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In This Issue

About the Authors

In this issue of the *Montana Business Quarterly*, we are pleased to have Dr. Clarence C. Gordon of the University of Montana Botany Department write on "Air Pollution—Montana Style." This article will be of great interest to those concerned with the problem of pollution. Dr. Gordon is an Associate Professor of Botany, having received his B. S. degree at the University of Washington in 1956 and his Ph.D. from Washington State University in 1960. Dr. Gordon has received a grant to study diseases of conifers and has carried out research on damaged conifers in the Garrison, Montana area since 1964. He has been a consultant to various governmental agencies and private concerns as well as a member of various professional organizations including Sigma Xi, Phi Kappa Phi, and Montana Scientists Institute for Public Information.

Mr. Rauf A. Khan, Assistant to the Director of Technical Services, has authored "From The Director's Desk" in this issue. Mr. Khan discusses the field service programs, which give the businessman a practical and more personal method of solving his particular problem. The field service programs are sponsored by the Montana Technical Services and can be of great value to Montana businessmen, especially those who do not have research and development capabilities. Mr. Khan, an engineering graduate from Montana State University, received his M.B.A. from the University of Montana in 1967 and is a Research Assistant with the Bureau of Business and Econmic Research.

Dr. Jack Kempner, Professor of Accounting at the University of Montana, engages the reader in a discussion of what a computer is and how it works in his article "Inside The Computer." Recently Dr. Kempner has been speaking around the state in connection with the Computer Seminars that the State Technical Services has presented. Dr. Kempner came to the University of Montana in 1956, and prior to that time taught at Columbia University, Balboa University, the University of Colorado and Ohio State University. He took a leave of absence for two years from the University of Montana to assist in Michigan State University's Brazilian Program by instituting a graduate program at the School of Business Administration in Sao Paulo, Brazil.

As we have all read there has been much discussion concerning the consumer and the inevitable legislation for protection of the consumer. One industry that has held a prominent spot in connection with consumer protection has been insurance. Dr. Patricia P. (Bragg) Douglas's article "The Insurance Investor—A Forgotten Party?" lends some insight into the property-casualty investor's needs. Dr. Douglas is quite familiar with the insurance business. While doing graduate work for her Ph.D. at the University of California at Berkeley, she contributed to the researching and editing of *Taxation of the Life Insurance Industry in California,* published by the Association of California Life Insurance Companies and her doctoral dissertation was entitled *Financial Reporting Standards for Property-Casualty Companies.* Dr. Douglas has been with the Bureau of Business and Economic Research since 1966 in the capacity of Research Associate. She is also an Assistant Professor of Finance and the Director of Montana Technical Services. She received both her M.B.A. and Ph.D. from the University of California at Berkeley.

From the Director's Desk . . .

RAUF A. KHAN
Assistant to the Director of Montana Technical Services

"Words, words, words," replied Hamlet to Polonius's question, "What do you read, my Lord?" Hamlet's lament could very well be the comment of many a Montana businessman continually bombarded with pamphlets, magazines, and various publications purporting to show how to run a business efficiently and profitably. But what is the impact of this barrage of words? In many cases, businessmen have neither the time nor the training to analyze the new technological information for effective use. Seminars, conferences, and workshops attempt to save the businessman from the avalanche of words and data; but owing to large and divergent representation these methods often fail to deal immediately and effectively with any one problem.

To alleviate some of the problems of information and technology transfer, the Montana Technical Services (established and supported in part by the Office of State Technical Services, U. S. Department of Commerce) has instituted field service programs directed toward specific industries. Because of personal visits and consultations by field representatives who take a direct approach to problem solving, these programs offer an excellent means for distributing technology. Two programs, the Industrial and Management Engineering Field Service sponsored by Montana State University and the Mining and Geology Field Service, sponsored by the Montana College of Mineral Science and Technology, are now in operation serving manufacturing and mining industries around the State. It is anticipated that a new field service, directed at the forest products industry, will be initiated in the fall of 1968 by the University's School of Forestry.

Generally, a field service under the Montana Technical Services undertakes the following activities: (1) visits by field representatives to firms within the specific industry to inform them of innovations in equipment, production, and other aspects of business; (2) analysis and isolation of problems within the conceptual framework of the particular business organization; (3) offering on-the-spot advice and suggestions, including the distribution of various government and industrial publications pertaining to particular problems; (4) assisting or arranging field demonstrations of new equipment; and (5) offering subsequent referrals and recommendations through follow-up correspondence, and in some cases suggesting competent professional consultants.

The assistance provided under the Montana Technical Services field service programs is diverse and flexible, placing in the hands of the participating firms effective, practical solutions to their specific problems. These programs do not pretend to solve all the economic ills of Montana business and industry; rather they will make available technical expertise to firms for the profitable operation of their businesses.

It is the aim of the Montana Technical Services to develop a meaningful dialogue between field service activities and other programs, such as workshops, conferences, and seminars. Through planned visits and consultations certain problem areas common to firms within an industry may be isolated, leading to the development of workshops, conferences, and seminars. Hopefully, the experiences gained through each activity would complement the others, thus adding to the overall effectiveness of the entire Technical Services program.

To be profitable, business generally should be competitive; and it can be competitive only when it attempts to keep abreast of technological developments, which are growing at a prodigious rate. The Technical Services program in general, and the field service activities in particular, are just initial steps in making these developments known and available to private enterprise—especially to small businessmen who do not have research and development capabilities. The University of Montana's Bureau of Business and Economic Research, in cooperation with Montana State University and Montana College of Mineral Science and Technology, is offering field service programs in an attempt to translate "words" into "action." It is now up to Montana business and industry to take full advantage of these services.

Air Pollution--Montana Style

CLARENCE C. GORDON
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"Adapting to Pollution," an article by Dr. Rene Dubos, appears in a recent issue of *Scientist and Citizen* (January-February 1968). In this article Dr. Dubos relates how 2/3 of the villagers of Finisterre, Mexico are suffering from chronic arsenic poisoning from their contaminated underground water supply (628-949 micrograms per liter). Even though they have symptoms such as neurological disorders, blood protein abnormalities, goiter, and skin lesions, only a small percentage of the people are unable to work and most go about the usual activities of Mexican life. Dr. Dubos also discusses the adaptations of Northern Europeans to air pollution caused by the Industrial Revolution. He points out, however, that although chronic pulmonary disease now constitutes the greatest single medical problem in Northern Europe, the long and indefinite time between cause and effect makes it difficult to convince officials and the public of air pollution's insidious dangers. Dr. Dubos writes that "adaptability is almost by definition an asset for survival. However, the very fact that man is capable of achieving some sort of biological or social adjustment to many different forms of stress is paradoxically a source of danger for his welfare and his future. Atmospheric pollution in the industrial areas of Northern Europe provides striking examples both of man's ability to function in a biologically undesirable environment and of the dangers inherent in this adaptability."

According to Mr. Allen V. Kneese (Director of Water Resources and Quality of the Environment of the organization Resources for the Future) people who want an end to environmental pollution are extremists. In an article "Why Water Pollution is Economically Unavoidable" appearing in the April 1968 issue of *Transaction*, Mr. Kneese used the argument of economic feasibility to claim there is a middle road between those who want to stop pollution of the world's water supplies and those who are polluting. Mr. Kneese quotes Mason Gaffney: "One of the most important functions of economic analysis is to evaluate public policy. Economics, contrary to common usage, begins with the postulate that *man is the measure of all things.* Direct damage to human health and happiness is more directly economic, therefore, than damage to property, which is simply an intermediate means of health and happiness." On one hand Dr. Dubos discusses the dangers of pollution—especially man's adaptation to it—and on the other, Mr. Kneese argues that pollution control should and can be based on economic feasibility. This basic disagreement between biologists and economists (and usually between biologists and lawyers, politicians, industrialists, and businessmen) is becoming universal primarily because biologists are becoming acutely aware of the immediate dangers of air, water, and pesticide pollution in our environment. Unfortunately, a communications gap exists between biologists and the aforementioned professionals.

Before discussing the past, present, and future problems of air pollution in Montana there are a few points that I, as a biologist, would like to emphasize. First, if he believes that "man is the measure of all things" as he quotes in his article, Mr. Kneese is ignorant of the phylogeny of life. Second, of all the millions of species which have inhabited this planet, man has proven to be the greatest predator and destroyer of his environment. Third, almost all of the other species with which we share the earth could survive if man were to disappear tomorrow; the opposite is not now, nor ever will be, true. We are not the measure of all things. Rather we are a species which evolved 2 million years ago on this planet upon which life had already existed for 2 billion years. It is time we came to realize that man is not the host of this planet but a guest who may eliminate himself by his voracious appetite.

Several factors in Montana's history have profoundly influenced present-day governmental, industrial, and public responses toward air pollution. Air pollution in Montana may be assumed to date from the early crude attempts at smelting during the early 1880's. With the exhaustion of placer gold, early fortune seekers turned to mining ores and soon began experimenting with smelting, since transportation of the ores to smelters in Wales and England was slow, costly, and undependable. When in 1884 the original Anaconda smelter was built—the largest at that time in the world—the political and economic climate in Montana was typical of most such frontier areas. Government existed only as a feeble pulse, and wealth and power belonged to those who could grab it. During the ensuing 80 years Montana haltingly moderated its way of life.

Tactics accepted as necessary and expectable in the early disputes for power are now socially unacceptable. Consequently, ambitions for power and wealth have been veneered. In the early development of Montana's economy, widespread and outright theft of public timber land and grazing privileges was defended by the majority of settlers. What any individual or fledgling industry wanted from the public domain, it took and with general approval. The right to use the public domain for individual gain persists in Montana and is basic to present day problems of water and air pollution, land abuse and taxation.

Smelting had been recognized in Europe as detrimental to plant and animal life for several decades before the first smelters were built in Montana. Agriculture was impossible in the vicinity of smelters due to the toxic gases and dust emanated. To reduce the cost of smelting and thereby benefit financially, Marcus Daly in 1889 built and put into operation new facilities at the Washoe Smelter (Anaconda) to which was shortly added the present high stack. This high stack was the first of its kind in the world and was built on the theory that the pollutants from the smelter would cause no damage if released sufficiently high. The Anaconda Copper Mining Company had already paid $340,000 in damages to angry farmers and ranchers. As was discovered the following year, the theory was invalid. The result of releasing the pollutants at such a height was simply to extend the area damaged.

Establishing an industry toward the end of the 19th century was a scramble. Risk was great, and speculators abounded. In this setting industries could hardly be expected to have had humanitarian tinges. Their concern was to stay alive, not make friends. Consequently, when complaints began to come in about the failure of the new stack, the Anaconda Copper Mining Company denied any problem and increased its volume. In 1902, ten months after completion of the new smelter, Dr. W. D. Harkins, chemist and professor at the University of Montana, began a study of the Washoe smelter smoke. This study continued until 1906 and was expanded to encompass the smoke's effects on vegetation and animals. Results published the following two years[1] showed clearly that the wastes from the Washoe smelter

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[1] Harkins, W. D. and R. E. Swain. Papers on Smelter Smoke and Arsenical Poisoning. 3 papers: (1) "The Determination of Arsenic and Other Solid Constituents of Smelter Smoke, With a Study of the Effects of High Stacks and Large Condensing Flues," American Chemical Society, Vol. XXIX (4) April 1907; (2) "Arsenic in Vegetation Exposed to Smelter Smoke," American Chemical Society, Vol. XXX

were extremely toxic, especially the high concentrations of arsenic,[2] and precluded agriculture in the valley. With Montana government a phantom, Deer Lodge Valley ranchers and farmers appealed to the United States Department of Agriculture for aid. A 1906 U.S.D.A.-sponsored study on livestock in the valley by Robert Formad agreed with the previous one. In 1906 only 423 horses remained from the 2,347 in the valley in 1902, the reduction being almost entirely from deaths. Other animals were similarly affected, and those that survived were in poor condition.

The evidence was in, but several factors combined to block an action toward abatement. First of these was the disinterest of the company. As has been explained, other more pressing problems confronted the company at this time, and it felt no responsibility for the smoke or the damage ascribed to it. Secondly, state government was not vigorous enough to enforce correction, even if it had been inclined to do so. The actual feeling at that time was that such controversy between industry and agriculture was beyond the sphere of state responsibility. Thirdly, the general public accepted such conditions as unavoidable and of no interest. The only Montanans who were concerned were those directly affected, and they lacked sufficient influence to prevent the continuance and expansion of the air pollution that was suffocating their livelihood. This first major air pollution controversy in Montana set the pattern for subsequent industrial and public response.

It was during this period that Montana's economy became colonial. Capital to develop the mining and lumbering industries did not exist in Montana, and the men who later became successful were those who saw the need for and were able to obtain financing from out of state. As is typical of colonial development, the investors were interested in only one thing—profit. They were willing to spend considerable money to retain and extend their power and privilege, and there was little,

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(6) June 1908; and (3) "The Chronic Arsenical Poisoning of Herbivorous Animals," American Chemical Society, Vol. XXX (6) June, 1908.

[2] In an article by W. C. Hueper, M. D. concerning "A Quest into the Environmental Causes of Cancer of the Lung," U. S. Public Health Monograph No. 36, the incidence of lung cancer death in males for 1948-49 was given as 145.7/100,000 in Deer Lodge County compared to 5.2/100,000 in Gallatin County. A 1961-62 study by the Montana State Board of Health showed that the average arsenic concentration in air in Anaconda (Deer Lodge County) was 0.45 micrograms per cubic meter of air which is twenty times greater than that found in Libby, Billings, or Missoula (Bozeman not tested).

if anything, during that era in Montana that money would not buy. So attempts by local groups to force the various industries to cease polluting the air had little chance of success. Many outside Montana were shocked by the bold power politics of the day, just as many today are amazed at the freedom to pollute granted industry by Montana's citizens. The situation has changed only slightly since the beginning of the century. Industry's arguments are the same, and public acceptance of pollution as unavoidable persists. Only a few—those directly damaged and those with insight on pollution's consequences—are concerned.

