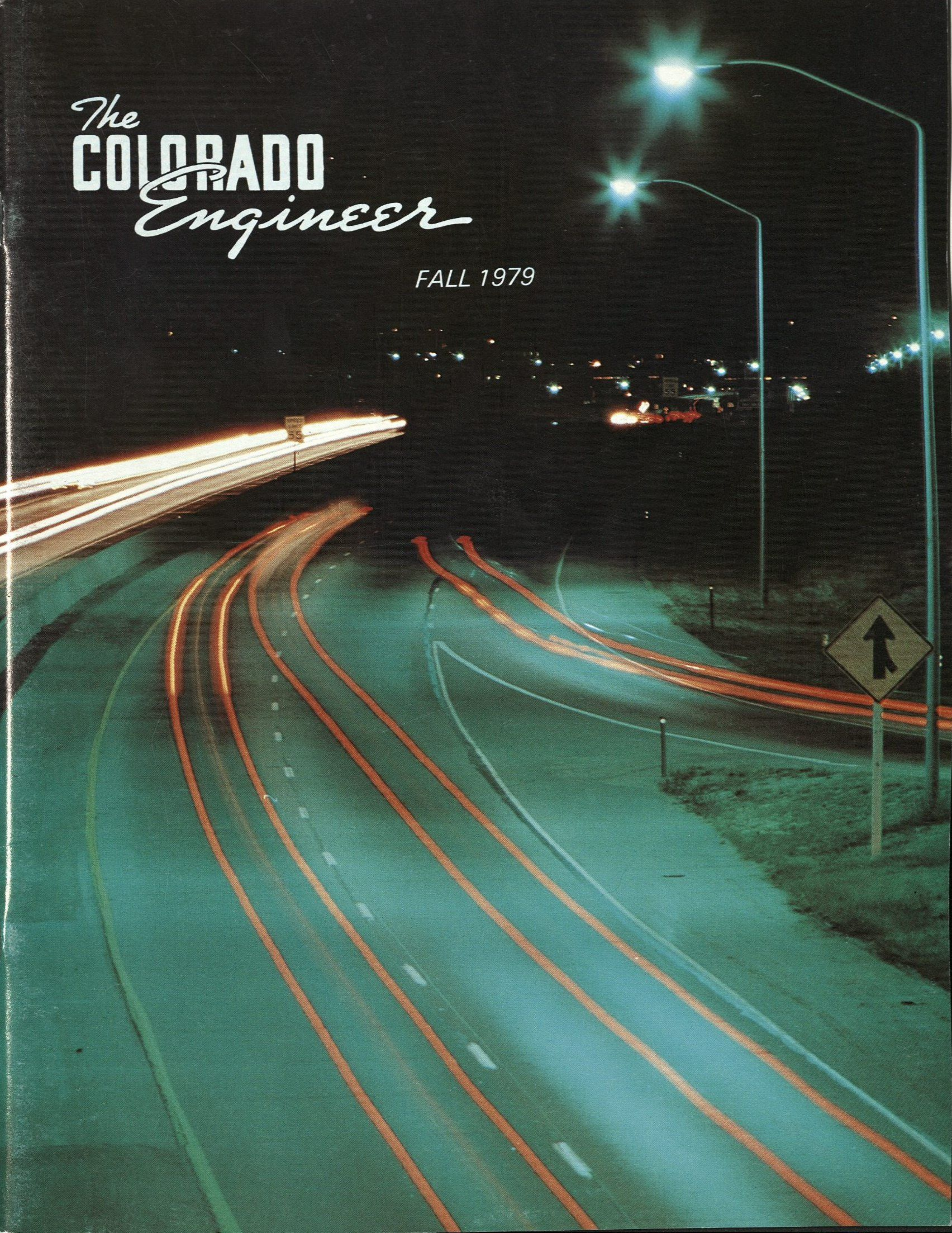
The COLORADO Engineer

FALL 1979



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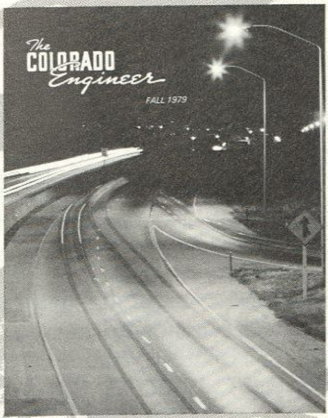
FEATURES

DEPARTMENTS



COVER

The cover this month is a time lapse photograph of westbound U.S. 36. The film used was Ektachrome 64. This photo shows the importance of proper roadway lighting. For more information on the subject turn to this month's Focus, "Reflections on Asphalt," an interesting look at an architectural engineering research project. Photo by Rich Luxford.

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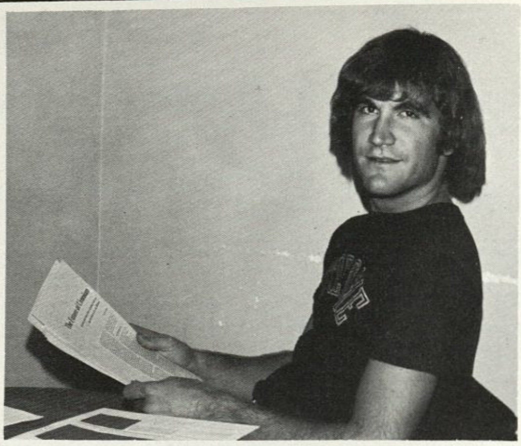
The Editor's Outlook

There's a Light



There seems to be a light at the end of the tunnel. For those of us who are seniors, the end is in sight. If you take a look around you will see dozens of seniors frolicking around campus in three piece suits. Off to a funeral you say? Wrong. These students are doing what every senior in engineering should be doing right now. They are out interviewing for a permanent job. Now that the end is near, finding that job is essential.

Getting registered to interview here on campus is easy. All you have to do is fill out some forms over at the Career Placement Office in Willard Hall. Then they will have you make up a personal data sheet that you will keep copies of. Be sure you make enough. It is very irritating to have to go back and make more. By the way, they will want $10.00 to pay for their services. It may seem like the university is trying to soak up your last few dollars, but for once the money is worth it. They perform an invaluable service for us and the cost for the time and effort that goes into setting up those interviews probably exceeds that $10.00.

Now you are all set to interview. Hopefully you have started well before you graduate. It always helps to start early and talk to more companies. Numerous interviews will increase your knowledge of available career opportunities and may even bring in more job offers. Of course, the more job offers the better. However, the more offers you have, the harder it is to make a final decision. I plan on narrowing the selection down to 5 companies and using darts to select the lucky winner.

There is one last thing that nags at seniors all through their final year. The subject of professional registration must be dealt with before we leave school. I am so amazed to see professors suddenly turn into clones of our mothers and nag us into taking the E.I.T. and P.E. exams. I think it is a lot like when mom used to tell us to wear clean underwear in case we had to be taken to the hospital in an emergency. We may never have had to go, but we were prepared just in case. The E.I.T. and P.E. registrations are something we may never need, but it is nice to have it taken care of now. The E.I.T. is a test that is supposedly much easier to pass while we are in school and our memories are still fresh. For that reason alone it is worth taking the test. There are a few other things I should point out though. Some companies (usually consulting firms) require their engineers to have passed the E.I.T. If you have, they may pay you a little more. If you have passed the P.E. exam some companies will pay you more and advance you through the chain of command faster. So as you can see, professional registration is very important. It is worth noting that the E.I.T. is transferable to all 50 states. The P.E. is transferable to all 50 states also, but in California and New York there is a required specialty test that goes along with it.

If you can still see that light after all I have said, you are doing good. There may be a few trains trying to block the way (Mosher who?), but a few side steps and some careful dodging will get us through. In the three years it took to get to be seniors we have learned how to deal with most every obstacle. Now with graduation almost within reach it won't take much to pass a few more tests and enter the real world of engineering.

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The Future of Uranium

Current projections show uranium reserves may be depleted in our lifetime.

By John Seidle

It can be argued that there are four, not three, necessities for the current lifestyle in the developed countries of the world: food, clothing, shelter and energy. Presently a large part of that energy comes from oil and gas, the reserves of which are finite and increasingly more expensive. The popular belief is that as oil and gas reserves are depleted coal and nuclear energy will be used until solar energy and fusion are practical, economical energy supplies. At the current rate of consumption, coal reserves will last for centuries. However, it is difficult to locate estimates of the lifetime of uranium reserves; possibly because there are so many different kinds of nuclear fuels, reactor types and fuel cycle technologies to be considered. This article is an attempt to model the consumption of world uranium resources when used in modern pressurized water reactors (PWR) subject to the present fuel cycle.

Of course, modelling uranium consumption on a global rather than a national or regional basis precludes prediction of uranium resource depletion on all but the grossest scales. Regional effects, such as the depletion of uranium resources in Western Europe and its subsequent dependence upon imported uranium, will be completely masked in this study.

It will be assumed that political, economic and environmental concerns do not impact the exploitation of nuclear power. While these aspects of nuclear power are quite important, they are incredibly complex and perhaps cannot be answered in their entirety at this time. Besides, they are nearly impossible to quantify. Although a model which neglects political, economic and environmental concerns may rightly be judged simplistic, the predictions of such a model may help define these concerns more clearly. Uncoupling the purely technical considerations from these other (value laden) concerns may yield a reasonable first approximation of uranium consumption over the course of time.

THE RESOURCE BASE

To model uranium depletion the magnitude of world uranium reserves must be determined and a model of uranium consumption must be constructed.

Naturally occurring uranium has three isotopes: U-238, U-235 and U-234. It is 99.29% U-238, which can be "bred" into plutonium, .71% U-235, the fissionable isotope, and just a trace of U-234. Although some reactors can use natural uranium, PWR's must be fueled with uranium which has had the U-235 concentration increased to about 4%. Such uranium is said to be "enriched." The Fort St. Vrain reactor, a high temperature gas cooled reactor, requires highly enriched uranium, on the order of 95% U-235. Bomb grade uranium is uranium which has been enriched to a U-235 concentration of greater than about 95%. For the model, it will be assumed that no shortage of enrichment facilities will occur, which may or may not be the case.

Uranium is believed to be more abundant than mercury, antimony, silver or cadmium and about as abundant as molybdenum or arsenic. It occurs naturally in some half dozen minerals and the major ore deposits are located in Zaire, Canada, the US and South Africa. High grade uranium ore contains up to about 4% uranium. Known reserves of high grade ore are nearly worked out, ores with 0.4% uranium are now being

TABLE 1

WORLD U_3O_8 RESOURCE SIZE ESTIMATES (in kg)

Source	Size
Ref 1	$6.259(10)^9$
Ref 2	
Vol 14	
p. 237	$2(10)^9$
Ref 3	
SIPRI	
p. 48	$3.656(10)^9$
Ref 4	
DOE	$5.181(10)^9$

worked and ores down to 0.01% uranium are being noted for development. The ore is processed to yield uranium in the oxide form, U_3O_8, which the miners called "yellowcake" because of its color. Uranium reserves are measured in kilograms or tons of U_3O_8.

It is difficult to accurately determine the amount of uranium in the world. Due to political and technical factors different sources give widely differing estimates. Many nations regard estimates of their natural resources as privileged information, especially the USSR, the People's Republic of China, and communist-bloc nations with the exception of Yugoslavia. The reported values of uranium reserves of any nation may be politically colored.

For a given reserve, determination of the uranium content is almost more of an art than a science due to the technical problems encountered, especially for reserves with low grade ore. An example of the difficulty in evaluating the size of a reserve is provided by the evaluation of the uranium contained in the San Juan Basin in New Mexico. The AEC (now ERDA) estimated the basin's U_3O_8 reserves were 740,000 tons. The AEC then had thirty-six independent geologists review the data and make their own estimates of the amount of U_3O_8 which could be recovered. The thirty-six estimates were then averaged, giving a value of 450,000 tons U_3O_8, more than a quarter of a million tons less than the AEC estimates. On the other hand, some members of the nuclear community maintain the ERDA estimates of U_3O_8 reserves are too low.

Uranium reserves are reported in a most confusing manner. They are divided into broad categories depending on the degree of certainty of the resource, e.g., proven reserves, potential reserves, probable reserves, speculative reserves, all in tons of U_3O_8. Each category is sub-divided by market value in dollars per pound. Some of the confusion results from the fact that there is no standard classification system: one person's probable reserves may be another person's speculative reserves. Another element of confusion lies in the market value of the U_3O_8. Because of inflation, the cost per pound must be constantly revised upward but also the real price has been driven up by a worldwide uranium producers cartel, similar to OPEC but less visible.

For this study, the total reserve was used, that is, the sums of all different categories and all the different prices, on the assumption that the uranium will be mined by an energy-hungry world almost regardless of the cost, especially once the reactors are constructed. Moreover, as uranium demand increases, more prospecting will be done and new ore discoveries will be made, increasing the resource base. Even though only total reserves are used in this study, estimates still vary widely. Estimates of world resources of U_3O_8 in kg are given in Table 1. The DOE values were employed in this study as they were the most recent and deemed to be the most reliable. However, DOE has estimated the U.S. contains nearly 80% of the world's uranium. Rather than reflecting actual ore deposits, these estimates probably reflect the fact that the rest of the world, especially the Third World, has not been as thoroughly prospected as has the U.S.

Due to the uncertainty in uranium reserves, the model was run using three different values of the U_3O_8 reserves: The value given by the DOE, twice this value and ten times this value.

TABLE 2

INSTALLED NUCLEAR CAPACITY (MWe)

Year	Capacity
1954	7
1955	7
1956	113
1957	214
1958	753
1959	1114
1960	1304
1961	1569
1962	2895
1963	4568
1964	6100
1965	7106
1966	8483
1967	10172
1968	10894
1969	14942
1970	20015
1971	26166
1972	34530
1973	47162
1974	72417

URANIUM CONSUMPTION

Uranium consumption depends on reactor type; different types of reactors consume uranium at different rates. Further, not all reactors are powered by uranium.

There are a variety of reactor types in commercial operation today and they fall into two broad categories. The first category contains "burner reactors." These are reactors which obtain energy by the fissioning of atoms. There are many kinds of burner reactors including the gas-cooled reactor (GCR) popular in the UK and France, the advanced gas-cooled reactor (AGR), the pressurized heavy-water reactor (PHWR), or Candu reactor used in Canada, the high temperature gas reactor (HTGR), employed at Fort St. Vrain, and the pressurized water reactor (PWR). The PWR is by far the most widely employed reactor configuration and almost all burner reactors in operation, under construction, or planned are PWR's.

The second type of reactor is a "breeder" reactor. There are several types of breeder reactors but the only one presently being extensively researched and used commercially is the liquid metal fast breeder reactor (LMFBR). Instead of using water for a coolant, as do the PWR's, this type of breeder reactor uses a liquid metal, such as a sodium-potassium mixture, to convect heat away from the core, which has a much higher power density than burner reactors. Breeder reactors create more fuel than they consume by virtue of being surrounded by a massive blanket of "fertile material" which is not fissionable but is transmuted to a fissible material upon absorption of neutrons. In the LMFBR, plutonium 239 is used as a fuel while the fertile material is uranium 238, which becomes plutonium 239 by the breeding process. However, breeders will probably not supply a large fraction of the electrical energy generated from nuclear fuels before the turn of the century.

The typical PWR produces about a thousand megawatts electrical energy (1000 MWe) and requires about 182,000 kg of uranium oxide fuel, U_3O_8, a year. It will be assumed that the PWR technology will achieve no radical breakthrough in fuel efficiency in the years ahead and that a scaling up or down of the plant size does not grossly affect fuel efficiency.

The number of nuclear reactors is increasing and therefore a realistic model of uranium consumption must include this growth. Estimates of the rate of growth of nuclear powered generating capacity in future years varies between 2 and 25%, depending on the source.

But predicted growth rates are no more than predictions; they may or may not materialize. A more accurate model of uranium consumption can probably be forged from

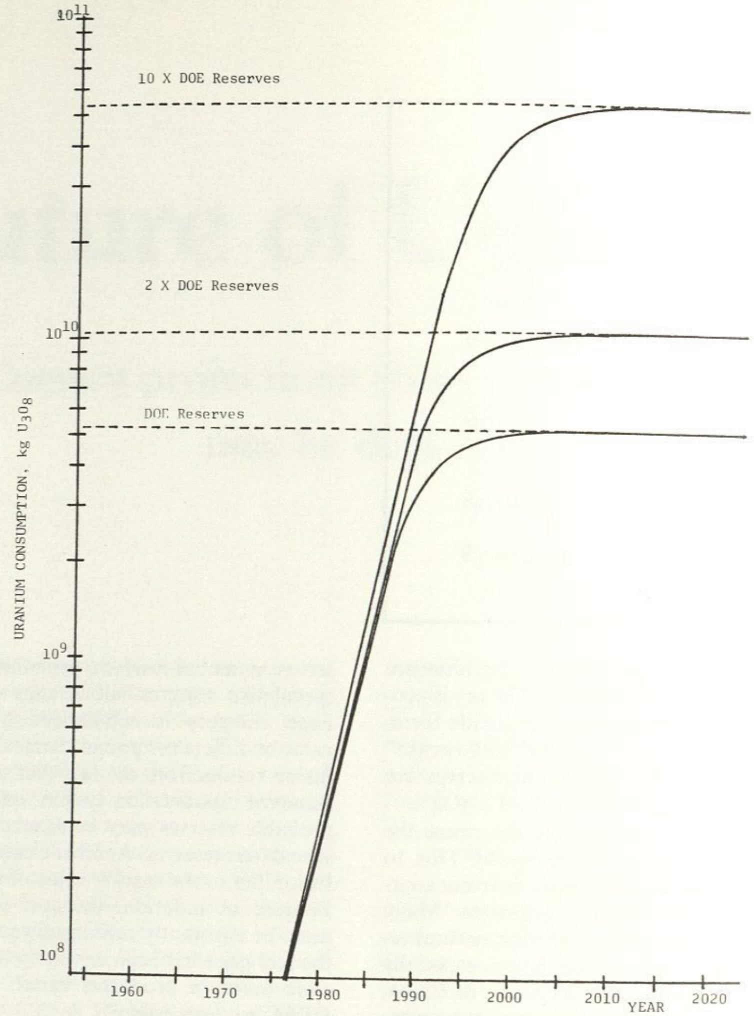

Figure 1

the history of uranium consumption. Installed nuclear generating capacity in the world over the years is given in Table 2. From this table historical uranium consumption can be estimated.

