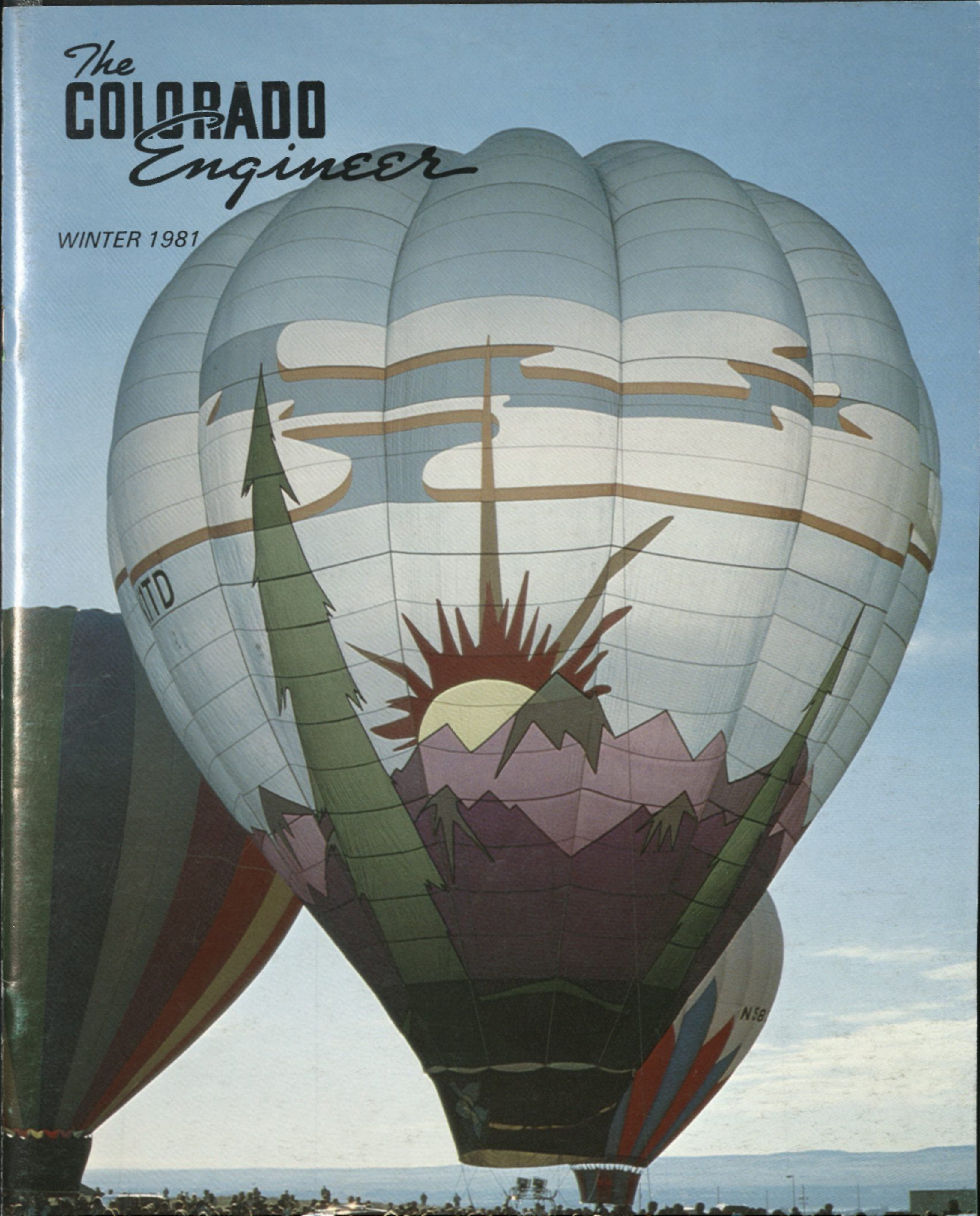
The COLORADO Engineer

WINTER 1981



COLORADO ENGINEER

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FEATURES

DEPARTMENTS

COVER

The cover photo features several balloons preparing to take off at a la. site in the Colorado Rockies. For a more complete description, see the article about ballooning which starts on page 6. The photo was taken with Ektachrome 200. Photo by John Pohle.

published since 1904

The Editor's Outlook

A Job at the Top

Recently I was invited to go a plant trip with Santa Industries (North Pole, Top of the World). Many recruiters are offering such trips to the engineers they prospectively wish to employ, and I felt quite fortunate to get this one.

My plane landed in Anchorage on a snowy afternoon. The sun was desperately trying to show through the clouds a little. One of Santa's company Lear jets picked me up there for the rest of the trip to the pole. I met briefly with Thor, the S.I. (Santa Industries) elf in charge of college relations who said, "Santa is looking for engineers of all types, primarily mechanical and electricals, though." If I were to be offered a job, I was told, I would be working with the dual Santa 172 computers which take care of most of S.I.'s data processing needs. That includes of course, maintaining a large data base of information about which children have been naughty and nice, as well as other information Santa likes to keep "on line". The jolly fellow (whom I did not actually get a chance to meet) apparently has a terminal in his office, linked to the main computers. He can recall with just a few commands the complete file on any particular child when he is deciding who will get what for Christmas.

One problem which Santa does not share with other big employers of engineers, is that of personnel leaving for other companies and taking trade secrets with them. You see, only the elves are trusted with proprietary information, and it is well known that elves are practically unemployable outside of the north pole.

As a mechanical engineer one would work primarily in Santa's toy and game products division, although an increasing number of computer science people are employed every year, it seems. In fact, Santa is now starting construction on an in-house integrated circuits division to provide a reliable supply of those little silicon chips which go into about half of his new toys.

The S. I. complex is spread out over several square miles in low buildings. There is a small rapid transit system installed between the sleigh parking areas and the various buildings. I spent the rest of the day touring this complex and it's various highly automated workshops.

Normally when one goes on a plant trip, part of the time is spent exploring the surrounding environment to decide if it would be a suitable place to live. At the North Pole unfortunately there is not much to see outside the S. I. complex, and what there was of it was obscured by a gentle but steady snowfall. After wandering out the next day, I soon found myself in a small but crowded tavern. A cozy place with a fire burning in a huge fireplace on one wall and a generally jovial atmosphere. I sat down at a table with about 7 elves and a couple of MIT graduates, and joined them for a beer, which was served in huge mugs. It turns out they liked working for Santa very well. His salaries are very competitive. The fringe benefit package inculdes insurance, use of a company sleigh, and a long vacation (about Jan. 1 to Aug. 1).

We talked and drank beer for quite a white there. I remember being helped to my feet by a couple of short, slightly wobbly on their feet, elves. Somehow I got back to the airstrip. I regained consciousness fully in the Lear jet just before it landed in Anchorage again. Soon I was on my way back to Boulder in a DC-10. I hope my performance didn't offend Thor. At any rate I still look anxiously in my mailbox every day for that letter with a North Pole postmark, which is sure to be a good job offer from Santa.

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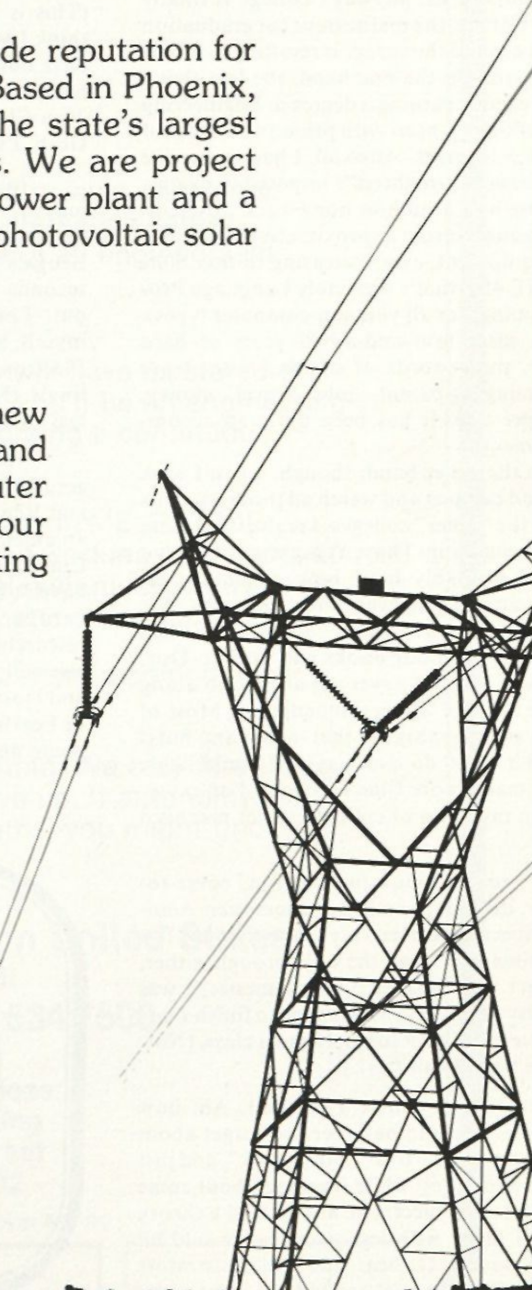

A FEW MINUTES WITH . . .

(Reflections of a Senior Engineering Student)

by Mike Furman

One of the most pleasant aspects of being a student in Engineering is that sooner or later (for most of us, anyway), college is finally over. For me, the realization that graduation is just around the corner is resulting in mixed emotions. On the one hand, the fact that I succeeded in earning a degree in Engineering is swelling my head with pride and a sense of accomplishment. After all, I had to survive countless "all-nighters", impossible exams, at least half a million homework problems (from engineering approximation), obsolete lab equipment, ever-increasing tuition bills, and EE 453 (that's Assembly Language Programming, for all you non-computer types). Now, after four-and-a-half years of hard labor, the rewards of sticking with it are becoming apparent—jobs, travel, money, and prestige. It has been quite an accomplishment.

On the other hand, though, when I look around campus and watch all those students from the "other" colleges, I realize that there have been things I haven't accomplished that would probably have been worth the effort—and might even have been fun. We engineers lead a fairly sheltered life, holed up at a desk with our books and our No-Doz, and as a result, I never got around to doing some things I always intended to. Most of them are probably not that important, but if I had it all to do over again, I would likely have made more time for them. For example, in my years of college I never managed to . . .

