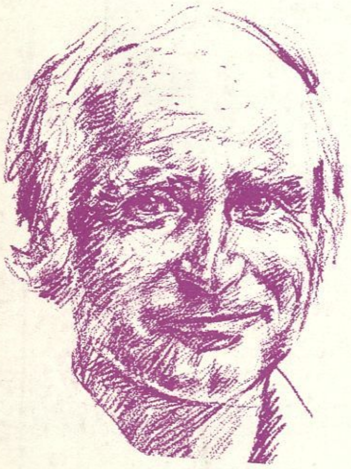
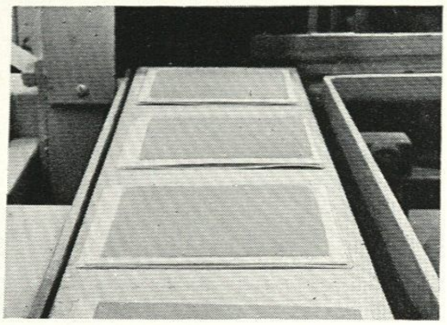
The COLORADO Engineer

Nov. 1973 ECMA

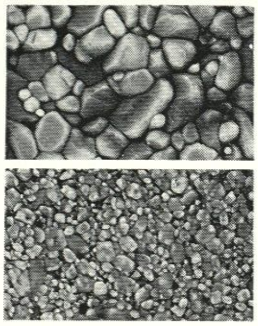


"NUCLEAR POWER • is it ready ...?"

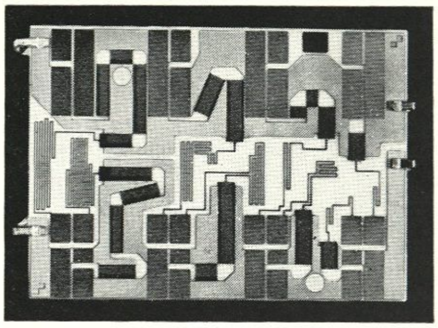
WESTERN ELECTRIC REPORTS



1500° C furnace was specially designed to fire these new substrates. The relatively low temperature results in smooth substrate surfaces for practically fault-free thin film bonding.



Electron micrographs show the great difference in grain size between new ceramic material (lower) and the previous material (upper).



Thin film integrated circuit shown here is part of a resistor network. It is one of many that benefit from the improved substrate. Metal leads on sides are bonded by thermocompression to tantalum nitride resistor film.

Smoothing the way for perfect thin film bonding.

Aluminum oxide, or alumina, is considered to have the best combination of properties for thin film circuit substrates. Until recently, however, the bonding of metal elements to gold-coated tantalum nitride resistor film on alumina was somewhat unpredictable.

Now, an advance at Western Electric has made it possible to get practically fault-free bonding of these materials.

This new perfection in bonding came through the development of finer grained alumina substrates.

The process has four basic steps: milling, casting, punching and firing.

During milling, alumina is combined with magnesium oxide, trichlorethylene, ethanol and a unique deflocculant. For 24 hours, this mixture is rotated in a ball mill. In a second 24-hour period, plasticizers and a binder are included.

The deflocculant plays a major role by dissipating the attraction forces that exist between the highly active alumina particles. This prevents thickening, which would ordinarily make an active alumina mixture unworkable.

The 48 hours of milling is followed by casting. When the material comes off the casting line, it is in the form of a flexible polymer/alumina tape, dry enough to be cut into easily handled sections.

After casting, a punch press cuts the material into the desired rectangles or other shapes. Holes can be punched at the same time.

Finally, because of the use of active alumina, the material is fired at an unusually low temperature which results in smooth substrate surfaces for reliable thin film bonding. The finished substrate is then ready for the various processes of thin film circuit production.

In developing this new process, engineers at Western Electric's Engineering Research Center worked together with engineers at the Allentown plant.

Conclusion: This new way to produce substrates is a truly significant contribution for thin film circuit production.

The ultimate gain from this smoother substrate is for communications itself. For through the achievement of nearly perfect bonding of metal leads to tantalum nitride, thin films can be produced with even greater reliability and economy.

Western Electric

We make things that bring people closer.

THE COLORADO ENGINEER

COLLEGE OF ENGINEERING • UNIVERSITY OF COLORADO

VOLUME SEVENTY NUMBER ONE NOVEMBER 1973

STAFF

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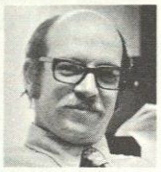
NEW PROFESSORS IN THE COLLEGE OF ENGINEERING AND APPLIED SCIENCE



ROBERT I. CARR JR.

Dr. Carr is an associate professor of Civil and Environmental Engineering. He earned his M.S. AR. E. in August 1963 at the University of Texas, and his Ph.D. in September 1971 at Stanford University, where his thesis was "Synthesis of Uncertainty in Construction Planning." Dr. Carr is a member of number of honoraries and is a registered professional engineer in Texas. His major research project is evaluation of low cost housing, preparing the construction and cost evaluation.

PATRICK J. TOOLE

Dr. Toole is an assistant professor in Engineering Design and Economic Evaluation, with his B.A. in Math, 1966, and M.A., Ph.D., 1971 from the University of California (Berkely). His thesis title is "An Appointment, Promotional, and Retirement Model For a Graded Manpower System of Total Fixed Size." Before moving to CU, he was an assistant professor of the management department at the University of Michigan for two years. He is a member of the Operations Research Society of America, and specializes in manpower systems and mathematical programming. Dr. Toole expressed surprise at the idea that the University of Colorado has only 20,000 students, as compared to Michigan State which has many more students on a campus of practically the same size!

L. ELLIS KING

Dr. King is also an associate professor of Civil and Environmental Engineering, and teaches mostly at the Denver Center. He has a Civil Engineering degree from North Carolina State, 1963, and a Doctor of Engineering degree from the University of California (Berkely), 1967. His thesis was "Pavement Surface Characteristics: An investigation of the Reflecting Properties of Several Representative Pavement Surfaces." Dr. King had a National Science Foundation traineeship at the University of California (1967-1973) and he taught at West Virginia University before coming here, where his major research involved specialization in transportation.

DEAN'S COLUMN:

by Dean Max S. Peters

As we move into our 1973 fall semester, I welcome all of our students back to the campus and extend a special welcome to our new freshmen. I also take this opportunity to extend my best wishes for a successful program to Sam Woodward, President of the Associated Engineering Students, and to Kurt Olsen, Editor of the *Colorado Engineer*. I hope all of you students will work with Sam and Kurt as well as with our other engineering student leaders to make certain this is a good year for engineering involvement both college-wide and university-wide.

Trends across the United States indicate that freshmen enrollments and the total enrollment of engineers have apparently stopped decreasing. A noticeable increase is occurring in the eastern part of the United States and some increases are occurring in our part of the country. Those of you who are students here now can anticipate an opportunity and a responsibility in the projected shortage of engineering graduates, which is expected to be more than 20,000 by 1976. As an indication of the situation for the forthcoming two or three years, this past spring our engineering students were having little trouble in finding good jobs; some of our students were receiving five to eight offers for employment, at salaries ranging up to $1,000 per month or more.

The estimates of the projected engineering shortage as presented by John D. Alden, executive secretary of the Engineering Manpower Commission of Engineers Joint Council, are the results of careful analyses of industrial growth and the professional requirements related to this growth. His facts appear to be well documented. Mr. Alden's case for the 1976 shortage of engineers in the area of 20,000 or more is really quite convincing and is based on an estimated average demand for new engineers in the neighborhood of approximately 50,000 or more per year versus the estimated supply of new engineers in the neighborhood of about 30,000 per year.