Although in succeeding years numerous individuals worked diligently to obtain an air pollution law for Montana, not until pollution became so obviously detrimental to cattle in the Garrison area (1963) was "something" finally achieved. The events in the Garrison area more than any other factor permitted the passage of an air pollution law. However, it should be stressed that the destruction of trees and crippling of cattle were not responsible for convincing legislators and the Governor that a law had to be passed. Instead it was the agitation by the residents of the Garrison area. Probably no other factor is greater in changing the laws and the opinions of public officials than agitation by the masses. If tomorrow the people of Montana were to become sincerely concerned with environmental pollution, they would obtain not only the laws necessary for a clean environment but also the funds to enforce these laws. But this concern will not arise until catastrophies similar to or greater than that which occurred in Garrison occur in the larger cities of Montana.

There are several reasons why I believe catastrophies must precede action in Montana. Foremost is that the economy of many of our cities is based (or seemingly so) on a single industry. Examples of a few such cities are Anaconda and Butte (smelting and mining), Missoula (wood and pulp), Columbia Falls (aluminum), and Billings (oil.) Numerous small communities in Western Montana could also be included as company-dominated towns (*i.e.*, Bonner and Libby) where pollution exists and little is said about it except behind closed doors. Due to the workmen's need for economic security, little or no agitation arises and the health of individuals and the landscape declines.

Another reason for inaction is the almost complete lack of information on specific human health hazards in the polluted areas of Montana. In my opinion this is due not to the lack of evidence but to the apathy of the medical profession. I know of no medical doctor in Montana who is devoting even 1/5 of his time to determining or making known the hazards of air pollution. Furthermore, in Missoula there are at best only 3 or 4 medical doctors out of over 100 who are willing to and do make public speeches on the human health hazards of air pollution. Montana's medical doctors are timid about risking injury to their carefully-built image.

Another cause for the impending catastrophies is the attitude of scientists themselves. In this specific case I include as scientists engineers, biologists, chemists, foresters, and sociologists. In general these Montana scientists, as groups and individually, have remained completely apathetic to environmental contamination. This can be verified by their almost complete absence in Helena during public hearings on air and water quality standards. The oil, lumber, pulp, and mining industries are not apathetic, however, and have imported numerous scientific "experts" to testify at these hearings that Montana should not have stringent pollution abatement laws. These imported "experts" come from universities, research centers, and medical centers and are highly-paid consultants who have a vested interest due to industry-financed research grants or the consulting fee itself. Social conscience, scientific honesty, and man-to-land ethics offer little reward compared to a large research grant and/or a consulting fee. Any doubting reader must ask himself whether he would rather work for $150 to $200 a day (approximate consulting fee) plus expenses or for the $3 to $5 an hour paid by local and state governments for air pollution "expertise." The Ph.D. or M.D. is not a different species of mammal, and all the greed and ego manifested by laymen can be found on a grander scale among the various groups of scientists.

Another reason why Montana's air pollution will not be soon abated is our apathetic and uninformed judges, lawyers, and legislators. It is probably somewhat unjust to lump all these together, but in this discusison it is apt. Lawyers write the bills for the legislators, and the legislators pass or reject the bills depending on their beliefs, their party affiliation, or the lobbyists' influence. Although lawyers may be competent when it comes to knowing the laws of man, they are for the most part completely incompetent when dealing with biological laws. They expound at length on the rights of the individual man and free enterprise and yet have little to say about the rights to existence of the other millions of species which inhabit this earth. In his daily reading the lawyer rarely encounters articles explaining the dependence of man on his ecosystem or the increase in carbon dioxide from one hundred years ago. But just as lawyers are ignorant of science, so scientists are naive about the law. As with scientists. the brightest young graduating law students are sought and usually hired by the more prominent law firms or industries. Obviously these firms became affluent not by defending the poor or oppressed but by securing local industries or railroads as their clients. Unless the plaintiffs have all the evidence and happen to have bright lawyers fighting for them, this difference in talent and financing presents a horrible imbalance in any court case. In the Dutton *et. al.* versus Rocky Mountain Phosphate Co., Inc. case, the first permanent injunction against an industry in Montana was granted. However, I am convinced that the ranchers of Garrison would not have won this case if the Anaconda Company had thrown the might of its money and lawyers behind Rocky Mountain Phosphate. So, although a jury found the Rocky Mountain Phosphate Company guilty and the judge finally decreed a permanent injunction, we need not feel justice toward our environment is imminent. When, motivated by respect for the residents and environment, the prosecuting attorneys of Missoula, Deer Lodge, Cascade, Flathead, Silver Bow, or Yellowstone counties bring action against the polluting industries, I'll esteem some lawyers and our present laws.

There is little one can say about judges (former lawyers) in Montana air pollution cases for only a few have been involved in the last five years. However, of those judges who presided over the several court actions on pollutants from Rocky Mountain Phosphate Company, Inc. only one can claim any concern for our environment. I have often wondered to what extent a judge, who has previously had some of the larger industries as his clients, subdues his conscience or yields to subconscious bias. This subjectivity is no minor impediment in cleaning up our environment. I have the impression that the "justice" of the judge's decision is determined as much by the personalities of the witnesses as by the evidence presented. Laws may indeed be intended for the protection of all the people, but I believe that at present laws for the protection of the environment and future populations do not exist. In Montana today neither the environment nor our progeny have any lobbyist, legislator, lawyer, or judge who has acted significantly on their behalf.

Finally catastrophies must and will precede significant action toward cleaning up our environment because of people's ignorance and trust. People have an unshakable, fantastic faith that what man harms or destroys can be restored by the scientists, technologists, and the medical doctor. Because of the great strides in technology and the millions of products and ideas derived from the sciences, men's minds have become confounded and convinced that anything required for "better" living is possible. This misconception is promulgated by scientists, manufacturers of products, and recently by medical doctors (via heart transplants). Although the prestige and ego satisfaction stemming from this absolute faith is welcomed by the recipients, this faith is likely to lead us to destroy our ecosystem and thus ourselves. That this is so was impressed upon me in one of my courses where students questioned the importance of contaminating our air since technologists could produce 0_2 from oxygen-containing elements (Huxley's *Brave New World*). They further challenged the importance of destroying agricultural land by air pollution, pesticides, or land abuse because of the vast oceans full of food waiting for the harvest. Although their specific challenges were not difficult to answer, it was not possible to shake their belief that man can solve all the problems he creates by his greed and ignorance. If teachers were to spend as much time telling students what isn't known about our environment as in describing in minute detail the little we do know, their faith would not be so intense.

In spite of "better living through chemistry," the vital interrelationships among living organisms remain enigmatic to all scientists. If we continue to believe that scientists can and will solve the problems we create when we pollute, plunder, and overpopulate, irreversible disaster is not far off. It is inexplicable that anyone could believe, when we treat our land and air with such contempt, that we will treat the ocean more wisely. For instance, we produce and pour into the environment millions of tons of synthetic pesticides each year to control organisms which compete with us for our food supplies. Every plant species which we might harvest from the ocean also has its parasites. Will we then spray the oceans with pesticides to kill these species which exist on what we now claim as our food supplies? The insidious destruction of organisms from pesticides has only lately been realized. I believe the poisons (known and unknown) which pour constantly into our air (upon which we and millions of other species depend for respiration) will be proven eventually to cause debilitating and lethal diseases. It seems we must witness cattle crawling on their knees and dead vegetation over thousands of acres before we are motivated to abatement programs. We Montanans have resigned ourselves to our polluted one-industry towns for at present we can escape.

We must adapt to a changing world but not necessarily a polluted one. If society would accept three alternatives to its present ways of life, air pollution as well as other types of environmental pollution and land abuse could be reduced substantially. The first alternative is to supplant economic feasibility with long-term biological desirability. The second is to accept a less-affluent society—a society in which utilization of natural resources is measured according to biological necessity rather than the Gross National Product. The last is to devote much greater time in our entertainment and communication systems (television, magazines, newspapers, and movies) to educate society on the physical, biological, and economic aspects of our environment and on desirable man-to-man and man-to-land ethics. This education is now being carried out in small part in the primary and secondary schools and in universities.

These alternate living patterns will probably be considered by many readers as idealistic, not realistic. As a biologist, however, I believe it is quite the reverse. For economists to talk about natural resources such as water, air, land, coal, oil, and natural gas as undepletable is fantasy. The reader will recollect that life has been on this planet for 2 billion years and that it took hundreds of millions of years for these natural resources to evolve. Is it realistic, then, for mankind to have utilized and destroyed such a large portion of them in only the last 100 years or for him to have accepted insidious, chronic pollution based on economic feasibility? In Montana the answer will come only after a series of local and painful catastrophies.

Inside the Computer

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The electronic computer is beginning to have a decided impact on our society and will inevitably influence our daily lives at an accelerating pace. Although not everyone will be called upon to design or even operate a computer, most of us are going to be associated with it in one way or another and we might be curious about how it works. Although many esoteric terms have been used to describe the computer, it is a machine built by man and an understanding of how it functions can be grasped without benefit of an engineering or mathematical background. This article will explain in simple terms what goes on inside the computer.

EARLY ELECTRO-MECHANICAL SYSTEMS

Perhaps the best way to begin is to relate the computer to its simpleminded ancestor, the desk calculator. This rather elementary machine is composed of gears and shafts which perform arithmetic calculations considerably faster and more accurately than an individual can. However, an operator must transmit instructions to this device by pushing keys with his fingers. Each sequential operation must be fed into the calculator one digit at a time. Intermediate results can be stored only in the head of the individual operator or they can be written on a piece of paper. When the operator stops punching keys, the calculator stops calculating.

The tabulating or accounting machine was the next logical step in the development of the computer. These machines which have been on the scene for several decades are often referred to as punch card equipment. Although tabulating machines have no memory or capacity to store large quantities of data as is true with the computer, they can be programmed in a limited fashion through wired panel boards. Once the panel has been wired, however, it is impossible to alter the prescribed instructions without first rewiring the panel; for this reason, one does not ordinarily think of a tabulating machine as possessing programming capabilities. Furthermore, it is an electromechanical device consisting of gears, shafts, and electric brushes. It does not contain the electronic circuitry and, therefore, the speed or storage capacity of a computer. Data which are accumulated on punch cards must be stored in files—not in the machine itself—and, when needed for processing, must be manually fed to the tabulator.

THE COMPUTER

Briefly the modern computer has the ability to:

(a) store, control and retrieve vast quantities of data;

(b) store lengthy and complex programs of instruction;

(c) modify its own program by making logical decisions; and

(d) control diversified peripheral equipment.

All of these features can be accomplished with a minimum amount of intervention on the part of the operator.

Speed

One must accept the fact that the speed of a computer is beyond human powers of comprehension, at least when related to our daily experiences. In the early days of the computer (1950's) operations were performed in milli seconds (thousandths of a second). A few years later micro seconds were common operating speeds (millionths); some of today's computers are capable of operating in nano seconds (billionths). Some of the larger machines that were built a few short years ago could add 16,000 five-digit numbers in one second. Some of the newer models can perform 16,000,000 multiplication steps in a single second.

It becomes possible to absorb these fantastic figures only when you appreciate the ability of electronic circuitry to move current at rates approaching the speed of light, which travels at approximately 186,000 miles per second. To put it another way, light can move one foot in one billionth of a second and the term nano second was coined to describe it. Small wonder that we find it almost impossible to conceive of such speeds; far better to accept electronic speed as a law of nature and go on to other aspects of the computer.

Storage

Another essential part of modern computer operation is its capacity to store large quantities of information. Without this feature, the machine would not be able to control and process complicated data. Components with storage capacities of four million words are already in use and four-billion word storage for moderate-sized business computers is not too far distant. A special storage system has been built for the Atomic Energy Commission which is capable of storing one trillion bits of information. Although a bit (binary digit) is not as large as a word, it still amounts to considerable data. This tremendous storage capacity may be compared to providing a person with 200 years of uninterrupted reading material.

In spite of the enormous accumulation of data now possible, our three-pint brains have more storage capacity than all of the electronic equipment on the North American continent. If it were possible to build a computer that equalled the storage capacity of the human brain, it would be larger than the state of Texas! No need to get smug, however, for we cannot retrieve much of the information stored in our brain, and what we can retrieve is usually slow to materialize and often inaccurate or distorted. The computer is not handicapped by such human failings.

Can the Computer Think?

Whether or not the computer can think is an argument that will be debated for many years. To explore the question, we would need to define what we mean by the word "thought"; when does man think and when does he merely perform routine mental chores? Certainly the computer can perform routine mental operations; whether it can also enter the higher realms of creative thought may be left to your judgment.

Three Generations of Computers

You have no doubt heard of first, second or third generation computer models. First generation computers were essentially vacuum tube operated. They were relatively slow, generated enormous amounts of heat, and were oversized, bulky contraptions. They are no longer available except as museum pieces. Solid-state or transistor operated computers are categorized as second generation hardware. They are smaller than their predecessors, cooler, function at higher speeds, and contain more storage space. Many of them are still in operation, although they are rapidly becoming obsolete.

The grandson or third generation computer incorporates many of the latest innovations in microcircuitry. Because of the refined development of miniature circuits, it has been possible to reduce the size of these computers while increasing their storage capacity and speed. They also are characterized as modular or building-block machines which permit a user to rent or purchase a small model at first, later adding to the original equipment without the need to rewrite existing programs or to alter the format of currently stored data.

Third generation computers are also called general purpose systems. Originally, hardware was designed to solve scientific problems that require very little input or output of data but do require vast amounts of laborious calculations. The computer is admirably suited for this sort of problem since its electronic circuitry chews up computations at a fantastic rate. Most business problems on the other hand, call for relatively simple calculations but require the processing of large quantities of data, both as input and output, e.g., payroll calculations are trivial when compared to many mathematical problems but considerable data must be fed into the computer initially.

Although internal operations are performed at electronic speeds, it is well to remember that the flow of data into and out of the CPU (central processing unit) must pass through mechanical devices. The moment mechanical gears, linkages, and the like, are introduced into the system, it is no longer accurate to think in terms of electronic speeds. Consequently, computers adapted to business data processing were designed differently from those built for solving scientific or engineering problems. A single firm often needed two types of expensive computers, which made for uneconomical operation. Thus a general purpose hardware, adaptable to either type of problem, was a natural outgrowth of this need.