. . . read a book just for fun, cover-to-cover, during the course of a semester. Actually, there have been very few *text* books I've had time to read all the way through, either. (Aren't you shocked?) One semester, I was so busy I didn't even have time to finish *Lady Chatterly's Lover* for an Honors class. (Now that's what I call *busy*.)

. . . take a course Pass/Fail. Ah, how glorious it would have been to forget about grades, to refuse to do "busy-work", and just relax and enjoy while learning about some interesting subject. I've always had a theory that if faced with less stress, we would all learn more. (I hear the Administrators laughing in the background. . .) I just never took the time to try out my theory.

. . . take time out from school to go skiing. (This is a serious one, folks.) You would think I would have found at least a couple of days during the last nine semesters when I had both the time and the money to go play Jean-Claude Killy, but somehow I haven't. Gosh, I've been dedicated!

. . . join a Trivia Bowl team. Every year I make it to one or two matches, and sit there firing off the names of the 1974 Cincinnati Bengals' front four in my mind at least 3 seconds before anybody on stage figures it out. I'm always wishing I was up there myself, but every year it seems like I have an Electronics exam scheduled during the semi-finals. (Naturally, if I entered, I would get at least *that* far.)

. . . vote for a Presidential candidate who actually won. I'm good at picking Senators and Representatives, and I'll guess right on an amendment most of the time, but as for Chief Executives, I'm batting *zero*. Either I haven't been out stumping for my candidate hard enough, or I haven't spent enough time researching him to figure out why nobody else will vote for him. At any rate, America and I just don't see eye-to-eye on who should be Fearless Leader. Maybe that's why we are going downhill . . . right?

. . . write a nasty letter back to those national magazines that have been pretty mean to Boulder and CU lately. Despite what one article said, I don't have any Gucci's to run home and put on so I can go to the Harvest House on Friday afternoons. And in spite of another article, not everyone in this university spends lots of time and money to illegally lure football coaches from the pros and 17-year-old football players from California. This university has a lot of serious problems, but sometimes I think we've been too apathetic to tell people that some good things are accomplished here, too.

Oh, well, I guess if I had another life, I could spend a little more time concentrating on the "little" things in college. I may never have won a contest at "Alferd Packer Days", but I guess I can be pretty pleased with what I have accomplished. After all, I'm an engineer now, aren't I?

Mike is graduating in December with a B.S. degree in Electrical Engineering and Computer Science. Never one to waste effort, he submitted this article after presenting it as his pledge paper to Eta Kappa Nu. His secret ambition is to replace Andy Rooney on "60 Minutes."

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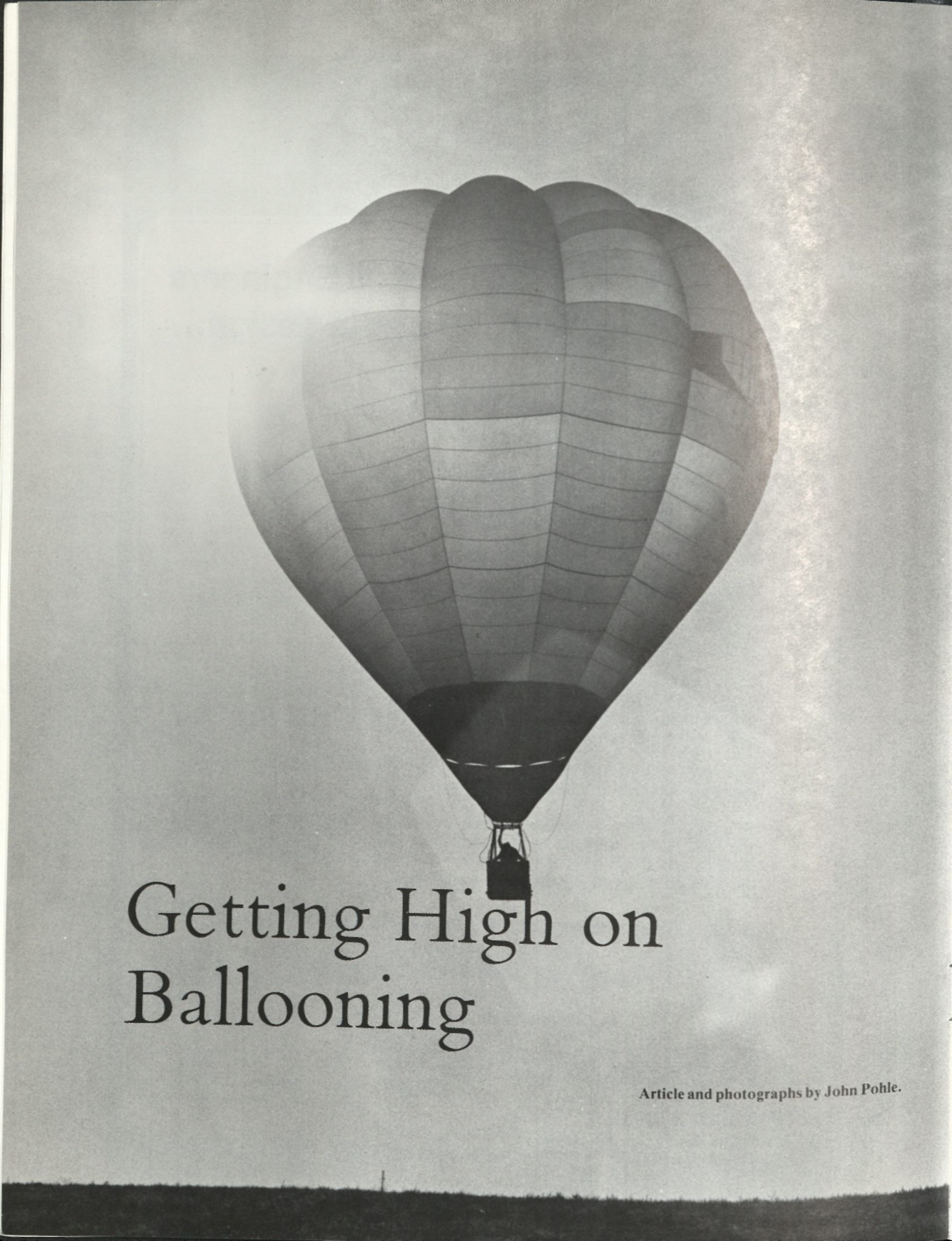
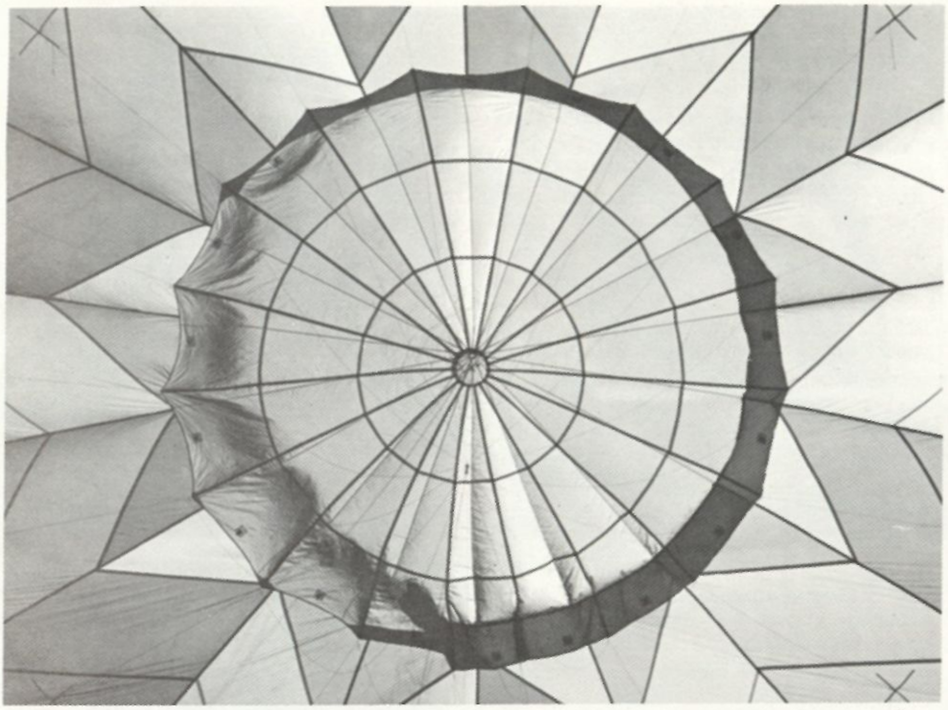


Getting High on Ballooning

Article and photographs by John Pohle.



A view looking up at the Apex of the Balloon. In this balloon, the vent is the circular section in the center. There is a rope from the vent down into the basket.

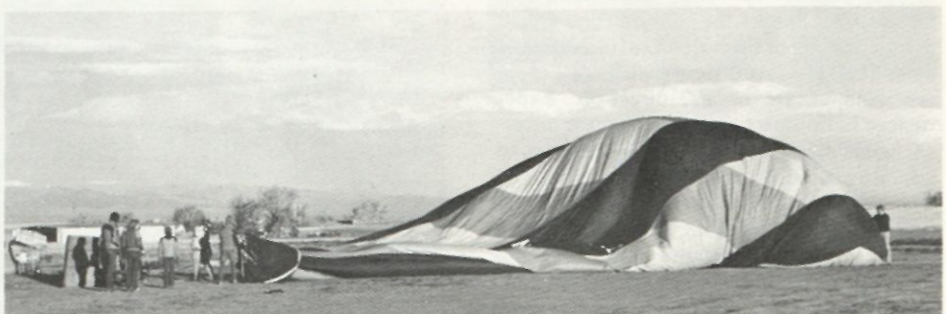
It is a crystal clear morning, my breath freezes before me and there is a hint of breeze as the sun inexorably climbs above the horizon. We are 25 miles east of Boulder at an old dirt airstrip. The balloon lies on the ground, a lump of multicolored fabric. At the moment it is useless, but with effort, in a few minutes, it will enable us to embark on one of man's oldest dreams, to slip the bonds of the earth.

Balloons have been around for many years but until recently few people have enjoyed the peaceful and relaxing nature of floating above the earth. Four years ago there were ony 39 balloons in the state of Colorado, now there are over 200 balloons. At the Albuquerque balloon festival ten years ago there were seven balloons. Now the number of entrants is restricted to 400. More people every year are beginning to enjoy sport ballooning.