Determination of uranium consumption in the past is complicated by two main factors. First and foremost, the amount of uranium which has been made into nuclear weapons is virtually unavailable in the open literature. Secondly, a nuclear power plant has planned shutdowns for maintenance and refueling. The length of these shutdowns varies from year to year and country to country. In addition they depend on reactor type.

In response to these complicating factors, it can be said that the lifetime of uranium consumption predicted by the model would be an upper bound on the resource lifetime. Use of uranium for weapons only shortens the lifetime of the reserve. Secondly, most power reactors today are PWR's and the trend will probably continue into the future. So treating all power reactors as PWR's will probably not incur great errors.

Assuming that all the nuclear generating capacity in Table 2 is in the form of pressurized water reactors which have a uranium consumption of 181.82 kg U_3O_8 per MWe-yr, the annual rate of world uranium consumption can be estimated. Numerically integrated the annual uranium consumption gives the total amount of uranium consumed through 1974 as $4.260(10)^7$ kg U_3O_8. Which is about 1% of the DOE estimate of world uranium reserves.

THE MODEL AND ITS PREDICTIONS

A simple model of uranium consumption can be constructed by assuming a constant growth rate, 6% per year, for example. That is to say the time derivative of uranium consumption equals .06 times the uranium consumption. Such a model predicts uranium consumption will grow exponentially. By integrating this uranium consumption over time, one can calculate the total amount of uranium consumed. The lifetime of the resource is simply the value of time such that the amount consumed is equal to the size of the reserve.

But such a model is not realistic. It is ludicrous to think that people are going to blindly build reactors at a constant growth rate of say, 10% per year, until they get up one morning and all the uranium is gone. People don't act like that.

Instead, as the end of a resource comes into sight, the price goes up and people start developing alternatives. The rate of production of the resource peaks then decays. A model which exhibits this type of behavior was applied to fossil fuels by Kreith (9). Details of the model are lucidly given in Kreith and the increased reader is urged to consult reference 9 for a complete description of the model.

In this study, uranium consumption was modeled by the equation

$$P = \frac{U}{1 + \exp\left[-\frac{c_1 (t-t_m)}{u}\right]}$$

where P = Amount of uranium consumed
U = Size of uranium reserve
C_1 = constant
t = time
t_m = time of maximum rate of uranium consumption.

This equation is used with historical uranium consumption and estimates of uranium reserves to predict the time when uranium consumption will peak.

Using a nonlinear least squares program this equation fits the data of Table 2 with a coefficient of determination of 0.88. A fair fit but not a good one. Looking at the data, it is seen that in the first five years, from 1954 through 1958, nuclear generating capacity grew by two orders of magnitude. In the next sixteen years, from 1958 through 1974, nuclear generating capacity again grew by two orders of magnitude, a much slower growth rate. Casting aside the data of the first five years and fitting the model to the data for the last sixteen years of the table gives a coefficient of determination of 0.98, clearly a much better fit. Consequently, the data of the 1958 through 1974 was used for this paper.

Using the DOE estimate of uranium reserves, the model predicts uranium production will peak in 1988. The uncertainty in the size of world uranium reserves was noted above. To investigate the sensitivity of the model to the size of uranium resource employed, the model was run using different values for the resource base. For uranium reserves twice that of the DOE estimate, uranium production will peak in 1990. If the uranium reserves are ten times the DOE estimate, uranium production will peak in 1995. Increasing the reserves by an order of magnitude increases the peaking time by a scant seven years.

Equation (1) is plotted in Fig. 1 using the size of the uranium reserve as a parameter. It is seen that the size of the reserve raises the height of the curve but does not substantially shift it in time. Even if the DOE reserves are low by an order of magnitude, the model predicts most of the world's uranium will be consumed by early in the next century.

The derivative of eq. (1), that is, the annual uranium consumption predicted by the model, is plotted in Fig. 2. For all three sizes of the uranium reserve, the peak of uranium consumption is seen to occur around 1990.

Perhaps the principal conclusion to be drawn from this study is that the PWR technology which is so popular today will have to be superceded by some other type of reactor or fuel cycle if nuclear energy is to be a long term energy source for the world.

Due to the tremendous complexity of nuclear technology and the long lead time

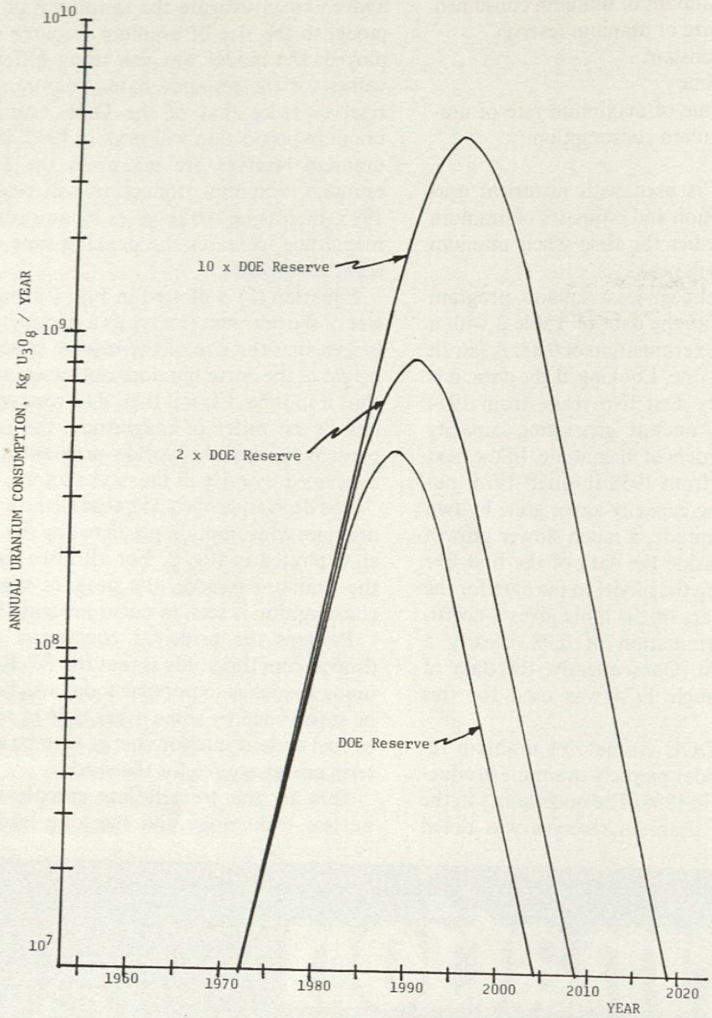

Figure 2

necessary to develop a reactor type to the level of commercial viability, it would perhaps be prudent for government and industry to initiate research into alternative reactor systems as soon as possible.

One obvious avenue of investigation is that of the LMFBR mentioned above. However, a variety of safety and environmental questions remain to be answered before it can be widely deployed. It is anticipated that many long and bitter political battles will be waged over the exploitation of breeder reactors in America. LMFBR's are operational in France, England and the USSR and are under construction in the Federal Republic of Germany, Japan and the U.S.

One of the most exotic alternatives to PWR technology is the Canadian "near breeder reactor" which converts thorium, which is not fissionable, into U-233, which is fissionable. Such a reactor is said to not need any net fuel after an initial load of less than 400 tons of 3% enriched U-235. At the Oak Ridge, Tennessee ERDA laboratory here in the U.S., scientists have developed a similar reactor using thorium and U-233 which employs a molten salt as a coolant. Such breeders would offer an alternative to today's PWR's but estimating the thorium reserves and predicting thorium consumption is absolutely fiendish. Suffice it to say there is apparently a lot more thorium around than uranium.

This study has attempted to predict consumption of world uranium reserves, assuming the nuclear industry continues to favor the PWR technology which is popular today. According to the model, world uranium production will peak before the end of this century. Implying that other forms of nuclear energy will have to be rapidly developed and deployed on a large scale if nuclear energy is to be a significant energy source.

It was noted above that uranium consumption through 1974 constituted approximately 1% of the DOE estimate of the world's uranium. Certainly, one of the strongest criticisms of this study is that it is doubtful whether a highly credible model for the consumption of the remaining 99% of the world's uranium can be constructed from the history of the 1% which has been consumed. Simply not enough uranium has been consumed to accurately predict how the remainder will be consumed.

But it can be argued that the factors which most strongly affect the lifetime of uranium resources are those which have been neglected in this analysis because they are so subjective and hard to quantify: Political, economic and environmental issues.

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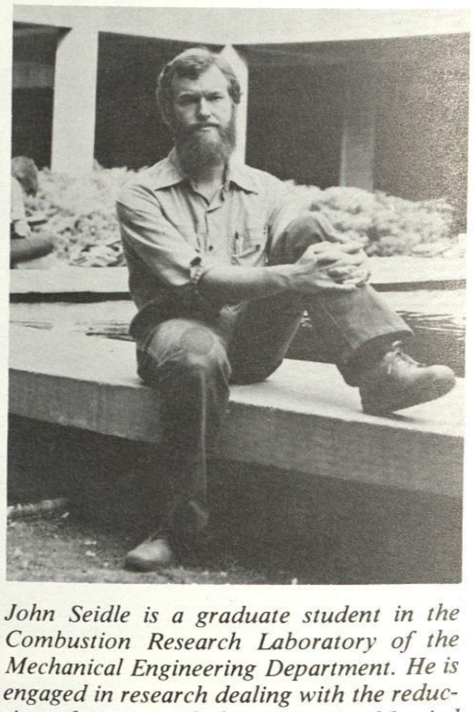
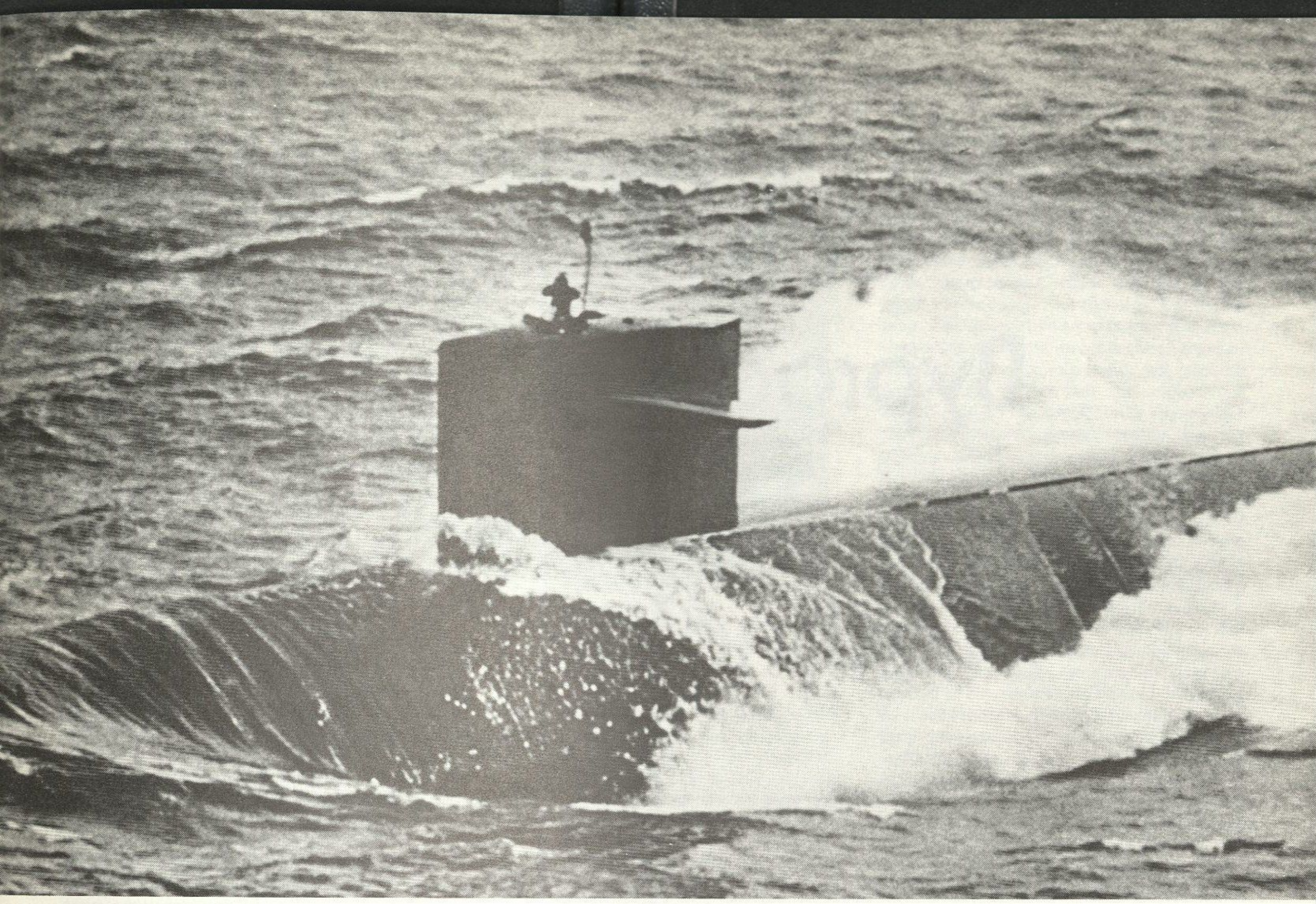


John Seidle is a graduate student in the Combustion Research Laboratory of the Mechanical Engineering Department. He is engaged in research dealing with the reduction of nitric oxide by ammonia. Married and the father of two children, he claims to be living proof of the old adage: "Insanity is hereditary—you get it from your kids."



Cancer: A Byproduct of Today's Technology

By Lloyd Kemena

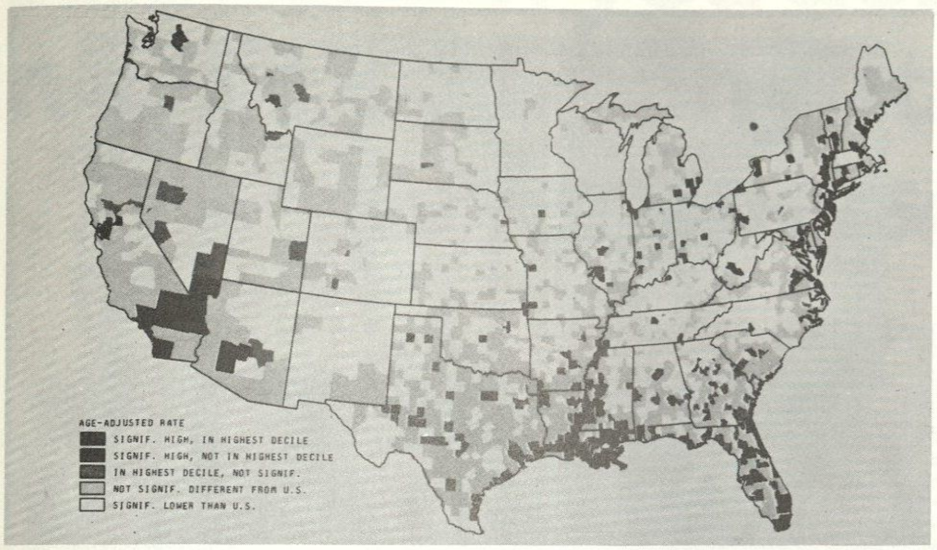
Cancer is a disease characterized by the failure of cells to regulate growth, develop normally, and function properly. These failures are caused by mutations in the genetic expression of DNA which governs all bodily functions. These mutations can be the result of exposure to cancer causing chemicals (carcinogens), radiation, viruses, or hereditary predisposition. The disease is not consistent among individuals which makes treatment difficult. Cancer is also characterized by its ability to spread throughout the body (metastasize) and effect tissues other than that of its origin. The ability of cancer to invade a vital organ and block normal tissue function and development along with its power to inhibit the body's immune system are the usual causes of death.

Chemical Engineers must face the horrors of industrial carcinogens

Cancer is one of the most threatening diseases to plague modern society. Indeed, the elimination of once fatal viral infections in most of the western world has brought cancer to the limelight. Unfortunately, the fears long associated with the disease are not unduly exaggerated as reflected by its 75% fatality rate. Despite the miracles of modern medicine, the isolated successes in cancer research and treatment since 1930 have been more than offset by the losses to cigarette smoking, environmental pollution and the increasing use of chemicals in our every-day lives.

The cure-all vaccines long associated with past diseases have not been found for cancer. The intricacies of cancer cell development involve the very essence of normal body cell regulation and our ignorance in this area is particularly overwhelming. Almost without exception, cancer agents mutate the normal genetic expression to induce cancer by a multi-step mutational process. As research continues to proceed, we are quickly discovering that our modern technological environment, with its wide variety of new untested chemicals and pollutants, may be the single largest contributor to cancer inducement. In fact, some studies claim that our environment may be the ultimate culprit in 70–90% of all reported cancer cases either by direct involvement or by combining with other factors. Such suspicions have brought our attentions to re-evaluate those environmental agents once considered safe.

Although the politics of cancer has become a complex web, the chemical engineer in particular (guided by what will hopefully be the sound advice of our educated political leaders) is in a unique position to aid in the elimination of chemical carcinogens. Many of the carcinogenic chemcials inadvertently produced by our industrial forefathers — with originally good and honest intentions — must be dealt with now. One of the most humanly exciting challenges chemical engineers face is to devise means by which to eliminate these chemicals from our environment. Even a mere .01% decrease in cancer incidence in the United States with regards to the total population could mean



The geographic pattern of lung cancer among white males. The highest mortality rate is around metropolitan areas and along the Gulf of Mexico.