Who knows when the fourth generation computer will arrive on the scene or what precise form it will take. Judging by the rapid technological advances made during the past fifteen to twenty years, however, further significant developments may not be far away.

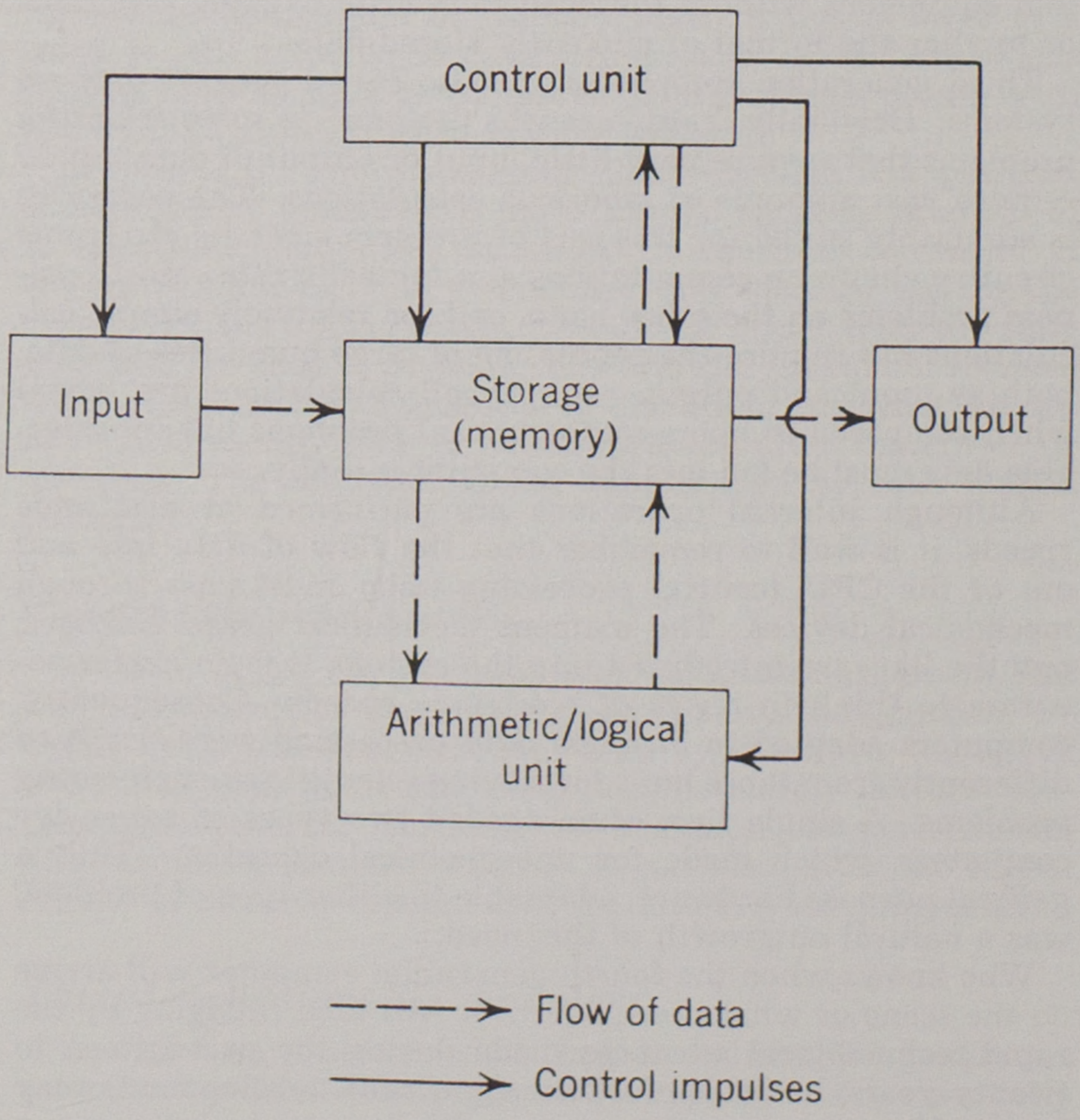
Computer Storage

Internal Storage

To really understand the computer we must go inside the magic box and take a look at its major components: the internal memory system, the arithmetic/logic section, and auxiliary storage units. Figure 1 is a simplified diagram of these major components. It can best be understood if its parts are analyzed individually.

FIGURE 1

MAJOR COMPONENTS OF AN ELECTRONIC COMPUTER



The heart of a modern central processing unit is its internal memory or core storage which contains the programmed instructions and as much of the data as possible. Now, consider the fact that if data and instructions are stored here, there must be a method for retrieving it, i.e., the information must have an address. Each item of datum is stored in a ferrite core (often called a doughnut) and has its own unambiguous address. Wires are circuited to form a grid at the doughnut, and current passing through these wires magnetizes the core. If the core is at the function of two live wires, it will be activiated so that information can be "written" on the core or "read" from it. Figure 2 is a simple illustration showing how two wires are used to activate a particular core. The selected core is the one at the center of the diagram, since the wires passing through it are both charged with an electric current.

FIGURE 2

SELECTING A CORE

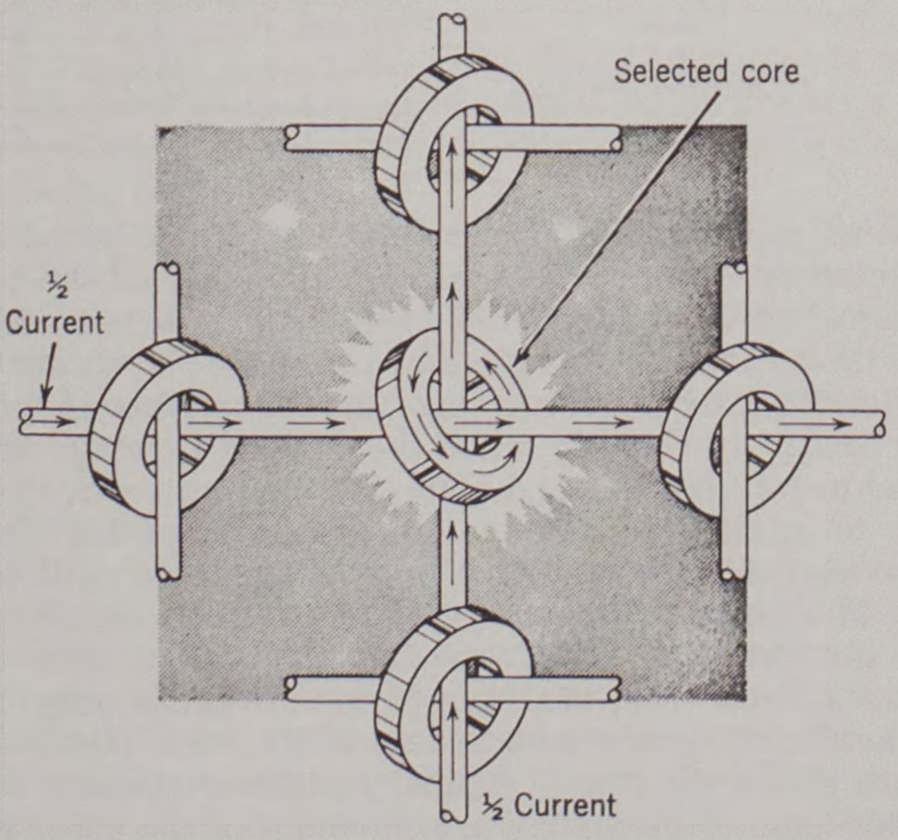
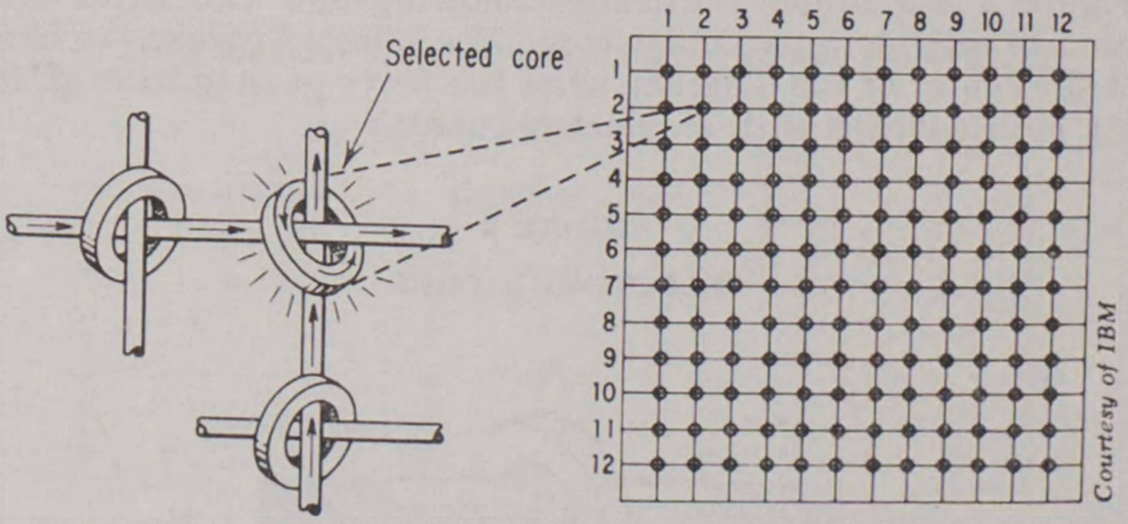


Figure 3 shows the arrangement of cores in the form of a matrix. Each column and row of this array is assigned a number so that a particular core may be chosen for selection by referring to its address. In the diagram, the selected core is located at address number 22; by sending electrical currents along column 2, row 2, the desired core will be activated. Although the circuitry of a core memory unit is more complex than what is indicated in the diagrams, a person can understand the basic functioning of core storage without becoming expert in electronic circuitry.

FIGURE 3

A MAGNETIC CORE PLANE



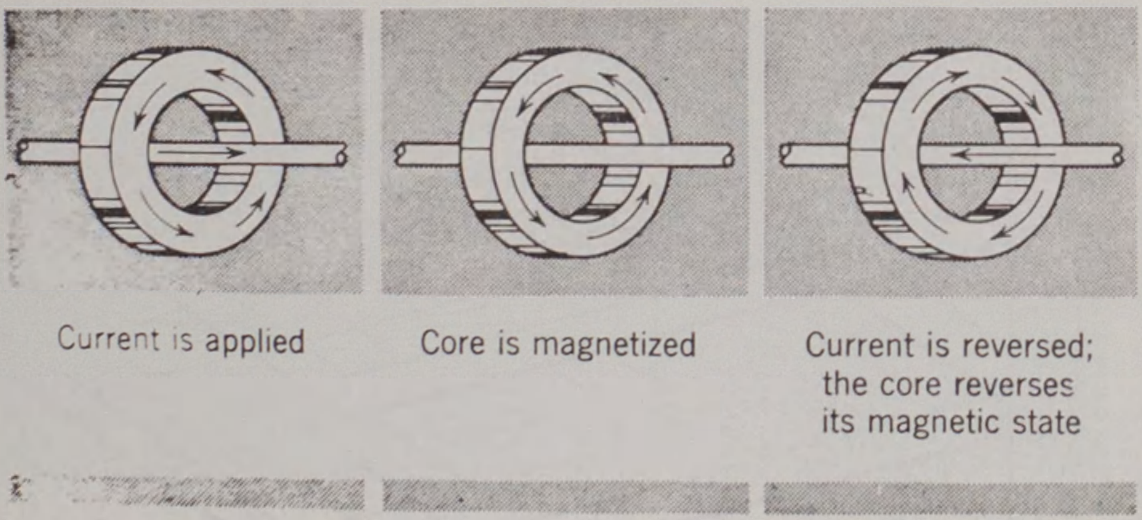
Courtesy of IBM

Locating a particular core is only part of the problem. It is also necessary to convert the electrical energy of the core into meaningful information. This problem has been successfully dealt with by taking advantage of the magnetic characteristics of the ferrite core. Figure 4 diagrams the manner in which the core is positively charged when the current flows in one direction and negatively charged when the current is reversed. The answer to intelligible information lies in a numbering system that corresponds to a positive or negative electrical charge—0 or 1. The binary number system, familiar to fourth graders, solves the problem. Whereas the decimal system requires numbers from 0 to 9, the binary system needs only 0 and 1; 0 for the negative magnetic state and 1 for the positive state.

Before elaborating on the binary number system, let's take a further look at the matrix arrangement of the core. Figure 3 illustrated a single plane of the core where it was possible to store only a single bit (binary digit) of information, 0 or 1. In order to build up these bits into characters consisting of decimal numbers or alphabetical letters and then words, one must

FIGURE 4

REVERSING A CORE


Current is applied

Core is magnetized

Current is reversed; the core reverses its magnetic state

increase the number of planes. Figure 5 is a sketch of seven planes of core matrices which is adequate to handle the character A. An actual core unit contains fifty or more planes so that entire words can be read into or out of memory. The method of locating a particular core through its unique address remains the same; but instead of activating a core on a single plane, the cores that bear similar locations on each plane are activated simultaneously.

Another feature of core memory is the ability of the CPU to proceed directly to the required address without hunting or searching for the desired information. In other words, core storage has random access capabilities, a characteristic which enables it to reach operating speeds for greater than almost any other form of storage.