The principle behind ballooning is extraordinarily simple. The fabric envelope holds air heated by a propane burner. Balloonists call it "blasting" when the burner is fired because it sounds like a jet engine. The hot air which is not as dense as the outside air will produce lift. The amount of lift varies with the size of the balloon and the temperature difference between the air outside and inside the balloon.

The balloon is composed of the basket and envelope. The basket is normally made of wicker due to its light weight, flexibility, and durability. It contains the passengers, propane, and flight instruments. The burners are normally secured above the basket with some form of support structure. There may be one or more burners on the balloon which are fueled by propane. The burners are made of stainless steel and are designed to vaporize the propane before it is burned. The envelope is generally made of polyester fabric or in some cases ripstop nylon. The polyester fabric is used because it is durable at higher temperatures which is the crucial factor in the life of a balloon. The envelope, when deflated, fits into a bag that is about two feet in height and four feet in diameter. The weight of the balloon can vary tremendously: for a Barnes' "Firefly" it is approximately 520 pounds. The "Firefly" can lift up to 1600 pounds at maximum temperature. The less lift needed, the lower the necessary temperature and the longer the lifespan of the balloon. The unassembled balloon can be easily transported on a trailer or in a pick-up truck.

If the air is calm and not shifting, inflating the balloon is relatively easy. The field used for the launch should be free of trees and power lines and should be level. Upon arrival at the launch site, the basket is unloaded and the burner is attached to the basket. The instruments in the basket include an altimeter, a variometer (measures the rate of descent), and a pirometer (measures the temperature at the apex of the balloon). The propane tanks are checked for pressure and



The fan is inflating the balloon. It is powered by a small gasoline engine.

The balloon is about half inflated with cold air.

The balloon begins to rise.

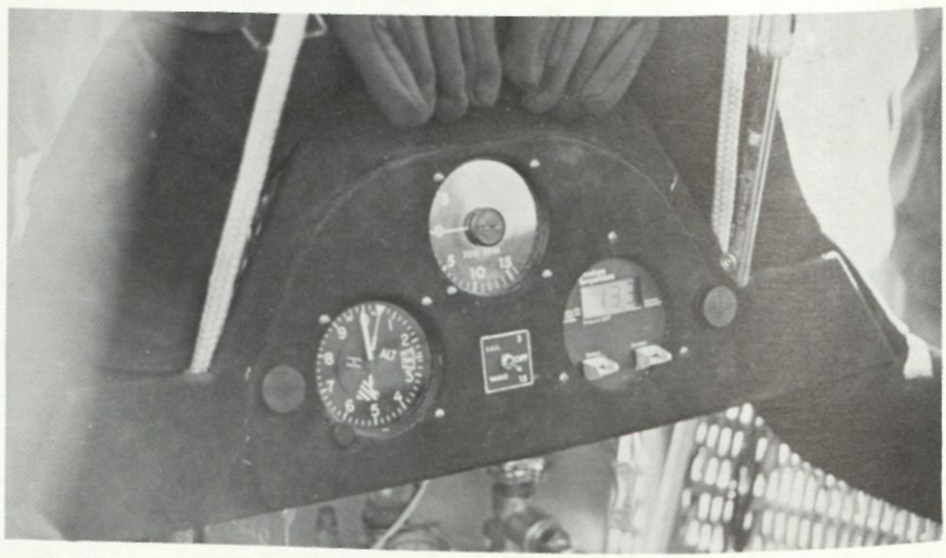
Now fully inflated, the balloon is held to the ground by the weight of the ground crew.

each is used to run the burner for a few seconds as part of the pre-flight inspection. After the operation of the burner is checked, the envelope is placed directly downwind of the basket, about eight feet away. The envelope is removed from its bag, stretched out away from the balloon, and hooked on to the basket with a set of steel cables. Then the balloon is inflated by a powerful fan. At this point, the burner "blasts" hot air into the envelope causing the balloon to rise to the upright position. The weight of the basket and crew keep it on the ground. The balloon is now ready to lift-off.

The balloonist has control over only two directions, up and down. The up control is "blasting" where the burner is lit and the air in the balloon is heated up, causing it to rise. To descend, there are vents, either at the apex of the balloon are in the side, which can be opened to allow some of the hot air to escape. This causes the balloon to descend. Control in any of the horizontal directions is up to the wind. At different altitudes, there are wind shears in any direction. Experienced balloonists, recognizing these different wind directions, vary their altitudes to get into a wind in the desired direction. The trick is to find this wind and stay in it.

The most difficult part of ballooning this author has seen is the landing. In calm conditions, the landing is quite easy. However, this is not the case in a high-wind landing (over 10 mph). At those times the balloon, with a total mass of over two tons (including air in the envelope) has a large amount of momentum and can drag the basket 30 yards from the point of touchdown. These landings can be safe as long as the balloonist recognizes the situation and acts accordingly.

Balloonists have developed many types of competition. "The Hare and the Hound" is one of the best type of competitions for the spectator. A single balloon, the Hare, lifts-off and follows any flight path desired. After ten minutes, the remaining balloonists take-off. About forty minutes later, the Hare lands. The idea of this competition is for the Hounds to try to land where the Hare landed. The Hound who lands closest to where the Hare landed is the winner. This is quite spectacular because all the balloons lift-off from the same spot and travel about the same path so the spectators on the



The three necessary flight instruments are shown above. On the left is the Altimeter. Above and in the center is the variometer.

On the far left is the pirometer which measures the air temperature at the top of the balloon.

The propane burner sits on top of the basket. The stainless steel coils heat the propane which is vaporized and the burned. Balloonists call this blasting.

ground can easily follow the competition.

Another game is "CNT." In this game, a spot is marked in the center of circle (three miles in diameter). The balloonists lift-off anywhere outside of the circle and aim for the marked center. The balloonists choose a launch site where the winds will be most favorable to guide them to the center of the circle.

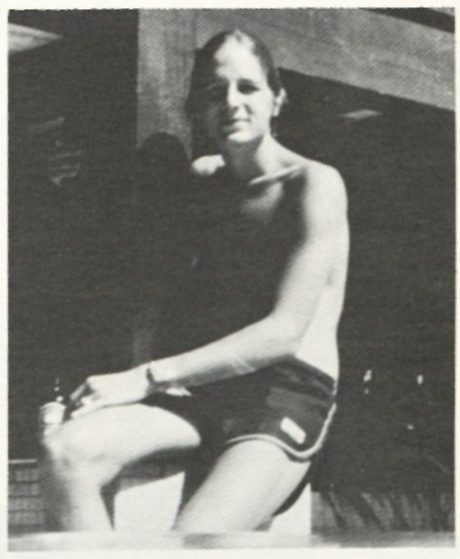
If you have read this far you may wonder just how to get involved in ballooning. The sport is not cheap, but it is worthwhile. The cost of an introductory ride is around $150. At first this may seem very expensive, but the business becomes virtually a breakeven proposition when one considers that a $15,000 balloon only lasts 400 hours and propane costs about $30 a flight.

The FAA regulates ballooning as much as they do other types of air travel. To pilot balloons, it is necessary for a person to obtain a license in a manner similar to that of obtaining a drivers' license. To qualify for a balloon license, one is required to have ten hours of flying time which is to include a solo flight. Then one must pass a written test which asks questions pertaining to weather and ballooning regulations. (The cost at a balloon school to receive the necessary hours and instruction is $1,275). After passing the test and accumulating the hours, one must go up with a FAA flight examiner who certifies the balloonist's proficiency.

Ballooning seems to appeal to a wide cross section of people. Some of the people involved in ballooning are very rich, while others may invest their life savings in a balloon. Among balloonists, there are more architects represented than any other profession. The ages are as diverse as the incomes. A couple who owns one of the balloons shown in the photographs on these pages are in their 50's, their instructor is about 26. The balloonists are very friendly and will talk about ballooning for hours, given the chance. If you would like to get involved all you have to do is call a few of the ballooning schools listed in the Yellow Pages and tell them that you would like to crew in a few launches. They always need people to help out with the launch. Ballooning is an amazing way to relax and leave the troubles of magazine writing or school thousands of feet below.

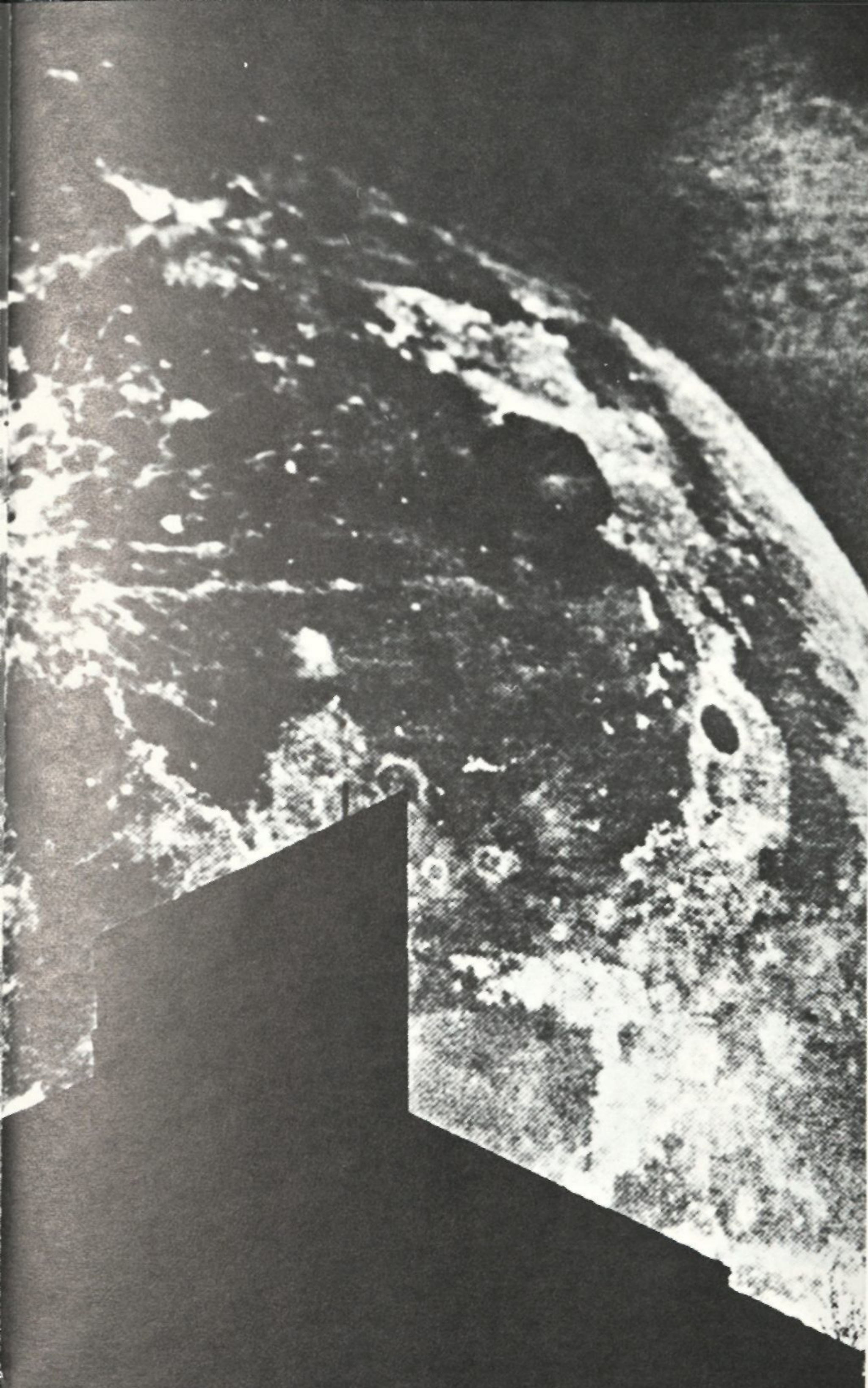
The author would like to thank Ed Vandeheof of Life Cycle Balloon School and Barb Walsh of Columbine Airway Ltd. for their invaluable help in producing this article. The awesome typing and proof reading ability of Mary Kimminau should also be recognized as contributing to it's creation.