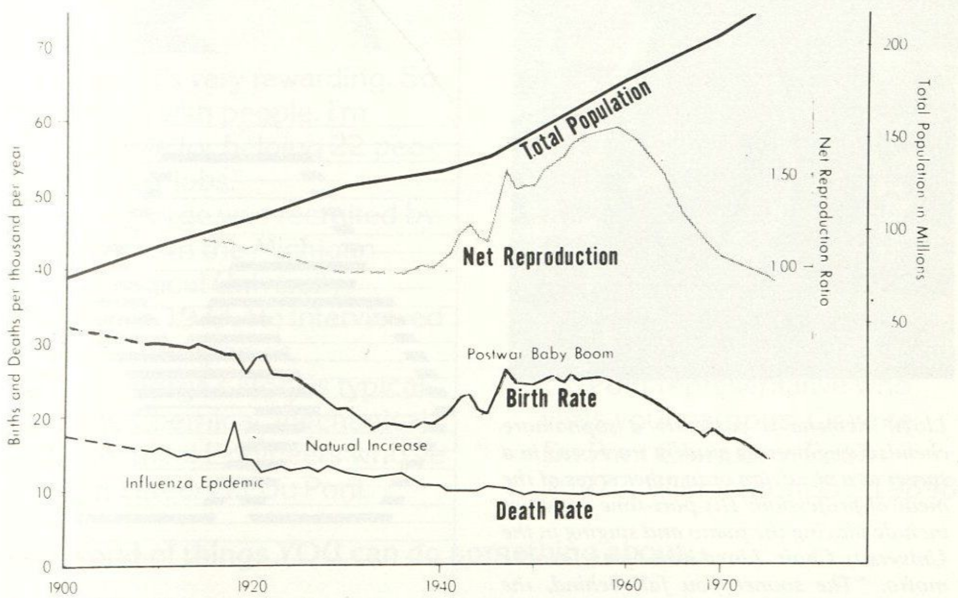
saving 22,000 persons from facing the threat of cancer.

The link between chemicals and cancer is very real. It is no real surprise to discover that counties in the United States heavily involved in mining, manufacturing, and refining have a high incidence of cancer, nor is it unusual to correlate cancer with the pollution of large metropolitan areas. Unfortunately, the considerable "lag time" between carcinogenic exposure and the occurrence of cancer has hidden the causative agents until recently. With over 12,000,000 chemicals produced in the United States, it is definitely time to deal with the proven offenders! Undoubtedly, chemical engineers could help alleviate these potentially lethal situations by designing better filtering, scouring, scrubbing and disposal techniques according to the chemical involved. Situations such as chemical burial contamination in the Love canal near Buffalo, New York, and the dumping of ketone into the James river of Virginia illustrate the need for safe and efficient chemical engineering techniques to handle these problems now that we are no longer ignorant of their presence.

One of the contributing factors to the high incidence of cancer along the Mississippi river delta may be due to the fact that the river is serving as a pollution disposal for cities upstream. One way in which to alleviate the problem is to eliminate the production of chlorinated hydrocarbons formed by water treatment in many cities. A currently feasible ozone process is available to deal with this problem by removing organic material from the water before it is treated. The massive petro-chemical industry is also suspected in the high cancer incidence of the region. The variety of industries attracted to not only the Mississippi but other navigable rivers complicates the problem of pollutant removal. One of the chemical engineers toughest future problems may be to understand how a variety of disposed chemicals react with each other and whether or not these reactions are safe. Binding carcinogenic chemical wastes with other chemical compounds into a stable disposable form may be a solution. For those petro-chemicals as well as other manufacturing processes for which no safe process is found, we must consider the risks and judge whether the costs justify the benefits.

Many of the food additives thought to be harmless in years past have now been discovered to have a possible cancer connection and the controversy boils continually. The addition of nitrates and nitrites to preserve processed meats for example, are thought to undergo a chemical reaction in the body to form nitrosamines which are one of the most carcinogenic compounds known to man. The alternative to withdraw preservatives from meat and increase the chances of botulism poisoning is no choice, but research has recently shown that the addition of ascorbic acid (vitamin C) with the present meat preservatives greatly inhibits this carcinogen producing reaction. The introduction of any new substance, particularly an acid such as the one mentioned, means an altered processing procedure. The chemical engineer has the opportunity to guide new paths of preservative treatment using different materials which can safely and efficiently handle this process on a massive scale. It is the high cost of these transitions which disturbs industry, but tough choices must be made and hopefully, the chemical engineer can aid in the smooth transition. However, by transposing a chemist's laboratory reactions into mass production, the chemical engineer may also have the responsibility to determine whether or not the carcinogenic substance eliminated is not merely traded for another that has been produced by an unexpected method.

The college age generation of today has the most at stake in the cancer struggle, being near or at the glut of the so-called post-war baby boom. Cancer incidence increases with age, and as this nation enters the twenty first century, it will be this swollen aging generation that will have to deal with a disease which already effects 25% of the American population and continues to increase. The



Reprinted from "A Geography of Mankind," *3rd edition, McGraw-Hill Book Company, 1978.*

engineers pivotal role in implementing the discoveries of science, the decisions of government, and popular opinion make his role particularly vital to this generation as our struggle against cancer continues.

Fortunately, but paradoxically, our government permits the freedom of choice which subsequently results in thousands of cancer deaths due to cigarette smoking. Obviously, the ingenuity of an engineer will not succeed here, but we must utilize what means we have available to reduce the cancer risks. The solutions to these problems are expensive and the decisions along the way will be difficult, but the pseudo-alternative is human life. Though we may always hope for an overall cancer cure, it may be that environmental carcinogen elimination is the only solution. Hope for a miracle is no substitute for action that may unexpectedly bring us closer in conquering this disease. It will certainly require a special breed of engineer to deal with human problems of such magnitude. Our future may depend upon how engineers prepare and respond to the challenge.

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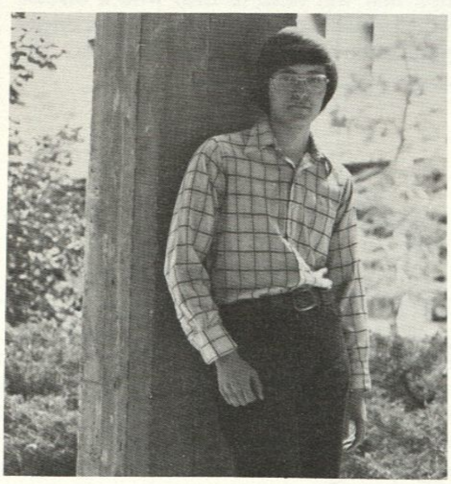


Lloyd Kemena is currently a sophomore chemical engineering student interested in a career as a physician or in other areas of the medical profession. His part-time activities include playing the piano and singing in the University Choir. Lloyd lives by his favorite motto, "The sooner you fall behind, the longer you have to catch up."

Average County Age-adjusted Mortality Rates for Lung Cancer among Whites, 1950–1969

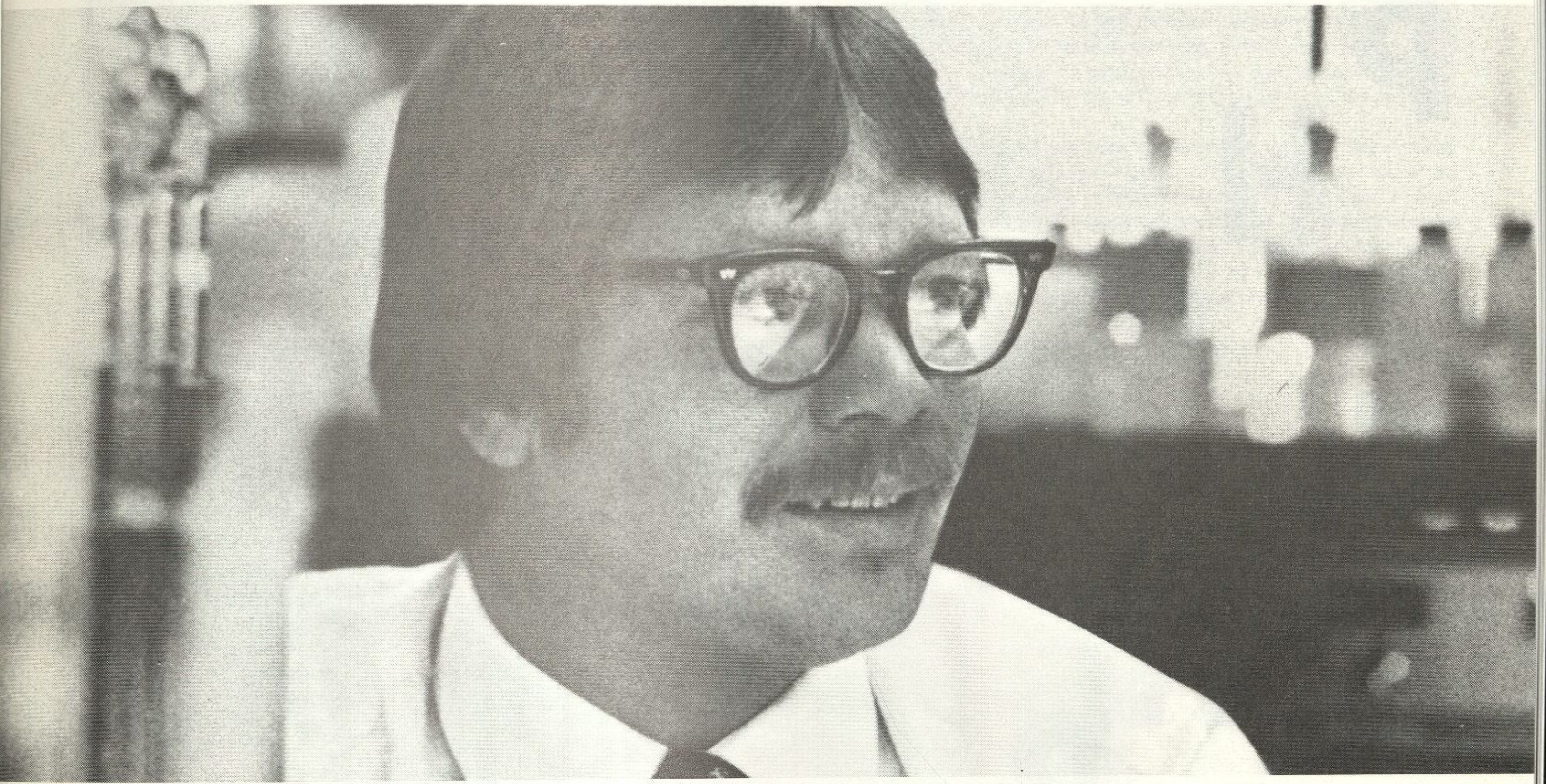
Sex	*Geographic region*	*Percent urban*[a] 0–24.9	25–49.9	50–74.9	75+
Males	Northeast	32.8	35.2	37.7	43.5
	Southeast	29.1	32.4	38.7	46.0
	Midwest	26.1	29.2	32.6	39.6
	South Central	31.2	34.4	36.0	40.3
	North Central	21.9	23.9	27.2	34.5
	Mountain	23.0	23.9	26.8	30.4
	Far West	32.0	32.8	34.2	40.7
Females	Northeast	5.9	5.6	5.6	6.7
	Southeast	5.1	5.1	6.0	6.8
	Midwest	4.9	5.0	5.4	6.3
	South Central	5.4	5.3	5.9	6.9
	North Central	4.2	4.7	4.8	5.4
	Mountain	4.3	4.6	5.1	5.6
	Far West	5.7	6.2	6.2	7.7

Data from Blot and Fraumeni (1976a).
[a] Rates are per 100,000 person-years.

Reprinted with permission from "The Origins of Human Cancer," *Cold Spring Harbor Laboratory, 1977.*

"At Du Pont you don't get lost in a big company atmosphere. It's very personal."

—George D. Peterson BS, Chemical Engineering



"Du Pont is a big company but it's broken down into satellites. So you don't get lost in a big-company atmosphere. It's very personal, and I think the people are top-notch.

"I started in technical here at the Belle Plant in West Virginia. Now I'm a production supervisor. Production is solving problems on a day-to-day basis. I like working under that kind of pressure. When things work out, it's very rewarding. So is working with people. I'm responsible for helping 22 people do their jobs."

George was recruited by Du Pont from the Michigan Technological University campus in 1973. He interviewed about 25 companies.

George's story is typical of many Chemical, Mechanical and Electrical Engineers who've chosen careers at Du Pont.

We place no limits on the progress our engineers can make. And we place no limits on the contribution they can make—to themselves, the Company or to society.

If this sounds like your kind of company, do what George Peterson did. Talk to the Du Pont representative who visits your campus. Or write: Du Pont Company, Room 35972, Wilmington, DE 19898.

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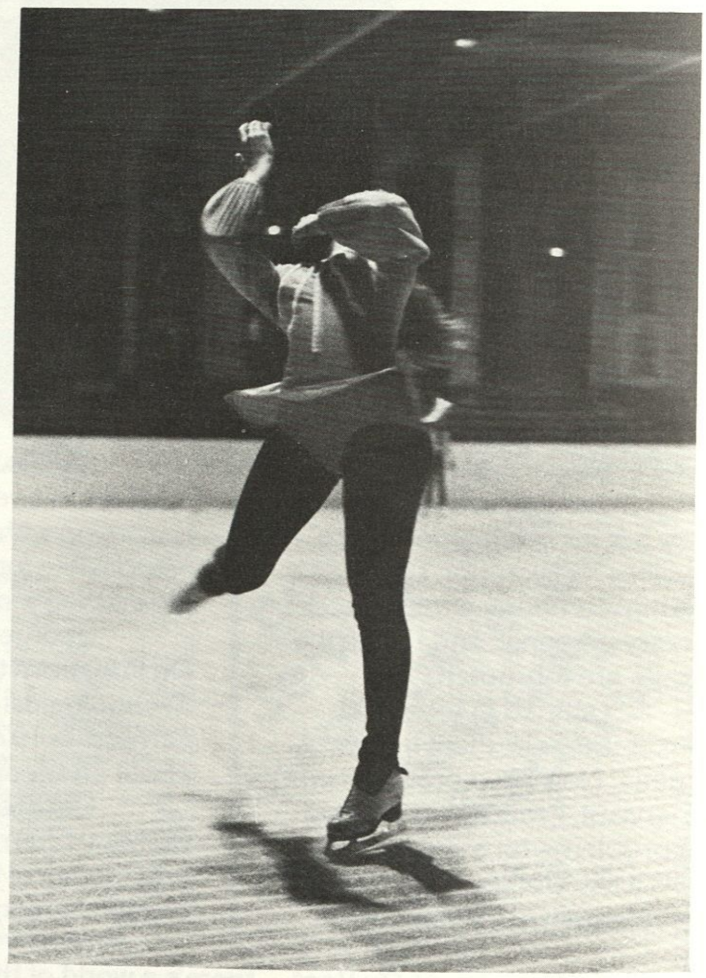
PHOTOGRAPHY

Article and Photos by John Pohle

Film selection is a vital aspect of good photography.

Today one of the basic parts of photography allows more versatility than ever to the photographer. The film you put into your camera allows you to choose between black and white, color, slides, or prints. There are a multitude of film companies who make a wealth of different films. The purpose of this article is to introduce the variety of films available, and the benefits and faults of the different types of films. Black and white film will be discussed more heavily than color because the format of the *Colorado Engineer* is black and white.

The film you put into your camera now is useful because of a unique characteristic of silver. When chemically combined with a halogen such as chlorine, bromine, or iodine, silver halide crystals are formed. When exposed to light these crystals are altered. Upon development the unexposed silver halide is washed off leaving areas



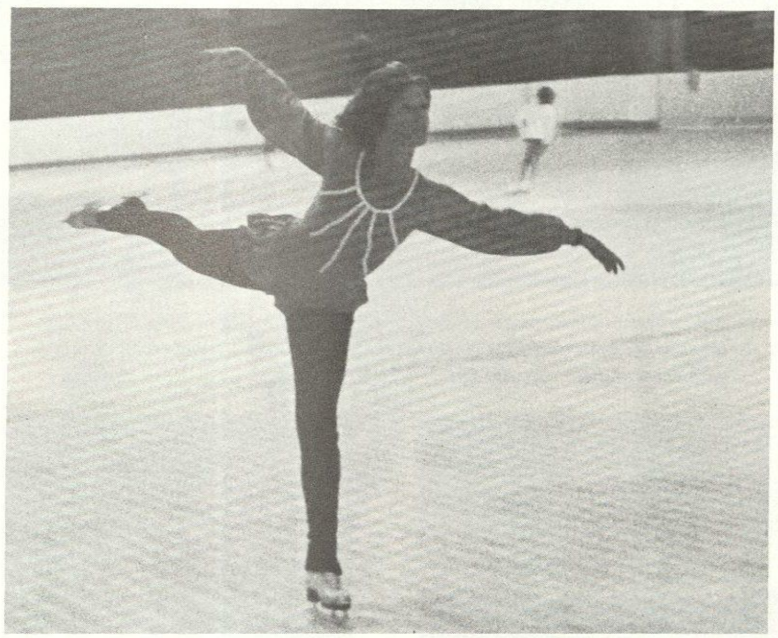
The low light level of an indoor ice arena and the fast motion of the ice skater necessitated the use of fast film, Kodak recording film pushed to ASA 4000.

of darkness and lightness corresponding to the amount of silver halide exposed. It is possible to use gold or platinum but this is economically unfeasible. Because light causes thicker deposits of silver, the image is recorded in reverse, creating a negative. The silver halide crystals are imbedded in gelatin, and the result is an emulsion. The emulsion is coated on a clear strip of plastic along with other coatings to keep the film from curling.

Various dyes and manufacturing techniques can be used to create color negatives and color slides with a wide selecton of film speeds (ASA).

Color negative film, from which prints are normally made, is available from ASA 25 up to ASA 400 and also in an infrared film which renders colors differently than we normally see. With infrared film green grass and trees become red, the sky remains blue and red roses turn yellow. This film is good for surrealistic effects and also has some applications in aerial photography and medical photography. Color positive film for slides is available in ASA ranging from 25 to 400 and can be developed in various ways to increase the speed even more. Of the two types of film available, slides are cheaper, but they are difficult to view without a projector. Prints can be viewed anytime and with more convenience. However, prints cost twice as much, if not more. Prints can be made from slides by most every store that develops film. There is also professional film available in variety of film speeds with a choice of slides or prints. A disadvantage of professional films is the necessity for immediate use after it is made. Therefore, it must be refrigerated to prevent aging, which causes color shifts and a loss of brightness of the colors. Normal film is made so that it reaches its peak after it has aged for a while. So if you wish to store your film for a long period of time, it should be refrigerated.