In any case, it is very clear that engineers are going to be in considerable demand in the United States during at least the next five to ten years, and our present engineering students are going to be in a very fortunate situation when it comes to graduation and seeking appropriate positions.

I suggest that each of you keep the employment opportunity in mind as you are completing your education and recognize that you will have some choices as to which way you will go after graduation. Consider the importance of developing social awareness in your education program through the courses you take, your special projects or thesis areas, and your involvement in inter-campus activities. Look at the possibility of

(continued on page 12)


DANGER
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80 Million GALS
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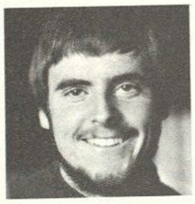
600 TO 24,000 YRS

NUCLEAR POWER

A THREAT TO HUMANITY



by Quentin H. Davis

Editor's Note:

Quentin H. Davis is a third year Civil Engineering student. Mr. Davis' interest in nuclear power issues began when the Commonwealth Edison Company purchased property for a nuclear power plant near his home in Illinois. During the ensuing zoning battle, public opposition to the plant grew, but the site was soon approved by the local zoning board. Mr. Davis researched and wrote this article to raise questions about the safety of currently feasible nuclear power plants.

The consumption of electricity has increased rapidly for the last thirty years. This electrical power is produced primarily from steam generation plants fueled by coal or residual oil. However, in the last few years, air pollution laws have restricted the use of coal, and the oil supply has become extremely short, placing power companies face to face with the crisis of power shortages. Scientists have been searching for alternate sources of power, knowing that the supply of fossil fuels will not last forever. After observing the enormous amounts of energy contained in the nuclear fission process of the atomic bomb, in 1946 Congress established the Atomic Energy Commission to develop and promote nuclear power for peacetime use and to insure its safety.[1] "By the end of 1971, there were twenty-three nuclear power generating units operating in the United States, fifty-four under construction, and fifty-two being planned."[2] By 1985, nuclear power will represent a $180 billion industry[3] and will generate nearly one-half of the nation's electricity.[4] The AEC expects to license nearly one thousand plants by the end of the century.[5]

Since they have developed over a twenty-five year period, one might assume that these plants were thoroughly tested and proven safe before being constructed for commercial use. Unfortunately, this is not the case. Recent court battles have warned the public about certain hazards which the nuclear industry had previously concealed. Some of the emergency systems designed to prevent major accidents have never been tested, and other major parts of the reactors are failing. One senior engineer stated:

> What bothers me most is that after twenty years we are still making purely subjective judgments about what is important and what is not in reactor safety. Purely by decree, some things, like the rupture of a reactor pressure vessel, are ruled impossible. To decide these things without some objective measure of probabilities is, to me, almost criminal.[6]

The AEC admits they should spend more on research, but think the utilities should pay for it. The two companies which supply most of the nuclear plant orders do little safety research with their funds, and the utilities do practically none, prefering to spend greater sums on advertising, for example. In 1969, utilities spent $323 million on sales and advertising but only $41 million for research and development.[7] Should the power companies be allowed to build these plants, when they have not even taken the responsibility to test their safety?

A simplified description of a reactor's operation will help understand what is failing and why it is dangerous. The kind of reactor being used today is the *light water* type. Another, the *breeder* is currently being developed and may be available by the early 1980's.[8] Both types are similar to fossil fuel plants in that they convert water to steam which turns generators to produce electricity. The difference lies in the fuel used to heat the water. In a light water reactor, the *core* consists of up to 250 tons of uranium dioxide pellets, depending on the size of the reactor, contained in a cluster of fuel rods. The fission of this nuclear fuel produces enormous amounts of heat. A continuous flow of water through the core carries the heat through a heat exchanger. This, in turn, produces steam in a sealed water system, which turns the turbines, is condensed, and then recirculated. This entire system is contained under a dome of one-inch thick steel and is supported by a base of concrete six feet thick.[9] A breeder reactor is similar except that it uses plutonium for fuel, and liquid sodium, a much more efficient thermal conductor, as the cooling agent.[10]

Most of the recent dissent about reactors concerns the Emergency Core Cooling System, or ECCS. This system is designed to guard against the potentially worst reactor disaster — a complete meltdown of the nuclear core — known as a "China Accident". In the event of a major break in a pipeline or valve which circulates the cooling agent through the core, the core must be flooded by the ECCS within about thirty seconds. Otherwise, the temperature would rise from the normal operating condition of 600 degrees Fahrenheit to over 3000 degrees, converting the core into an uncontrollable molten mass. Eventually, it would melt through the reactor vessel and cement base in the direction of China, spreading lethal doses of radiation over a large area.[11] In 1963, the AEC decided to build a full scale simulator of the ECCS for testing. Nine years later construction was only eighty percent complete — six years behind schedule. Instead, they are depending on mathematical computerized results which say the system will work.[12] In 1971, the AEC National Reactor Testing Station at Idaho Falls, Idaho, ran a small scale mock-up of the system and found that in six consecutive tests the ECCS failed to work because escaping steam kept the water from reaching the core.[13]

Another problem directly involved with the reactor is the recent discovery of fuel rods which have bent, crushed, or even cracked under normal operating conditions. This seems to be the result of an unexplained settling of the fuel pellets in the rods, leaving cavities which cannot withstand the high pressures maintained in the reactors. Crushed rods could develop "hot spots" making them much more dangerous than normal rods if there were a loss of cooling agent. Cracked rods would enable radioactivity to escape into the cooling water — and into our lakes and streams — if not immediately discovered. Ironically, fuel rods are one of the most thoroughly tested parts of the reactors.[14]

Luckily, the AEC has recognized the potential dangers of these problems and has ordered a number of plants to operate at reduced levels. The point here is that even though there are technical problems in the design of reactors and tests have not been completed, *the AEC continues to license more plants.*

What is the potential danger from a major accident?

In 1957 the AEC sponsored a study to calculate what the worst possible nuclear accident could be. It assumed that a hypothetical accident took place in a suburban location, under the worst combination of weather factors, that none of the safety devices worked, that half of the radioactive materials escaped, and that nobody was evacuated. The conclusion: 3400 people would be killed and 43,000 injured, with property damage running from one-half million dollars to seven billion dollars.

Today's plants are some five times larger and may contain ten times as much radioactive material.[15] The AEC argues that the chances of having a serious accident are very remote. Indeed, the chances of one particular plant having a major accident are slim, but multiply this by thousands of plants that will be in operation and it becomes much more of a reality.