Another balloon prepares for an early morning flight.



John is currently majoring in Architectural Engineering and has managed to stay on the four year program though he is now a junior. He has his Private Pilots License, enjoys scuba diving and likes long legs. He hopes Santa Claus will bring him hang gliding lessons.

Settling Down in



How we will eventually build space colonies.

Outer Space

by Jamie Childress

The captain fires the port retro-rockets and the space ship begins to swing parallel to the moon. From your viewing port the brilliant moon seems only a few miles away, and you must squint as you look at it. As the ship continues to orbit, you catch sight of a huge metallic cylinder in the blackness of space just beyond the moon's edge. The cylinder is your destination: the space colony Eden II.

No such colony exists today, but if such a colony did exist it would lie in an area of space known as L-5 (Lagrange Point 5). Any object placed in L-5 will remain at approximately the same point relative to the moon forever. The colony would have an earth-normal gravity and house hundreds of thousands of people in normal apartments; the residents would work at jobs processing ores from the moon. They would enjoy a pollution-free environment full of shops, theaters, and restaurants. There would also be sunrises, sunsets, trees, flowers, birds, streams, clouds, snow, rain, and most of the other natural aspects of earth. This all sounds pretty much impossible, but in fact, it is well within the realm of current technology.

The colony at L-5 would be in the shape of a cylinder with a diameter of four miles and a length of twenty miles;[4] this would give the inner shell of the cylinder a total surface area of 250 square miles (twice the area of Boulder). The cylinder would rotate on its axis at 1.8 rpm resulting in earth-normal gravity at its inner shell. Most people can adjust to rotation rates as high as 4 rpm,[4] the rotation would not be felt. The cylinder would point towards the sun and sunlight would be brought into the colony by mirrors running parallel to the colony's axis. The mirrors would be rotated to creates sunrises and sunsets. Electric power for the colony would be provided by steam turbines that are heated by parabolic mirrors concentrating the sun's rays.

The clouds mentioned earlier would be real clouds residing along the axis of the cylinder, created by seeding the atmosphere. In this fashion the climate could be commanded to snow at night and be sunny during the day (perfect for skiing). The colony could have normal seasons, or any type of climate the inhabitants desired. Approximately one-third of the inside surface area of the cylinder would be used for mirrors to direct the sunlight. This leaves 166 square to be devoted solely to apartments, schools, parks, shops, theaters, restaurants, and perhaps even lakes or mountains.

The food would be grown in other smaller cylinders around the colony. Ideal growing conditions could be maintained in the cylinders, and extensive cosmic ray shielding would not have to be maintained. It would even be possible to have different agricultu-

ral cylinders in different seasons so that fruits and vegetables would always in available. Turkey, chicken, and pork could also be economically raised.

The people living in the colony would be of all ages, and have occupations ranging from engineer to garbage collector. There would be schools for children and even a small university. Besides smelting ores from the moon the people would be employed building other space colonies, large satellites, solar power generators, or even large space craft for exploring the solar system.

The large objects would actually be built outside the main cylinder. Working areas would be independently rotated in order to create a gravity that is optimal for the type of construction being done. Large structures, such as colonies, would be simpler to build in space because heavy equipment would not be necessary to lift massive objects and the structure would not have to support its own weight, decreasing the necessary strength of its materials.

A pollution-free environment with shops, theaters, and restaurants.

Almost all the materials would be brought from the moon. Apollo samples show that lunar ore is approximately 41% oxygen, 19.5% silicon, 13% iron, 5.5% titanium, 5.5% aluminum, and 4.5% magnesium. This is a much higher mineral content than any comparable earth ore.[1] Even the slag would be used to make soil and cosmic radiation shielding for the colonies.

The ore would be transferred from the moon by "throwing" the ore at the colony. A moon mining station would be set up at which a bulldozer shovels surface ore into a machine that compacts it into iron buckets. The buckets can then be placed on an aluminum ramp and accelerated magnetically to a speed of 2,400 meters per second.[4] At the end of the ramp, the bucket will release its ore and the compacted ore will then escape the moon's gravity on a trajectory that brings it to the colony. By this time it will only be travelling at 15-20 meters per second and can be collected for smelting.

All the technology for the space colony and the moon mining exists today, but the question is: How do you get it there?

There are several ways to get a space colony to L-5. One is to launch it piece by piece on a Saturn V rocket just as the Apollo astronauts were launched. However, this would cost 40 billion dollars. A more realistic approach would be to use a combination of Space Shuttles and "Space Tugs" (vehicles permanently based in space) that would ferry loads from earth to a low orbit and on to L-5. The first space colony would not be brought up from earth piece by piece. Instead, a smaller factory facility and the first moon mining station would be in the shape of a sphere, hold 2,000 people, and weigh 40,000 tons. The moon's mining facility would have 100 people and weight 10,000 tons.[1] The mining facility would send ore to the factory facility, which would smelt it and build sections of the first space colony inside its sphere to be assembled outside using arc-welders.

The cost of such a factory and the lunar mining station would not be small, at the same time, not outrageous. The Space Shuttle has a payload capacity of 32.5 tons and seven passengers, including three crew members.[3] This means that it would take approximately 1,500 Shuttle launches at an estimated cost of 28 million dollars each. The additional cost of getting a payload to L-5 is estimated to be four times that of getting the payload into earth orbit, while getting a playload to the moon is estimated to be twice the cost of getting it to L-5.[4] Add on a conservative estimate of personnel and materials costs of 50 billion dollars and you have a basic price tag of 250 billion dollars for the first space colony. This is not cheap.

All the technology for a space colony and moon mining exists today.

However, if extended over an eleven-year period it amounts to only 16% of the 1980 U.S. military budget per year. This is comparable to the budget NASA enjoyed during the moon race years.

All subsequent space colonies would be built with very little earth materials, and so will be in comparison free. Short term cost would be offset by the ability of the space colonies to produce and put extremely large satellites into earth orbits at low cost. Space exploration could also benefit by the construction of large space ships at the colonies. Ships capable of carrying dozens of scientist on multi-year voyages about the solar system could be built.

Once the first manufacturing space colony has been established, the possibilities are endless. The asteroids could be mined and homesteaded. Large orbiting laboratories could be placed around Mars. Entire colonies of people could journey about the solar system. Colonies with a diameter of 15 miles and a length of 75 miles having an area greater than that of Delaware and Rhode Island put together would be possible.

Space colonies are a realistic dream. They are an important dream, since they may help solve some of the problems facing the earth, such as overcrowding, lack of new resources, and pollution. They will not be cheap, but the benefits will outweight the costs a thousandfold.

Jamie Childress is a Jr. Aerospace Engineering student, with interests in hang gliding, photography, and alternate energy sources.

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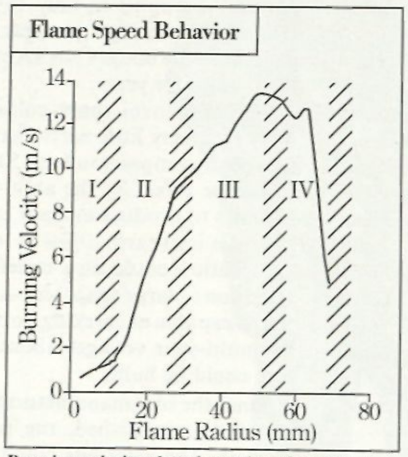
The Turbulence Parameter

Energy-efficient operation of the internal combustion engine requires the highly turbulent movement of fuel and air in the chamber. Recent advances at the General Motors Research Laboratories provide a new basis for determining what degree of turbulence will get the most work from each drop of fuel.



Burning velocity plotted as a function of flame radius. Combustion stages are indicated by roman numerals.

High-speed photographs showing flame evolution (lasting six milliseconds) through four stages: initiation (I); flame growth (II); full development (III); termination (IV).

