crest of its early opportunities. During those years, and on into the period of division of labor in the field, many of us tried to fight the changing conditions of our labor, but we lacked a conceptual base from which to present our arguments.

At First A Craft ...

What was missing from these early evaluations was a firm understanding of the labor processes of capitalism. Marx's analysis is no less applicable to an occupation that could not have been conceived of in his day. In a short twenty-year span, work in the computer field has been transformed by capitalism to suit its needs, through carefully planned division of labor.

While economists, sociologists, and propagandists for computer usage have been so enamored of automation, it is no wonder that workers within the field have been blinded by their view of the growing high-skilled occupation. Harry Braverman, however, in his book Labor and Monopoly Capital, has at last separated the forest from the trees:

> For a short time in the 1940s and early 1950s, the data-processing occupations displayed the characteristics of a craft ....The development of a data-processing craft was abortive, however, since along with the computer a new division of labor was introduced and the destruction of the craft greatly hastened. Each aspect of computer operations was graded to a different level of pay frozen into a hierarchy: systems managers, systems analysts, programmers, computer console operators, key punch operators, tape librarians, stock room attendants, etc. It soon became characteristic that entry into the higher jobs was at the higher level of the hierarchy, rather than through an all-around training. And the concentration of knowledge and control in a very small portion of the hierarchy became the key here, as with automatic machines in the factory, to control over the process. /1/

...Later, a White-Collar Assembly Line

Starting from Braverman's overview, the purpose of the analysis presented here is not to bemoan the long-gone days of craft-like activity, but rather to highlight the course of events so that those of us in the computer field, and workers affected by it, can better grasp the implication. (I shall bend Braverman's time frame slightly as my evidence suggests that the real impetus for division of labor did not take hold until the mid-sixties. Subdivisions of computer workers existed during the earlier period, but the full effects were not felt by the workers until the industry expanded in the sixties.) The focus will be on those workers employed in computer related jobs, specifically those jobs having to do with the processing of data. The computer field under study is made up of both computer-manufacturing companies, and the service bureaus, banks, and insurance firms heavily dependent on computer use. Although the largest user of computers has been the U.S. government and within it the military, this analysis will concentrate on commercial uses of computers in the office sector. In demonstrating the impact of division of labor on the labor process in the computer field, I hope that the illustrations will clarify the process of discipline used to reduce a largely "technical" work force to a highly segmentized "white collar" assembly line, where control of knowledge is concentrated. The tasks of programmers and computer operators will be explored here to offer examples of

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the transformation. The major themes include:

(1) The division of labor and degradation of work already witnessed in the manufacturing sector, and to a growing degree in the service sector, has been compressed into a twenty-year time frame within the computer field. Its pattern differs only slightly from that drawn in other fields.

(2) The rapid growth of computer use initially created the urgent need for skilled workers. These workers were drawn away from other fields with the lure of high pay and job mobility. By the time the growth of computer use had begun to mature, there was a need to discipline workers to new productivity standards. Attempts to discipline workers played a major role in the movement toward standardization, routinization, and the downgrading of skilled tasks.

(3) While discipline played the major role in changing the work descriptions, technology was used to intensify productivity. In this, the most technologically based of areas, it appears that technology was not the cause of division of labor, but rather the battering ram to open the door to labor acquiescence. Indeed, changes in computer technology offered management the opportunity to speed information processing, cut personnel costs, and demand stricter standards from the workers.

(4) The rigid hierarchy was created to reinforce the effects of standardization. Job categories were minutely defined so that tasks could be performed at the lowest possible rate of pay. The resulting hierarchy reflected the class and race positions obtaining in society as a whole.

(5) The current crisis has driven smaller computer manufacturing companies and users from the field, resulting in increased centralization. The workers laid off from these firms, as well as the large supply of trained technicians turned out by schools, have formed a surplus labor force in the field. The effects on wages and further task reductions are now beginning to be felt.

(6) Trends in the immediate future seem to be toward lower salaries relative to the cost of living, expansion of clerical-like jobs, and a shift away from computer specialists. Technological skill has been removed from all but a handful of workers.