Black and white film is cheaper to work with, and the film is easier to develop. It can be very forgiving if it is over or underexposed by an *f* stop. It is readily available in speeds as low as ASA 32 and as high as ASA 4000. A variety of speeds are obtainable by developing the film in various ways along with the speeds available as specified by the manufacturer. I will discuss KODAK made films because they are readily available and well known by most photographic stores. A low speed film, like Kodak's Panatomic-X which has an ASA of 32, is a very low grain film. Grain refers to the clusters of silver halide crystals which are caused by their irregular distribution and creates a sand-like appearance on the film. Because it is a low grain film it is good for making large prints or for shooting very detailed objects. Its low film speed has its drawbacks since it can be used only where the lighting is bright. Pan-X is great for outdoor shots and where very little grain is a prerequisite. A large depth of field is difficult to achieve because it is necessary to stop down the camera therefore the shutter speed must be so low a tripod is needed and moving objects become difficult to photograph. The faster film speeds available



This picture was taken of our resident figure skater with Kodak's recording film 2475 pushed to 4000 ASA. It was taken at a speed of 125 at f2.8 in a poorly lit ice arena. The grain is apparent in the gray tones.

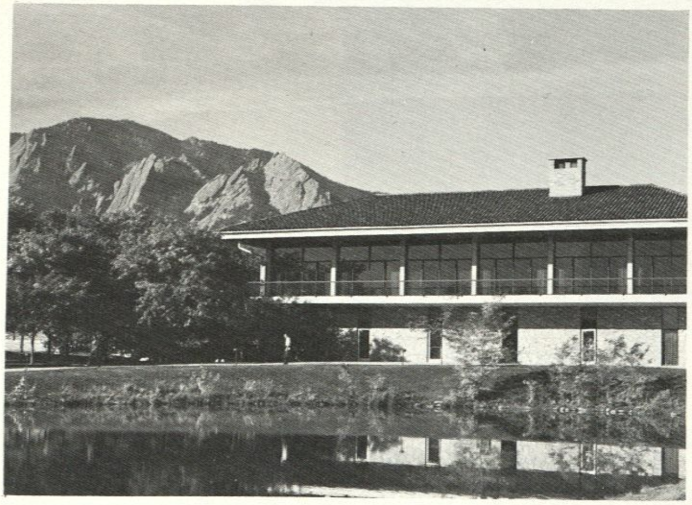
trade-off more grain for more speed. Plus-X, ASA 125, has a little more grain but the increase in speed normally more than balances the increase in grain. Even faster is Tri-X, ASA 400, which is ideal for shooting indoor sporting events where the increase in grain is less important than the increase in shutter speed.

Another film of interest is Kodak's Recording Film 2475, which is intended for use at speed of ASA 1000 but it can be "pushed", (developed differently), up to ASA 4000. It has considerable grain and there is a loss of shadow detail but this allows for some very unique effects in very low light levels. It also is used for surveillance photography.

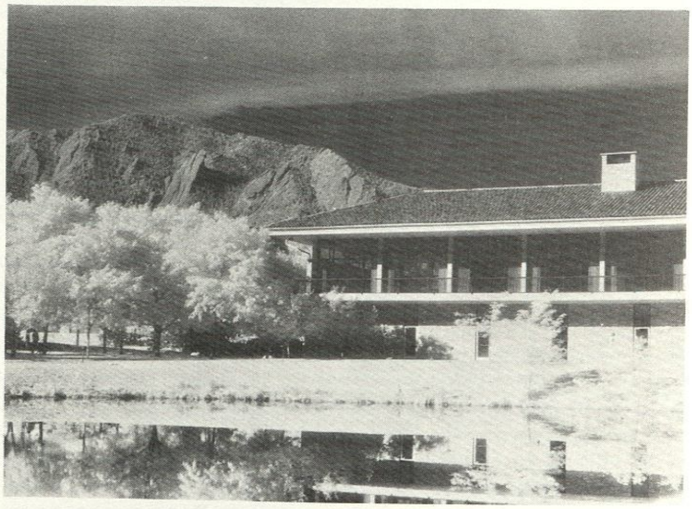
A unique film is Kodak's High Speed Infrared Film, which can be used for distant haze penetration, special effects, and also has applications in medical and biological fields. A No. 25 filter is recommended to absorb the blue light to which the film is sensitive. The recommended speed with a No. 25 filter is ASA 50. A focusing correction is needed; otherwise when it appears focused the film will not be. Some cameras have an auxiliary focus mark just for that purpose. Focus as you normally would; read off the distance from the barrel of the lens and set that distance on the auxiliary mark. This film creates unusual photographs of landscapes and architectural objects. The sky appears almost black and the shadows are darker than usual. Live grass and plants appear very light and objects obscured by haze become visible. A flash with the correct filter can be used to photograph people in the dark without their knowledge. Unlike most film, infrared film must be loaded into your camera in the dark.

All of the films I have mentioned are available in 135 film size and most are also available in a variety of other sizes: 110, 120, and 126. The idea with film is to remember what situation you are going to shoot and what your objective is. Speed for grain is the trade-off and your priorities will decide which is best.

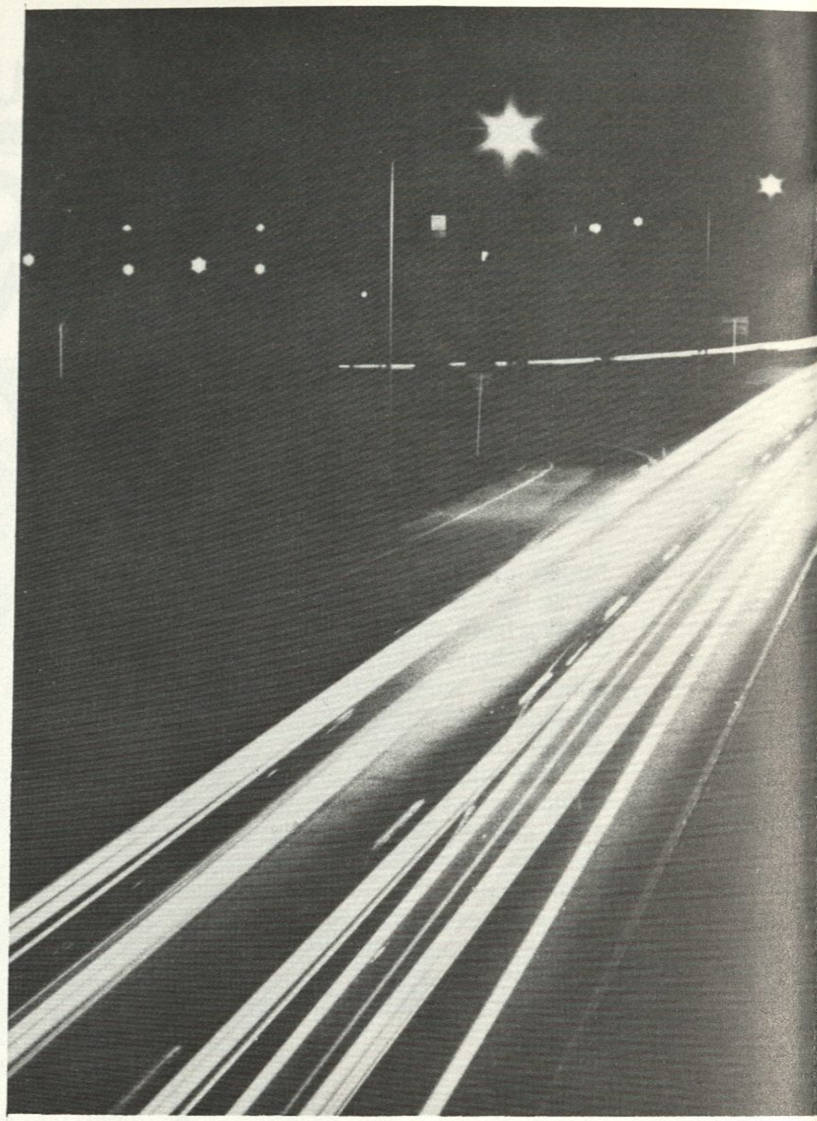
This infrared photograph of the south side of the Engineering center was taken in the early morning. Note that the trees and grass appear to be covered with snow though they are not.



This picture of the Kittredge Commons was taken in the early morning, using Plus-X film (ASA 125). In the sky, there is a barely-visible line of clouds, and the reflection of the trees (lower right) on the water is not visible.



An identical scene to the one on the left was taken with High Speed Infrared Film, with a #25 red filter. The reflection of the trees is now obvious, and the green plant life appears to be covered with snow, while shadows appear almost black.



Reflections on Asphalt

Architectural Engineers strive to take the glare out of nighttime driving.

By Nichol Poliac

Road lighting is essential for it increases the level of visual sensitivity. The type of lights (or luminance) depends upon the reflective properties of pavement. Light hitting the pavement at different angles reflects different quantities towards a driver. This reflectance must be known before designing a proper lighting system to ensure quality. Measurements in laboratories have been made of reflectivity of different pavement surfaces and the formation of a classification system has been proposed. But there is some difficulty in quickly relating these lab samples with existing conditions for certain pavement surfaces.

Safe movement on roadways at night relies on the visibility of the road and other objects. Professor Ronald N. Helms is the principal investigator and project director of a ¼ million dollar research program to quantify the most complex variable associated with this, namely, pavement surfaces. Working with Professor Helms are Professor Hon-Yim Ko, determining the pavement characteristics (texture, density, finish, grading content and wear); Mr. Robert Faucett, the coprincipal investigator and president of Independent Testing Laboratories (ITL); Mr. Gray Emerson, design of instrumentation; and Kurt Kohler, a graduate student at the University of Colorado.

The objective of these five people is to design a pavement reflectance classification system which will be used by highway lighting designers to improve visibility and safety aspects.

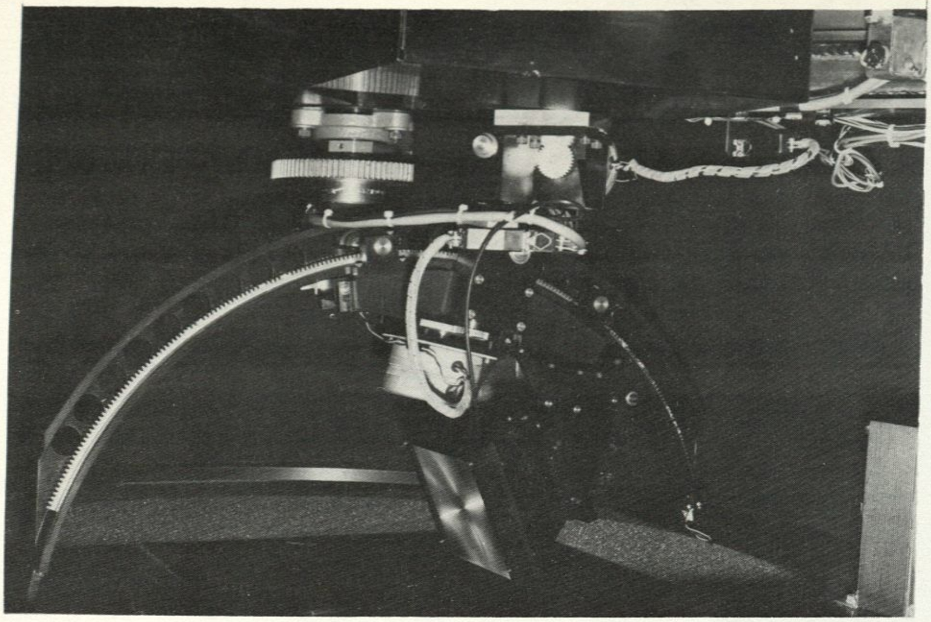
The first and major part of the project is to take measurements to determine hardness, texture and wear of pavement surfaces. There are several factors which affect the reflectance properties: (a) weather, (b) seasons, (c) moisture on the road, and (d) amount of traffic. The research is to do field observations of directional reflectivity characteristics of road surfaces to develop a classification system. After the statistics are compiled for such a system, a light-weight field instrument will be designed and in the second phase of the project. This instrument will be called a field gonio-reflectometer.

The research gonio-reflectometer is composed of a base ring that is anchored to the pavement. There are guide supports for a light projector which moves around the base ring. This projector is programmed to move in an angle of horizontal and vertical deviation. The photometer is attached to the base ring on an adjustable platform to enable it to obtain its various positions for testing. This device fits in a 4' x 4' x 2' container, small and light enough to fit in a stationwagon. Along with this is a data case, connected to the photometer, containing a microprocessor and cassette deck for acquiring the data.

Professor Helm's project has two phases but at the present is in the first phase. In the first phase are ten subphases. The first is a literature search to obtain all past information on pavement reflectivity and classification systems. The second is the testing plan, measuring the reflectance in test sites over a twelve month period in Colorado to evaluate the effects of weather and wear.

There are ten test sites (5 asphalt and 5 concrete) located in various parts of the state. Out of these ten, four are new surfaces while the other six are high traffic volume roads to obtain data from the extreme cases of wear of pavement. The sites are located in Rifle (2), La Junta (2), Fort Morgan area (2), and four in the Denver/Boulder area. The new pavement areas were chosen because it is expected that the most reflectance changes will occur during the early months of the testing time. Four of the ten test sites (2 asphalt and 2 concrete) are relatively new, being open to traffic one year or less.

Core samples from the concrete and asphalt sites will be taken from the road surfaces for a data abasis. Three times during the field measurement period, these samples will be taken. Several tests will be made as to determine a wear versus time scheme based on texture, hardness and porosity of these samples. The texture is determined by the mixture of different mineral substances, den-



A close up of the light projector attached to the hemisphere which moves the light around the base ring.

sity of the mixture, and the roughness. Impact resistance is a measure of the surface hardness.

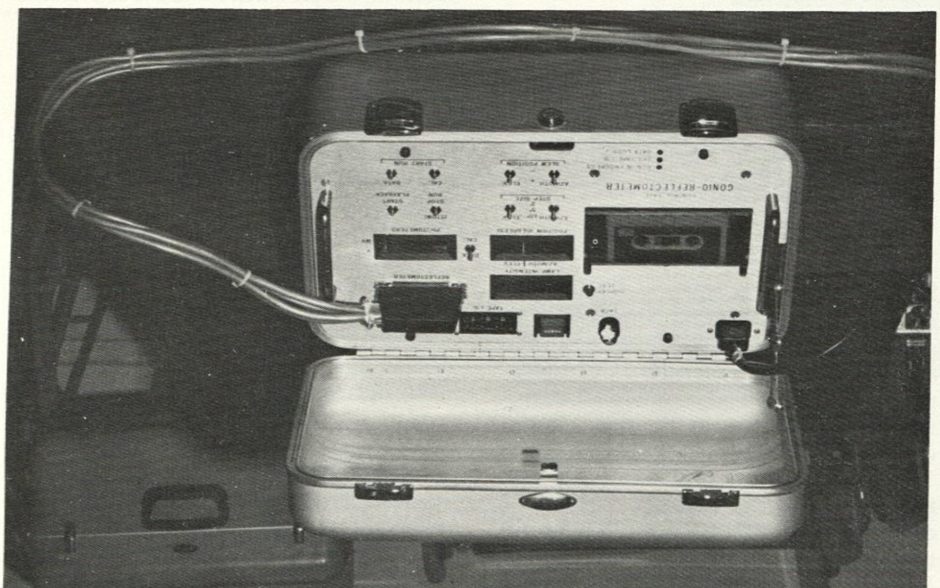
The testing plan is in four parts. First, the project director has scheduled right hand land closing of highway traffic at the test sites with the State Highway Department and the Colorado State Patrol. Following the scheduling the team will close traffic and install base ring anchors, which will take about an hour to install the three or four sets at each test site. After the anchors are in, the testing for reflectance begins by placing the research gonio-reflectometer in its proper position. The instrument enclosure is light tight to ensure correct readings during either day or night testing. After everything is set up, motors in the instrument are activated to move the light projector through the horizontal and vertical angle deviations. This procedure is started by turning on a switch on the data case that causes a microprocessor to turn on the light projector and photometer, and in turn activates the motor. Also traffic counters will be placed at some of the best sites to keep count of the traffic flow related to the pavement wear. Once the sweep is finished at all four areas the gonio-reflectometer is deactivated, packed into a stationwagon and barricades are removed and stored in the transport trailer for use at the next test site. After the testing is completed the data is analyzed and following that is the development of a classification system based on the data analysis.

Each sample has its texture, density, composition, porosity and mass evaluated. Also, the changes of these are recorded during the testing period of one year. These changes are compared to the changes in the pavement reflectance.

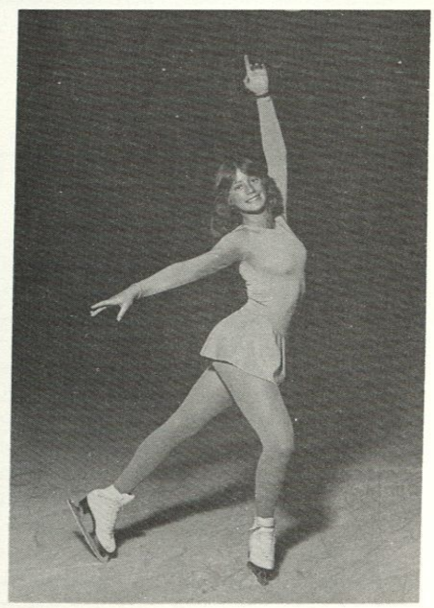
Phase two consists of the composition of a manual to assist a design engineer in properly choosing and designing fixed lighting systems for highways. A manual will be developed to aid the engineering in designing lighting systems using the directional light reflecting properties. The project calls for two formal briefings in Washington, D.C. on the project's progress. The final phase involves the construction of the field gonio-reflectometer to be used by the state highway departments, not just for the Colorado region.

So, if you see a van with an orange trailer attached parked in the middle of a road with, ample warning of course, you can fairly safely guess that it is Professor Helms and his trusty black box.

The data case containing the microprocessor and cassette deck.