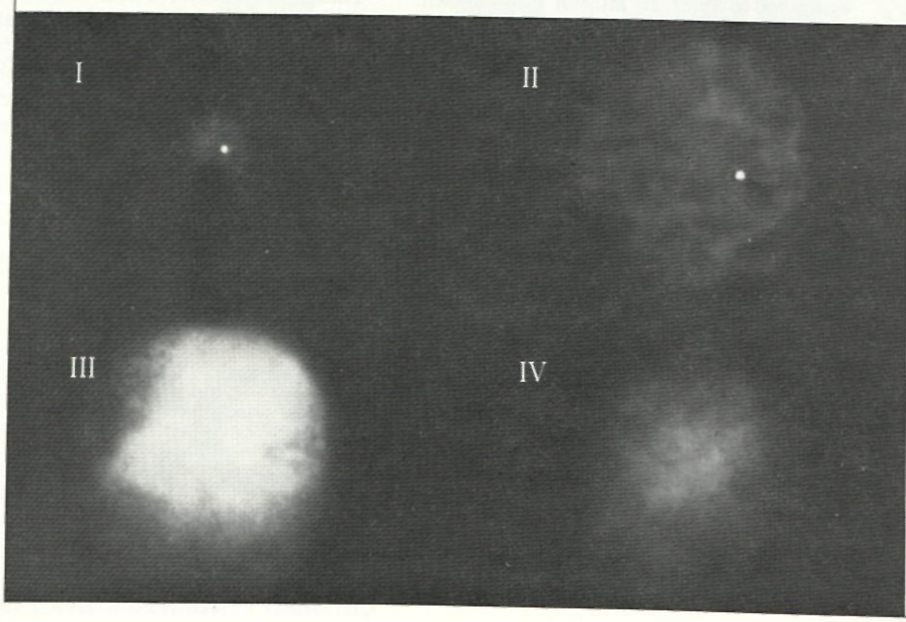
WITHOUT TURBULENCE, the highly agitated motion of cylinder gases, combustion would take place too slowly for the gasoline engine to function. Predicting combustion behavior in order to design engines with greater fuel efficiency depends upon understanding the relationship between vital, turbulent gas motions and burning rate. The challenge is to quantify this relationship--a complex task made more difficult by the requirements of measuring a transient event occurring in a few milliseconds within a small, confined space.

New knowledge of how turbulence affects flame speed has been revealed in fundamental studies conducted at the General Motors Research Laboratories by Drs. Frederic Matekunas and Edward Groff. Their investigative results have been incorporated into a model that successfully predicts the effect of engine design and operating conditions on power and fuel economy.

The researchers separated their experiments into two phases. In the first phase, they measured turbulence in the engine cylinder; in the second phase, they determined flame speeds over a broad range of operating conditions. Testing took place in a specially designed, single-cylinder engine equipped with a transparent piston to permit high-speed filming of the combustion event.

Hot-wire anemometry was applied to measure the turbulent flows while the engine was operated without combustion. Instantaneous velocities were calculated from the anemometer signals and simultaneous measurements of gas temperature and pressure. More than 400,000 pieces of data were processed for each ten-second measurement period.

The significant measure of turbulence is its "intensity," defined as the fluctuating component of velocity. Because conditions in the cylinder are both transient within cycles and variant between cycles, separating the fluctuating and mean components of velocity is inherently difficult. The researchers overcame this problem by using a probe with two orthogonal wires properly aligned with the direction of the mean flow.



In the combustion phase, tests were performed at over one hundred operating conditions of varied spark timing, spark plug location, engine speed and intake valve geometry. Detailed thermodynamic analyses were applied to the recorded cylinder pressures to calculate flame speeds throughout combustion. High-speed films were analyzed frame by frame to validate flame speeds and to characterize how gas motions influence the initial flame.

The researchers used these measured flame speeds, turbulence intensities, and the conditions under which they occurred to formulate a burning law for engine flames. They divided the combustion event into four stages. The initiation stage begins with ignition and ends as the flame grows to consume one percent of the fuel mass. In the second stage, the flame accelerates and thickens in response to the turbulent field. The third stage exhibits peak flame speed. In the final stage, the thick flame interacts increasingly with the chamber walls and decelerates.

OVER THE RANGE of turbulent intensities encountered in engines, the researchers were able to describe the turbulent burning velocity, S_T, during the critical third stage of combustion with the expression:

$$S_T = 2.0\, S_L + 1.2\, u'\, P_R^{0.82}\, \beta$$

S_L, the laminar flame speed—a known function of pressure, temperature and mixture composition—is the flame speed that would exist without turbulence. The variable u' is the turbulence intensity. P_R represents a pressure ratio accounting for combustion-induced compression of the unburned mixture. The dimensionless factor β accounts for the effect of spark timing on geometric distortion of the flame which occurs during the first combustion stage and persists into the later stages.

The researchers also observed that the burning velocity in the second stage increases in proportion to flame radius, and that in predicting the energy release rate from the burning velocity equation, it is necessary to account for the finite flame-front thickness.

"The form of our burning equation," says Dr. Matekunas, "shows a satisfying resemblance to expressions for non-engine flames. This helps link complex engine combustion phenomena to the existing body of knowledge on turbulent flames."

"We see this extension," adds Dr. Groff, "as a significant step toward optimizing fuel economy in automotive engines."

THE MEN BEHIND THE WORK

Drs. Matekunas and Groff are senior engineers in the Engine Research Department at the General Motors Research Laboratories.

Both researchers hold undergraduate and graduate degrees in the field of mechanical engineering.

Dr. Matekunas (right) received his M.S. and Ph. D. from Purdue University, where he completed graduate work in advanced optics applications.

Dr. Groff (left) received an M.S. from California Institute of Technology and a Ph. D. from The Pennsylvania State University. His doctoral thesis explored the combustion of liquid metals.

General Motors welcomed Dr. Matekunas to its staff in 1973, and Dr. Groff in 1977.

Biomedical Engineering Society

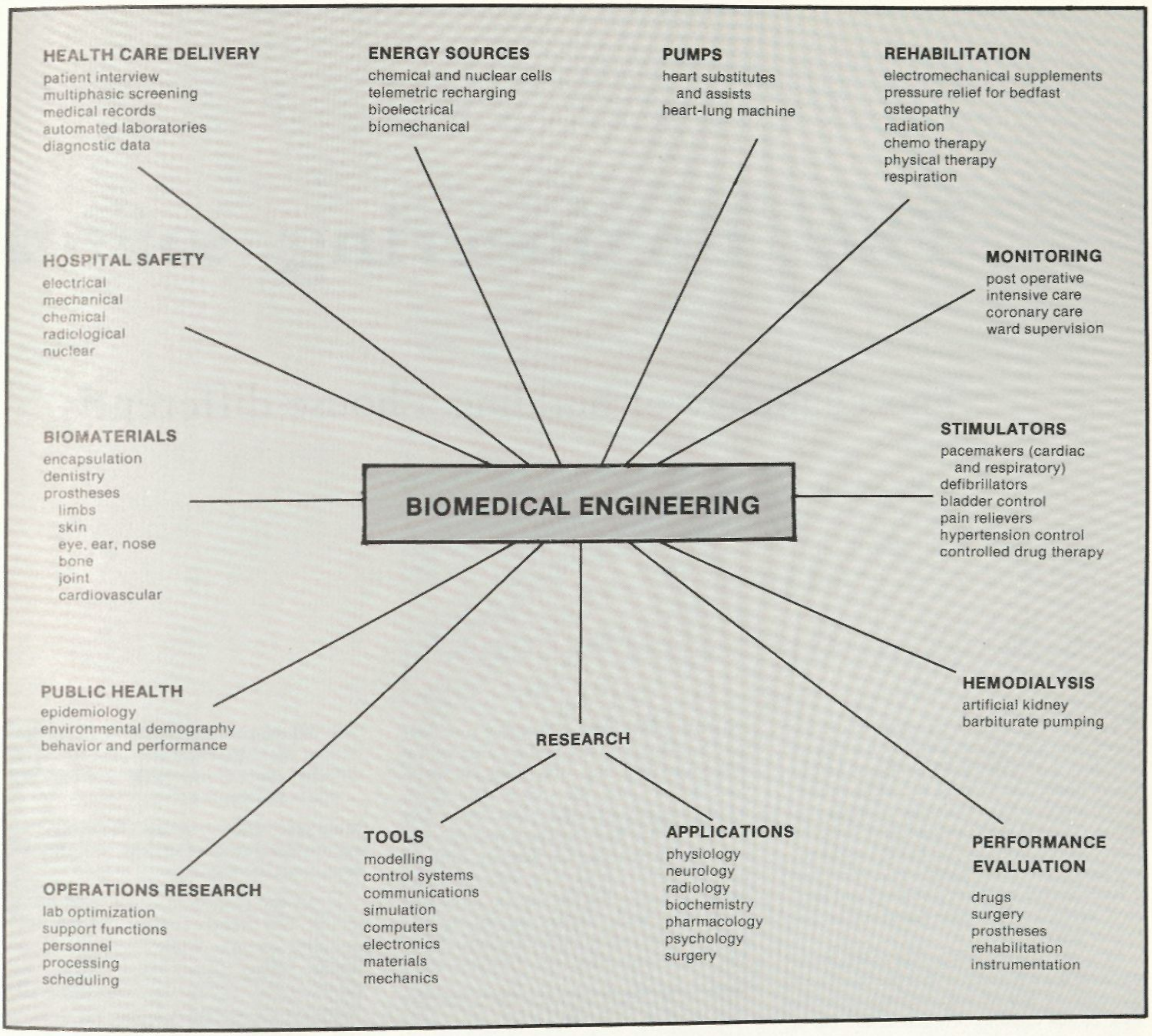
A new chapter of the national Biomedical Engineering Society starts at C.U.

by R. Igor Gamow and Ellice Goldberg

The Biomedical Engineering Society is proud to announce the recent forming of a student chapter at the University of Colorado. Last spring they were involved in jointly sponsoring (with the department of Chemical Engineering) a lively informal seminar entitled, "Einstein-Darwin and Mankind in the Universe". Approximately 120 people attended. The student chapter's primary involvement in the activity included planning the meeting, assisting in advertising and its distribution, and helping with refreshments. The chapter sponsor, Professor Igor Gamow invited the speakers (Prof. J. Dreitlein, Prof. R. McIntosh) and was also responsible for a large portion of the advertising. In addition, he monitored the discussion. This series of discussions is an annual event in the College of Engineering, but it was the first time it was cosponsored by the BMES student chapter, whose president is Lloyd Kenema.

The other officers are Ellice Goldberg, Vice President, Nancy Kemp, Secretary, and Patricia Ormsby, Treasurer. The two faculty sponsors are Professors Neal Kindig and R. Igor Gamow of Electrical Engineering and Chemical Engineering, respectively.