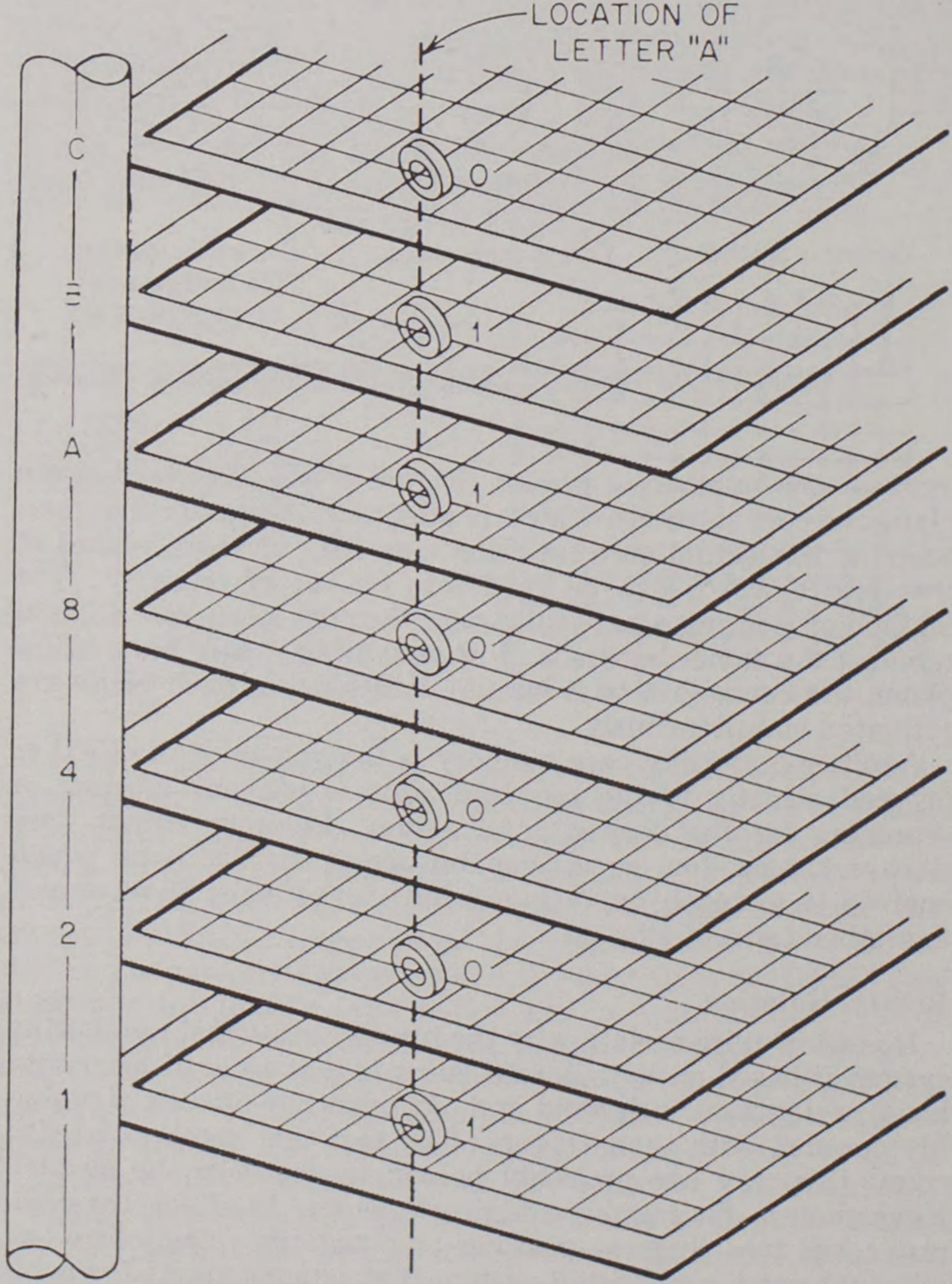
Binary Notation

No one is quite certain why the present universal numbering system is based on ten. A safe guess is that most of humanity has five digits on each hand and our primitive ancestors probably counted with their fingers. The fact that some of us still count this way has probably helped to preserve the system. Nevertheless, the number ten is not sacred. In effect, the computer has two fingers—positive and negative magnetism—so why not use a numbering system that is convenient for a bi-fingered machine?

In a decimal system, each digit has a value ten times the digit on its right. Turn to Figure 6 and note the tabulation under the