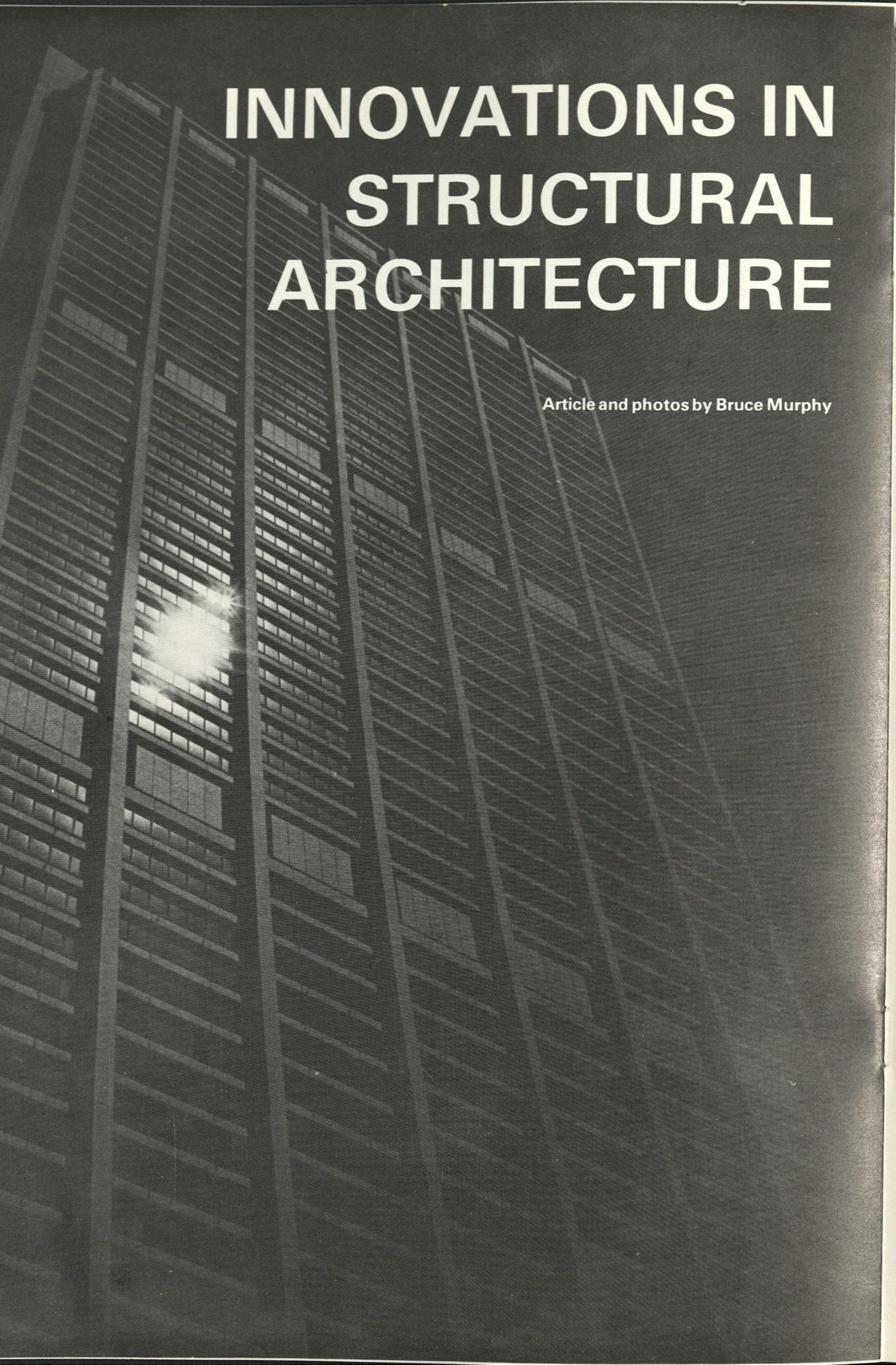


Nichol has managed to make it to her sophomore year in Electrical Engineering and Computer Science. She divides her time between ice skating, class, the Colorado Engineer, *and "other" outside activities.*



INNOVATIONS IN STRUCTURAL ARCHITECTURE

Article and photos by Bruce Murphy



The Chicago School of Architecture revolutionized the theory and construction methods in America. William Jenney, Louis Sullivan, Dankmar Adler, Daniel Burnham, John Root, and others converged upon Chicago after the Great Fire in 1871. Sharing a common challenge of rebuilding the city, they also pursued a new doctrine of architectural theory.

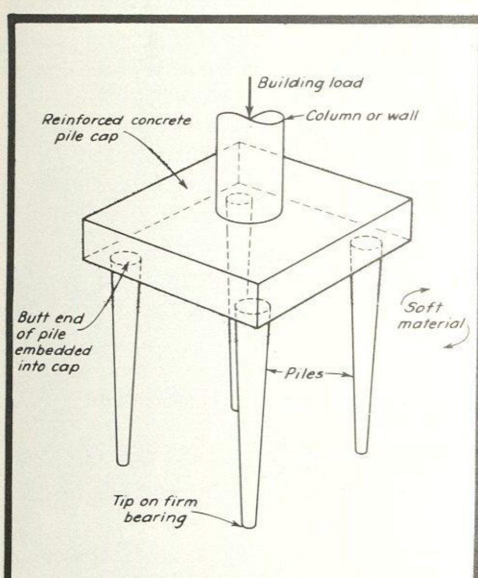
However, a rift developed between these architects. On one side were those who favored the neo-classical architecture brought from Europe; the other side favored an original American architectural style that represented a break from Gothic or Romanesque architecture.

" . . . The Chicago School of Architecture was instrumental in creating a new wave of modern design. . . "

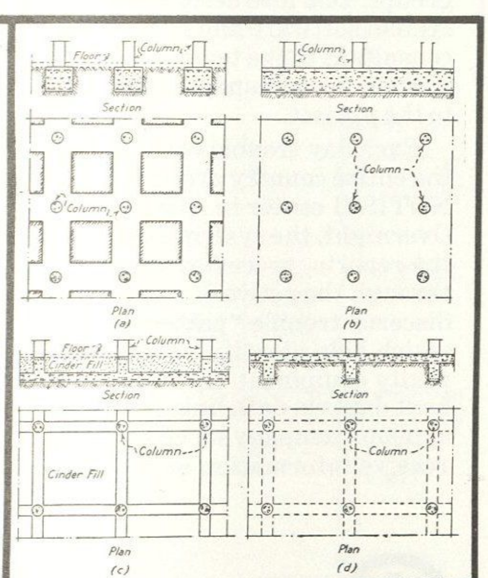
The Chicago School's concern for a new architecture rested upon ideological concepts that included 1) the most simplistic and natural approach to building, and 2) a consideration of the socio-democratic dependence of an American architectural form. The school's spirit was bounded by the need to be original as well as developing the most simplistic and self-evident solutions. It sought reality in creating a natural style in a city without strong neo-classic elements. By exploring the natural element, members of the Chicago School examined the building itself. They felt that the building had a "soul" which must be understood. If not, the meaning of the building itself would be lost. From this the architects realized that they could develop a "character" or "personality" for their buildings through the use of building materials and exterior design. But while each architect explored his individual philosophy, the city of Chicago could not wait.

The Fire had destroyed most of the buildings, but it had not destroyed the people of the city. In fact, after the fire the population began to increase so rapidly that the architects couldn't keep up with the demand for new structures. Between 1880 and 1890, the population increased 100%, from 500,000 to 1,000,000. Coupled with the growth was the problem of finding enough space to erect these new structures for both businesses and residents. The price of land had increased so astronomically that the architects were forced to design a building that minimized the amount of space it was erected on as well as accommodating a large number of offices. What made the problem even more difficult was the soil conditions. The sand and clay mixtures would not support tall structures. The maximum height permitted could not exceed 5 floors without complications arising. If the Chicago architects were to build a tall building, they were going to have to create a foundation that could support the weight of the building without causing unnecessary settling in the foundation. The next problem to be solved was to design a structure that could carry both the dead and live loads of the building. Under present building practices, the architect would have to have very thick bases and then continue the thickness throughout the upper floors in order to attain structural support. Compounded with that was the necessity for light to enter the building. If the window was any larger than what was essential, it would seriously weaken the exterior walls and they in turn would not be able to support the upper floors. In addition, the advances made in electricity and telephone communications caused more problems. The architect had to make provisions to include these new systems in his building.

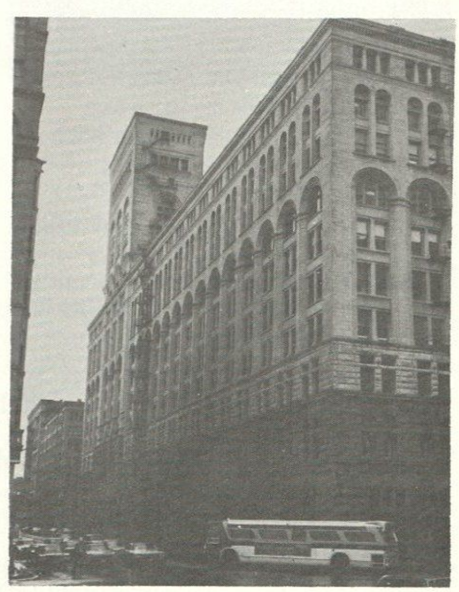
The first and primary consideration lay in creating a foundation that the building could safely rest upon. In the 1880's there were two forms that the architects used that had limited use in construction of large buildings: the timber pile (driven by a pile driver into the hardpan clay) and the stepped foundation (which resembled a pyramid). Daniel Burnham and John Root conceived and developed a third foundation, the floating foundation or raft. Basically it was built over the soil with a bed of poured concrete reinforced with iron or steel rails that crisscrossed the concrete. The next step was to imbed this in another layer of concrete. The resulting foundation was then able to transmit the applied loads evenly over the soil without causing any form of differential settlement. The floating foundation received



Isolated pile foundation.



Floating or raft foundation.



The Auditorium. Adler & Sullivan. 1887–89.

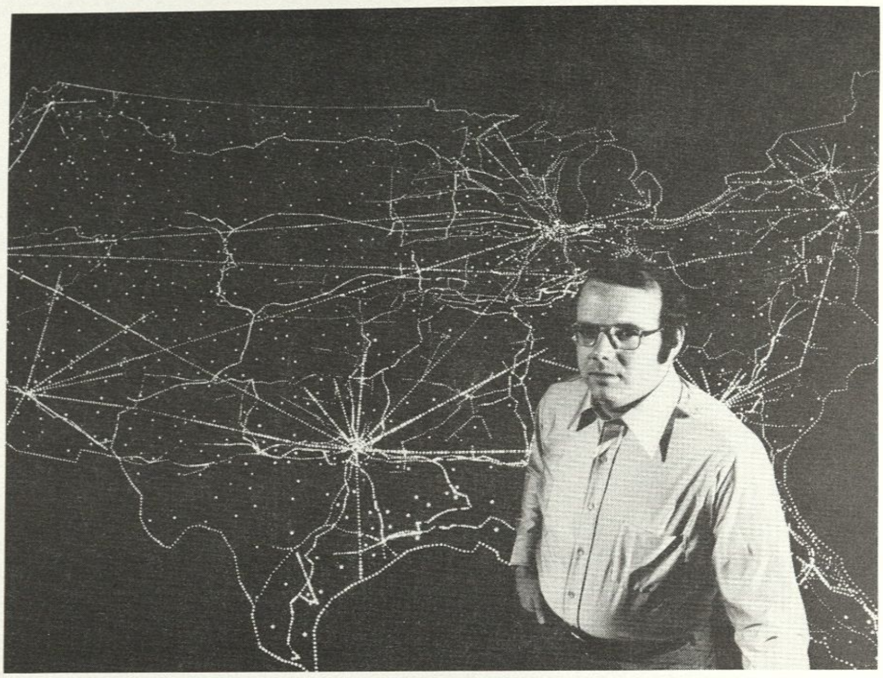
Don Hartman found a "model" way to troubleshoot the network.

The nationwide telecommunications network carries over 515 million phone calls on an average business day. Only a small number of them run into trouble, such as failing to go through the network, getting noise on the line, or being disconnected prematurely. Craftspeople in Bell telephone companies fix most of these problems quickly. But the causes of some can be difficult to find among one-billion-plus miles of circuits and thousands of switching offices.

For several years the Bell System used its computerized Network Operations Trouble Information System (NOTIS) to try to pinpoint those causes by analyzing trouble reports from all over the country. NOTIS was good. But Bell System managers wanted it to be better, more precise in identifying possible trouble spots. And they wanted the data in compact, easy-to-use form.

We assigned a new employee, Don Hartman, to improve NOTIS. Don came to us with a B.S. from the University of Texas and an M.S. and Ph.D. from Massachusetts Institute of Technology. He and his associates developed a second-generation system (NOTIS II) that does the job superbly.

For the new system, Don developed a mathematical model of the telecommunications network, including 28,000 local and



long-distance switching offices and nearly a half-million circuit groups. Don also designed the system software and served as a consultant to the team of Bell System programmers assigned to the project.

Each day trouble reports from the entire country are sent to the NOTIS II center in Atlanta. Overnight, the system analyzes the reports, processes them through the network model, and discerns trouble "patterns" which help identify potentially faulty equipment. By 8 a.m. the next day, via data links, analysts at phone company service centers receive information on troubles traceable to circuits or switching equipment in their territories. Result: Better equipment maintenance. And better service.

With NOTIS II up and running, Don has moved on to other projects. Today he's a supervisor with broad responsibilities for planning the telecommunications network of the future.

If you are interested in exploring equally challenging employment opportunities at Bell Labs, write to:

Director of Technical Employment
Center 831 EM
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Bell Laboratories

From Science: Service

wide acclaim from the other architects in Chicago due to its practical applications when building over poor bearing-capacity soil. This foundation was first used by Burnham and Root with the Montauk Building in 1882. While the building had load-bearing walls, the foundation distributed the loads evenly over the soil. Louis Sullivan and Dankmar Adler used the raft foundation in the construction of the Auditorium, (1886–89). The floating foundation was used extensively until 1893 when Dankmar Adler introduced a new foundation for the Stock Exchange Building.

Pressed by the need to develop a solid foundation next to a newspaper building, Dankmar Adler had to forego the use of a timber pile in favor of an early version of the caisson. Had timber piles been used, the driving action of the pile driver would have disrupted or damaged the printing presses in the adjacent building. The use of the caisson, a cylindrical hole drilled to supporting bedrock or soil and then filled with reinforced concrete, eliminated any settling. The Chicago architects, having solved the foundation problems, were then able to concentrate their efforts on building tall buildings.

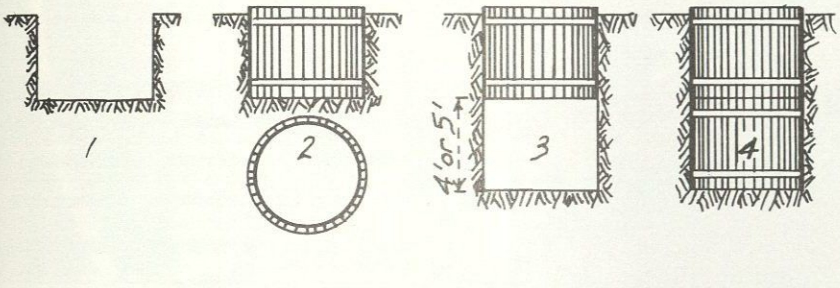
By 1885, Elevator buildings (6-10 floors) had come into style. The major problem surrounding these buildings was their weight. In order to reduce the weight of the building, the architects had to find a way to reduce the size of the load-bearing walls. These walls supported the masonry and the framing members of the structure. Turning to a French theorist, Viollet Le-Duc, Louis Sullivan adapted the theory of the metal cage.

In 1881, Viollet Le-Duc proposed a system by which a skeletal construction would be built for a vaulted enclosure with the structural members made of iron. Though he had only proven this mathematically, William Jenney, Louis Sullivan, and Dankmar Adler all struggled to find the building solution. It was William Jenney who reached the conclusion first.

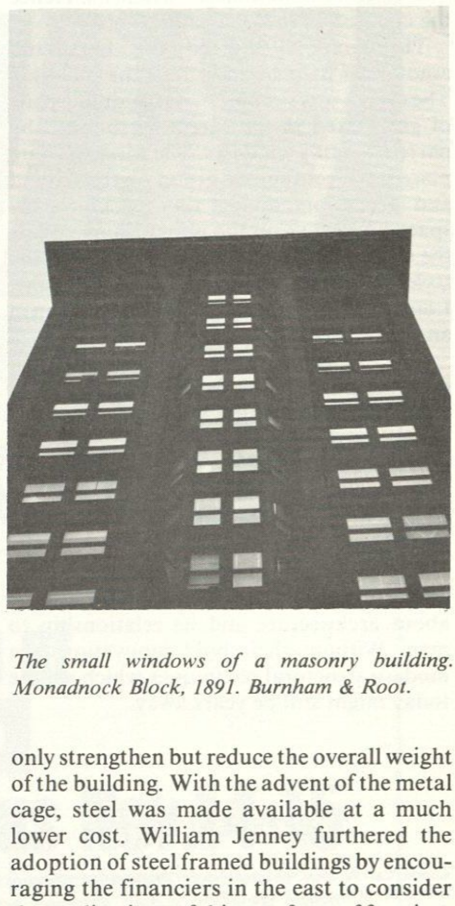
While he had already built a skeletal framed building made of timber in 1879, William Jenney was still a long way from building a steel or iron framed building. The Home Insurance Building (1884) was the first complete steel framed building. He used a series of columns, girders, and piers to not only strengthen but reduce the overall weight of the building. With the advent of the metal cage, steel was made available at a much lower cost. William Jenney furthered the adoption of steel framed buildings by encouraging the financiers in the east to consider the applications of this new form of framing. His encouragement helped lead to the formation of the United States Steel Corporation. Since the idea was conceived in Chicago, the steel skeleton was appropriately termed the "Chicago construction".