Early Computer Use: 1950-1965

The generally acknowledged start of the computer age dates from the early 1950's. As in the case of most technological birthdays, there is no precise date; some say the installation of the first UNIVAC computer for use in the Bureau of the Census in 1951 marks the start of widespread commercial use, while others move the time to the entry of a UNIVAC computer for payroll processing at General Electric in 1954. It is clear that during the early 1950s Sperry Rand, the manufacturer of UNIVAC, had a "jump on the market," while IBM turned down a deal to acquire rights to this machine "because it felt that the greatest market potential for computers was in scientific rather than business applications." /2/ The clamor for commercial computers, coupled with the development of mass-production techniques in computer manufacturing during 1954-1955, seems to have convinced IBM of the error of its ways. "By making the most of Sperry Rand's mistakes," /3/ IBM prevented itself from becoming a brief footnote in history. In 1955 it overtook Rand for the computer manufacturing lead.

Repetitive Clerical Functions

The first business computers were used for purely repetitive clerical functions which had previously been done by electric accounting machines. These systems, often seen as the predecessor to the modern computer, were based on electromechanical devices for processing keypunched cards. They evolved from keypunch card procedures developed by Herman Hollerith for the Bureau of Census in 1890. While it is true that accounting functions (like payrolls and accounts receivable) performed by the card-processing machines were absorbed by the faster electronic computers in the 1950s, the latter differed greatly from their mechanical ancestors. The most striking difference lay in the fact that the computers could be programmed by a series of changeable instructions, while the processes of the accounting machines were dependent on fixed actions initiated by a wired board. The programmable memory of the new computers allowed logical processes, such as routine decision-making functions, to be automated. The technological distinction created the need for a new breed of workers to program or instruct the new machines. Additionally, the increased equipment speed established the precedent for continuous processing, whereas the electric accounting machines (EAM) relied on multiple job steps involving worker intervention at each stage of processing.

An Urgent Need for Skills

By 1955 the industry was in urgent need of skilled personnel to operate, repair, and program the burgeoning computer applications. The workers who had previously operated the accounting machines could only partially fill this demand. It was not until the mid- to late-1960s, when computers were well entrenched, that EAM equipment began to be phased out. Until that time most companies maintained their accounting equipment in parallel operation with their newer computers. The tremendous demand by management for additional business information, and therefore control over information, led to a great increase in the demand for information processing, resulting in the use of both EAM equipment and computers simultaneously.

Lacking a large enough pool of pre-trained labor power, the computer manufacturers and users began to woo people away from the sciences, often offering them unlimited flexibility in their work, as well as comparatively high wages. Programmers, in particular, were like virtuosos in high demand who could jump from job to job, writing their own tickets to match their expectations. Almost all were quite young and sought independence and creativity in a field which promised status as well as a high pay. /4/

A Seller's Market for Labor

This system of pirating skilled labor power from other fields paid off for the industry until the widespread use of computers began to cause other pressures on capital. By 1962 there were 10,000 to 12,000 computers installed, employing about 15,000 workers in their manufacture, programming, operation, and maintenance. /5/ While the workers were enjoying the effects of a seller's market for their labor power, management journals and marketing literature were beginning to call for standardization of job descriptions and routinization of tasks. High on the management list of reforms was an effort to stop the costly effects of personnel turnover, created by workers jumping to higher-paying data processing jobs. Certainly, the 50 percent growth in computer worker's salaries during the 1958-1962 period intensified the corporate drive to cut costs. /6/

Job Restructuring

Another argument put forth by management in favor of job restructuring stressed the fact that while early computer centers were often charged to Research and Development, by 1963 they were expected to pay their own way and show a "return on investment." /7/ The need for middle management to control the undisciplined, job-hopping work force, combined with the pressures from upper management to account for their expenditures, greatly hastened the death of craft-like worker activity.