FIGURE 5

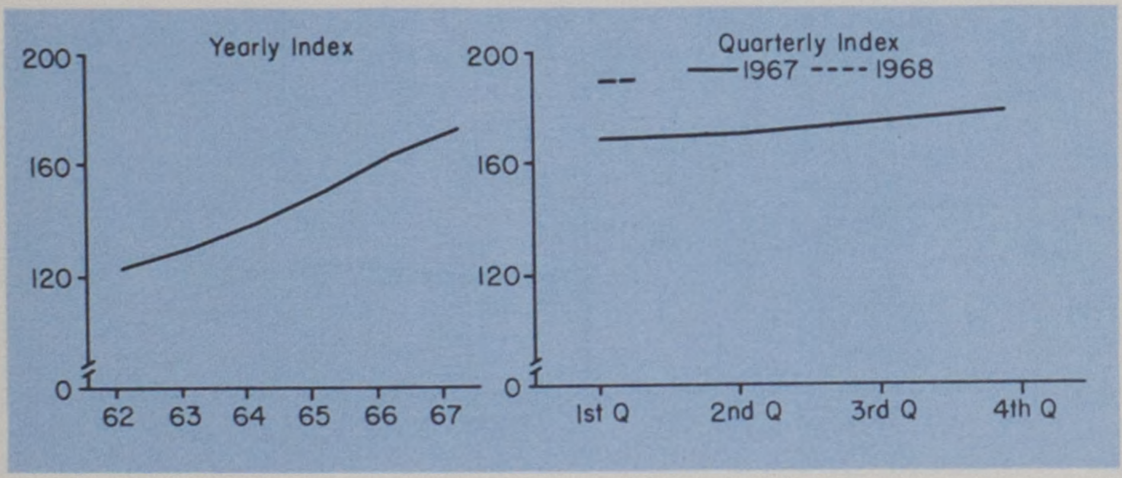
CORE-PLANE CHARACTER STORAGE



National Indicators —

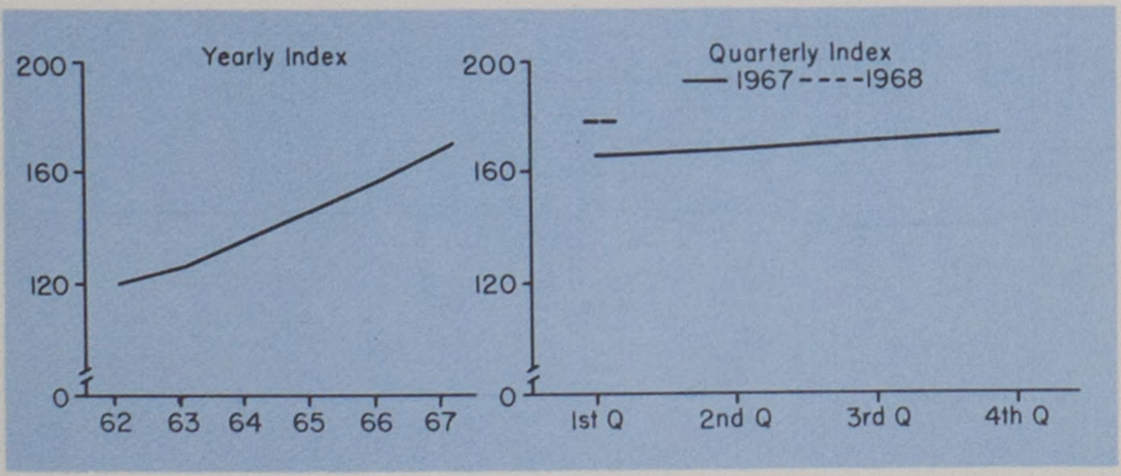
GROSS NATIONAL PRODUCT

1957-59 = 100 — Seasonally adjusted, annual rates



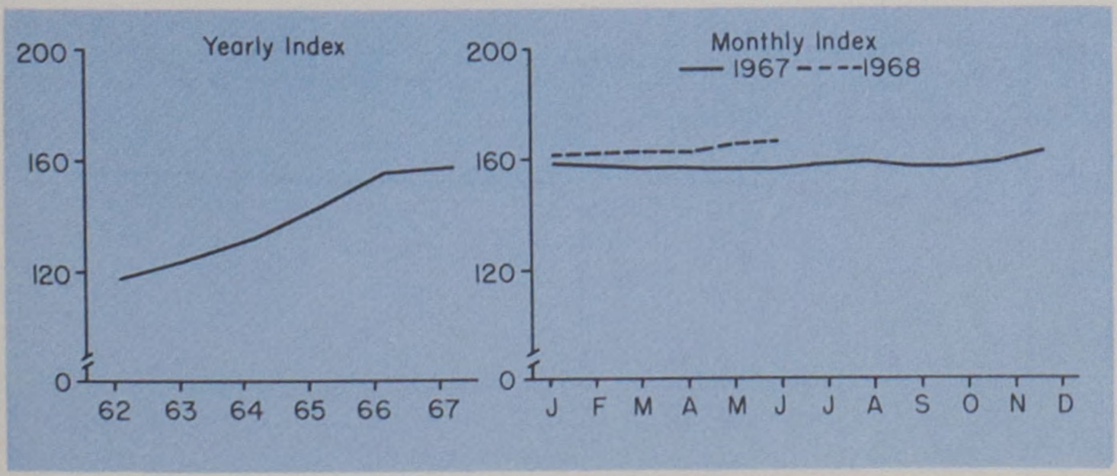
DISPOSABLE PERSONAL INCOME

1957-59 = 100 — Seasonally adjusted, annual rates



INDUSTRIAL PRODUCTION

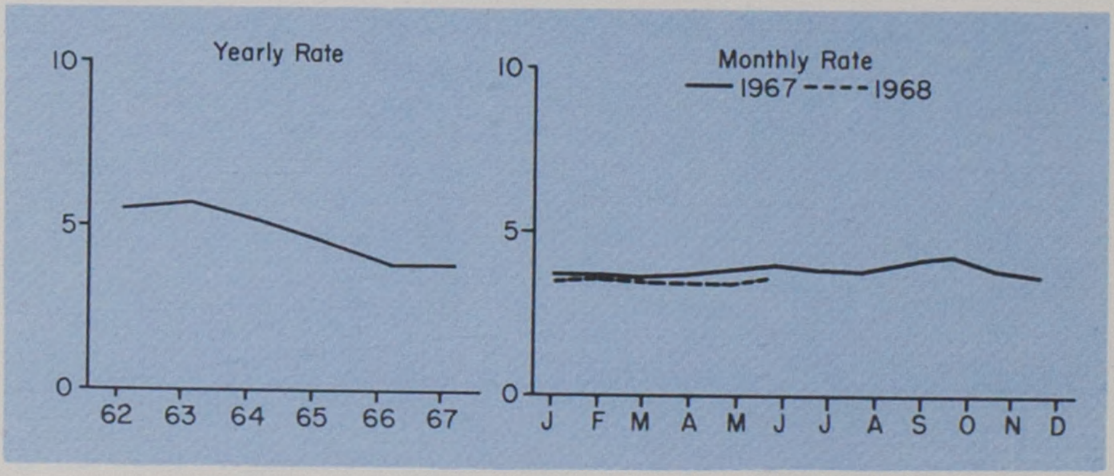
1957-59 = 100 — Seasonally adjusted



National Indicators —

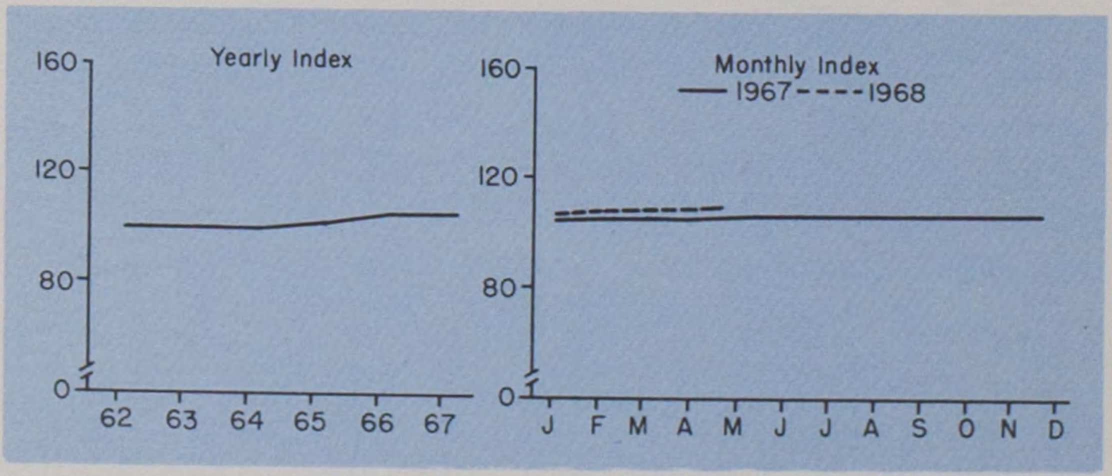
UNEMPLOYMENT AS % OF THE LABOR FORCE

Seasonally adjusted



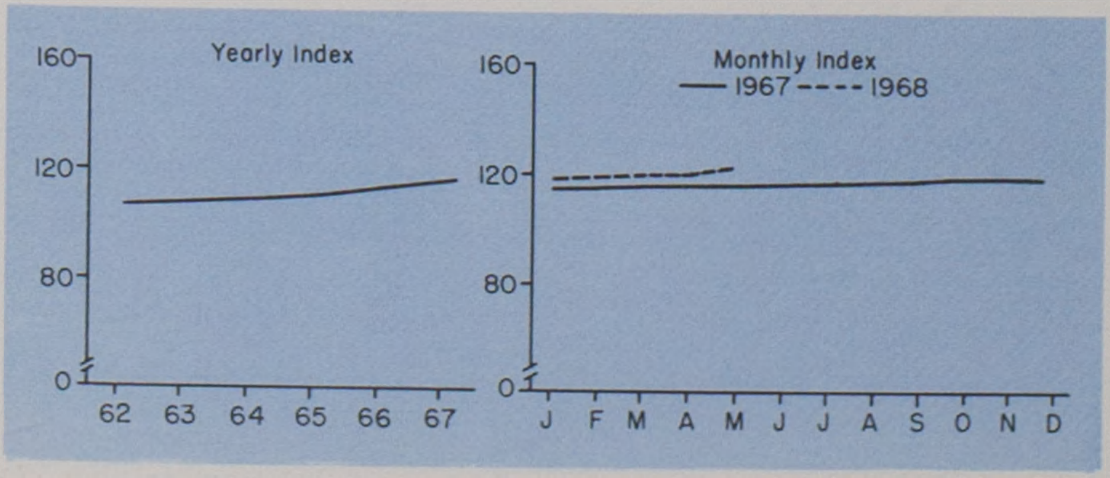
WHOLESALE PRICE INDEX

1957-59 = 100



CONSUMER PRICE INDEX

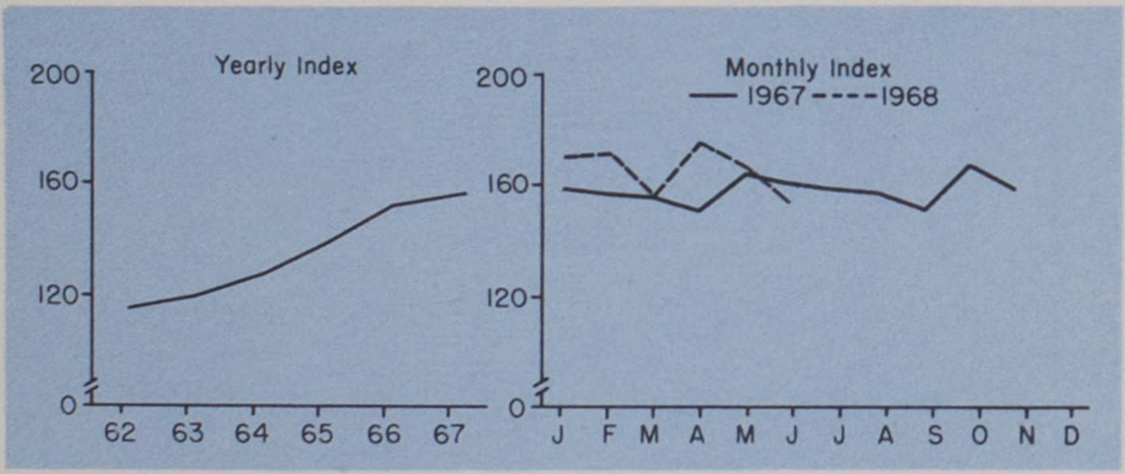
1957-59 = 100



Montana Indicators —

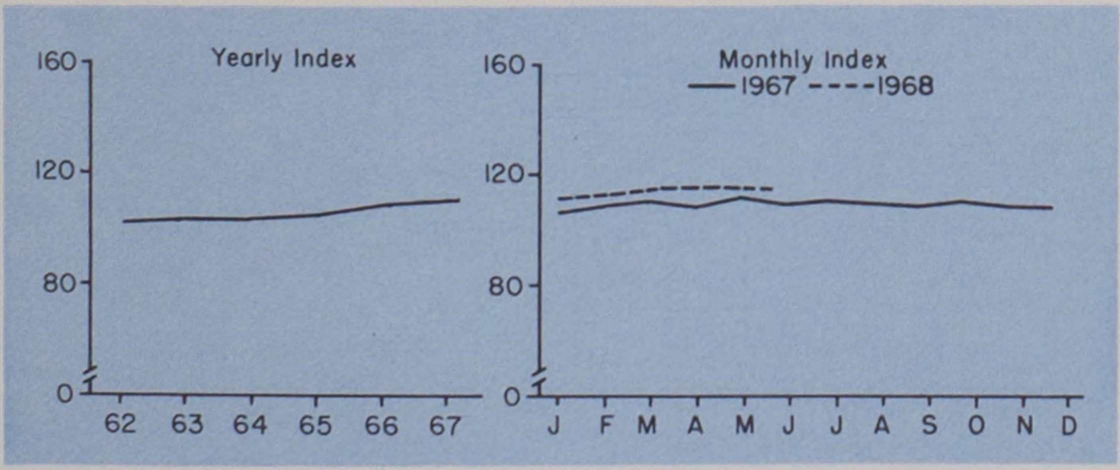
BANK DEBITS

1957-59 = 100 — Seasonally adjusted



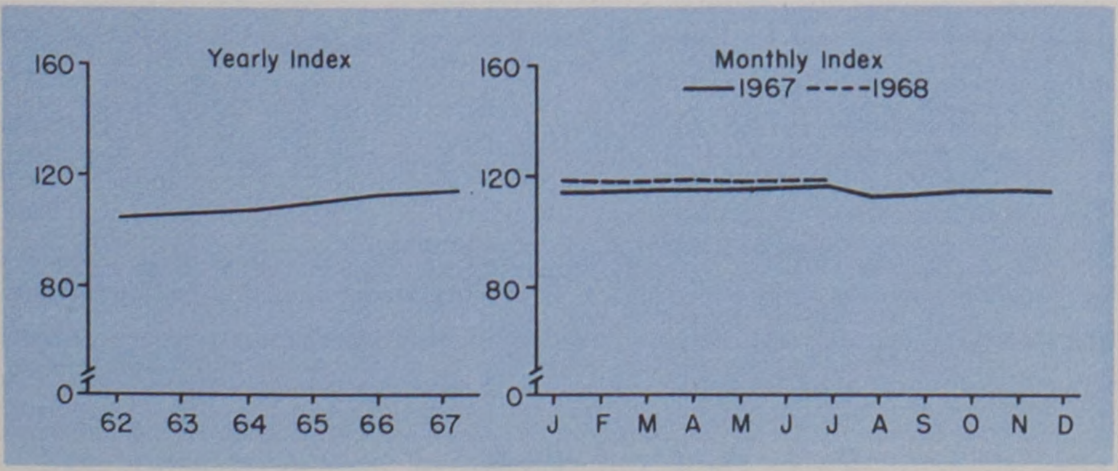
EMPLOYED WORK FORCE

1957-59 = 100 — Seasonally adjusted



NONAGRICULTURAL EMPLOYMENT

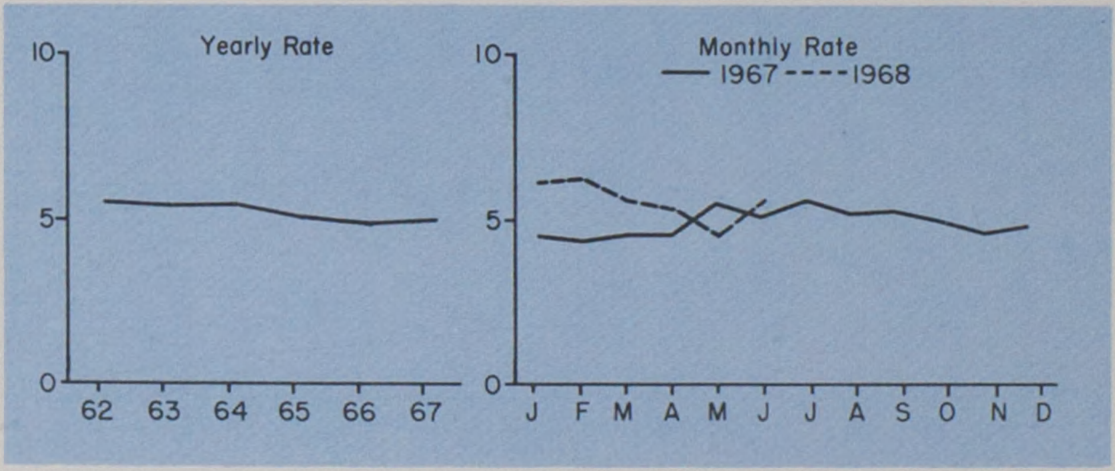
1957-59 = 100 — Seasonally adjusted



Montana Indicators —

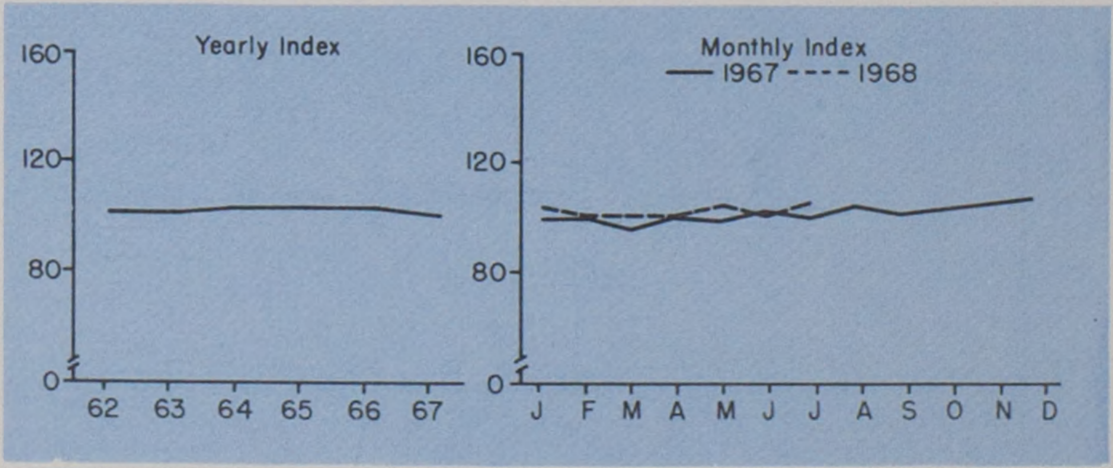
UNEMPLOYMENT AS % OF THE LABOR FORCE

Seasonally adjusted



AVERAGE WEEKLY HOURS, MANUFACTURING

1957-59 = 100 — Seasonally adjusted



SOURCES OF DATA

National Indicators

Gross national product: U. S. Department of Commerce, Office of Business Economics.

Disposable personal income: U. S. Department of Commerce, Office of Business Economics.

Industrial production: Board of Governors of the Federal Reserve System.

Unemployment as a percent of the labor force: U. S. Department of Labor, Bureau of Labor Statistics.

Wholesale price index: U. S. Department of Labor, Bureau of Labor Statistics.

Consumer price index: U. S. Department of Labor, Bureau of Labor Statistics.

Montana Indicators

Bank debits: Federal Reserve Bank of Minneapolis.

Employed work force: Unemployment Compensation Commission of Montana, in cooperation with the U. S. Department of Labor, Bureau of Labor Statistics. Excludes military.

Nonagricultural employment: Unemployment Compensation Commission of Montana, in cooperation with the U. S. Department of Labor, Bureau of Labor Statistics. Wage and salary workers only.

Unemployment as a percent of the labor force: Unemployment Compensation Commission of Montana, in cooperation with the U. S. Department of Labor, Bureau of Labor Statistics.

Average weekly hours in manufacturing industries: Unemployment Compensation Commission of Montana in cooperation with the U. S. Department of Labor, Bureau of Labor Statistics.

decimal heading. Each digit in the number 4,148 has a value ten times as great as the number to its right and the number can be written in the customary manner, as above, or spread out under a column for thousands, hundreds, tens and so on.

FIGURE 6

DIGITAL POSITIONS OF DECIMAL AND BINARY SYSTEMS

Decimal System

Decimal Number	**1000's**	**100's**	**10's**	**1's**
4,148	4	1	4	8
362		3	6	2
11			1	1

Binary System

Decimal Equivalent	**64**	**32**	**16**	**8**	**4**	**2**	**1**
3						1	1
18			1	0	0	1	0
45		1	0	1	1	0	1
86	1	0	1	0	1	1	0

Binary Addition

$$\begin{array}{r}0\\0\\\hline 0\end{array}\qquad\begin{array}{r}0\\1\\\hline 1\end{array}\qquad\begin{array}{r}1\\1\\\hline 10\end{array}$$

$$\begin{array}{r}101\\010\\\hline 111\end{array}\qquad\begin{array}{r}011\\010\\\hline 101\end{array}\qquad\begin{array}{r}100\\110\\\hline 1010\end{array}$$

Now look at the binary system in Figure 6. Each digit position contains twice the value of the digit at the right 1, 2, 4, 8, etc. Since 0's and 1's are the only digits in this system, the decimal equivalent of 3 is 11. The digit at the left has a value of 2, the digit at the right, 1; add the value of both digits and the sum equals 3. It is possible to convert any binary number to its decimal equivalent by adding the positional values of each digit. For example, take the decimal number 86 in Figure 6 and add the positional value of each positive binary digit: $64 + 16 + 4 + 2 = 86$. There are more sophisticated ways to convert from the decimal to the binary system and back again, but they need not concern us since the computer is designed to make the conversion automatically.

For those who may be interested, a short exercise in binary addition also is included in Figure 6. The principles of addition parallel decimal addition, however, the highest possible number in the binary system is 1. Whereas decimal numbers permit the operator to add up to 9 before carrying, binary numbers require the operator to carry whenever the total exceeds 1. This procedure poses no particular difficulty when adding only two or three rows of numbers; it is not recommended for adding long rows of figures.

Fortunately the computer has no inhibitions against working with a two-numbered system, nor does it find it awkward to carry a series of 1's in its "head." The rules for subtraction, multiplication, and division follow the same arithmetic principles as the decimal system, but again the computer's mental gyrations are not recommended for the average person with a built-in bias for decimal numbers. As a matter of fact, most computers are designed to use complements when subtracting and addition when multiplying.

By now it should be evident that large decimal numbers require rather lengthy binary equivalents. For example, the decimal number 86 in Figure 6 has a binary equivalent of seven digits, 1010110. The relatively small decimal number 750 would require ten digits, 1011101110. The number 50,000 would obviously take a great many more digits. Although the computer can be designed to handle such cumbersome numbers, space and operating time have been saved by devising a coded binary system instead of pure binary as discussed up to now.

Coded binary, more properly called Binary Coded Decimal, uses a set of four binary digits (bits) for each decimal digit, and as will be illustrated, a set of four digits is adequate to represent any decimal number from 0 to 9. In other words, instead of using an unlimited number of digital positions such as 1, 2, 4, 8, 16, and continuing on to infinity, the computer uses only four digital positions. Figure 7 illustrates how each of the ten decimal digits can be converted to a four-digit binary number. The number 86, for example, would be displayed in the computer as: 1000 0110, each four-digit code representing its decimal equivalent. The decimal number 750 would be displayed as: 0111 0101 0000, 7, 5, and 0 respectively.

Other coded systems have been developed to further reduce space requirements and increase speed capabilities. One of them is an octal-coded binary system that uses a numbering technique based on 8 and 2. Once we understand the concept of binary notation, it becomes obvious that any number can serve as a base.