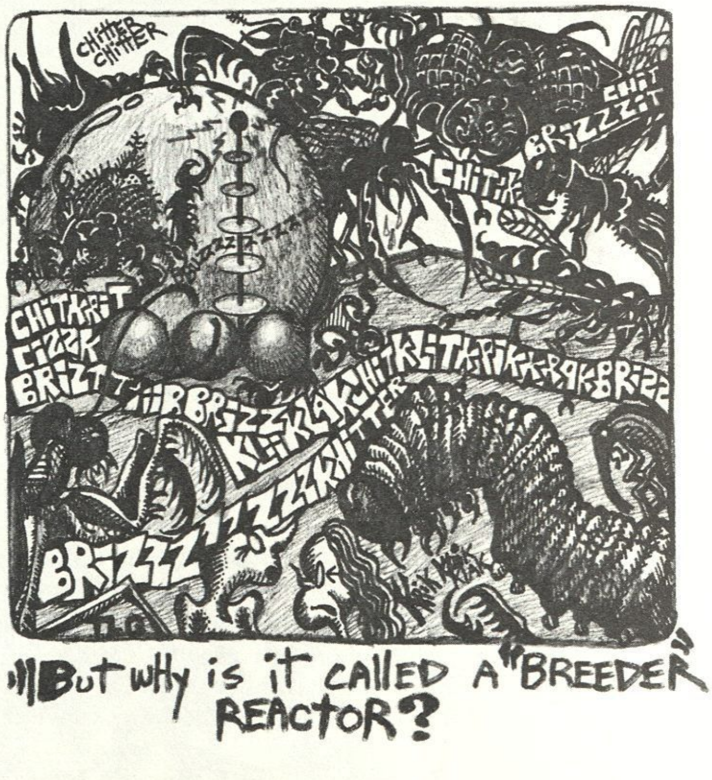
The potentially large number of nuclear plants also makes the possibility of radiation pollution so great. Small doeses of radiation exist around the nuclear plants which are carefully monitored.[16] It is conceivable that over the years, there will be a continual increase of radioactivity in the atmosphere, slowly contaminating the environment much the same as DDT once threatened. Radiation released into the water from the Windscale plant on the British Coast has already deformed the backbones of embryo fishes. Also, studies show that infant deaths have risen in areas where nuclear tests have taken place.

Even if no radiation escaped during normal operation, there are many chances for leaks in the handling of the fuel. About every six months, nuclear reactors must be refueled. The fuel rods are removed from the reactor and placed in water for a few months, allowing the short-lived radioactive substances to decay. Then, the remaining fuel is placed in huge casks and shipped to a reprocessing plant. The reusable fuel is sorted out and sent back to the plant for further use, and the radioactive wastes are packed for long term storage.[19] A recent accident during the handling of a nuclear product was discovered in Colorado last September. Dow Chemical Corporation's Rocky Flats plutonium plant was found to be releasing abnormally high levels of radioactive tritium into Walnut Creek and the Great Western Reservoir, part of the water supply for the city of Broomfield, Colorado. The probable source of the contaminants was disclosed as an improperly identified shipment of materials, containing the tritium, from an off-site laboratory.

Breeder reactors, which *produce* fuel during operation, will especially add to the amount of wastes. The chairman of the AEC estimates as much as 100 tons of waste plutonium will be produced annually by the end of the century, if the expected number of plants go into operation.[20] The number of casks of waste fuel shipped annually will rise from thirty in 1970 to 9500 in the year 2000.[21]

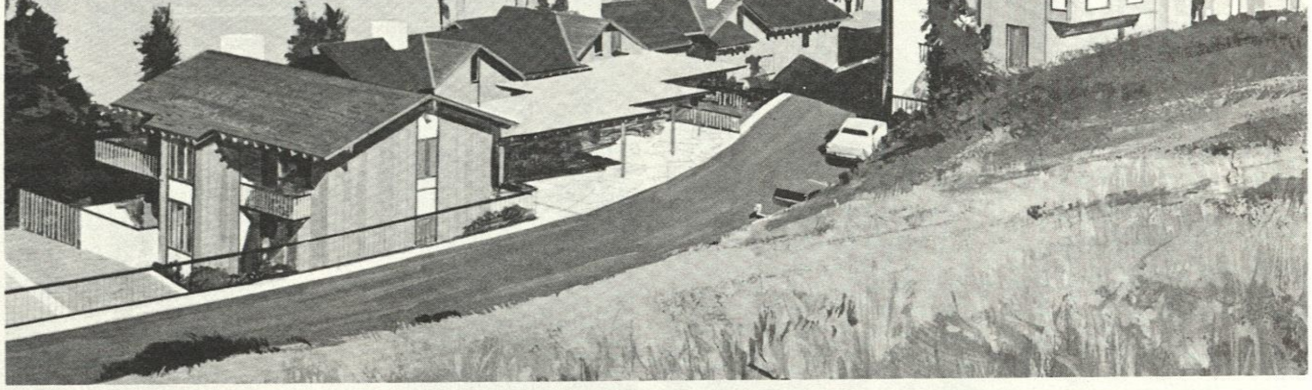
With this much radioactive material being transported each year, there are bound to be accidents. It is known that railway cars derail about once every million miles.[22] In fact, some twelve accidents have already occured with the small number of reactors operating today. Fortunately, these accidents were only minor although they could have been worse.[23] The number of shipments could be reduced if shipped in larger containers, but then there is greater danger from the larger amounts of radioactivity present.[24]

The AEC has not yet solved the problem of long term storage of the wastes. The time period for which these wastes remain radioactive range from 600 years to a half-life of 24,000 years for plutonium.[25] The great accumulation of these wastes will require vast areas for storage,



"But why is it called a "BREEDER" REACTOR?

PREFAB HOUSING



by John Sundheim

Until five years ago most large U.S. industry thought it impractical to invest in or produce factory-built housing. However, construction cost increases of 20% a year combined with a $1.2 million production deficit are rapidly eliminating the problems of low market demand, non-uniform building codes and consumer acceptance.

Although prefabricated construction elements have been increasingly utilized since the 1851 construction of the Crystal Palace in London, the factory-built residential home did not come into vogue until the erection of Habitat, a prefabricated, modular apartment complex, at the 1967 World's Fair in Montreal. Because there were no economies of scale, each four-bedroom unit in Habitat cost $150,000 to produce.

The challenge of creating the equivalent number of total dwelling units existing in 1960 during the next fifteen years has resulted in a marked decrease in cost for factory-built housing. One Colorado firm now markets a line of homes selling at under $20,000, a substantially lower price than an equivalent conventionally built home.

The Life Style Homes Company of Colorado Springs markets a house that utilizes the *panelized* method of construction. Most homes built today are constructed by what is known as the *stick-built* method, requiring several months to complete. Life Style's panelized assembly allows the house to be completely finished in only one day, after the foundation has been completed.

While eliminating the weather deterioration and vandalism occuring during conventional construction, panelized homes also dramatically reduce the single most expensive item in modern home building—labor. Other advantages of the factory-built home include, electronically glued stressed-skin panels for floor components built to withstand a 60 p.s.f. live load. Walls are constructed with one-piece drywall that is twice as strong and has four times the insulating quality of conventionally constructed walls, an important consideration for today's energy conscious society. The factory tested plumbing, heating and power systems are pre-packaged and ready for field hookup.

Because a $10,000 house built in 1951 could *not* be replaced at under $20,000 today, the highly efficient panelized method offers a viable alternative to high costs. The Life Style Company offers homes ranging in size from two to four bedrooms, starting at $12,000, along with pre-fabricated duplexes, apartments, and motels.

A multitude of outdated building codes in Colorado could not accomodate the innovative approach of panelized construction, so the Colorado Division of Housing was given the power to certify a factory-built home on a state-wide basis. The state legislature established this power in the Division of Housing so that local *specification* building codes could be replaced by more realistic *performance* codes.

The replacement of archaic specification codes with performance standards was a primary recommendation of a 1970 Department of Housing and Urban Development experiment designed to analyse the problems and prospects of factory-built housing. The 1969 statement that "We're losing ground every year. We're not even building enough to stand still," by HUD Secretary George Romney caused many to recognize the housing shortage dilemma.