Marx foresaw the imprint of capitalism on any industry when he wrote: "The separation of the intellectual powers of production from the manual labor, and the conversion of those powers into the might of capital over labor, is...finally completed by modern industry erected on the foundation of machinery."/8/

Three Classes of Workers Carved Out

The computer field was no exception to this rule. During the 1950s three classes of technical workers were carved out: operators, the manual power to tend the machines, who were rapidly on their way to becoming "feeders" and "attendants"; programmers, the intellectual power to write the instructions and make the computer perform its tricks; and technicians, to repair the "engine" and watch over its functioning. (A fourth category, that of data entry clerks, had previously been extracted from the technical labor pool, as its work patterns resembled those of other clerical workers, and therefore could not hide behind the mask of technical skill. See Braverman, Labor and Monopoly Capital, pp. 329-337, for a detailed treatment of routinization of clerical tasks among the workers.) Although the trilogy existed by job classification in the 1950s, the workers themselves often overlapped tasks. It was not uncommon for programmers to forsake some of their more "intellectual" tasks in order to run the computer for the sheer pleasure of doing so. Similarly, operators, coming in contact with programmers in the computer room, would seize on the chance to learn what the programmers were doing, and thus enhance their understanding of programming and the possibilities for promotion. The computer center, or machine room, as it was appropriately called by the workers, was like a social hall, where the different categories of workers could meet and exchange techniques and ideas.

Management's Cry for Job Definitions

This initial division of labor was clearly not sufficient to meet the needs of management and capital. While workers were taunting management with their technical "expertise," management stepped up its drive for efficiency and what it was to be its necessary co-requisite, division of labor. The independent computer labor force with its concentration and interchange of skills among the workers was clearly a threat to management. One loud cry from management was heard from Dick Brandon, an influential industry consultant, who argued that the industry had reached "economic maturity" without developing proper working methods, procedures, and disciplines. He called for tighter management controls, formal standards, and performance measurements, while decrying the "loss of management control" over data-processing functions. /9/ Scientific management, or the systems approach as it was known in the computer field, took over, and the process of removing skills from each job classification was carefully executed.

Capital Takes Control: 1965-1970

Management demands for a more controllable work force were not the only impetus for change. Commercial uses of computers were catching on rapidly; and by 1965 IBM read the forecasts accurately and began to market the 360 computer system. The IBM 360 was the first general purpose computer designed to process the large volumes of data needed for business information processing. Although the technical base of this machine was not a marked departure from earlier models, it was promoted on its ability to speed the processing of information. The reasons for the success of the 360 could fill many volumes, for they range from IBM's self-held belief that the machine is technically superior, to its competitors' contention that IBM's 70-80 percent share of the computer manufacturing market insured success from a monopolistic point of view. /10/ What is significant from the workers' viewpoint is that the larger machines promised greater efficiency and thus supported management's demands for greater worker productivity.

The Introduction of the IBM 360

Those of us in the field at the time of the introduction of the 360 remember it well, for almost overnight a division of labor occurred, not by chance as it seemed to us then, but by clear design. One of the first management rulings to be enforced was a prohibition on programmers entering the computer room, thus isolating the two categories of labor, diminishing exchange of ideas. From a financial point of view, upper management saw the 360 as an increase in capital expenditure, requiring tighter controls and greater security for their new investment. Thus, to them, the separation of operators and programmers was a necessary step to control the computer room and protect their investment. Line management, on the other hand, was quick to respond to the need to divide the work force as an aid in their struggle to transfer some of the technical skill from the workers into their own domain.

The Separation of Systems Analysts from Programmers

Perhaps the best way to understand the changes that took place is to examine the functions of workers in the field. Programmers represented the pinnacle of intellectual job involvement and diversified skills. Basically, the programmer "directs the computer to do a job and provides it with detailed instructions — a program — as to how to accomplish the task. Thus, the programmer is, in a sense, an interpreter who, given a problem in science, engineering, or business, translates it into a form and language with which the computer can deal." /11/