FIGURE 7

BINARY CODED DECIMAL

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

One further point needs to be mentioned in connection with the binary-coded decimal. Although four bits are adequate for any equivalent decimal number, two additional bits are added in order to symbolize an alphabetical or special character such as a dollar sign or quotation marks. In other words, it is possible to project any number, letter, or special character with six bits.

To summarize, the core memory of the computer can deal only with a positive or negative magnetic state. Decimal numbers and/or alphabetical characters are fed into the computer, where they are converted into binary digits. Any storage or manipulation within the central processing unit is carried on in this format. Finally, the computer converts these data back into alpha-numeric symbols in order to print out a readable language for its users.

Auxiliary Storage Units

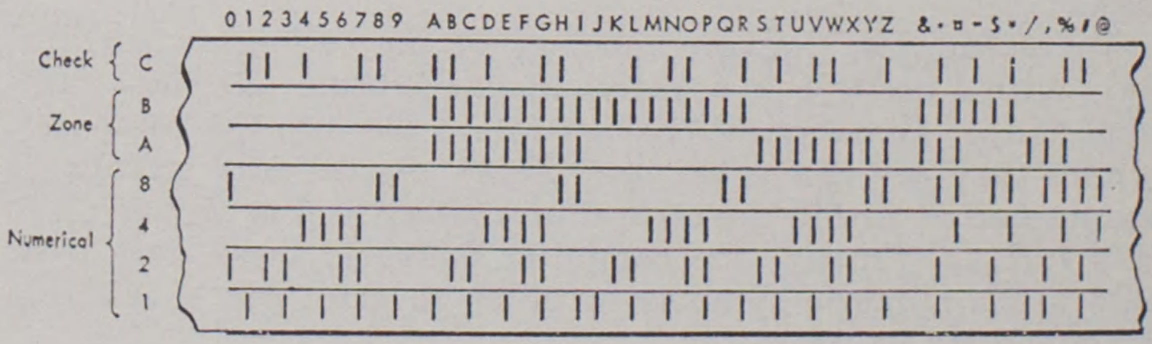
It would be ideal if all data used by the CPU could be included in its core memory. Storage and retrieval of information is practically instantaneous since all manipulation is handled at electronic speeds and address location is obtained through random access techniques. As might be expected, however, limitations in the size of the central processing unit as well as the need for economy have made it mandatory to develop forms of auxiliary storage which, although slower, are capable of accumulating vast quantities of data. Furthermore, these secondary storage media permit the computer direct control, eliminating the need for human intervention. Two of the more common auxiliary storage devices will be reviewed briefly.

Magnetic Tape

Magnetic tape is similar in appearance to common stereo tape; but instead of storing music or human speech, magnetized bits (0 and 1) are used in the form of binary notation. Note the familiar 8, 4, 2, 1 binary-coded decimal system illustrated in Figure 8. Numeric symbols are defined in much the same manner as they were in core storage and the extra zones (rows A and B) have been added in order to define alphabetical and special characters. Now, knowing the basic concept of the binary code, you should be able to convert the magnetic bits into their decimal equivalents. The binary notation for 0 is represented by positive bits in the eight and two rows; the notation for 1 by a positive bit in the first row, and so on. Alphabetical notation is an arbitrary code which can be memorized; but, since the computer is circuited for this code, it can do a much better memorizing job than the operator can do.

FIGURE 8

MAGNETIC TAPE, 7-BIT ALPHAMERIC CODE



The top line in Figure 8 is called a check bit and is one of the built-in devices that permit the computer to verify the transfer of information. This automatic system of verification is important in the design of the computer but need not concern the operator or programmer.

The main advantage of magnetic tape lies in its almost unlimited storage capacity. Some of the large CPU's can control up to 300 tape drives; additional tape reels can be stored off the system and may be brought "on-line" when needed. A single reel of tape holds about the same amount of information as 500,000 punch cards. Although operating speeds for tape usage cannot be compared to core memory units, the computer can still read or write at a rate of 300,000 characters per second.

Tape storage is relatively slower because it is necessary to combine electro-mechanical devices instead of relying exclusively on electronic circuits. Nevertheless, one must admit that reading or writing information at these speeds is indeed rapid.

The major disadvantage of magnetic tape is its lack of random accessability. Information on the tapes must be arranged sequentially, so operating time would be slowed considerably if it became necessary to search for data. On the other hand, many applications lend themselves to data that are stored sequentially. Examples would be an accounts receivable file or employee payroll record. Customer or employee records normally are arranged alphabetically or by code number and can be manipulated conveniently in that order. On balance, magnetic tape sacrifices electronic operating speeds for expanded storage capacity.

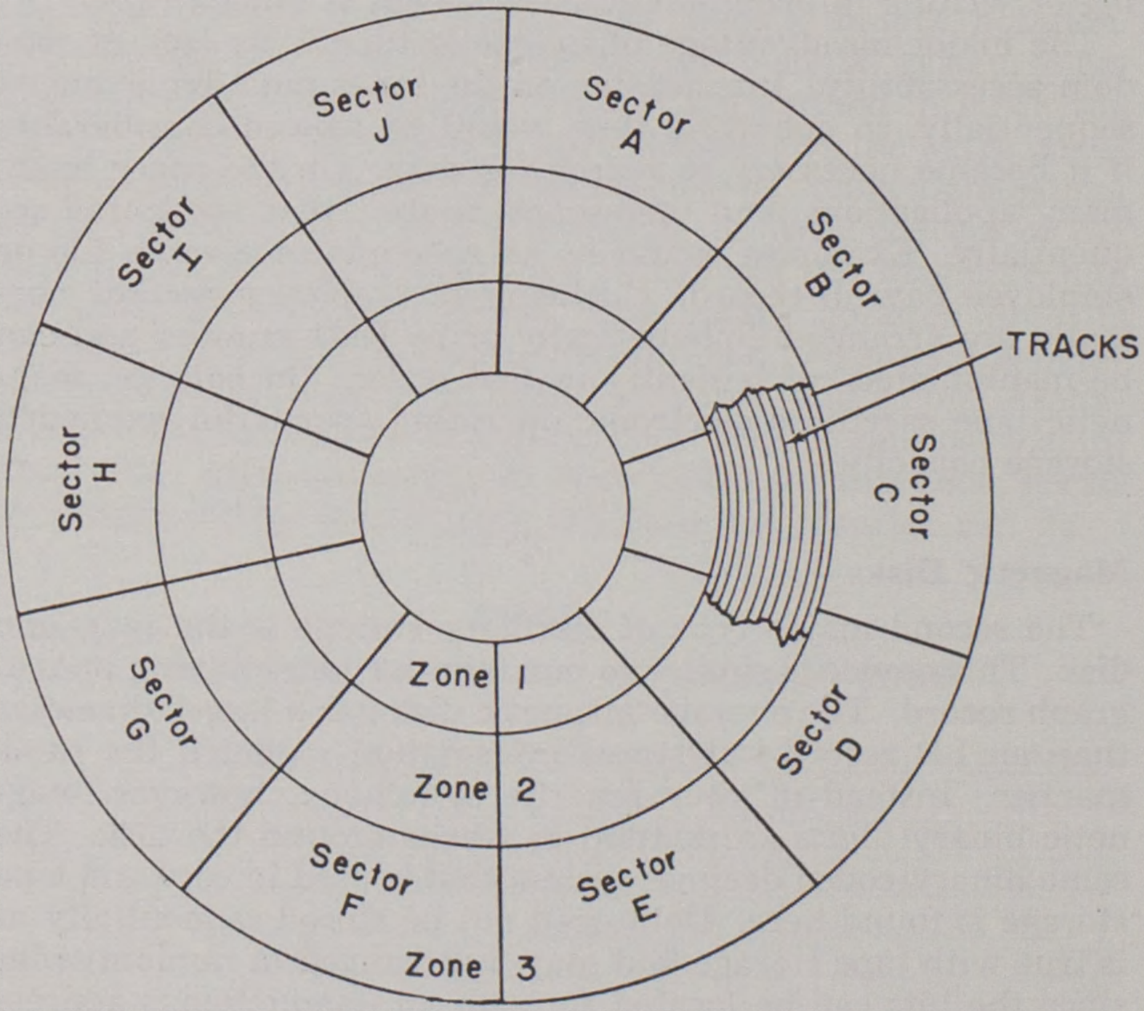
Magnetic Disks

The second major type of auxiliary storage is the magnetic disk. This device is similar to our familiar long-playing phonograph record. The average magnetic disk has a larger diameter than an LP record but stores information in much the same manner. Instead of your favorite symphony, however, magnetic binary digits are located in tracks around the disk. The same binary-coded decimal system that is used in core and tape storage is found here. Data need not be stored sequentially as is true with tape storage, but may be arranged in random order since the bits can be located through an unambiguous address system. Instead of the matrix arrangement common to core memory devices, the disk is segmented into zones, sectors, and tracks. Figure 9 illustrates the general layout of such a disk. Modern disk assemblies are arranged in stacks of six and rotate on a common vertical shaft at about 1,500 r.p.m.'s. Read/write access arms extend between each disk and are capable of moving in or out from the center of the disk to the periphery so that data may be transmitted to or from any sector.

The development of magnetic disks as a form of storage has resulted in a compromise between core memory and tape storage. The ability of the access arms to reach any location on the disk permits limited random access transmittal of data which is comparable to core memory. Speed, however, is reduced due to the employment of mechanical devices and random access is limited because the access arms must wait for the rotating disk to place the desired address immediately over or under the

FIGURE 9

ADDRESS SYSTEM—MAGNETIC DISK



read/write heads. Access time is at the rate of about .2 of a second rather than at the micro and nano second speeds feasible in the core. About 2 million characters can be stored on the average disk pack which is considerably less than the storage capacity of magnetic tape.

To review the three major forms of storage: core memory permits the recording and retrieving of data at electronic speeds with uninhibited random access. Cost and storage limitations, however, preclude using core memory as the only form of data storage. Magnetic tape allows for enormous expansion of storage capacity but is slower than core and requires sequential rather than random access. Magnetic disks, on the other hand, are characterized by limited random access coupled with storage capacity and speed that fall between the performance of core and tape. Most modern business-oriented data processing systems adopt a combination of all three forms of storage.

Arithmetic and Logic Sections

It is best to visualize this section of the computer as a desk calculator. However, instead of performing calculations by rotating gears and shafts, we have substituted electronic circuits. Registers similar to those found in a desk calculator are also used, only these too are built into the circuits. Data are brought out of storage, put into registers where they are manipulated, and then returned to storage or printed out, depending upon the instructions in the program.

It is possible to trace a simple problem in addition by referring to the diagram in Figure 10. Assume that the numbers 125 and 150, both located at their particular addresses in storage, are to be added together and printed out. The first number, 125, has already been brought from storage, run through the adder, and is now located in the accumulator register. The second number, 150, is now transferred to the storage register and, in accordance with step one in the diagram, is carried from the storage to the adder. In the next sequence, the first number, 125, flows back to the adder where it is next combined with number 150. An instant later, step three is completed; the total, 275, is now available in the accumulator register awaiting the next instruction which will send the sum back to storage or to an output device such as a printer, punch card, or tape. The preceding illustration is oversimplified, yet the manipulative sequence essentially parallels the actual operation of a computer's arithmetic section.

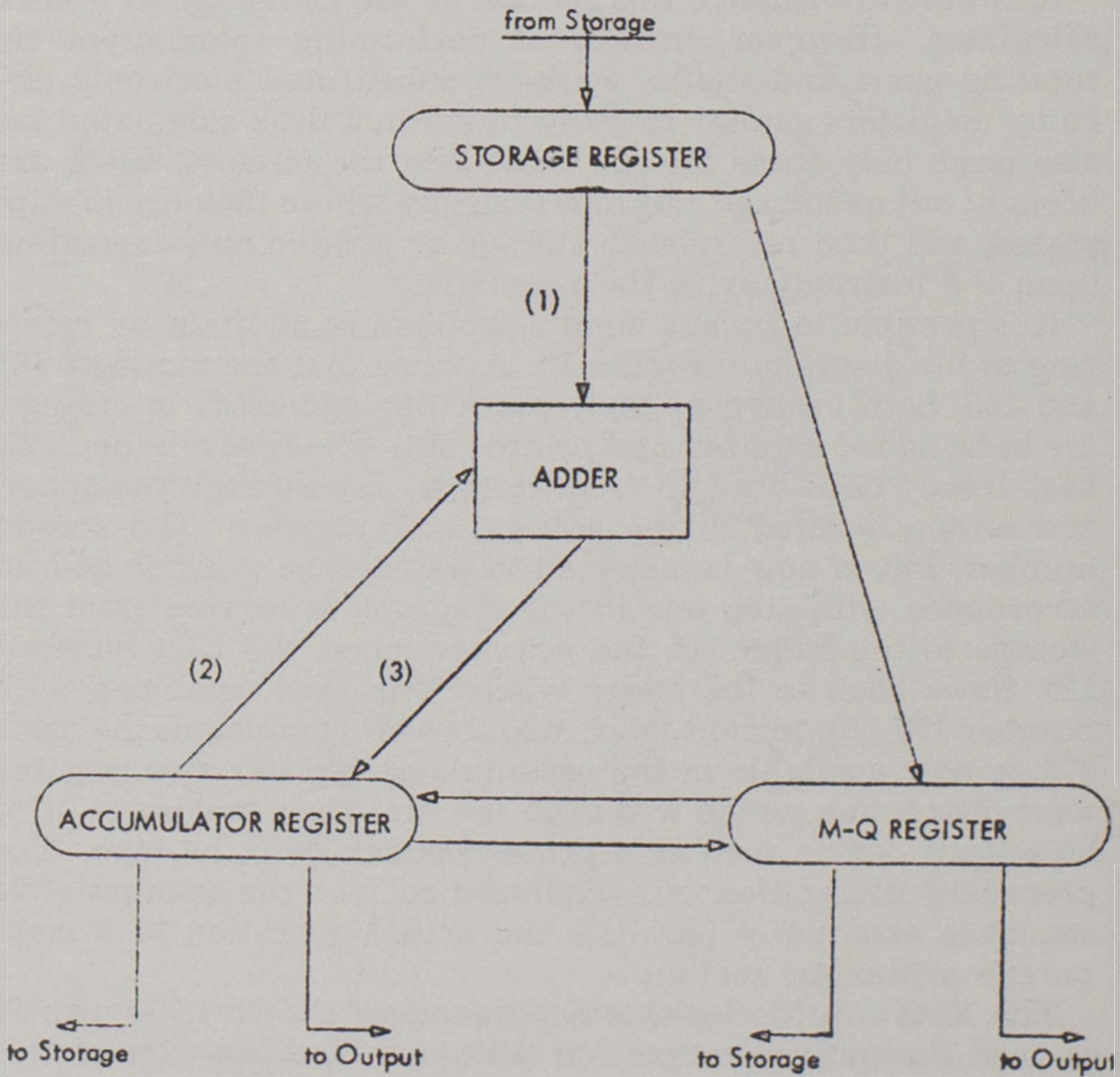
The M-Q (Multiplier-Quotient) register shown in Figure 10 is used for multiplication and division. The function of this register is more complex than the adder and accumulator registers since a shifting process is required analogous to the shifting carriage of a desk calculator and circuits are more sophisticated.