On October 2, 1980 Dr. Henry N. Claman, from our University of Colorado Medical School, gave a talk to the Biomedical Engineering Society entitled "Immunological Regulation." He certainly impressed the society members in presenting the highly complex engineering design of the biological immune system. The fact that three immunologists received the 1980 Nobel Prize further punctuates Claman's enthusiasm. Our third happening was on November 13 when the Acting Dean of the Engineering College, Dr. Frank Barnes, presented a noon research seminar, discussing his research concerning the effect of microwave radiation on biological systems. Dr. Barnes works with two other professors from the C.U. Engineering College, Dr. Howard Wachtel of Electrical Engineering and R. Igor Gamow of Chemical Engineering, and one tired graduate student, Joe Forster. Dr. Barnes' laboratory has recently made the important finding that low intensity microwave radiation changes the electrical characteristics of the nervous system, which cannot be explained as a heating effect. Perhaps the



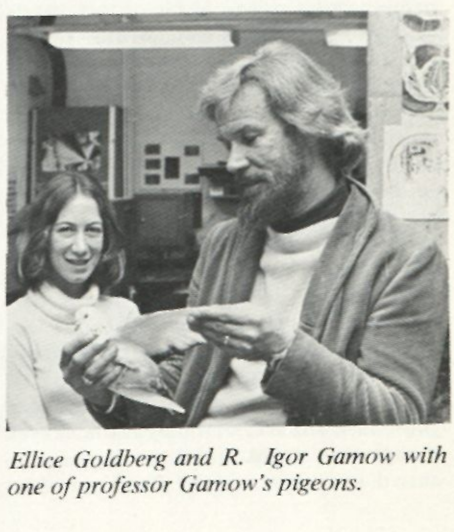
U.S. embassy people in Russia did have a valid complaint. The nervous system that is used in Dr. Barnes' laboratory is the giant Pacific mollusk called *Aplysia.* Dr. Gamow, with another tired Electrical Engineering graduate student Rob Hallgren, has subjected the model sensory system, *Phycomyces,* to low levels of microwave radiation, but to date the "Phyco" shows little or not concern.

It is clear that many modern questions, such as what the effects of microwave radiation on biological systems are, can only be solved by researchers who can handle both the biological and engineering discipline. Joe Forster, an M.S. student in Electrical Engineering, plans to work for a Ph.D. in Physiology; Professor H. Wachtel has a B.S. and M.S. in Electrical Engineering but a Ph.D. in Physiology (Electro-physiology, of course). The society hopes to attract students who are interested in pursuing research careers in bioengineering. The Paths used to reach such research goals are often varied and perhaps even romantic, as is suggested in Robert Frost's poem,

"The Road Not Taken"

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

The above diagram presents a finite set of paths.



Ellice Goldberg and R. Igor Gamow with one of professor Gamow's pigeons.

The Engineering of a

The challenge of building a house differently

by John Kettling

If you want to build a car, such as a Rolls Royce, one part or one assembly at a time, it will cost you $70,000.00 or more before you're done. The average American householder doesn't have that kind of money to spend. The problem with housing today is that, like the Rolls, if you build it by hand, one part or one assembly at a time, you'll pay a Rolls Royce price for your end product. And again, the average American householder can't afford it.

In a traditional house there are many parts to work with at a very premium cost per part—a bill of materials may include over 20,000 custom parts and assemblies at made-to-order prices. Many of these parts are regulated or even mandated by county and state law to the point that there is little room for engineering creativity under the present statute. For example, *Foundations* are still single unit multi-shaped cement or block monstrosities that take forever to put up. Moving cement around in mixer trucks is at best inconvenient and forms can take days to assemble. Many state and county regulations require block or cement—no alternatives allowed. *Interior walls* are governed by center to center stud distances uniform to all wood structures, regardless of other stress control inputs. *Wiring* is still assembled mostly on-site; self contained you-bolt-it kits are not widely available even though they might save huge expenses incurred in custom wiring. *Roof assemblies* are mostly of the one board at a time variety. You'll very rarely find a house with a bolt down single unit roof, though it can be done. and *material calls* are based on what's traditional, not necessarily what's cost and utility-optimal. Building codes specify materials that are in increasing scarcity, difficult to move, impractical to modify with any degree of quality and not always optimal for stress efficiencies. Rafters and tar-shingles don't make the best roofs, and wooden 2X4's don't necessarily make the strongest walls.

. . . shoot and hang the first engineer who comes up with a cost efficient house.

In the final analysis, there is a building code and there are designers. What there should be is a new code and *engineers*, as the last word and authority on how to build.

The problem in home engineering is twofold:

a. arrive at optimal home construction, techniques, materials, costs per part, costs per square foot, etc.

b. sell the government on the advantages of more practical less expensive construction, or bypass the government if it isn't receptive.

More specifically there are 5 basic engineering problems to solve in achieving cheaper, more practical housing:

1. An end to custom on-site part manufacture. Buy over the counter and only final-assemble on site. While this step reduces design variety somewhat there are still plenty of design conscious opportunities for home individualization.
2. Design for joining of major parts, such as wall to wall, floor to wall, roof to floor, etc. Geodesic dome builders have standardization of joints down to a science; other design styles are far behind on this item.
3. Architects and engineers should get together and re-assess square footage needs per person. Many municipalities mandate certain square foot minimums that probably exceed today's real needs.
4. Material calls and specifications should be totally reevaluated. New building materials emphasizing versatility and economy should be identified and put into use. Building codes should be revamped to allow builders to put into use what the engineers identify and prescribe.
5. Bills of materials and overall designs should be worked and reworked toward keeping the number of parts that make up a

House

house down to an absolute minimum. The optimal house is the one with the fewest parts and the most standardization, but with the most creative design at the same time.

So much for pure engineering. There is a more difficult side to this problem (a problem that should be singularly of economic design and engineering evaluation)—that side is government and special interest adversaries.

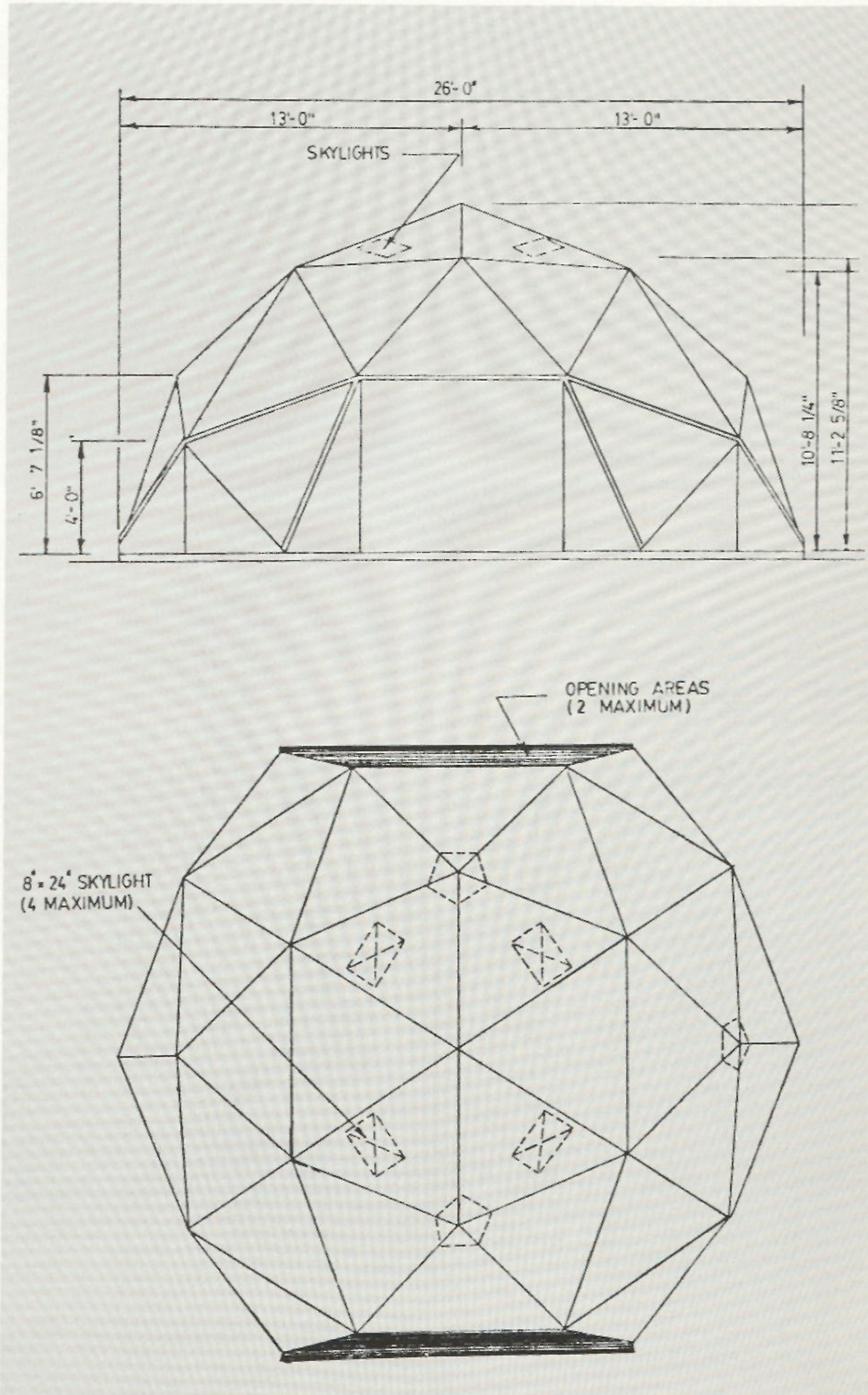
Real estate people, custom contractors with a market, banks, savings and loans, tax assessors and any one else who stands to lose commissions, interest, profits, tax revenues and importantly *authority over the cost of housing* will shoot and hang the first engineer that comes up with the cost-efficient house.

In addition, some builders using new factory-assembly methods and technologies are already tooled to only minimum cost improvements and they're not likely to go with any more changes until they've recovered those tooling costs.