The advantages that the steel frame produced were enormous:

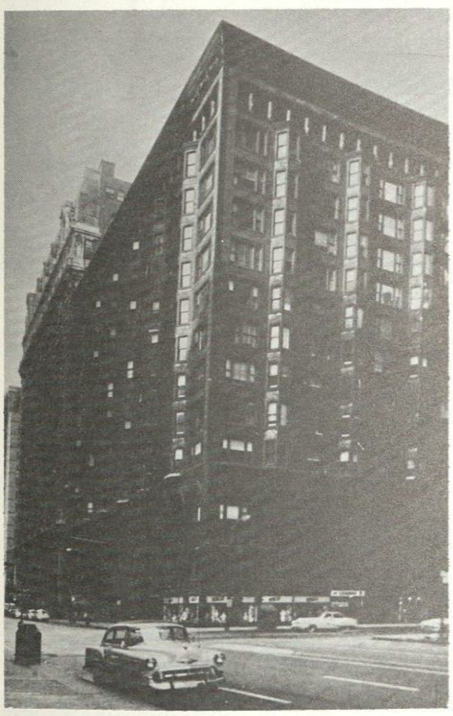
1) the steel frame removed the need for supporting exterior walls while reduc-



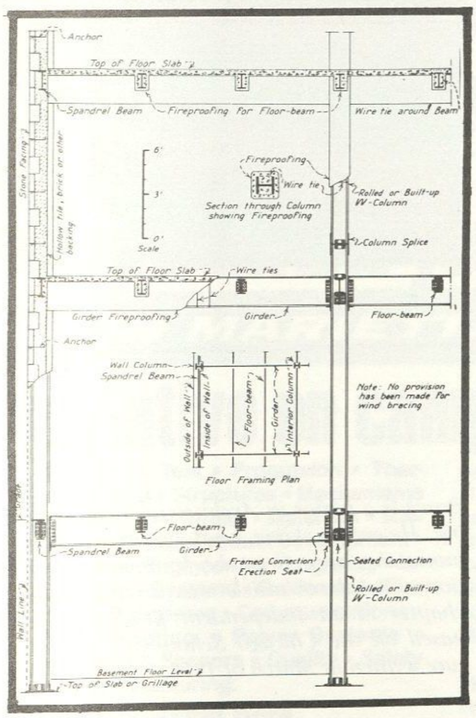
Caisson method for open wells.



The small windows of a masonry building. Monadnock Block, 1891. Burnham & Root.



The Stock Exchange. Adler & Sullivan. 1893–94.



Steel framing.

ing the weight of the building by 1/3 and increasing the height to whatever limit was necessary.

2) The amount of glass that could be put into the structure was increased by 100%.
3) The reduction in the size of the columns, and the new wide window bays, greatly increased the freedom of the interior partitions.
4) The economy of cost of the materials, and the speed by which the building was erected convinced the skeptics that the steel and iron method was of superior quality.

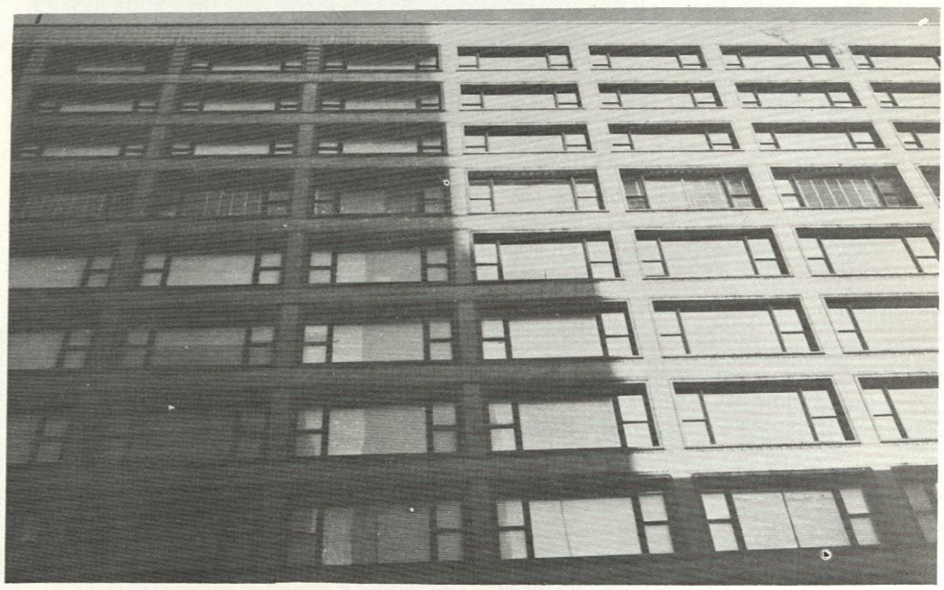
With the creation of the Elevator buildings, the architects had been faced with the need of getting more natural light and ventilation into the building. With the steel framed building, the Chicago architects now had room to install larger windows. Hence the creation of the "Chicago window."

The window allowed the maximum amount of light to enter into the building. The design was simple — a large simple pane of glass fixed in the center surrounded by narrow venting windows. The windows were placed in a continuous group on the ground and 1st floors giving way to uniformly spaced windows on the upper floors. While the exterior differed with each building, the style and groupings remained the same. Louis Sullivan broadened this application in an interesting way.

Sullivan had created a horizontal structure, the Carson Pirie Scott building (1899–1906). In order to stay within the aesthetic guidelines of the window format, he had to develop a horizontal "Chicago window." The result captured both the horizontal statement of the building and created a pleasing visual aspect.

The Chicago School at the turn of the century presented new ways of thinking about architecture and its relationship to man. Without their bold innovations the modern structural techniques which we use today might still be years away.

Carson Pirie Scott main entrance. 1899, 1903–04, 1906. Louis Sullivan.



The "Chicago Window" Carson Pirie Scott Building, west face. 1899, 1903–04, 1906. Louis Sullivan.

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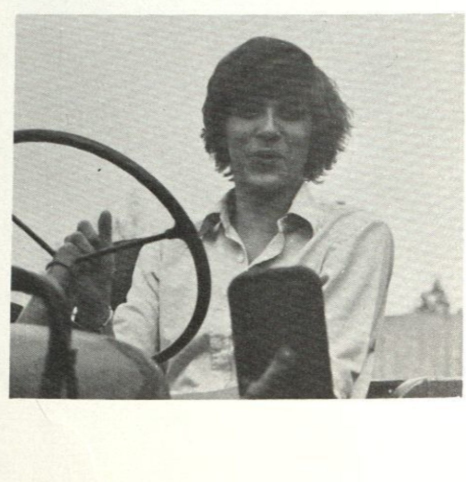
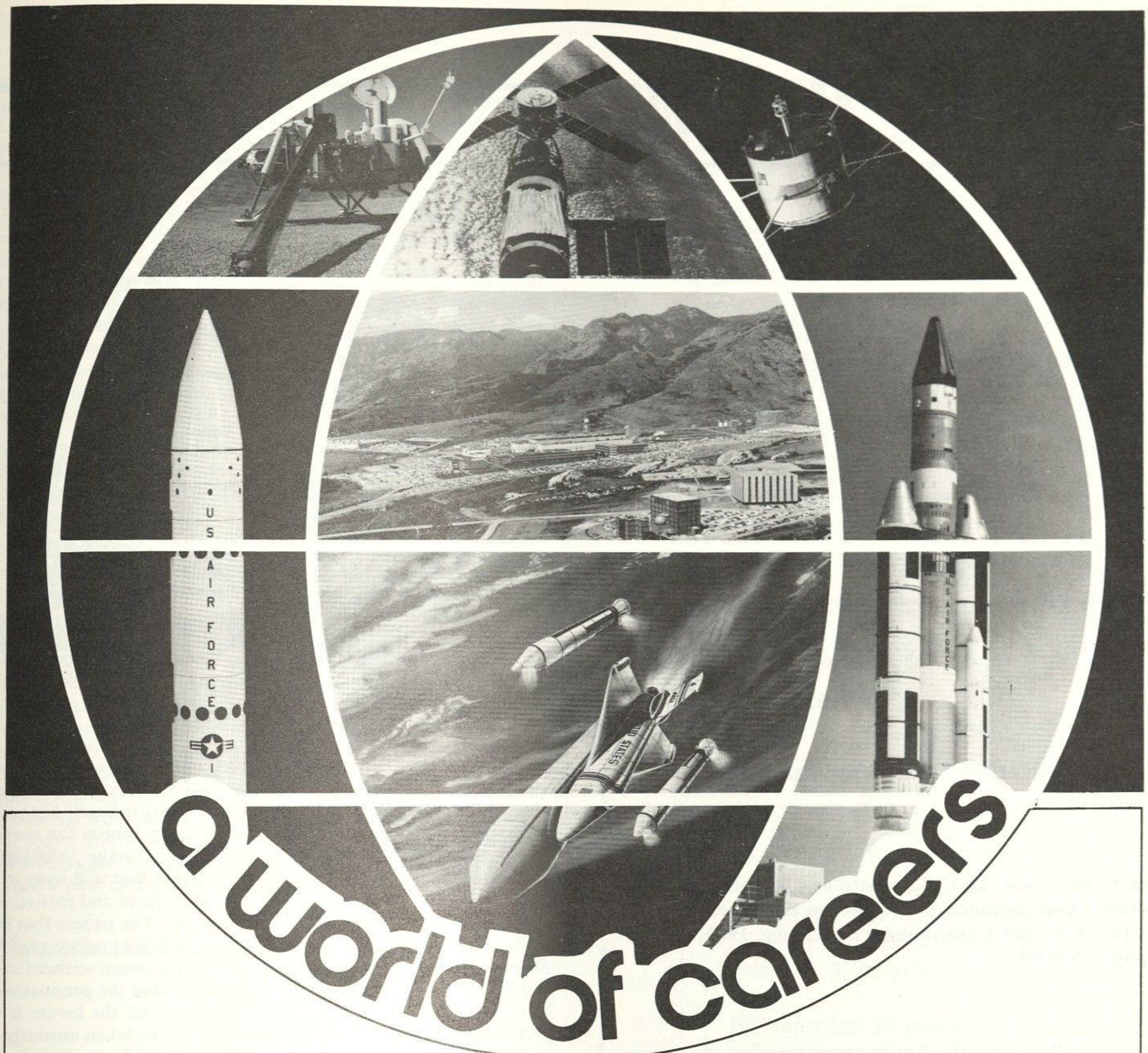
Figures reprinted from Building Construction Materials & Types of Construction, *4th Edition, John Wiley & Sons.*

Bruce is a junior in Architectural Engineering. He enjoys skiing, photography, and the mountains as well as the feminine persuation. The above article was originally one chapter in an Independent Study Project based on the Chicago School of Architecture written in March of 1977.

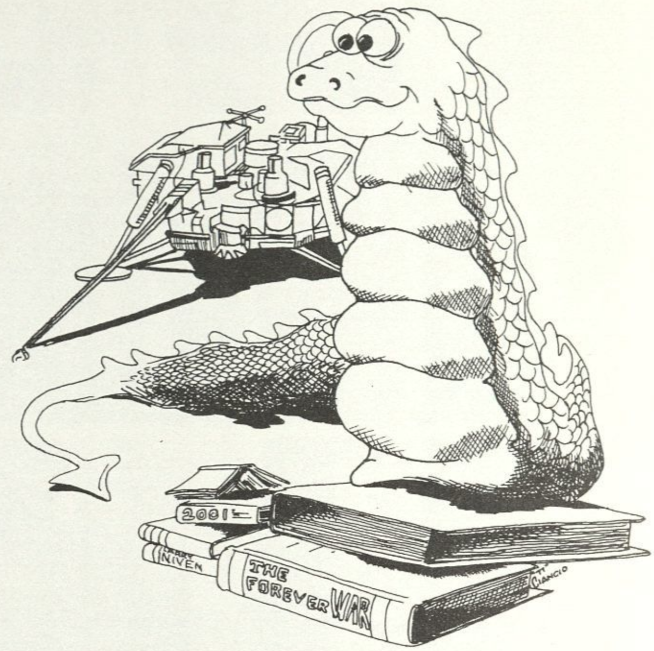



a world of careers

Book Review

AN INTRODUCTION TO APPLIED FUTURISM

by Paul De Arment



Macro-Engineering and the Infrastructure of Tomorrow

Frank P. Davidson, L. J. Giacoletto and Robert Salkeld
Westview Press, Boulder, Colorado, for the American Association for the Advancement of Science, 1979.
256 pages, $20.00

The Great Pyramids, the Apollo space program, the Panama canal, the Eiffel Tower, and the Roman aquaduct system are some of the major technological landmarks of the past. These are engineering achievements of such magnitude that they take on historical importance. The future may hold such milestones as a permanent colony in space, mining operations in the asteroid belt, the development of a major synfuels industry in the U.S., and the transport of icebergs from the Antarctic to the arid Middle East. These are some of the macro-engineering projects currently being discussed, and as engineers, participation in one of these projects may become a part of our careers.

In February of 1978, the American Association for the Advancement of Science (AAAS) conducted a symposium on the subject of macro-engineering, and this book, which is a collection of papers from that meeting, is the first attempt at a comprehensive treatment of the subject. Although macro-engineering itself is ancient, its identification as a subject for study is quite recent. This relative newness may account for the wide scope of the book, and the sometimes confusingly abrupt changes of tone and focus from one essay to another.

There is a polarity established among those who are thinking about macro-engineering that is reflected in the structure of the book. The pragmatists, who are actively engaged in current macro-engineering projects, discuss the organizational structure that manages the construction and financing of a new city in Saudi Arabia, or the hazards inherent in programs with the potential for causing global environmental impacts. These papers make valuable, if somewhat dry, reading. They raise the issues that will have to be resolved before any such proposal can be accepted and carried out. But the stars of the book are the visionaries. The papers that deal with specific proposals for new macro-engineering projects read like the pages of *OMNI,* standing at the frontier between science fiction and fact. But there is the added excitement that the proposals are being put forward by recognized scientists, and the forum is the prestigious AAAS. We know these ideas can be taken seriously.

There are two such proposals presented in detail. The first is Robert Salter's "Planetran", a supersonic subway system. The cars in the Planetran system travel long distances in evacuated tunnels, carried by "electromagnetic fields just as a surfboard rides ocean waves." A superconducting current loop in the car and a traveling electromagnetic wave front in the tunnel provides the motive force. A computerized course correction system is added to provide the fine tuning necessary for successful operation, and a number of hypothetical routes and travel times are computed with given various acceleration allowances. For example, with a continuous acceleration of 1 g (reversed at midpoint), the Planetran would reach a maximum velocity of 14000 mph and provide coast to coast service in 21 minutes. The design opportunities that this plan would provide for electrical and geotechnical engineers are obvious. Perhaps not so obvious is the feasibility of the plan under the scrutiny of a cost-benefit analysis. But if the proposal is compared to the alternatives, such as continued overuse of the automobile or a complete rebuilding of the passenger rail system, the cost may seem less prohibitive.

The second macro-engineering proposal that is put forward in detail here is Peter Glaser's Solar Power Satellites. Actually, as is made clear in the paper, the solar power satellite is a concept on which several groups are currently working, including Boeing and

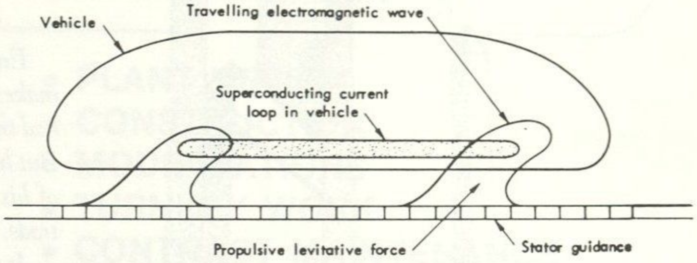
Rockwell International. One version is presented here. Briefly, the system consists of an array of photovoltaic solar cells on the order of sixty square kilometers in area and is constructed in geosynchronous Earth orbit. The electrical output of this grid is transmitted to Earth via a microwave beam at about 2.45 GHz with a transmitting antenna about 1 kilometer in diameter, and with a receiving antenna on Earth about ten kilometers in diameter. At this point the power is converted back again to electricity and fed into a conventional electric power grid.

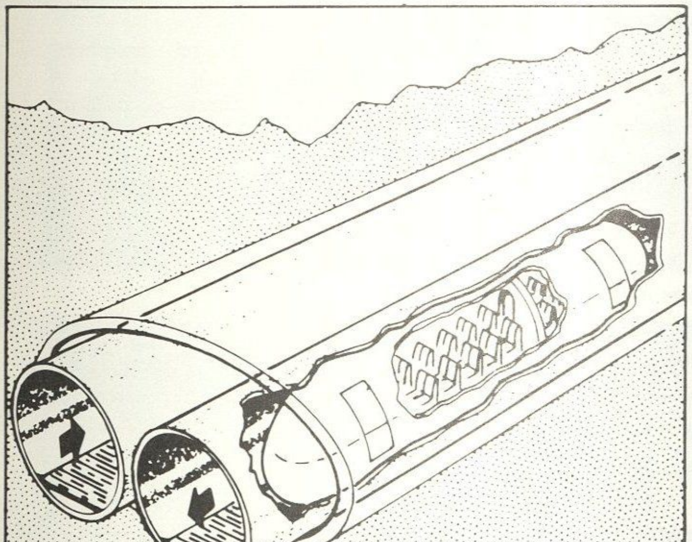
The construction of a system of these satellites would require an infrastructure of its own, including a space shuttle fleet, a permanent space colony for the workers, possibly automated factories in orbit, and even mining on the moon. The initial investment is high, but the potential benefits of a move of heavy industry and power generation technology to space are also high. As Philomena Grodzka argues in a paper proposing a "TVA for Space",

> "... in the distant future, space activities such as energy production and moon mining may even obviate the need for conducting these activities on earth. An environmentalist's and politician's dream come true!"