Anyone remotely familiar with electronic equipment is aware of the claim that a computer can make logical decisions and modify its own program of instructions. Such a claim is valid but is not as profound as it sounds. The computer can make decisions only within narrow limits which require the measurement of two known quantities. The ingenuity of this decision-making process lies in the programmed instructions that are devised by the programmer, not in the hardware itself.

FIGURE 10

ARITHMETIC REGISTERS

REGISTER DIAGRAM



1. STORAGE REGISTER to ADDER
2. ACCUMULATOR REGISTER to ADDER
3. ADDER to ACCUMULATOR REGISTER

A program can be designed to instruct the computer to measure two quantities and follow one of three possible courses of action, depending upon whether one quantity is greater than, less than, or equal to another. The need for reaching such a decision and thereby causing a modification of the program occurs in the common payroll problem. Social security taxes must be deducted from each employee's pay until his annual earnings have reached $7,800. It is therefore necessary to write a program that will require the computer to verify each employee's earnings before deducting social security taxes. The program will direct the computer to compare $7,800 with each employee's year-to-date earnings. If the latter is equal to or greater than $7,800, the computer will skip the deduction and proceed to the next instruction. If earnings are less than $7,800, it will go to an instruction that directs it to calculate the necessary deduction.

Automatic inventory reorder points are handled in much the same manner. The desired reorder level is set in advance. Each time an inventory item is withdrawn from stock, the computer is instructed to compare the quantity on hand with the reorder point. If the quantity on hand is equal to or greater than the reorder point, no action will be taken. When the inventory balance falls below the preset reorder level, the program directs the computer to transfer to a particular instruction that will call for the print out of a purchase order.

The above discussion was not intended to minimize the importance of the decision-making accomplishment of computers. On the contrary, the computer's ability to reach logical decisions, thereby modifying its program, has enabled it to become a very powerful tool. In fact, the development of this technique was a necessary prelude to the modern computer. In order to understand computer operation, however, one must realize that there is nothing mysterious about the computer's decision-making process.

Programming

Man still controls the computer. Without a program, a computer is nothing but a mass of electronic circuitry, science-fiction notwithstanding. A program is a series of highly-detailed instructions that direct the CPU to proceed from one logical step to another. Unlike the instructions one might give to a subordinate or even to a child, a computer program must be extremely detailed and completely logical. Nothing can be left to the imagination of the computer since it has none.

Compare the operation of a computer with that of an errand boy who has been instructed to take your car and pick up a parcel at the post office. If the boy were familiar with the city, no further instructions would be necessary. If a computer or robot were to be programmed to carry out the same assignment, very specific instructions would be mandatory. To begin with, our imaginary robot would have to be told, in a step-by-step fashion, how to find his way to the street. Further instructions would then be needed to advise him how to get to the car, how to open the door, how to start the motor, how many feet to drive in one direction, how many degrees to turn the steering wheel either left or right, and on, and on, and on. By this time you may be so exasperated that you would decide to pick up the package yourself.

A lesson may be learned from the above analogy: it is seldom economical to program a computer for a single operation. Since several hundred or thousand man hours may be required to write a program, it would not be worth the expense unless the program could be used over and over again. There are some exceptions of course; a program may be written to solve a complicated mathematical problem which would otherwise take several months to solve manually.

Programming Language

Languages are necessary to communicate with people; languages are also needed to communicate with computers. Machine language is the only language that a computer can understand; and different computers, like different peoples, are often limited to their native tongue. Furthermore, machine language can be written only in numerical notation. Obviously, such a format is cumbersome for a programmer since he must learn a different code for each computer and must deal in numbers rather than alpha-numeric symbols. Further complications arise, such as the need to keep track of the specific addresses of all programmed instructions and the exact location of all data.

A natural sequence in the evolution of programming techniques has been the development of sophisticated problem-oriented languages which, unlike the more primitive machine language, permit adaptation to many different makes of computers. The symbols of such "languages" contain alpha-numeric combinations, often in the form of abbreviated English, so that programmers can become more proficient with far less training. These newer languages are also referred to as macro-languages. This means that one programmed instruction will automatically generate several additional steps when translated into machine language. Instead of the one-to-one ratio common to machine language or the robot in the post office analogy, programming software is approaching the point where a few basic instructions to the errand boy will result in obtaining the parcel from the post office.

A few simple examples illustrating a specific programmed instruction might be enlightening at this point. "21 00734 69846" is a machine language instruction for a particular computer. It directs the computer to add the data in address number 69846 to the data contained in address 00734 and put the sum in 00734. In the process of addition the original data contained in 00734 would be lost; if the programmer had wanted to preserve it, he would have had to transfer it to some other location beforehand. The programmer would also have to remember the location of his data by address number so that he could refer to it when necessary. The programmed instructions for this particular machine would appear meaningless to anyone unfamiliar with the code—just a series of twelve digits. Actually, the first two digits represent an operating instruction whereas the next pair of five-digit numbers refers to addresses in storage.

FORTRAN is a commonly used problem-oriented language which places the burden of space allocation and address memorization on the computer. "COST = MAT + LABR" is a representative FORTRAN instruction. When carrying it out, the computer will add the material and labor charges for a particular job, transfer the sum (COST) to an address in storage, and return the material and labor charges to their original locations. If at any time during the operation of the problem the programmer wishes to refer to this total cost figure or the material and labor charges, he need refer only to COST, MAT, or LABR. The computer will locate the data at the proper address, for the programmer is no longer concerned with specific location in memory. He must be certain, however, that he does not misspell the original symbolic designations. If labor were to be spelled LABOR, the computer would discard the instruction. Remember, this electronic marvel cannot spell, think, or use its imagination; it can only follow detailed instructions.

Another relatively simple FORTRAN instruction is related to the payroll example discussed earlier. The social security tax is to be deducted from an employee's gross earnings if the annual accumulation is less than $7,800. The instruction reads: IF (GROSS-7800) 12, 15, 15. The computer is now required to make a decision and take one of two courses of action, depending upon the outcome of the comparison. Each employee's year-to-date earnings will be compared to $7,800. If the result is negative (gross earnings are less than $7,800), the computer will go to instruction number 12 in the program, where directions call for deducting social security taxes. If the result is equal to or greater than $7,800, the computer will go to instruction number 15, where it will be directed to carry out the next step in the payroll sequence.

The above routine is a simple example of how a computer, with the aid of a properly designed program, makes a logical decision and modifies its program based upon the outcome of that decision. One further note about the routine of following a series of instructions: once a computer is started on a stored program, it normally will proceed in sequential order until the end of the program. Deviations from this orderly progression will occur only when directed by the program or when the results of a decision warrant transfer to another instruction.

In the past year or two, we have witnessed further refinements in programming techniques that permit anyone with a minimum amount of training to write a program from a typewriter thousands of miles from the central processing unit. All that is needed for this operation is a command of English and a knowledge of a few algebraic expressions. The typist-programmer can spell out one instruction at a time in a conversational mode using remote terminal equipment. If a mistake has been made, the CPU will reply with a de-bugging instruction thereby enabling the operator to correct the program as it is written. Laboratory experiments are presently under way which provide for transmitting oral programming instructions to a computer. Practical applications of this mode of programming are not too distant.

Compilers

The reader may be wondering by this time how the computer became so intelligent. An earlier section stated that a computer could understand only programs written in machine language. With the development of more sophisticated languages such as FORTRAN and COBOL, the task of the programmer was simplified since more and more of the detailed bookkeeping was supervised by the computer. Nevertheless, it is still necessary to communicate with the CPU in machine language, as the computer cannot directly handle the more powerful languages such as FORTRAN and COBOL. The highly complex, specially designed program that translates problem-oriented language into machine-readable language is called the "compiler." These translators are furnished by the manufacturer of the hardware and are different for each type of computer. Highly-qualified programmers are needed to develop compilers, but the average programmer in the field can use them without having to devise them.

In recent years, many potential users have complained that the hardware is available but manufacturers are unable to meet delivery schedules because of the software bottleneck. These complaints are entirely justified. The third generation computers now reaching the market are so complex that they are useless unless accompanied by their compilers and other exotic supervisory and executive programs. Manufacturers are finding it much more difficult to provide the necessary software than to fabricate the circuitry and cabinets of the computers themselves. This bottleneck is likely to continue for several years, as more complex computers are developed and relatively fewer highly-trained programmers are available to provide the software to back them up. Eventually, the balance between the two will level off; meanwhile countless frustrations are inevitable.

Data and Program Distinction

The question often arises concerning how the CPU distinguishes between the data to be manipulated and the programmed instructions, particularly if both are stored in the core. This is no problem, since a program ordinarily is stored in one section of core with data stored in another location. In addition, the very nature of programmed instructions automatically provides for keeping the two separate.

After the program has been stored in core memory, the operator will instruct the CPU to begin running. Once the sequence of operations begins, the computer will start cycling by means of an electronic clock. It will draw the first instruction out of memory, read it, then execute it. After this first instruction has been executed, the electronic clock will direct the computer back to its reading cycle and the operations will be repeated. This cycling procedure will continue until the program directs the computer to stop or until there is no further input of data.

The manner in which the CPU locates its instructions and manipulates the data can best be illustrated by referring to an actual machine language code discussed earlier. On page 37, the coded instruction 21 00734 69846 was used to demonstrate a simple addition problem. Each instruction in the code for this machine contains twelve digits and the computer has been circuited to skip twelve digits each time it reads a new instruction.

A few operations from a typical program would appear as follows:

Address Location	**Operating**	**Data**	**Addresses**
10200	23	40002	40004
10212	26	40000	00099
10224	21	40011	40398

The operator will start the CPU by directing it to the first instruction found in core storage at address 10200. The CPU will read the operating code 23, find the data stored in addresses 40002 and 40004, execute the operation, and proceed automatically to the next instruction, which it knows will be found at location 10212—twelve digits greater than the preceding instruction. Bear in mind that no data are contained in the programmed instructions themselves, only addresses and an operating code. Address 10200, for example, contains the first instruction in the program. When this instruction is read out of storage, the computer will learn that it is to perform operation 23 on data to be found at locations 40002 and 40004. For the more curious reader, operation 23 directs the computer to multiply the factors located in addresses 40002 and 40004 and store the product in 00099 (all products are automatically transferred to address 00099 in this computer). The instruction at 10212 directs the computer to transfer the product, which is now stored in 00099, to address 40000. The last instruction has been encountered before; add the data in 40398 to the data in 40011 and store the sum in 40011.

Summary

The modern computer system contains three basic features: (1) vast storage areas coupled with rapid retrieval of information; (2) ability to manipulate data through arithmetic and logic components; and (3) a highly-detailed program of instructions which enables the CPU to control a myriad of complex operations without human intervention. Within the system, data are stored or manipulated in a very simple form of binary notation—positive or negative magnetized states which are interpreted as 0 or 1 by the computer. The equipment's versatility has been made possible because of the enormous speeds generated and the tremendous amounts of data that can be stored in relatively small areas.

This brief article has attempted to describe the operation of the computer in very simple terms, without minimizing the human ingenuity and highly-sophisticated technological resources that were required to develop this electronic marvel. Many individuals have equated the invention of the computer with the development of the wheel as important milestones in man's progress. It is perhaps too early to objectively judge the profound impact that computers will have on our lives and on the lives of successive generations; nevertheless, we can be sure that its current and potential influence is enormous.

In the event that some of you are concerned that computers or robots will ultimately control the world, let me allay your fears by reciting a little parody on Joyce Kilmer's classic poem.[1]

I think that I shall never see
A computer made like me.

A me who likes martinis dry
And on the rocks a little rye;

A me who looks at girls and such,
But mostly girls, and very much;

A me who wears an overcoat
And likes a risque anecdote;

A me who taps his foot and grins
Whenever dixieland begins.

They make computers for a fee
But only moms can make a me.

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[1] From a speech given by Mr. William T. Knox before the American Management Association, August, 1967.

The Insurance Investor--
The Forgotten Party

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Introduction

In the past two years a great deal of concern has been expressed over the treatment of the unsuspecting consumer. This wave of "consumerism" has resulted in legislation aimed at protecting the consumer. One industry currently under fire from groups interested in the welfare of the consumer is the insurance industry, particularly the property-casualty companies. Insurance associations have responded to this criticism by taking public polls; private groups have financed several studies to examine industry rate structures and rate-setting policies; and regulatory bodies are reviewing new measures of examining company policies, ranging from business acquisition to accounting practices.

In the property casualty field, consumers (policyholders) have received so much attention that it appears as though they are the only group which has any right to be interested in the insurance business. Yet, insurance companies also exist for other interested groups, including the investor. Without investors, there would be no privately-owned insurance companies. The purpose of this article is to examine the extent to which the property-casualty investors' needs are serviced.

Investors' Needs

Before we can determine the extent to which company practices satisfy the needs of investors, we first have to decide what those needs are. To make this decision, we must ask the question: What is the nature of investor decisions?