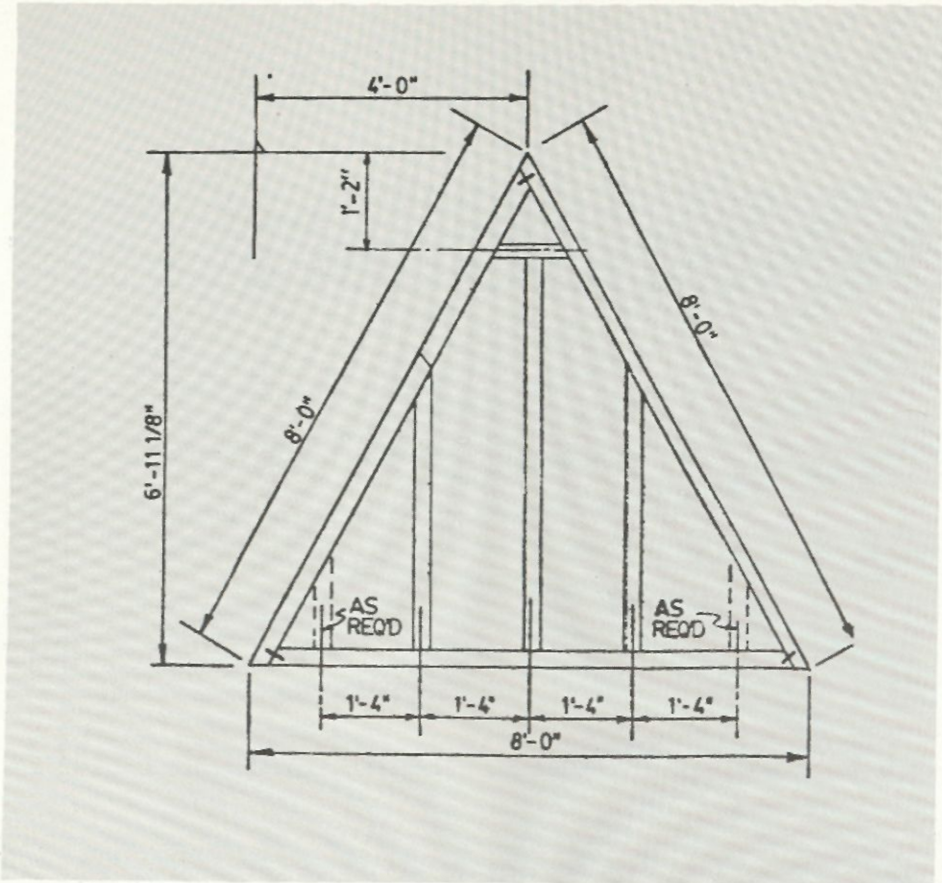
Government officials are not as much adversary by intention as they are adversary by ignorance. Since home construction is governed primarily by uniform building codes. As a result, a home owner with a non-conforming design may be faced with

a. getting a variance
b. getting a county or state law re-written.

Item a. is a lengthy, scary experience not



Triangle configuration for geodesic dome.
All triangles are standardized by size and material.

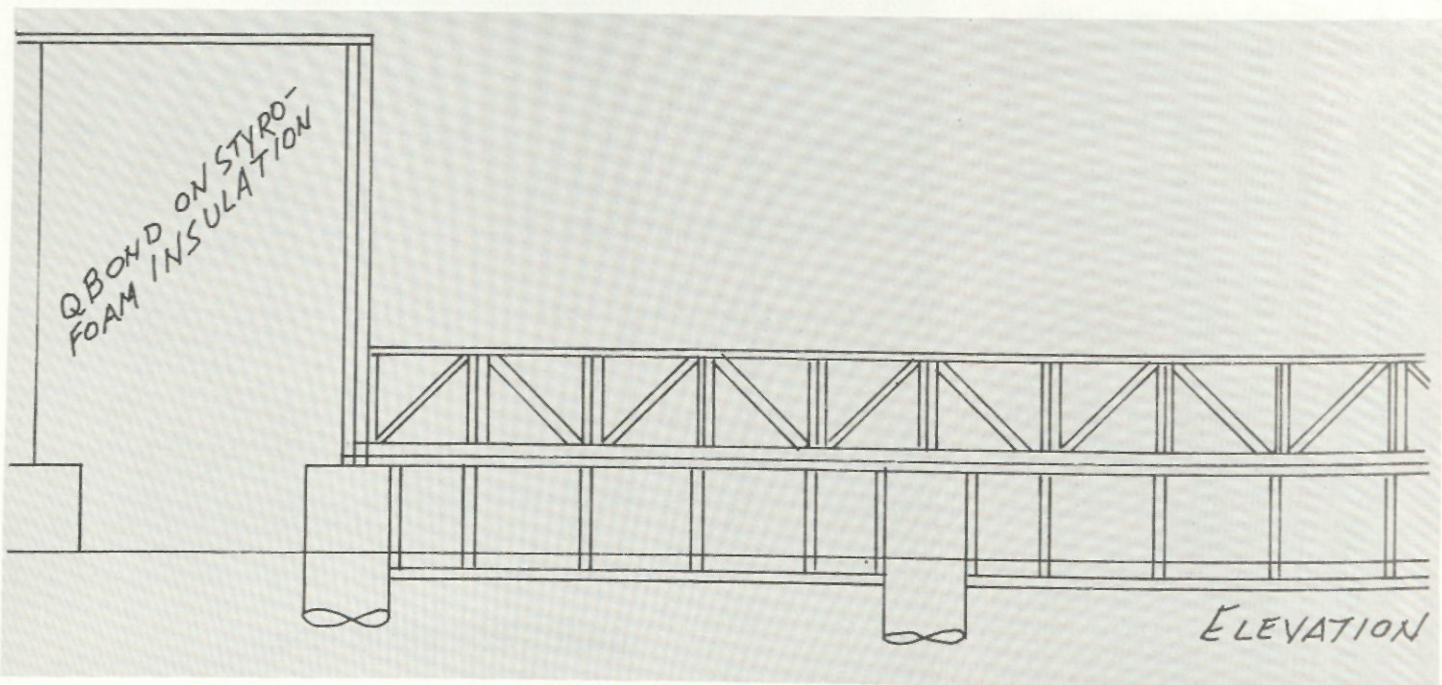


Standard Geodesic Triangle.
Standardization saves cost of custom construction.

always ruled by logic as much as it is ruled by chance. Item b. requires more innovative builders and home investors to hire legislative consuls to get proper legislative initiatives to the proper places. All for a roof and some walls.

There is little room for engineering creativity under the present statute.

A good example of the workings of both items a. and b. occurred on a project in Colorado by the XTC Mountain Corp. involving a variance for pylon foundation construction. XTC principals spent nearly a year on enabling litigation for pylon type construction for a geodesic home with a very low construction budget. The pylon foundation with wood skirting appeared on the preliminary building permit application to be first approved by the subdivision where the house was to be located. It was immediately rejected as a violation of subdivision code. XTC management applied for a variance and at the same time asked for an explanation of the line of thought that was used in developing the rule. If there was no line of thought, then legal counsel for XTC could bring suit. If there was a reasoning then the



The controversial pier detail. Solid concrete replaced by pylons with stucco skirting around wood frame. Item savings: $3500. Item required lengthy negotiation with subdivision and county officials before approval to build was granted.

TAU BETA PI

The Engineering Honor Society

Congratulates Its Fall 1980 Initiates

The Tau Beta Pi Association is a national engineering honor society which recognizes engineering students and alumni who have "conferred honor upon their Alma Mater by distinguished scholarship and exemplary character."

Tau Beta Pi is thriving at the University of Colorado with 60 active members and 45 pledges in the fall class. The Colorado chapter is one of 180 collegiate chapters which have a total initiated membership of over 234,000.

To be eligible for Tau Beta Pi at the University of Colorado, a student must be in the upper one-eighth of the junior class *and* have at least a 3.6 grade point average, or the student must be in the upper fifth of the senior class and have at least a 3.4 grade point average. All members are invited to attend an annual dinner banquet. The banquet this semester included a play, "The King and I" and everyone who attended had an enjoyable evening.

Tau Beta Pi is active in performing worthy causes which promote high standards of quality in the engineering profession. In addition to their banquet every semester, Tau Beta Pi conducts a freshman survey, gives high school tours of the engineering center, and helps keep the engineering center aesthetic. Also, each year the Colorado chapter presents an award to the outstanding freshman engineering student, the outstanding professor for the academic year, and the engineering company of the year.

Scott Allan
Darci Arnold
Keli Brown
Neil Carlson
Roger Carollo
Galen Carter
Richard Chalker
Jim Chapel
Craig Colby
Mark Crook
Seth Darst
Brian Easom
James Fergesen
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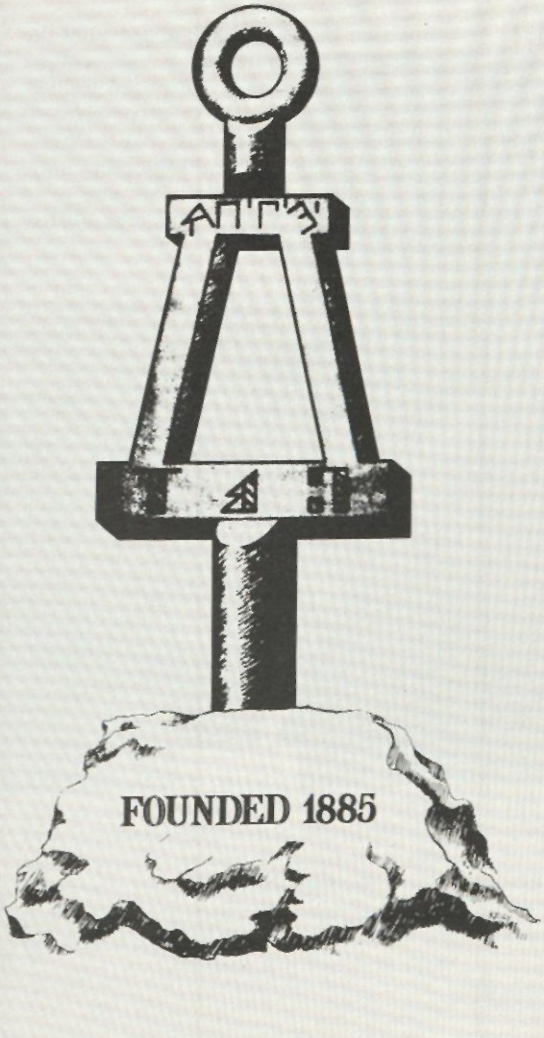