Another Colorado firm also introduced a product that is helping to fight the battle against a housing shortage. The forming of concrete foundation walls has been traditionally an expensively tedious process of building up forms and then tearing them down after the concrete has cured. Advance Foam Plastics of Broomfield has eliminated the need for this time consuming operation with the introduction of a polystyrene form. The two by four foot forms are simply stacked in position, requiring no additional support. After the concrete is poured, the polystyrene forms remain in place permanently, resulting in an additional four inches of insulation. With energy costs skyrocketing, the forms pay for themselves in reduced heating and cooling bills in a few months time.

Michael Kloster, 30-year-old engineering graduate of the University of Kansas and founder of Advanced Foam Plastics, said "In Miami, the forms were used to erect a 13-story building which won FHA approval despite its location in a hurricane-prone area."

With Colorado in the forefront of national economic growth, many innovative processes are being utilized to keep up with the increasing demand for housing. Several times in recent years however, almost every sector of the housing industry was unable to maintain its production and the mobile-home industry stepped in to help ease the shortage.

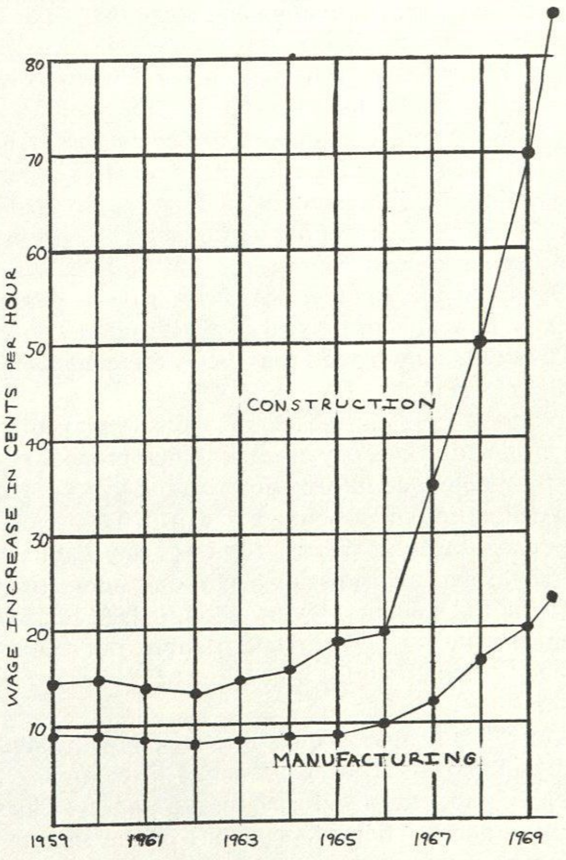
Tight money caused by rapidly rising interest rates, and a shortage of labor crippled the housing industry in 1970. The summer of 1973 again saw exorbitant interest rates but this time coupled with skyrocketing land prices and unobtainable gas and water permits.

In both cases mobile homes increased their share of the housing market reaching 33% of the new single-family dwellings available in the U.S. in 1970. Mobile homes have always been considered somewhat of a stop-gap measure,mainly because their construction is somewhat less sturdy than permanent homes, a disadvantage particularly in high wind areas. With approximately 100 companies a year entering the industry, mobile homes have become a mainstay in the housing market.

The lower cost of mobile homes is not only because they are built in factories; they also enjoy exemptions from building codes, union labor restrictions, and real estate taxes. Factory-built housing is also becoming exempt from archaic building codes. Although standard manufacturing wages are paid to workers building a house in a factory, much greater efficiency is gained as well as avoiding the average annual 18 percent yearly wage increase contract construction workers are commanding.

Factory-built housing cannot be construed as a panacea for Colorado and the nation's housing needs, but can be utilized to avert a crisis. When it costs 9.4¢ a square foot to brush paint a house in the field, and only 3.1¢ a square foot to spray paint a house in a factory, the savings become substantial.

The greatest challenge for the housing industry today is to produce an aesthetic home for the low-income family. One-fourth of the country's population today is housed only because of government subsidy. Creative engineering can begin to reduce this tremendous burden by continuing to introduce new housing techniques. Once local governments begin planning ahead to determine where they will allow people and how many they can serve, and the federal government allows the market system to stabilize, the housing industry can begin to eliminate the current shortages.

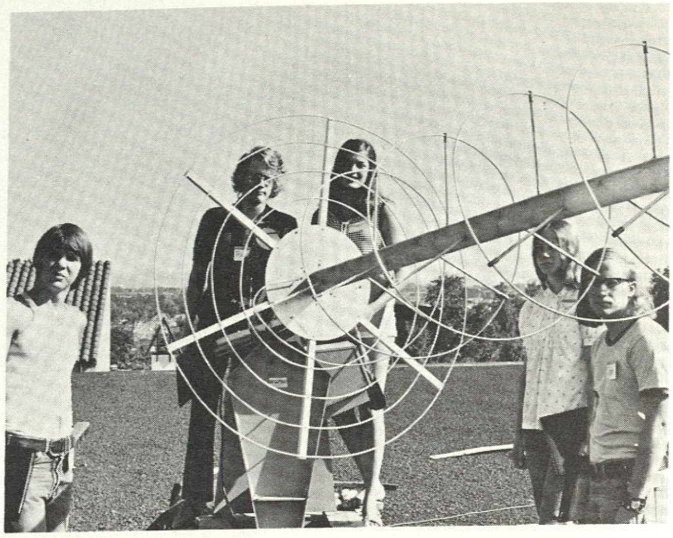


HIGH SCHOOL HONORS

by Vada Smith

The 238 Colorado high school students who attended the Sixth Annual High School Honors Institute, August 19-22, 1973 were afforded the opportunity to briefly experience campus life—8 o'clocks, dorms, lectures, and even mystery meat. The College of Engineering and Applied Science served as the activity center for the Institute. It was hoped that the Institute would provide a broader base of knowledge upon which the students could base a career selection. The primary concern was to introduce these people to engineering; a secondary concern was to show these Colorado high school seniors the University of Colorado.

The exposure to campus life and engineering was spread over a three-day period in which each of the participants had the opportunity to closely examine the major components of a college education. Five areas were covered in mini-course style in areas of interest selected by the students. Faculty members of the College of Engineering and Applied Science spent many hours coordinating departmental programs that would be representative of their work, as well as informative to the students who had expressed an interest in a particular phase of engineering.



On the roof of the Engineering Center, these students inspected a microwave satellite antenna.

Every college student is faced with the phenomenon known as a lecture. The Institute participants were also introduced to this campus tradition. As in real student life, the high school seniors were confronted with some lectures that were motivating and some that were somewhat less than stimulating...

A sophisticated form of play, better known as laboratory work, was also incorporated into the program. Here the students were encouraged to bend it, twist it, and even tie it in a knot (but not drop it!). From this experience it was hoped that the student could get a physical grasp of what had been presented in the lecture sessions.

Pre-arranged field trips to the Martin-Marietta Company and to the Boulder Reservoir gave a glimpse of industry in action to several of the groups. Those who took the field trips agreed that they were worthwhile and highly informative.

Sixteen representatives sent by industry played a major role in depicting industry in action. Their primary purpose was to disseminate information relating to an engineer's responsibilities in the business world. However, they were encouraged to discuss topics of any nature. Such a personal level of discussion led to some interesting comments by the students. "Very good, helped tell what an engineer's life is." "Warm and friendly, but rather cold-nosed." "Very helpful and honest." "Great football players."