A more glorified definition, and one often argued for by programmers themselves, states that they are "engaged in work which brings them to the brink of human knowledge," and that "the programmer must fulfill many positions in the course of solving a problem which include administrative know-how and scientific expertise." /12/ A 1963 survey of programmers found that 88 percent had bachelors degrees while 30 percent had completed a masters. /13/ The same study found that 75 percent of the programmers had a highly positive attitude toward their jobs, and emphasized that it was the diversity, challenge, and freedom of the work that accounted for this high degree of satisfaction. /14/

The Further Subdivision of Programmers

An early casualty in the movement to discipline this highly educated middle-class work force was the separation of analytical tasks from those that required only translation into programming. The job

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Computerized Tomography: Scanning With Moving X-Rays and Interpreting With Computer

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"Computerized Tomography may well be the most important diagnostic medical advance since x-ray was introduced in the late 1800's. There is no doubt that this exciting new approach to imaging will have a dramatic, long lasting effect on medical practice."

A new diagnostic tool, Computerized Tomography (CT), is one of the most revolutionary developments in medical technology. The technique makes it possible to obtain a cross sectional x-ray image of any body section. It also offers the diagnostic advantage of defining soft tissues that may not be revealed in any other way.

Equipment Development

Equipment development began in 1968 in England, with the first unit installed for clinical trials in 1971. In spite of their high cost ($250,000 to $700,000 each) about 1000 units have been sold, most of them in the United States. The first units produced, and consequently, the most common in operation, were limited to examination of the brain. Most units now being sold, however, are capable of imaging any section of the body, including the brain.

Signals and Detection

The CT technique resembles conventional diagnostic x-ray methods only in that a similar source of x-radiation is used. CT scanning combines a narrow beam of x-rays and an electronic detector system with a computer to examine a series of parallel "slices" of the body, unlike conventional radiology, which uses a relatively broad x-ray beam and a photographic film. In all but one commercially available system, both the source and the detector rotate around the body in the same plane. The detected signals are transmitted to a computer that calculates the x-ray absorption values of each of several thousand points within the plane. From these calculated x-ray densities a sort of mosaic picture is built up as a matrix of many adjacent points.

This picture is displayed on a video screen, instead of on film, but it can be photographed for a permanent record. The numerical absorption data are also printed out, and can be stored for later analysis or for regeneration of the display.

Pinpointing Locations

Cross-sectional CT images make possible the location of tumors or other diseased or damaged tissue that would often be indistinguishable in ordinary x-ray photographs. Such pinpointing provides information of a quality never before available about specific conditions such as brain and eye tumors, brain atrophy and hemorrhages, and generally makes biopsy procedures, tumor diagnosis, or planning and monitoring of radiation treatment easier and more accurate. Although most experience has been in diagnosis of neurological disease, new applications are being developed as more equipment comes into use.

Whole-body Scanners

Because the first CT equipment took five minutes to complete a scan of a single tissue slice, and because it was convenient to design equipment for that application, the first available equipment and consequently early clinical work was directed at the brain, an organ easily held stationary. New models that scan a cross section in five to twenty seconds can eliminate much of the image blurring associated with organ movement caused by normal respiration. Whole-body scanners are so new that most of their medical applications (other than for brain scanning) are not yet defined. Early clinical reports indicate, however, that they have found numerous diagnostic applications, not the least of which are diagnosing, identifying, and locating tumors in the pancreas, liver and lungs.

Replacement of Prior Diagnostic Procedures

Computerized Tomography will probably replace some other diagnostic procedures to a substantial degree because the information obtained is often superior and in many instances the risk to the patient is far lower than with conventional techniques. For example, the use of pneumoencephalography (removing spinal fluid, injecting air, and observing the movement of the air by means of a series of x-ray films) will probably be reduced as much as 75 percent. The use of cerebral angiography (injecting opaque dye and following the progress of the dye through the circulatory system) will be cut perhaps 20 percent. Both procedures require surgery, are risky and uncomfortable, and require several days' hospitalization. The number of radionuclide brain scans is expected to be reduced by approximately 30 percent.