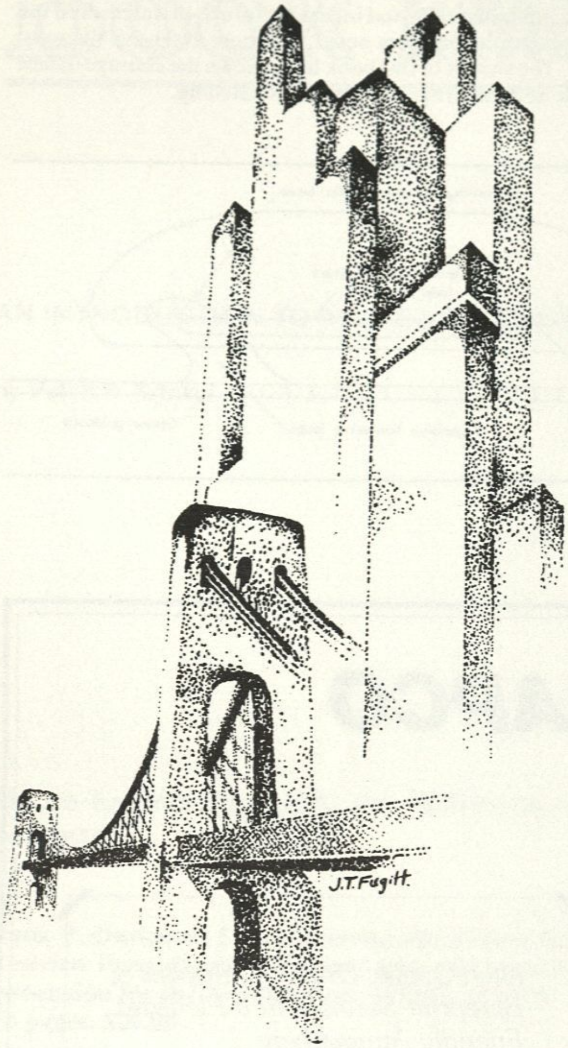
There is material in this book to tickle the imagination of engineers of every stripe. The field of architectural engineering, however, has been short-changed. The one paper on the design of shelter, Peter Land's "United Nations Model Neighborhood in Peru", is inappropriate in this forum, representing as it does merely the conventional architectural wisdom on urban planning. A paper on Paolo Soleri's work on Arcology would have complemented the discussion on human habitation in space with a vision of equal power for Earth: the building of cities in three dimensions and in a single structure. Soleri's prototype cities present a challenging future for the structural engineer as well.

This discussion of macro-engineering comes as a time when the conventional wisdom has it that "small is beautiful" (and therefore big is ugly), and that we ought to turn away from technological optimism toward a conservative survival psychology. The lessons of the recent past speak clearly that technology cannot solve every social ill with which we are faced. But, as this book demonstrates, engineers are fundamentally and incurably future-oriented. And the bigger the scale of the problem posed, the more extensive the solution must be. The writers of this book have shown the courage to face the future on its own terms. Let's hope its catching.





The "Planetran" supersonic subway system.



Engineering . . .

Engineering training deals with the exact sciences. That sort of exactness makes for truth and conscience. It might be good for the world if more men had that sort of mental start in life, even if they did not pursue the profession. But he who would enter these precincts as a life work must have a test taken of his imaginative faculties, for engineering without imagination sinks to a trade.

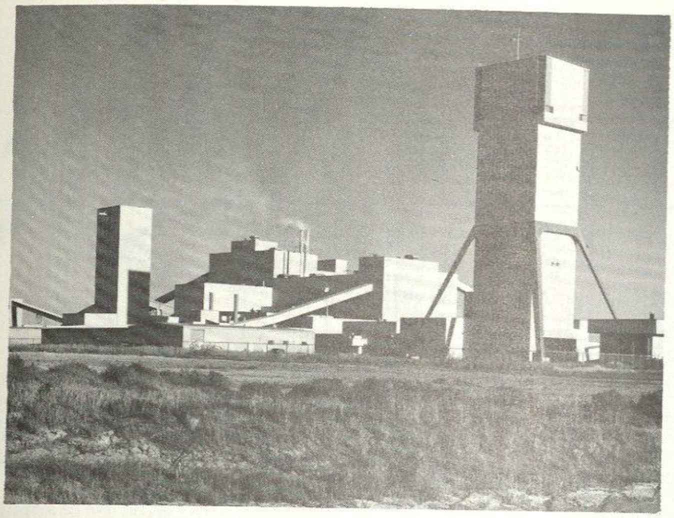
It is a great profession. There is the fascination of watching a figment of imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege.

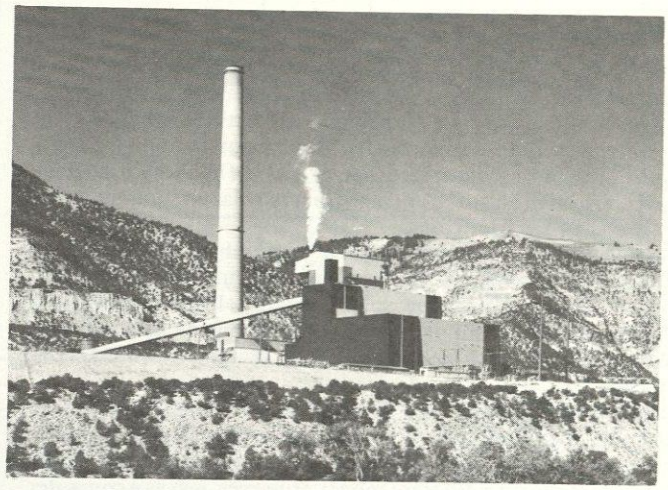
The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like the architect, cover his failures with trees and vines. He cannot, like the politicians, screen his shortcomings by blaming his opponents and hope that the people will forget. The Engineer simply cannot deny that he did it. If his works do not work, he is damned. That is the phantasmagoria that haunts his nights and dogs his days. He comes from the job at the end of the day resolved to calculate it again. He wakes in the night in a cold sweat and puts something on paper that looks silly in the morning. All day he shivers at the thought of the bugs which will inevitably appear to jolt its smooth consummation.

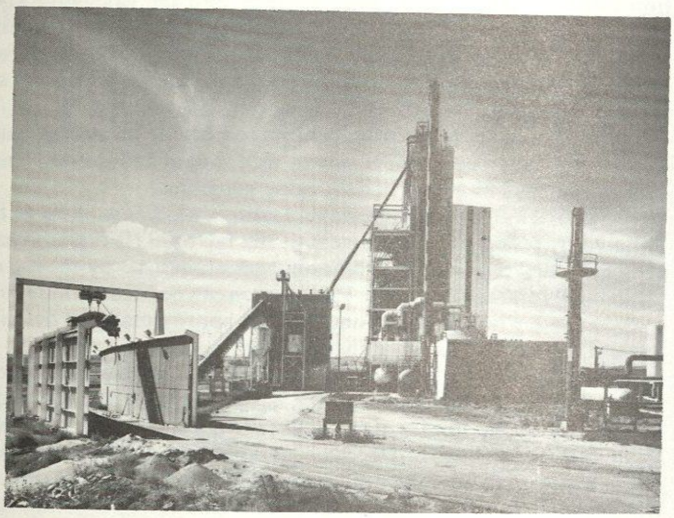
On the other hand, unlike the doctor, his is not a life among the weak. Unlike the soldier, destruction is not his purpose. Unlike the lawyer, quarrels are not his daily bread. To the engineer falls the job of clothing the bare bones of science with life, comfort and hope . . .

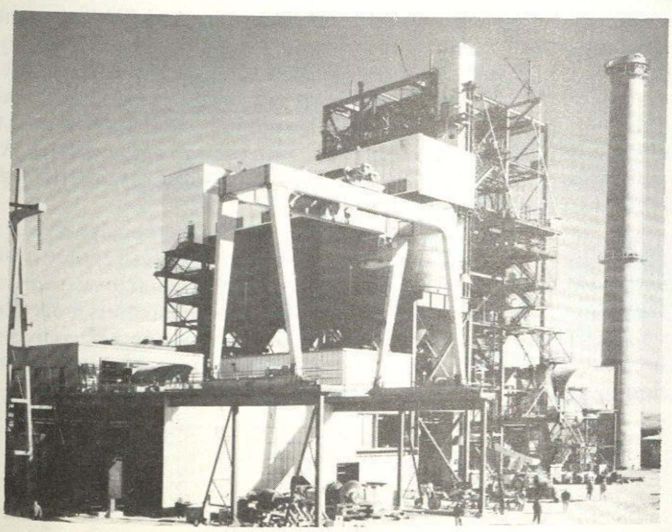
The engineer performs many public functions from which he gets only philosophical satisfactions. Most people do not know it, but he is an economic and social force. Every time he discovers a new application of science, thereby creating a new industry, providing new jobs, adding to the standards of living, he also disturbs everything that is. New laws and regulations have to be made and new sorts of wickedness curbed. . . . But the engineer himself looks back at the unending stream of goodness which flows from his successes with satisfactions that few professions may know.

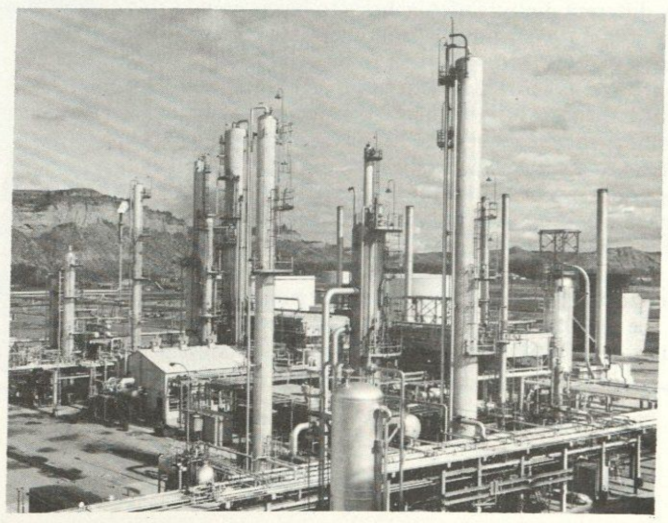
Herbert Hoover, *Memoirs of Herbert Hoover,* Vol. 1, *Years of Adventure,* Macmillan, New York (1951), p. 132.





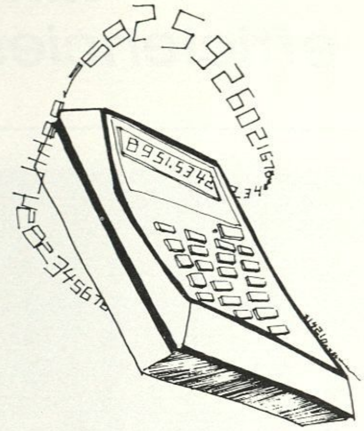






CALCULATOR UPDATE

By Kiyoshi Akima



THE PROGRAMMABLES

Since the introduction of the first personal programmable calculator in January of 1974, many different models have been introduced, each with a different combination of features. Until recently the market has been dominated by two manufacturers, Hewlett-Packard (HP) and Texas Instruments (TI). The American pair, however, are facing a stiff challenge from two Japanese companies, CASIO and Sharp Electronics.

A programmable calculator merely "remembers" a sequence of keystrokes used to solve a problem, and executes them whenever desired, faster than could be done manually. It also reduces the chance for error. By simply changing the input data, a series of similar or repetitive calculations can be done very quickly and effortlessly.

There are several different "languages" used to tell a calculator what to do. Just as a computer program written in BASIC will not execute on a FORTRAN compiler, a program written for one calculator may not run on a different model. However, just as a computer program can be translated into another language, most calculator programs can be converted to run on another calculator of similar capacity.

One common language is Reverse Polish Notation (RPN), so named because of the nearly unpronounceable name of its originator. RPN is an unambiguous, parentheses-free system of notation first described by the Polish mathematician Jan Lukasiewicz for use in sentential logic. This language is used by all HP programmables.

Most other manufacturers use some form of Algebraic. This is similar to the system we struggled with in high school. There are too many different dialects of Algebraic to be covered in this column. Sometimes different models from the same manufacturer will use different dialects, adding further to the confusion.

Sharp has taken a different approach with their EL-5100 and EL-5101. Instead of remembering sequences of keystrokes, these machines will remember formulae as they are written on paper. This may lead to a whole new application for personal calculators.

Programs can be loaded into a calculator in a variety of ways. On all machines programs can be entered from the keyboard. Some machines have a card reader, either built-in or as an add-on accessory. This feature allows the user to record a program on a small magnetic card no larger than a stick of gum, and then read it back into the calculator at any time. Data can also be stored in this fashion. The CASIO machines allow the user to store programs and data on magnetic tape, by using a standard cassette tape recorder.

Many calculators offer non-volatile memory. This feature stores the information (programs and data) in the calculator, even with the power turned off. This allows the user to retain a program in the calculator and use it at any time without having to reenter it each time.

Another feature available on some calculators is the use of application modules. These small modules plug into the calculator and contain a pre-recorded ROM (Read Only Memory), allowing instant access to a number of programs. HP also makes blank modules for their HP-41C, allowing the user to expand the memory capacity of the calculator.

Some calculators have the capability to provide printed output. Printers provide a convenient way to record data and results. They can also be used as an aid in debugging programs.

The new HP-34C has some novel features which are likely to be imitated by others. The usefulness of the factorial (!) function has been extended to negative and noninteger arguments by the use of the gamma function. The SOLVE function can be used to find roots of equations, while another function will approximate the definite integral over a finite interval for any function known explicitly.

HP has also produced the first calculator "system" with their HP-41C. The user can start with the basic calculator and add additional memory modules, a card reader, and a printer as he/she needs them. HP is planning to introduce an optical wand early next year and is expected to introduce more accessories later. TI's new top-of-the-line model to be introduced next year is expected to follow this system philosophy.

Bulky rechargeable batteries and power-hunger LED (light emitting diode) displays are on the way out. Liquid crystal (LC) displays draw very little power, so a set of small disposable batteries can last a year or longer. CASIO and Sharp are firmly committed in this direction. The HP-41C also uses disposable batteries and an LC display. TI has yet to go this route with their programmables. An innovation is Sharp's dot-matrix display, allowing much better legibility than has been possible.

Deciding which calculator, programmable or otherwise, to buy is no easy task. There is a bewildering array of models to choose from, with a wide range of prices. A calculator is still a major investment, so shop carefully. It's generally wise to buy one which offers more than you need now. You don't want to buy a new one next semester because you outgrew the one you have. It's cheaper to buy a good one now and grow into it, rather than stepping up each semester.

The calculator industry is currently at a major turning point. Calculators are getting to be more like computers, while microcomputers are getting to be more like calculators. The next eighteen months promise some great advances. Both CASIO and Sharp are planning to introduce hand-held microcomputers next year. It will be interesting to see what develops.

With the electronic calculator becoming more commonplace and more powerful, the slide rule is following the dinosaur. The term "electronic slide rule" is seldom used now to describe a calculator. Keuffel & Esser, one of the most respected names in engineering equipment, has announced that they will cease manufacturing slide rules at the end of this year.

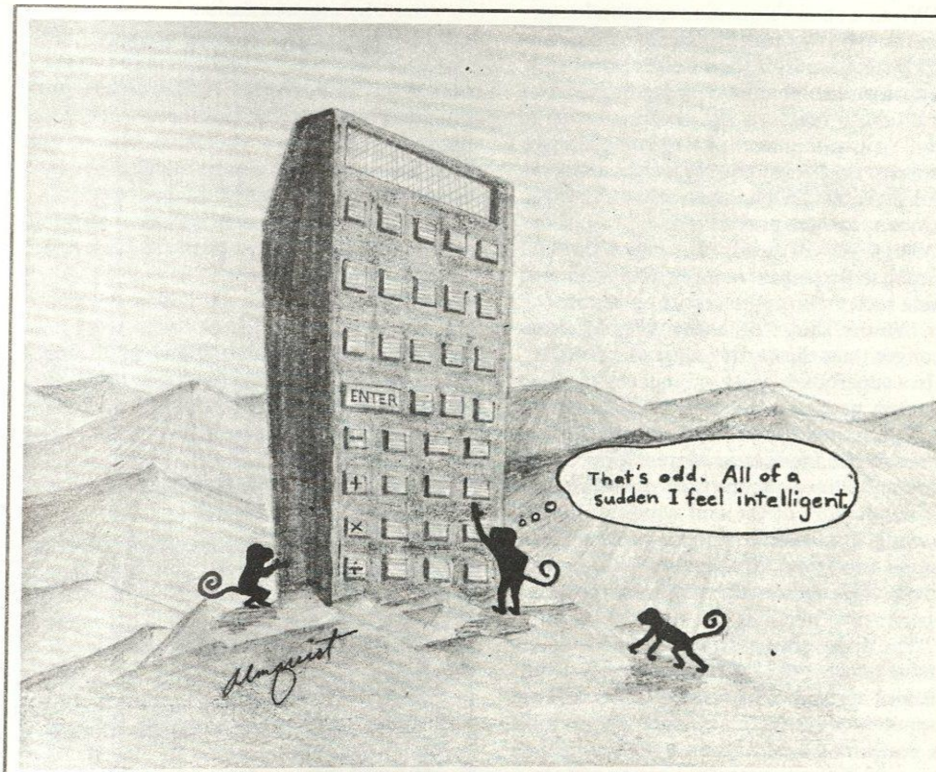
		Suggested Retail Price	Display	Steps at Turn On	Min/Max Steps	Merged Keycodes	Subroutine Levels	Indirect Addressing	Flags	Storage	Printer
CASIO	FX-501P	99.95	LC	128		F	4	★		N,T	
	FX-502P	129.95	LC	256		F	4	★		N,T	
HP	33E/33C	90/120.00	LED	49		F	3			/N	
	34C	150.00	LED	70	70/210	F	6	★	4	N	
	38E/38C	120/150.00	LED	8	8/99	F				/N	
	41C	295.00	LC		0/2233	P	4	★	56	N,C,M	Opt
	67	375.00	LED	224		F	3	★	4	C	
	97	750.00	LED	224		F	3	★	4	C	★
Sharp	PC-1201	89.95	F	128		F	1			N	
	EL-5100	99.95	D	80						N	
	EL-5101	79.95	D	48						N	
TI	57	60.00	LED	50		F	2				
	58C	125.00	LED	240	0/480	P	6	★	10	M,N	Opt
	59	300.00	LED	480	160/960	P	6	★	10	C,M	Opt
	MBA	70.00	LED	32							

NOTES

N - Non-Volatile
T - Magnetic Tapes
C - Magnetic Cards
M - Memory Modules

LC - Liquid Crystal
LED - Light-Emitting Diode
F - Florescent
D - Dot Matrix

F - Fully Merged
P - Partially Merged



News News

ATTRACTIVE INVENTION

PITTSBURGH — Westinghouse Electric Corporation has received a $6.5 million contract for the design, construction and testing of one of the world's largest superconducting electromagnets of the U.S. fusion energy program.