In an effort to answer questions raised by the students, an evening was set aside for panel discussions. These panels, composed of industrial representatives and university students, fielded questions of any nature. The spectrum of topics covered ran from job opportunities to "being swallowed up by the university."

As with any undertaking, time was allotted to R & R. Literally translated this meant "Rest and Recuperation" to the group leaders, but to the high school students it meant "Re-group and Re-gather." The free time activities were as diverse as the people who attended the Institute. They included football, cards, an evening at the Recreation Center, trips to the Cyclotron and Computer Center, rap sessions, volleyball, trips to the observatory, going to the Hill, reading, writing poetry, swimming into the Kittredge ponds after frisbees, wandering around aimlessly, and sleeping. The group leaders found some old movies shown in the recreation center to be their primary inactivity during the evening of fun.

Thirty-five spirited College of Engineering and Applied Science student volunteers served as group leaders. Their primary responsibility was to insure that the students were in the right place at the right time. Larry Mohnkern, of the Dean's office, worked many hours to insure that the thirty-five group leaders were in the right place at the right time! Other intangible responsibilities are reflected by the comments given by the participants about their group leaders. "Fantastic—never gotten along better with some older dudes than I did with the group leaders." "They've really got it all together." "Den Mothers." "These were fantastic people." "They were cool, but not pieces of Jello." "Willing to talk about anything you wanted." "Helped inform about college life."

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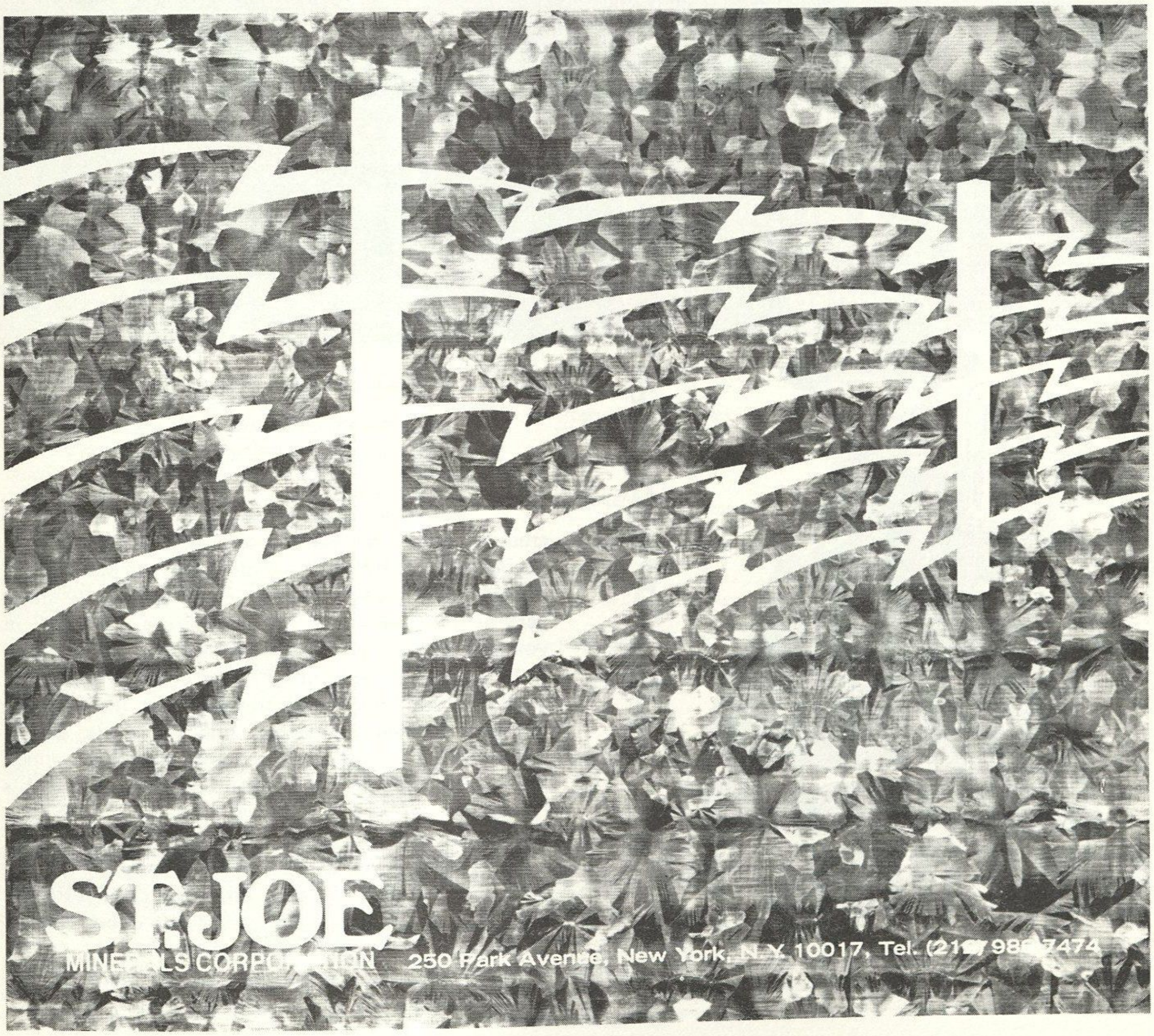
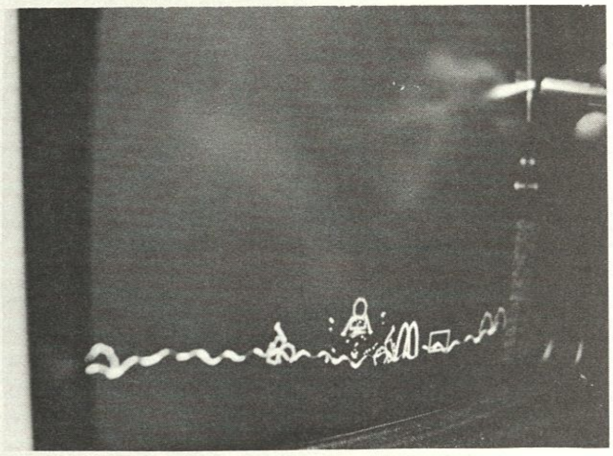


HONORS
(Continued from page 10)

As with any large organized activity, a few rules and regulations were necessary to insure the safety and well-being of the participants. This meant that the group leaders were responsible for enforcing several rules, but the effect of this supervisory role is best illustrated by the following participant comments: "The amount of discipline and lay-out and enforcement was just right—not too much, not too little." "I think the participants felt supervised but not harrassed." "I'm glad Dean Maler stayed away from the Commons area at night for the sake of his mental health."

After three activity-packed days and nights, the Institute closed with a brief ceremony where each high school student was presented a diploma as a memento of his participation in the Sixth Annual High School Honors Institute. And 35 weary group leaders went home to R & R —as well as to contemplate the intangible personal satisfactions of having volunteered to serve as a group leader. As one group leader expressed, "I have been a group leader at two high school honors institutes — and if I were going to be here next year, I would do it again."

An Honors Institute student lands the lunar module on the moon, using an interactive mini-computer in an Electrical Engineer's lab.