Probably, Reduction in Total Cost

Thus, although the cost of CT equipment may remain relatively high, CT scanning may actually reduce the overall cost to the health care system, if used properly, particularly since much of it is done on an

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Computing and Data Processing Newsletter

COMPUTER TERMINALS HELP CONGRESSMEN STAY INFORMED

Richard Weisman
The Boston Globe
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Dorchester, Mass.

In a town where information is power, 80 congressmen have installed computer terminals in their offices. Their aim is for Congress to have more of the kind of information that is hoarded by the executive branch.

"It's like fighting a war with the arrows of Congress against the tanks of the executive branch," says US Rep. Charles G. Rose 3d (D-N.C.), chairman of the ad hoc subcommittee on computers. "It's a battle to be better informed so we can not only make better laws but sounder judgments and better inform our respective constituents."

The basic congressional computer system catalogues and tracks every legislative action in both chambers, taps the Library of Congress's information storage and scans 100 data banks in private, commercial and government organizations.

The computers provide arcane information on a spectrum of topics ranging from agriculture to zero-base budgeting.

"There will probably come a time when all members will have these computer terminals in their offices," says Rep. Rose. "I think we'll wonder then how we managed to efficiently conduct the business at hand without computers."

"The system actually revolutionizes the way a member can handle the duties of their offices," says Neal Gregory, Rep. Rose's staff director at the subcommittee on computers. "When you have information at your fingertips, you have more time to worry about how to use the information and to analyze what it means, when assembled with other information."

The office of Rep. Edward Boland (D-Mass.) has used the system for three months and has found it systematic and time-saving.

For example, an aide can find the basic information relating to a given bill by typing a few computer commands.

When Boland recently received a constituent letter urging support of a disabled veterans' work program, a simple computer command produced an abstract of the relevant bill, its background, and current status.

The information expedited the congressman's evaluation of the bill and his letter of response to the constituent.

The office of Rep. David Emery (R-Maine) employs a rather sophisticated computer system. An electronic engineer by trade, Emery uses an additional "time-sharing system" which has simplified his filing system and dramatically increased office efficiency.

A difficulty for some congressmen, however, is the price. Rental for a basic office terminal costs $100 each month. The sophisticated system in Emery's office runs about $600 a month. But those congressmen who do use computers say that the benefits outweigh the costs.

According to Rose, a change to computers is sorely needed to keep pace with the White House. He estimates that 7000 executive branch offices use computers, compared to 180 offices in the House and Senate.

"Our inability to function smoothly may be indicative of the fact that Congress has taken its eye off the ball," he says. "But in terms of the information challenge, we are only just beginning to define what the ball looks like," Rose said. □

SOLUTION TO GIZZMO 769:

1.	Earth	9.	Mile	17.	Substance
2.	Planet	10.	Depth	18.	Temperature
3.	Ocean	11.	Place	19.	Atmosphere
4.	Water	12.	Projection	20.	Pressure
5.	Seventy	13.	Land	21.	Element
6.	Surface	14.	Thirty	22.	Cosmos
7.	Cover	15.	Solid		
8.	Six	16.	Liquid		

Forum – *continued from page 3*

infancy. I think the readers of "Computers and People" would be interested.

From the Editor:

I am very much interested, and I hope to find out much more about this important achievement. □

GAMES AND PUZZLES for Nimble Minds – and Computers

Neil Macdonald
Assistant Editor

It is fun to use one's mind, and it is fun to use the artificial mind of a computer. We publish here a variety of puzzles and problems, related in one way or another to computer game playing and computer puzzle solving, or to the programming of a computer to understand and use free and unconstrained natural language.

We hope these puzzles will entertain and challenge the readers of *Computers and People.*

NAYMANDIJ

In this kind of puzzle an array of random or pseudorandom digits ("produced by Nature") has been subjected to a "definite systematic operation" ("chosen by Nature") and the problem ("which Man is faced with") is to figure out what was Nature's operation.

A "definite systematic operation" meets the following requirements: the operation must be performed on all the digits of a definite class which can be designated; the result displays some kind of evident, systematic, rational order and completely removes some kind of randomness; the operation must be expressible in not more than four English words. (But Man can use more words to express it and still win.)