One of six such magnets being built for Department of Energy's Oak Ridge National Laboratory, the 32-ton, 18-foot-tall Westinghouse magnet coil is unique in its use of superconductors made of an alloy of the metals niobium and tin. Two similar units also being built under DOE funding by other U.S. firms and three being supplied under an International Energy Agency agreement from overseas will use niobium-titanium superconducting alloys.

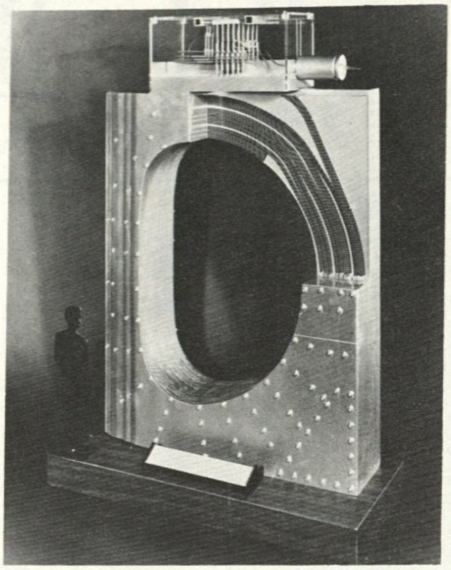
Only these special magnets can produce the highly concentrated magnetic fields needed to make fusion power reactors work — fields with peak strengths of eight tesla and higher.

"We chose a niobium-tin superconductor, even though it's a more difficult material to work with, because it shows more promise of producing the higher field strengths that full-sized fusion reactors will require," said J. Lynn Young, manager of large magnet programs for the Westinghouse technical operations division. "We hope to prove its practicality on this test project.

"Our coil will produce a magnetic field more than five times stronger than produced inside today's largest electrical generators," Mr. Young said, "or about 150,000 times stronger than the earth's magnetic field."

In a superconducting magnet coil the high currents needed to generate these intense magnetic fields are made possible by the lack of resistance to electric current flow at the extremely low temperatures maintained in the conductors of the coil winding. By circulating liquid helium through them, Mr. Young explained, temperatures are held at about -452 degrees F, very near absolute zero.

"The three miles of superconductor in our coil will circulate 17,600 amperes of current without resistance" he said. "If these were copper conductors this current would result in resistance losses that would consume about 30,000 kilowatts."



KEGGERS MADE EASY

MILWAUKEE, WIS. — Bartenders and other keg tappers alike have been wondering for nearly 200 years when someone would invent a method of emptying the last few ounces from a half-barrel of draft beer.

Consumers have been just as frustrated when they could not get all of the beer out of a keg at a picnic or party.

The Miller Brewing Company has come up with the answer in the form of its new Tap-O-Matic System, which virtually empties each 15.5 gallon keg (half barrel) of draft beer.

This innovative system from Miller allows for more efficient handling, cleaning and filling of beer kegs. The Tap-O-Matic system also makes tapping as easy as 1-2-3.

The system involves use of a new and safer Tap-O-Matic tavern head that couples into the keg and is a major improvement from many systems now in use, which can leave as much as 40 ounces of beer in the bottom of the keg.

When the Tap-O-Matic tavern head handle is depressed, the permanent stainless steel spear allows the removal of nearly every ounce of draft beer. It turns on the beer and carbon dioxide in the same movement making the system perfect for series tapping.

The new kegs have straight sides and two hand holes at the top to permit easier handling. They have one opening located in the top center, for more convenient tapping and untapping operations.

Miller began promoting this new tapping system in April with full-page advertisements in trade journals and industry magazines.

The Miller Brewing Company is an operating company of Philip Morris Incorporated. Principal beer brands include Miller High Life, Lite and Lowenbrau.

MONEY

WASHINGTON, D.C. — The National Research Council will again advise the National Science Foundation in the selection of candidates for the Foundation's program of Graduate Fellowships. Panels of eminent scientists and engineers appointed by the National Research Council will evaluate qualifications of applicants. Final selection of Fellows will be made by the Foundation, with awards to be announced in March 1980.

Eligibility in the NSF Graduate Fellowship Program is limited to those individuals who, as of the time of application, have not completed postbaccalaureate study in excess of 18 quarter hours or 12 semester hours, or equivalent, in any field of science, engineering, social science, or mathematics. Subject to the availability of funds, new fellowships awarded in the Spring of 1980 will be for periods of three years, the second and third years contingent on certification to the Foundation by the fellowship institution of the student's satisfactory progress toward an advanced degree in science.

These fellowships will be awarded for study or work leading to master's or doctoral degrees in the mathematical, physical, medical, biological, engineering, and social sciences, and in the history and philosophy of science. Awards will not be made in clinical, law, education, or business fields, in history or social work, for work leading to medical, dental, or public health degrees, or for study in joint science-professional degree programs. Applicants must be citizens of the United States, and will be judged on the basis of ability. The annual stipend for Graduate Fellows will be $4,320 for a twelve-month tenure with no dependency allowances.

Applicants will be required to take the Graduate Record Examinations designed to test aptitude and scientific achievement. The examinations, administered by the Educational Testing Service, will be given on December 8, 1979 at designated centers throughout the United States and in certain foreign countries.

The deadline date for the submission of applications for NSF Graduate Fellowships is November 29, 1979. Further information and application materials may be obtained from the Fellowship Office, National Research Council, 21010 Constitutional Avenue, Washington, D.C. 20418.

Minority Graduate Fellowships are also available from the National Research Council. The deadline date is November 29, 1979.

BICYCLE PATHS GET MAPPED OUT

To better serve bicyclists, the Colorado Department of Highways recently published a statewide map and nine strip maps. Working with a broadly representative Bicycle Advisory Committee, the Department's bicycle program coordinator, Bill Litchfield, mapped the Interstate 25 highway corridor which bisects the state south to north. Volunteers from four bicycle clubs helped inventory routes via bicycle, to add on-the-pavement reality to the cartographic effort. The result: carefully prepared bicycle maps, now available to the public.

The statewide map, entitled "Primary Bicycle Routing on the Colorado State Highway System," includes suggested routes and the Colorado segment of the Bikecentennial TransAmerica Bicycle Trail. Certain routes are denoted as having strip maps available or in production. "How to get maps" references also alert bicyclists to city bicycle maps detailing Denver, Colorado Springs, and Pueblo along the Front Range of the Rocky Mountains. The base map measures 18" by 30" unfolded.

Persons may visit or write Public Relations (Room 235), Colorado Department of Highways, 4201 East Arkansas Avenue, Denver CO 80222 for a free copy of the map.

Strip maps are also free for the asking. The Front Range Bicycle Route is a series of eight maps depicting bicycle travel information along the Interstate 25 corridor from Raton Pass (Colorado-New Mexico border) north to the Wyoming border just south of Cheyenne. The Front Range route of about 300 miles uses Interstate highway shoulders, U.S. and State highways, county roads, city streets, service roads and bike paths.

Volunteer bicyclists inventoried the entire Front Range Bicycle Route. Members of the Strada Cycling Club of Colorado Springs rode and catalogued southern portions of the Interstate 25 corridor. Near Denver, the Denver Bicycle Touring Club and the Colorado Mountain Club (Boulder) devoted volunteer time to examine proposed bicycle routes. I25 corridor segments from Greeley north were inspected by bicyclists from the Spring Creek Velo Club of Fort Collins.

Bike route inventory volunteers identified hazards such as railroad crossings, cattle guards, narrow bridges, and other potentially dangerous conditions or obstacles. They also inventories the locations of facilities offering food, water, telephone service, medical care, lodging, restrooms, and bike repair.

The series of strip maps is drawn to a scale of 1:250,000 (one inch equals about four miles) which means that each map depicts a corridor about 24 miles in width, and an average of 50 miles in length. Each map also contains an elevation profile. The size of each strip map is 8½" by 17", folded conveniently to fit the envelope of a handle bar bag.

In addition, a map depicting a suggested route from Vail to Denver is now available. The complete series of maps for the Interstate 70 corridor will be available in May 1980.

The Colorado Department of Highways continues to support bicycling as an energy efficient alternative mode of travel, and as a partial solution for gasoline shortages, air pollution, and traffic congestion. As the bicycle continues to gain in popularity as an urban commuter vehicle and as a recreational/touring vehicle, the Department will continue to encourage the construction and safe use of bicycle facilities.

IN THE FINAL ANALYSIS

Photo by John Pohle

There's more to the Kodak picture than snapshots

Look closer at some of the diversity that can mean outstanding career opportunities for you. More than 30,000 products and processes carry the Kodak name, testimony to many achievements by Kodak engineers.

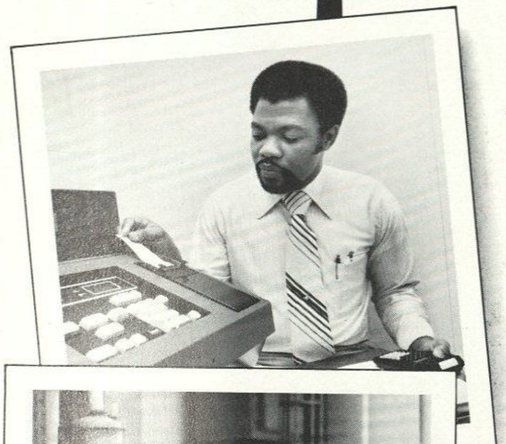
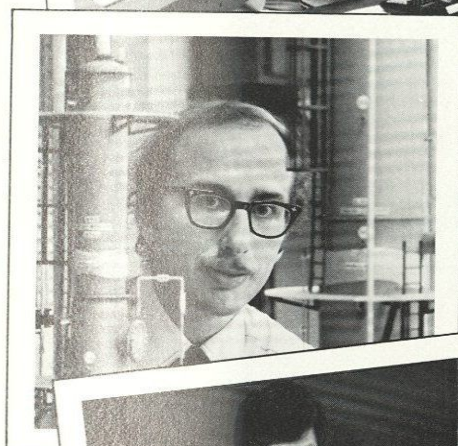
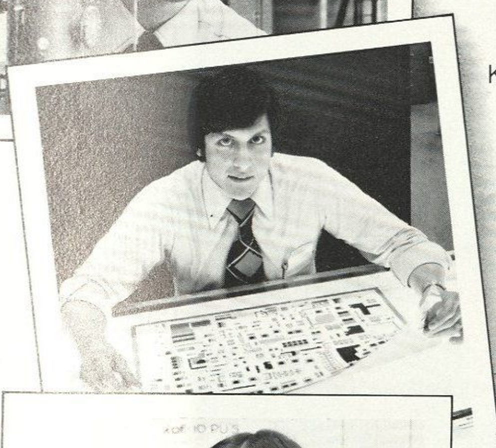
Our origins in photographic technology started us on a wide-ranging assortment of imaging products—from copying equipment for business systems to health-care products. Plus a completely separate array of fibers, textiles, and dyes for apparel and home furnishings. All offer an extremely wide range of assignments for technically trained individuals who want to help develop, design, manufacture, and market these products.

But there's more. Kodak's record as an innovator has frequently made it necessary to design unique facilities or complex production processes to make all of this progress possible. And that creates more choices for talented graduates with chemical, electrical, industrial, or mechanical engineering backgrounds. Those who prefer to help expand our stockpile of ideas might consider opportunities in research.

Whatever your inclination, start by meeting with a Kodak recruiter. It's a two-way exchange in which we try to find a starting point that matches your interests and talents with our needs. Prior to any offer, you'll be given a chance to take a firsthand look at the actual work setting to check that match.

Many of our engineers change career directions within the company as their knowledge of alternatives grows and they become more aware of their opportunities at Kodak.

Get more information. Visit a Kodak recruiter on your campus. Or contact: Business and Technical Personnel, Eastman Kodak Company, Rochester, N.Y. 14650.

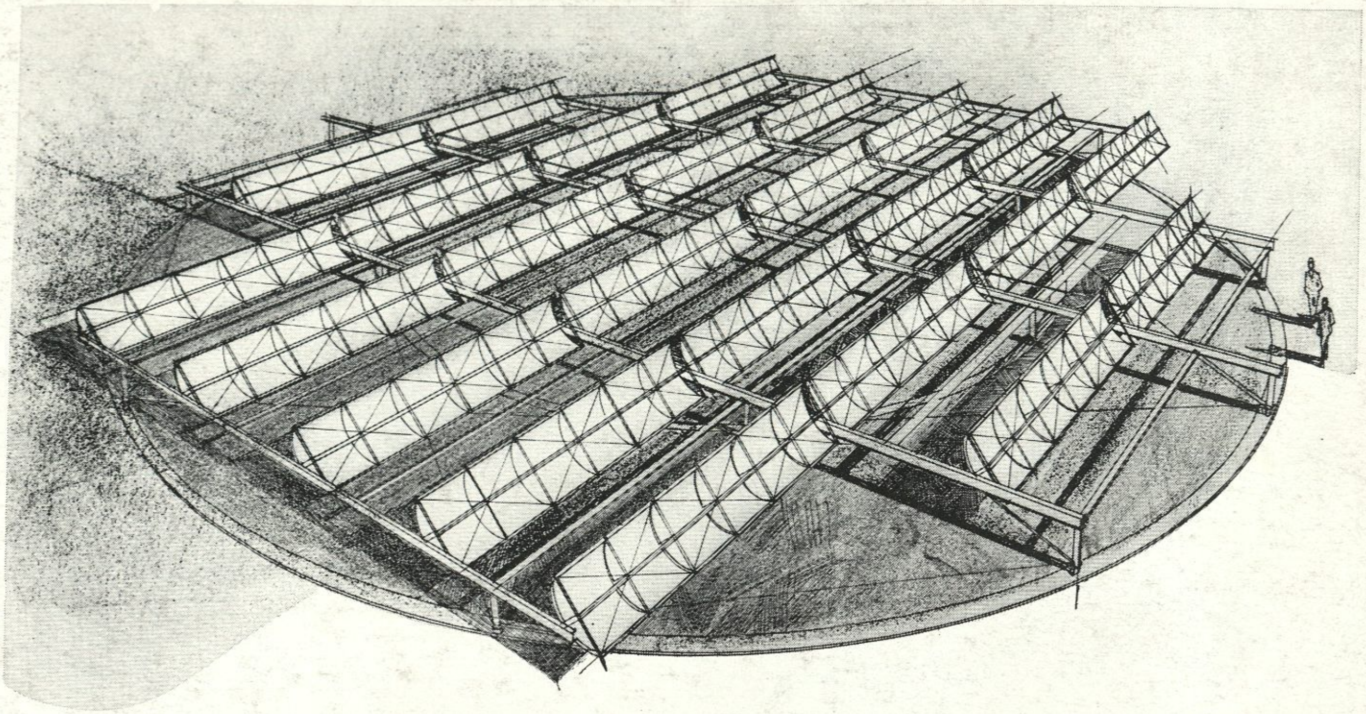

From top to bottom:

ME—development engineer, medical products. ChE—process design engineer, polyester recovery. EE—integrated circuits design engineer, consumer products. IE—quality control systems engineer, management services.

1880 Kodak *1980*

A 100-year start on tomorrow

An equal-opportunity employer (f/m) manufacturing photographic products, fibers, plastics, and chemicals, with plants in Rochester, N.Y.; Kingsport, Tenn.; Windsor, Colo.; Longview, Tex.; Columbia, S.C.; Batesville, Ark.; and sales offices throughout the U.S.A.

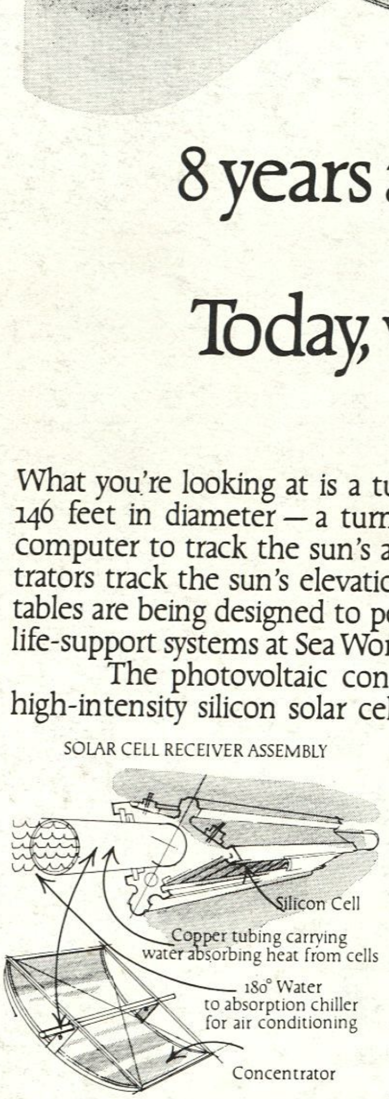


8 years ago, we designed turntables to track records. Today, we're designing turntables to track the sun.

What you're looking at is a turntable that measures 146 feet in diameter — a turntable programmed by computer to track the sun's azimuth while concentrators track the sun's elevation. Nine of these turntables are being designed to power marine-mammal life-support systems at Sea World in Florida.

The photovoltaic concentrator system uses high-intensity silicon solar cells to convert sunlight into electric power and is under study by General Electric for the U.S. Department of Energy. Parabolic troughs on each turntable are formed of aluminum sheets covered by a reflective film laminate. They are angled to concentrate energy on a focal line of solar cells. DC power generated by the photovoltaic cells will be converted to AC power providing up to 300 kw of peak electricity — enough power to service about 40 average homes.

SOLAR CELL RECEIVER ASSEMBLY



Water circulated through copper coolant piping in the solar cell assembly and carried to absorption chillers would be used to air-condition a shark exhibit. The generation of electricity and simultaneous ability to air-condition makes the GE system unique.

Our Sea World application is a test project. It will include researching ways to reduce costs to make photovoltaic systems practical for commercial or industrial-scale use.

Looking for new and practical energy sources is just one example of research in progress at GE. We're constantly investigating new technologies, materials and innovative applications for existing technologies — in such areas as medical systems, transportation, engineered materials.

This takes talent — engineering talent — not just in research and development, but in design and manufacturing, application and sales.

If you'd like to know more about engineering opportunities at GE, send for our careers booklet: General Electric, College Communications, W1D2, Fairfield, CT 06431.

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