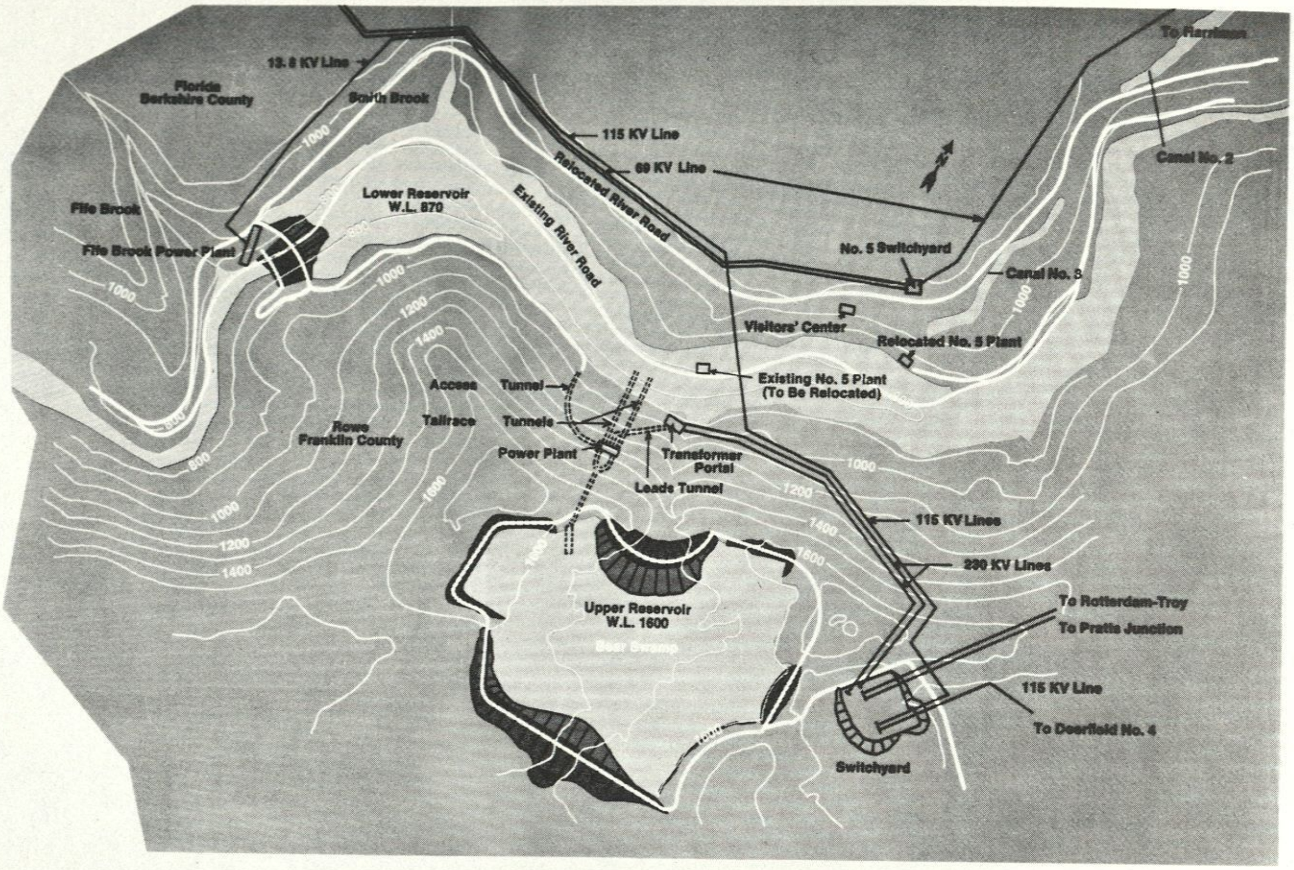
DEANS COLUMN
(Continued from page 3)

graduate school in numerous areas including advanced engineering, business, law, medicine, or other areas related to the needs of society. All of our faculty members in the College of Engineering are interested in you as a person, and I hope you will feel free to drop in to visit with them about your program and your future. In addition, I wish to emphasize the fact that we have specialized persons available in the dean's office to talk to you about academic problems which you may encounter. I urge you to come to the dean's office for conferences whenever you have problems. We will do our best to take care of the situation.

I wish each of you the best of success for the coming year. As you move forward into your chosen future, keep in mind the seventeen word motto of our College of Engineering and Applied Science:

"To be what you can be, you must first and foremost decide what you want to be."

BEAR SWAMP



Work on the 600-megawatt Bear Swamp Pumped Storage Hydro Plant, the new 10-megawatt Fife Brook Power Plant and relocation of the old 15-megawatt No. 5 Plant encompasses an approximately 1,400-acre tract in northwestern Massachusetts. (One megawatt can illuminate 10,000 100-watt bulbs.)

The project is being built by the New England Power Company, subsidiary of New England Electric System, primarily to provide a vast source of energy to meet "peaks" of high demand for power that occur each day.

Every so often an Edison comes along and electrifies the world with a really bright idea like a practical light bulb.

Then there is the kind of genius found at New England Power Company (NEPCO), construction-operations subsidiary of the New England Electric System, Westborough, Mass.

The heavy thinkers and doers of NEPCO, for example, right now are building an unusual storage battery so powerful that it will be capable of lighting 6 million 100-watt bulbs for several hours before it runs down—and yet can be fully recharged overnight.

They call it the Bear Swamp Pumped Storage Hydro Plant, the largest part of a multimillion-dollar project that will provide much of New England with a vast new temporary daily energy source. The plant is designed to provide 600 megawatts of electrical power for use as needed each day only during several critical hours of high-demand peaks.

In addition, the project involves construction of a new, more conventional 10-megawatt plant known as the No. 5 Plant. (One megawatt can illuminate 10,000 100-watt bulbs.)

More than 800 people currently are working on the project, which is under construction in a remote NEPCO-owned 1,400-acre mountainous area along the Deerfield River in northwestern Massachusetts near the towns of Rowe and Florida.

Here, in a nutshell, is the operating principle behind the storage-battery-like Bear Swamp Pumped Storage Hydro Plant:

An elevated reservoir is constructed, and water is stored in it. When a valve is opened, the water drops down a long shaft and races through tunnels to turbines in a powerhouse. The rushing water turns the turbines to generate electricity (converting mechanical to electrical energy). Its job done, the water leaves the powerhouse through tunnels and is discharged into a lower reservoir. The "battery" has run down.

Then, during the night, when cities slumber and industry is in low gear, extra power is available from nuclear and fossil-fueled plants. This surplus power is used to pump water in the lower reservoir back to the upper reservoir—and the "battery" is recharged, ready to repeat the cycle when there is a critical burst of demand for energy.

And while this whole idea sounds simple enough, its implementation is something else again.

Often working around the clock since activity began at the site in 1970, New England Power has had to move mountains of earth and rock—yet be considerate not to damage the environment—dig tunnels and turbine rooms deep inside a mountain, cover thousands of tons of steel reinforcing bars with more thousands of cubic yards of concrete, erect structural steel, divert the Deerfield River temporarily, build a dam, and even construct an on-site Visitors' Center.

The upper reservoir of the Bear Swamp plant, for instance, requires nearly 3 million yards of earth and rock fill for four dikes that will help contain about 8,800-acre-feet of water in a natural rock bowl high atop a mountain at the site. It will have a water surface of 118 acres at a maximum elevation of 1,600 feet. Work on constructing the reservoir is now nearing completion.

The finished vertical shaft (25-foot diameter) drops straight down 740 feet inside the mountain to a 410-foot-long bifurcated (two branches) horizontal tunnel, now being lined with concrete.

The bifurcated horizontal tunnel leads into the powerhouse room (227 feet long, 79 feet wide and 152 feet high) carved out 600 feet inside the mountain.

Two 500-foot-long tailrace tunnels, 22 feet wide by 29 feet high, will permit water to leave the inside of the mountain and rush out to the lower reservoir.