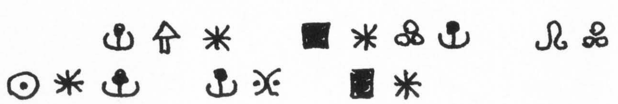
NAYMANDIJ 7611

3	9	3	9	4	6	3	0	8	6	1	2	0	6	6	9	6	3	1	4
7	3	8	7	0	2	4	4	2	0	5	8	5	8	8	0	0	7	1	9
2	0	7	2	2	1	8	3	8	6	2	8	4	6	2	8	5	9	8	4
9	1	9	5	6	1	0	8	6	8	0	3	1	5	7	7	3	7	4	9
5	7	3	1	8	4	8	9	5	7	8	1	2	1	5	0	6	0	1	6
5	2	7	9	8	8	5	4	5	9	6	8	3	9	7	7	9	4	0	8
3	3	2	8	9	9	8	3	0	1	8	1	1	9	1	5	9	6	6	8
8	6	0	7	7	7	5	8	4	8	1	8	7	2	1	1	6	1	6	4
1	8	4	5	4	3	7	1	8	4	6	3	9	3	6	2	2	7	3	7
8	5	9	2	1	8	3	6	8	1	1	4	1	4	9	1	3	5	7	7

MAXIMDIJ

In this kind of puzzle, a maxim (common saying, proverb, some good advice, etc.) using 14 or fewer different letters is enciphered (using a simple substitution cipher) into the 10 decimal digits or equivalent signs for them. To compress any extra letters into the 10 digits, the encipherer may use puns, minor misspellings, equivalents like CS or KS for X or vice versa, etc. But the spaces between words are kept.

MAXIMDIJ 7611



NUMBLES

A "numble" is an arithmetical problem in which: digits have been replaced by capital letters; and there are two messages, one which can be read right away and a second one in the digit cipher. The problem is to solve for the digits. Each capital letter in the arithmetical problem stands for just one digit 0 to 9. A digit may be represented by more than one letter. The second message, which is expressed in numerical digits, is to be translated (using the same key) into letters so that it may be read; but the spelling uses puns, or deliberate (but evident) misspellings, or is otherwise irregular, to discourage cryptanalytic methods of deciphering.

NUMBLE 7611

```
              D O A S
      x         Y O U
      ---------------
            A S D C R
          Y S H Y Y
        C S U R S
      ---------------
      = Y C Y A U H R
```

.20351

We invite our readers to send us solutions. Usually the (or "a") solution is published in the next issue.

SOLUTIONS

NAYMANDIJ 7610: Make octagon of 5's

MAXIMDIJ 7610: It is easy to give up too soon.

NUMBLE 7610: True love is ever glorious.

Our thanks to the following individuals for sending us solutions: Byung Sun Choung, San Diego, CA: Numble 769 – Frank DeLeo, Brooklyn, NY: Maximdij 769; Numble 769; Gizzmo 769 – T.P. Finn, Indianapolis, IN: Numble 769; Maximdij 769 – Diane Huard, Des Plaines, IL: Naymandij 769; Maximdij 769; Numble 769 – S. Shulman, New York, NY: Maximdij 768; Numble 768; Naymandij 768.

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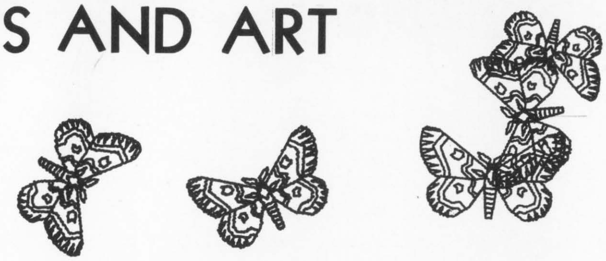

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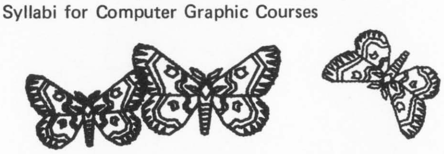

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