The nature of investors' decisions has changed as the stockholder-corporation relationship has changed. Historically, the corporation "belonged" to the stockholders and management was responsible to the stockholders. Therefore, stockholders were responsible for making decisions to maintain or change management and to set its policies. Comparisons between the stockholders' corporation and other corporations were made in terms of operating policies, organizational structures, and managerial abilities. More important, the primary purpose for such comparisons was to improve operating strategies for the single corporation in which the stockholders had made their investment. Although data which enable an investor to make a comparative analysis among corporations are still important, stockholders no longer maintain such absolute control over corporate activities except in small, closely-held corporations. Currently stockholders' decisions do not relate to *improving* the corporation but to deciding whether to *increase, decrease,* or *maintain* a current or prospective holding of common stock in the corporation.

Since investor decisions revolve around increasing, decreasing, or maintaining current or prospective stockholdings, investors must have enough information about the corporation to decide among alternative investment opportunities. Investors base their evaluation of current stockholdings on a review of the efficiency of management, an estimate of the firm's ability to pay current or future debts as they mature, and a prediction of future growth and its related risks. These decisions are neither arbitrary nor aesthetically based; rather, they are based on an evaluation of specific types of economic data. The types of economic data necessary for investor decisions include: (1) the amount and nature of the assets, liabilities and owners' equity; (2) the changes—both as to type and amount—in those assets, liabilities and owners' equity; (3) an assignment of those changes to specifiable time periods; and (4) management's future plans for the company—plans for expansion, mergers, prospective product and management changes.[1] To enable comparisons among alternative investment opportunities the data must be expressed in terms of money, the common denominator. Common terminology and measurement processes are also necessary to make valid comparisons. The fundamental source of these types of data is the company's annual reports, whether the investor gets that data directly from the annual reports or indirectly from a broker.

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[1] Type refers to the way in which changes occur. Changes can occur in several ways: invested capital, gains, and revenues represent three different types of increases in total resources; net profit (net loss) is the net increase (decrease) in resources, assuming no changes in the amount of invested capital, either from changes in prices or from additional investments and distributions to the owners.

Property-Casualty Reporting Practices— A General View

Now we have answered the question of what the investor or stockholder needs. We have found that he needs economic data that allow him to evaluate alternative investment opportunities. We have also found that the primary source of that data is the company's annual report. But the question of how well his needs are served still remains. In order to examine the industry's service to investors, we must go on to evaluate the quality of insurance company annual reports to stockholders.

The insurance industry is a regulated industry. Since the 1830's insurance companies have been required to file some type of report to a branch of government of those states in which they are licensed. Historically, published annual reports have been patterned after those reports filed with state governments. Although property-casualty companies are not legally required to present the same information in the annual report as in the Convention Blank (the financial statement prepared for regulatory agencies), they have typically followed this practice. Accounting practices used to evaluate solvency and liquidity for regulatory reports are also used in preparing annual reports.

The informational needs of investors, however, should be defined in terms of profitability and financial position rather than solvency and liquidity. We can find out how well this type of financial reporting meets investors' needs by determining the extent to which accounting practices that measure solvency and liquidity also measure profitability and financial position. From a broad viewpoint, solvency and liquidity tend to be creditor-oriented (or more specifically, policyholder-oriented rather than investor-oriented). They are usually based on the assumption of adverse economic conditions: if the worst possible conditions materialize, will the company still be able to pay all its claims? If asset values decline, what portion of current liabilities could be liquidated?

The conservative accounting practices used by insurance companies for regulatory reporting purposes dictate omitting certain asset accounts from the balance sheet—prepaid expenses, overdue premiums, office equipment, and so on; they also necessitate valuing liabilities at the highest possible value. In this way they can test whether the policyholders would be paid if the worst possible situation, namely liquidation, were to occur.

In contrast to solvency and liquidity measurements, profitability and financial position measurements assume that the company will continue operating under "normal" conditions. Unless there is substantial evidence to the contrary, it is assumed that a company will continue to operate. Furthermore, profitability and financial position are more inclusive measurements: presenting an investor with data from which he can determine profitability and financial position would also allow him to measure a company's solvency and liquidity. An investor could easily exclude certain "doubtful" assets from an inclusive balance sheet and proceed to evaluate the company's solvency under more adverse economic conditions. However, statements designed solely to measure solvency and liquidity do *not* allow him to measure profitability and financial position. An investor would find it exceedingly difficult, if not impossible, to add back asset accounts excluded from property-casualty balance sheets as they are now prepared. In many cases he may not even be aware of the exclusions, because the asset total is commonly entitled "total assets." The unwary investor will probably presume that the "total asset" figure is comparable to that which he notes in annual reports of other industrial companies.

We mentioned earlier that investors must be able to compare the annual report data of one company with that of another company, perhaps one in another industry. The investor who tries to make comparisons between an investment in an insurance company and some other industrial company is in for trouble. Data which reflect solvency and liquidity do not provide the same dollar amounts as those designed to measure profitability and financial position. Furthermore, there is not enough information presented in a property-casualty report to enable an investor to adjust the report so that it is comparable with other industrial reports.

Property-Casualty and Industrial Annual Reports—A Comparison[2]

As has been pointed out, property-casualty and industrial annual reports are prepared under differing philosophies: property-casualty reports are policyholder-oriented while indus-

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[2] Patricia P. Bragg, *Financial Reporting Standards for Property-Casualty Companies*, unpublished doctoral dissertation, University of California at Berkeley, November 1967. The author made a detailed analysis of property-casualty and industrial annual reports. The sample of prop-

trial reports are investor-oriented. Accordingly, the financial data of the two types of reports are not comparable. But how do they differ?

Property-casualty and industrial reports differ in many ways, ranging from the way the reports are designed to the valuations placed on assets, liabilities, and capital stock. A detailed analysis is beyond the scope of this article, but a review of the more significant differences may give the investor and analyst some idea of the extent to which the reports differ.

Differences in Design. Both property-casualty companies and industrial firms usually include one statement showing the asset, liability, and equity balances (balance sheet) and another showing the results of operations (income statement). However, the terminology describing the statements and their contents varies between the two industries. For example, property-casualty companies refer to the asset-liability-equity statement as "Statement of Financial Position" or "Financial Statement" rather than the more common industrial title of "Balance Sheet."[3] Seventy-eight percent of the industrial companies studies used the title of "Balance Sheet," while only 45 percent of the property-casualty companies did so.

By far the most significant difference in design is the "total asset"-"total admitted asset" contrast. The "total asset" figure for insurance companies refers to total admitted assets rather than to total assets. "Admitted assets" refer to only those assets which the regulatory authorities consider in evaluating the company's solvency. Generally only admitted assets are reported to stockholders, even when the reference is to "total assets." Examples of nonadmitted assets are: (1) overdue premiums [90 days]; (2) office furniture and equipment; (3) assets gained from salvage and subrogation; and (4) prepaid expenses. Because regulatory authorities regard these asset groups as having little or no market value, they are excluded in determining financial solvency. Their entire cost is recorded as an expense when they are purchased or acquired. The second asset group requires further explanation. Although most office equipment—typewriters, file cabinets, desks, chairs, and so

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erty-casualty reports includes reports for small and large operators, affiliated and independent companies, specialty and general insurers, those with and without listings on the New York Stock Exchange, and those with and without the certification of an independent auditor. Annual reports of 34 property-casualty companies were reviewed for 1963 and 1964; the sample for 1965 included 38 companies. Thus a total of 106 annual reports was reviewed.

[3] *Ibid.*

forth—is excluded, computer installations are regarded as admitted assets by the regulatory agencies. Computers warrant a special ruling because of the relatively large capital investment their purchase or rental requires.

Since property-casualty companies must report both admitted and nonadmitted assets on the Convention Blank, the dollar difference resulting from the omission of nonadmitted assets can be estimated. Nonadmitted assets for the companies surveyed total approximately $98, $124, and $149 million in 1963, 1964, and 1965 respectively. On the average this represented a little more than 1 percent of total assets; however, the omission was as high as 4 percent for some companies and as low as 0 percent for others. Assuming the experience of these companies reflects that of the industry as a whole, the total dollar difference resulting from the exclusion of nonadmitted assets was approximately $361 million in 1964. This means, of course, that retained earnings (surplus) was also understated by $361 million.

The Statement of Retained Earnings, or Statement of Capital and Surplus, as it is commonly entitled in insurance company reports, presents the most striking difference between industrial and property-casualty reporting practices. In fact, the only common reference is the item "dividends to stockholders."

Valuation Differences. Most asset values for industrial companies are based on cost prices: fixed assets are recorded at cost less depreciation; security investments at cost; and inventories at the lower of cost or market. With the exception of some bonds, cost figures are rarely used to value insurance company assets; market values are a more common valuation basis for insurance companies.

In terms of dollars, the most important valuation difference involves commissions and other acquisition expenditures. Insurance companies charge all such expenditures to operations during the year in which the insurance is sold. That is, all costs of getting the policyholder to buy the insurance are expensed, regardless of the length of the insurance contract. In similar situations, industrial accounting practices would require prorating the acquisition costs over the entire contract period. The difference is even more striking when one considers the fact that the income from an insurance policy is prorated over the entire contract period. Thus, insurance companies charge off all the expenses in the first year but recognize the income over the entire contract period. Industrial firms prorate both expenses and income over the entire contract period.

The dollar difference in periodic net income resulting from expensing as opposed to prorating all acquisition costs depends upon the trend in insurance sales: if a company writes a constant dollar amount each year and the average length of the policies is the same, the two procedures will eventually produce the same net income. Assuming a company writes $9,000 in premiums each year and the average length of a policy is three years, income at the end of the third year, and thereafter, would be the same under both accounting methods. This is illustrated for a hypothetical company in Exhibit I, Part A.

With declining sales, net income computed according to industrial accounting practices would eventually be less than that derived by insurance accounting practices. Assuming the same loss and expense ratios and a sales pattern of $9,000, $6,000, and $3,000 for three consecutive years, insurance accounting practices produce an increasing net income whereas industrial accounting practices gradually show a declining net income (Exhibit I, Part B). Again, because the length of a policy was assumed to be three years, these trends are not fully apparent until one complete policy cycle or three years has elapsed. That is, only at the end of the third year can we see that the net income derived by insurance accounting methods is greater than that derived by industrial accounting practices.

When sales are increasing, the exact opposite is true—net income will be larger under industrial than under insurance accounting practices. Exhibit I, Part C, shows the trend in income if premiums increase from $9,000 in 1966 to $12,000 and $15,000 in 1967 and 1968 respectively. Although the figures are hypothetical, it is important to note the total difference over a three-year period under these different accounting practices: an assumption of constant sales results in a $3,600 income differential for the three years, while the difference under an assumption of declining sales totals $1,600. The largest total difference of $5,600 results from an increasing sales pattern.

In summary, industrial and insurance company annual reports differ in both design and valuation procedures. Variances in financial magnitudes resulting from these differences depend upon the size of the firm, the absolute and relative volume of business, the type of assets held, and management policies.

Impact on Investors

Insurance companies have been severely criticized for their failure to provide data which is comparable with that of other businesses. The magnitude of the problem is well illustrated by the following extract from a typical auditor's report to the stockholders of a property-casualty company:

> The . . . financial statements have been prepared in conformity with accounting practices prescribed . . . by regulatory authorities and do not purport to be a presentation in conformity with generally accepted accounting principles. . . . The prescribed . . . practices are at variance with generally accepted accounting principles in certain respects which, in our opinion, are material in the aggregate.

Temporary measures designed to compensate for this lack of comparability have equally serious implications for the investor. Under the direction of the American Institute of Certified Public Accountants (AICPA), auditors first alerted the stockholders to the problem of comparability by: (1) revising the "in conformity with generally accepted accounting principles" to read "in conformity with accounting practices prescribed by regulatory agencies"; (2) pointing out that these practices are designed primarily to demonstrate ability to meet claims of policyholders; and (3) listing the major differences between insurance and non-insurance accounting and reporting practices. Although the revised AICPA opinion statement and its related footnotes alerted the investor to the problem of comparability, he was seldom given any basis on which to assess the magnitude of these differences. In fact, auditors frequently included a statement in insurance company annual reports explaining "that no determination was made of the effect of such differences on the accompanying financial statements."

The AICPA took more positive action in July, 1966, when it published an audit guide for fire-casualty companies.[4] In addition to recommending that auditors continue to use the revised opinion, Chapter IX of the AICPA publication recommends that supplementary statements, prepared according to generally accepted principles, be included in insurance company annual reports.

Even before the AICPA published the audit guide, property-casualty companies began furnishing adjusted earnings data and, in some cases, adjusted stockholders' equity data in their annual reports.[5] Because adjusted earnings or stockholders'

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[4] *Audits of Fire and Casualty Companies* (New York: American Institute of Certified Public Accountants, Inc.) 1966.

[5] Adjusted earnings are obtained by "adding back to statutory earnings (that computed by charging off all commissions, etc. in the first year, but prorating the income) the equity in the unearned premium reserve

equity figures are rarely explained in the annual reports, they are probably of little value to an average investor. Even if investors understood the underlying assumptions, these adjusted figures are still likely to be deficient because investors use a standard adjustment figure regardless of the loss or sales patterns of the individual company. As was illustrated earlier, the sales pattern definitely changes the magnitude of the over or understatement of earnings; therefore, the addback figure should also change.

The differences we have discussed between annual reports of industrial and insurance companies and the measures taken to compensate for these differences have left the average investor somewhat skeptical of insurance investments. Although there may be other reasons, this skepticism is reflected in the rather limited and uninteresting action in the market for insurance stocks during the past few years. Only a few brokers in the entire country—usually those with large national brokerage firms—will even recommend that the average investor consider investing in an insurance company. It is unlikely that this situation will change until the reporting practices of insurance companies show substantial change. In short, we may be overly concerned about the protection of the consumer. Policyholders who prefer private insurance should also have a keen interest in satisfying investor needs. Unless the investors' needs are met, the market for insurance stocks may be in serious trouble.

(the portion of the expenses that should have been shown as prepaid assets rather than expensed)." The addback figure is derived by applying a constant percentage—35 percent for fire lines and 30 percent for casualty lines—to the change in the unearned premium reserve.