About one-third of approximately 3,000 tons of ASTM A615 steel reinforcing bars being supplied by Bethlehem Steel Corporation for the overall project will be used to reinforce concrete in powerhouse and tunnel areas.

Much of the remainder has been used to construct a now-completed river diversion conduit (built primarily to permit construction of a 130-foot-high by 900-foot-long earth and rock fill dam for the lower reservoir), and in construction of the two small conventional power plants —Fife Brook and No. 5.

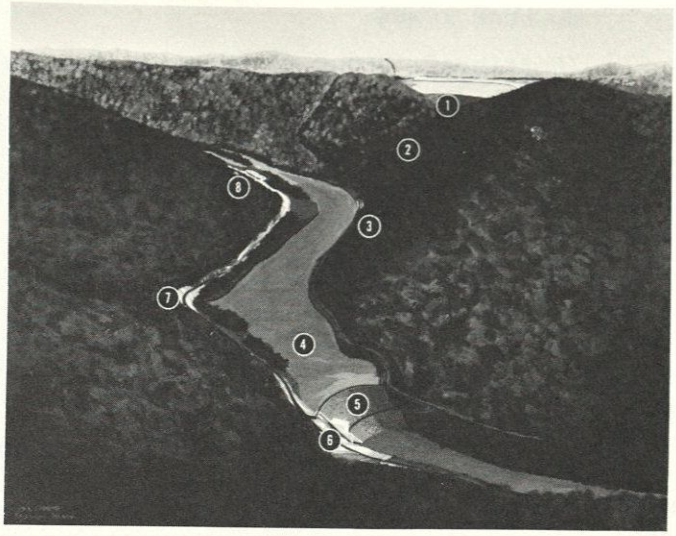
About 1,000 tons of ASTM A36 structural steel was also supplied by Bethlehem and fabricated by Lehigh Structural Steel Co., Allentown, Pa., for interior framing and crane runway supports in the powerhouse room.

Historically, the power potential of Bear Swamp was recognized in the early 1900s. The elevation of Bear Swamp coupled with the strength of the river made it an ideal pumped storage site. In 1926, NEPCO's field surveys confirmed the feasibility of pumped storage. But it wasn't until introduction of the reversible turbine in 1950 that the concept became economically attractive.

Finally, after extensive study and long dialogue among interested parties, NEPCO applied in 1968 to the Federal Power Commission for a license to build the Bear Swamp Project.

Work began at the site in 1970, and today the overall project is about 65 percent completed.

The small Fife Brook 10-megawatt plant, located at the edge of the lower reservoir dam, is expected to be in operation in the summer of 1974. Work currently is under way in constructing a new No. 5 15-megawatt plant about 2,000 feet upstream. The No. 5 plant will be fed by a canal system paralleling the Deerfield River. (With construction of the lower reservoir, the existing No. 5 Plant at the site would have been inundated.)



Artist's drawing of Bear Swamp project illustrates general topography of rugged remote northwestern Massachusetts site plus some key facilities. At upper right, for example, is the upper reservoir (1). (Beneath it, located several hundred feet inside the mountain, is a powerhouse (2) equipped with two 300-megawatt turbines to generate electricity.)

Barely visible at base of mountain below the upper reservoir is a white speck representing the opening of the tailrace tunnels (3) which permit water to exit to lower reservoir (4), foreground, behing dam (5). White structure next to dam represents Fife Brook Power Plant (6). Relocated river road (7) is at left and leads back to No. 5 Plant and vicinity of Visitors Center (8).

The 600-megawatt Bear Swamp Pumped Storage Hydro Plant is scheduled to be in operation in mid-1974.

Consulting engineer for the project is Chas. T. Main, Inc., Boston, Mass., working with New England Power Service Company, a sister company to New England Power Company providing such services as accounting, engineering and safety consultation.

General contractor is J.A. Jones Construction Company, Charlotte, N.C.

A Visitors Center—replete with electronic "daily power status" display board and working model of the Bear Swamp project — was officially opened to the public last fall. It currently may be visited Wednesday through Saturday from 10 a.m. to 5 p.m.

NUCLEAR POWER

(Continued from page 6)

posing a problem to future generations. The AEC is already holding more than eighty million gallons of wastes in various places. Any break in the containers could release large doses of radiation. A tank in Washington sprung a leak and drained sixty thousand gallons of radioactive waste into the ground before it was discovered.[26] Also, because plutonium combines readily with oxygen, there is a fire hazard where it is stored.[27] Plans of dumping the containers into the oceans or shooting them to the sun have been abandoned, and current plans are to bury them in abandoned salt mines in Kansas.[28]

If the number of plants planned to be built over the next thirty years is realized, Senator Mike Gravel of Alaska warns:

> . . . those plants will produce each and every year about as much long lived radioactivity as 500,000 Hiroshima bombs. If just one-tenth of one percent of it escaped into the environment annually, it would equal the contamination of 500 such bombs every year.[29]

What are the effects of exposure to radiation? Scientists are not certain of the effects from low doses, although the gradual accumulation of radioactivity may cause genetic disturbances and eventual mutation of the entire population.[30] High doses acquired over a short period of time may cause death within a few weeks or symptoms may delay up to twenty years. Here the outcome is much more severe — lieukemia, cancer of the bone, lungs, or thyroid, cataracts, impaired fertility or increased aging.[31]

Is this paper an over-biased opinion of one individual who refuses to advance with modern technology? Here is what some experts have to say about nuclear power:

From the beginning of the Atomic Age in 1945, a hard core of horrified scientists and environmentalists have argued that the United States is moving too fast into the realm of commercial nuclear electric power production without proper regard for public and environmental safety. These critics 26 years later still see nuclear power as an instrument of potential catastrophic death and destruction.[32]

Under the circumstances, it would be irresponsible to rush ahead without careful study and public debate; we would be unwise to barter our long-term future for short-term gain, whether political, economic, or environmental.[33]

Given the dangers, one might reasonably ask why we do not devote more resources to cleaning up fossil fuels (coal, oil) and to developing less hazardous sources of energy, such as nuclear fusion, solar energy, or geothermal energy, instead of building breeder reactors.[34]

It may be that the complexities associated with large inventories of plutonium are part of the price of living in a technological society. But it would be wise to be sure before the enterprise is too far advanced and the cost of error too high. We must free ourselves from the narrow vision of the past and ask for a reassessment of energy problems in a forum accessible to a wider range of interests than ever before. The call for a comprehensive national policy is now fashionable, but we have not yet begun to reallocate the reousrces and acquire the information that could provide a basis for such a policy.[35]

There are alternatives. Is it not time to take a second look at our ultimate goals, and to reevaluate our hasty steps before we bring about our own self-destruction?

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[1]Casey Bukro, "Nuclear Power; The Critics See Disaster Ahead," **Chicago Tribune,** March 12, 1972, Sect. 1, p.1.
[2]**Ibid.**
[3]Anthony Ripley, "Nuclear Experts in Secret Parley," **The New York Times,** October 1, 1972, n.p.
[4]Peter J. Bernstein, "AEC Challenged on Safety by Public, Own Scientists," **New Orleans Times-Picayune,** April 2, 1972, n.p.
[5]R.E. Lapp, "Nuclear Plant Controversy," **Current,** 127:42 (March 1971).
[6]Nicholas von Hoffman, "Visions of a China Accident," **Chicago Tribune,** October 11, 1972, Sect. 1, p.18.
[7]Lapp, p. 43.
[8]E. Flattau, "Atomic Power: Is It Really Necessary?" **Science Digest,** 70:17 (October 1971).
[9]Bukro, Sect. 1, p.7.
[10]"Great Breeder Dispute," **Time,** 98:102 (November 1, 1971).
[11]Bukro, Sect. 1, p.7.
[12]von Hoffman, Sect. 1, p.18.
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[15]R. Ganon, "What Are the Dangers?" **Science Digest,** 71:42 (January 1972).
[16]P.J. Lindop and J. Rotblat, "Radiation Pollution of the Environment," **Bulletin of the Atomic Scientists,** 27:21 (September, 1971).
[17]Flattau, p.18.
[18]Marjorie Hope and James Young, "The Great Nuclear Debate," **Redbook,** 138:33 (January, 1972).
[19]A.L. Hammond, "Breeder Reactors, Marvel or Menace?" **Harper,** 245:33 (January, 1973).
[20]"Another SST? Questioning the Development and Proliferation of the So Called Breeder Reactor," **Environment,** 13:18 (July, 1971).
[21]D. Shapely, "Radioactive Cargoes: Record Good but the Problems Will Multiply," **Science,** 172:1320 (June 25, 1971).
[22]Hammond, p.37.
[23]Lindop and Rotblat, p.21.
[24]Shapely, p.1321.
[25]Hammond, p.32.
[26]Robert Gannon, "Atomic Power: The Ecological Threats," **Science Digest,** 71:31 (February 1972).
[27]Hammond, p.32.
[28]Gannon, p.31.
[29]Flattau, p.18.
[30]L. Loevinger, "Nuclear Power and the Public," Science, 171:791 (February 26, 1971).
[31]Rotblat, p.17.
[32]Bukro, Sect. 1, p.1.
[33]Hammond, p.34.
[34]**Ibid.** p.30.
[35]**Ibid.** p.34.

CHECK OUR SPECS BEFORE YOU BUY THEIR 4 CHANNEL RECEIVER.

	Sylvania	Pioneer	Sansui	Fisher	Harman-Kardon	Marantz
Model	RQ 3748					
Continuous (RMS) Power[1] **4 channels** **Stereo Bridge**	50W x 4 125W x 2					
THD at rated output	<0.5%					
IM Distortion at rated output	<0.5%					
FM IHF Sensitivity	1.9μv					
50 db signal to noise ratio	2.8μv					
Capture Ratio	1.5db					
Price	$549.95[2]					

[1]All power measurements taken at 120 volts/60 cycles, 8 ohms, 20Hz-20kHz, all channels driven simultaneously.
[2]Manufacturer's suggested list price which may be higher in some areas.

If you're in the market for four channel, you already know you've got to spend a good bit of cash for a receiver. So it'd be a good idea to spend a good bit of time checking specs on everything available just to make sure you get the most for your money.

To make your search a little easier, we've prepared the blank comparison chart above with spaces for some of the best-known brands and most important specs. Just take it with you to the store, fill it in, and you'll be able to tell at a glance what you get for what you pay.

We took the liberty of filling in the Sylvania column with specs for our RQ3748 four channel receiver. We did it because we know we're not the best-known name in four channel, and we didn't want you to overlook us for that reason.

Because we think the RQ3748's specs are really worth remembering.

50 watts of RMS power per channel at 8 ohms, 20-20kHz, with all four channels driven. 125 watts per channel in stereo bridge mode. A THD and IM of less than 0.5% at rated output. An FM sensitivity of 1.9 microvolts. A discrete four channel receiver with matrix capabilities so you can use either type of quadraphonic material. And much, much more.[3]

We can offer so much because we have so much experience. We were one of the first in the audio field. And now we're applying all our knowledge, all our engineering skill to four channel.

Once you've proven to yourself which receiver has the best specs, move on down to that last line in the chart and compare Sylvania's price with all the others. Find out which one gives the most for your money.

We feel pretty confident you'll discover that the best-known names aren't necessarily your best buy.

[3]So much more that it won't all fit here. So send us a stamped, self-addressed envelope and we'll send you a four-page brochure on our four channel receivers.

GTE SYLVANIA

Sylvania Entertainment Products Group, Batavia, N.Y.

Now that you've decided to be an engineer, how do you decide what kind?

Trying to figure out the exact kind of engineering work you should go into can be pretty tough.

One minute you're studying a general area like mechanical or electrical engineering. The next you're faced with a maze of job functions you don't fully understand. And that often are called different names by different companies.

General Electric hires quite a few engineers each year. So we thought a series of ads explaining work they do might come in handy. After all, it's better to understand your options before a job interview than waste your interview time trying to learn about them.

Basically, engineering at GE (and many other companies) can be divided into three areas. Developing and designing products and systems. Manufacturing products. Selling and servicing products.

This ad is a brief outline of the most common engineering functions at GE. In future ads we'll cover individual functions in more detail.

Development and Design

BASIC/APPLIED RESEARCH ENGINEERING
Exploring for new materials, processes and systems for making new and improved products. Usually requires an advanced degree.

ADVANCE PRODUCT ENGINEERING
Thinking up ideas for new or improved products, then proving their technical feasibility. High technical expertise required.

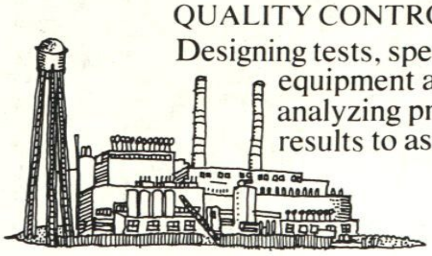
PRODUCT DESIGN ENGINEERING
Transforming the product idea into a design that meets given specs and can be manufactured. Following through to production.

ENGINEERING MANAGEMENT
Planning, organizing and supervising engineering work in a product business or project operation.

Manufacturing

MANUFACTURING ENGINEERING
Planning exactly how a product will be manufactured. From consulting with designers to creating tools and machinery to planning production flow.

QUALITY CONTROL ENGINEERING
Designing tests, specifying test equipment and procedures, analyzing production test results to assure product quality.



FACTORY MANAGEMENT
Supervising a factory's people and machines. Making sure all the many elements run smoothly.

MATERIALS MANAGEMENT
Designing materials flow systems to make sure vital parts and materials are at the right place, at the right cost, at the right time.

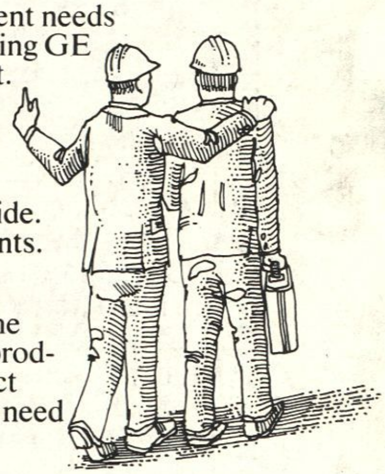
Sales and Service

SALES ENGINEERING
Identifying the needs of GE's utility, industrial and governmental customers and recommending the products and services to fill them.

APPLICATION ENGINEERING
Analyzing special equipment needs of customers, then specifying GE products and systems to fit.

FIELD ENGINEERING
Installing and servicing large machinery systems for GE customers worldwide. From motors to power plants.

PRODUCT PLANNING
Marketing. Determining the need for new or modified products. Making sure a product line offers what customers need at competitive prices.



GENERAL ELECTRIC

An Equal Opportunity Employer