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Terry McEvoy
Scott Mckerman
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Mark Schneider
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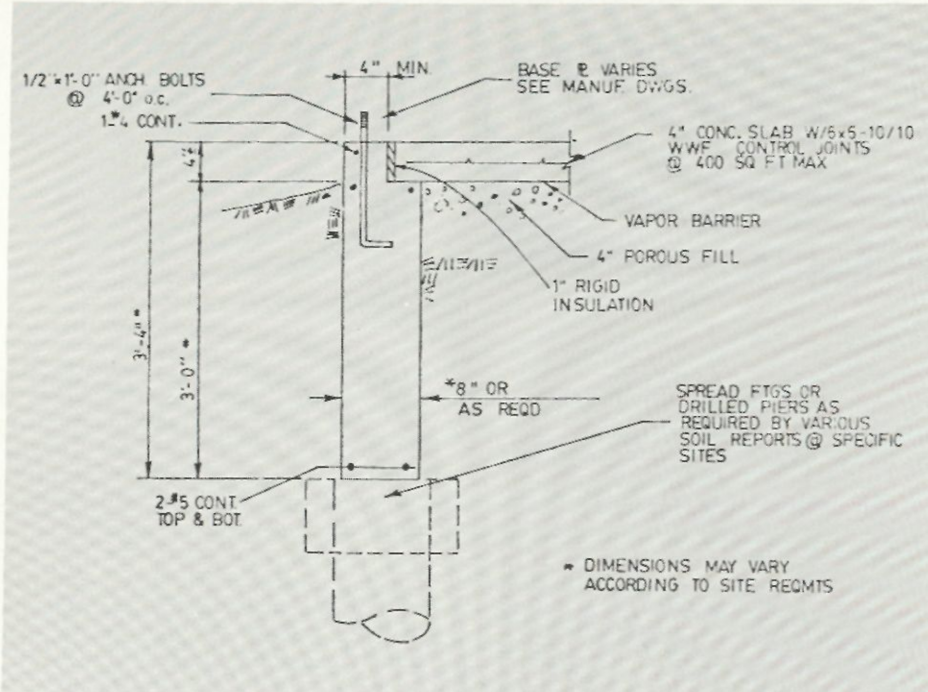


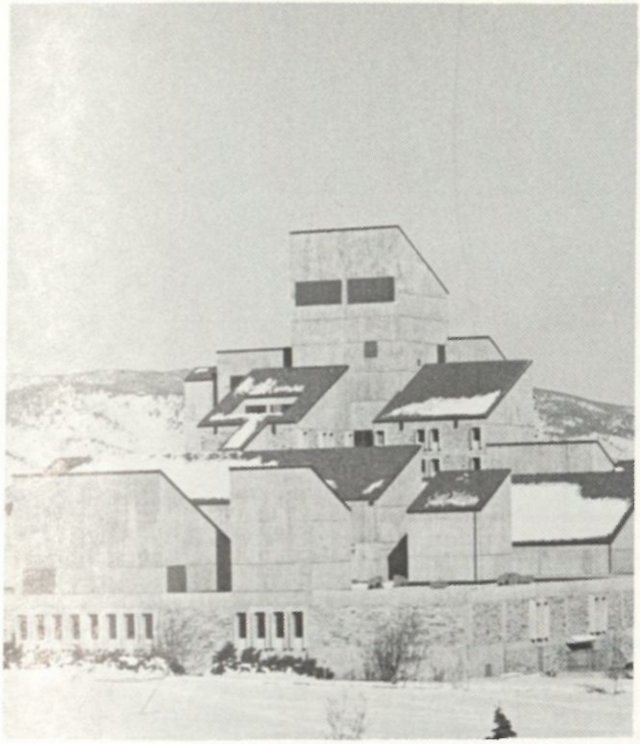
Foundation detail.

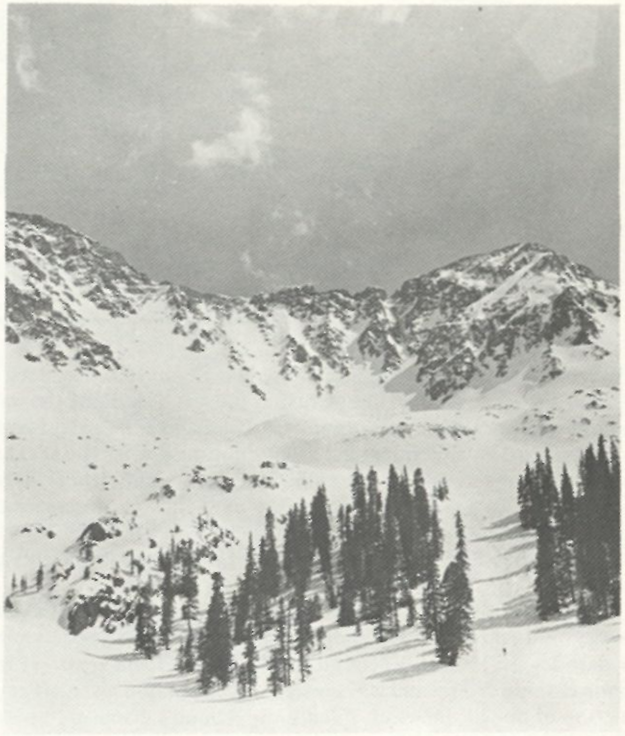
points of that reasoning could become the basis for an "equal or better substitute" variance request. It would then be up to the engineers to prove that skirted pylon foundations were just as good or better than conventional foundations.

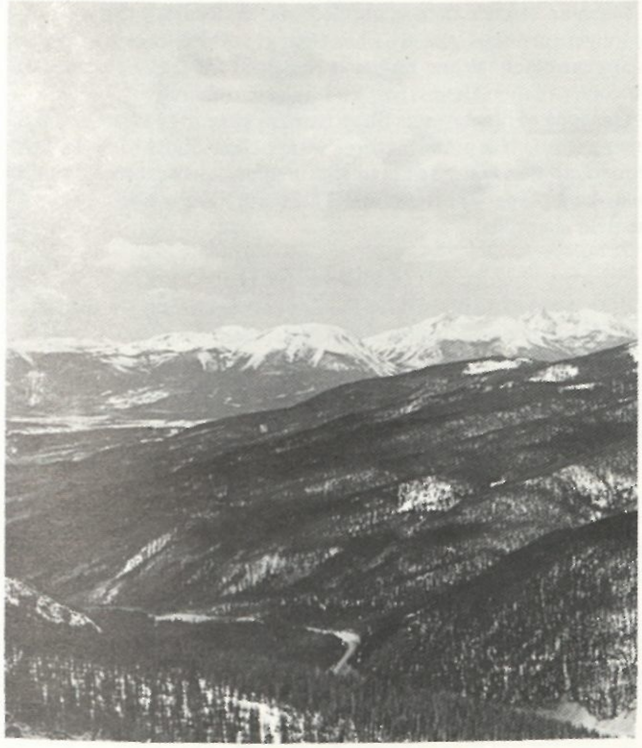
A line of reasoning was presented a few weeks after the original application was rejected. Reason 1: appearance. Reason 2: lack of insulation and potential for heat escape under the house. Further inquiry showed that reason 1 was by far the dominant one, and that the county didn't object nearly as much to this innovative form as did the subdivision. In the meantime XTC engineers began to work with the idea of pylons with stucco instead of wood skirting. This would later prove to look exactly like a conventional foundation from the outside, as well as combat the heat escape problem. The material was also cheap, easy to haul in, and locally available as needed. XTC management decided to approch the subdivision on question 1 only (appearance) and the county on question 2 only (heat escape). By approaching them at exactly the same time a three way, open discussion began on the idea. Unexpectedly, the subdivision approved the idea first, noting the resolution of the appearance question. Question 2 was ignored entirely. At this writing, the county is expected to give approval in a matter of days, having been satisfied with XTC engineering's handling of heat escape by the addition of conventional insulation under the floor.

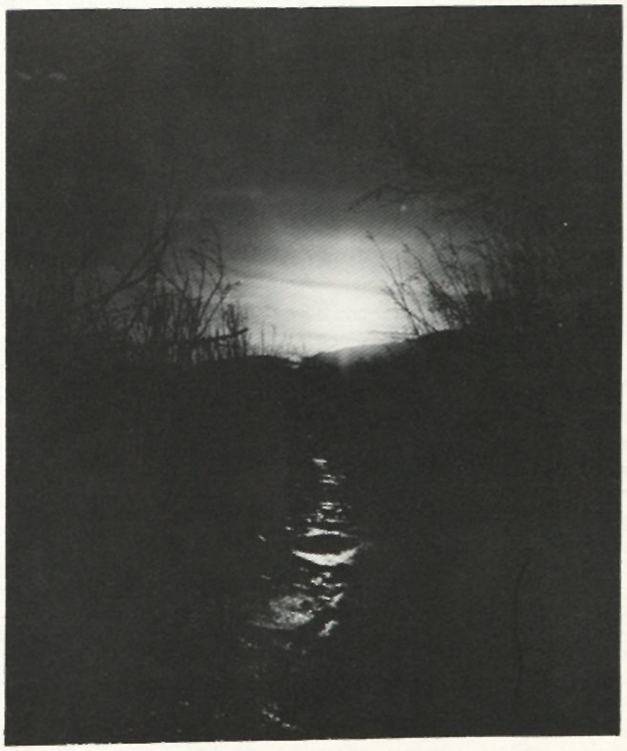
But after the unexpected approval of the variance by the subdivision, members of the XTC engineering team had mixed feelings about the lucky break. One commented, "you know, they never looked at the stress optimizations, or the heat flow or anything. They may have approved it but you get a feeling they didn't want it for anything. They didn't like us at all."

About the author: John Kettling, a former staffer on the Colorado Engineer, is presently legislative consul to the board of XTC Mountain Corp., a real estate investments firm. A Boulder area resident for 15 years, he was involved in many use variance and zoning wars during the growth and re-development of downtown Boulder.



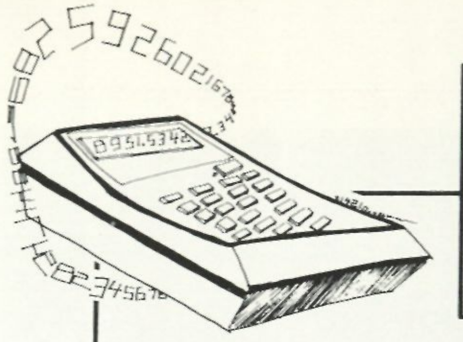






Winter Scenes

Photos by Bruce Murphy



CALCULATOR UPDATE

by Kiyoshi Akima

"There are two ways of spreading light: to be the candle or the mirror that reflects it."

When Edith Wharton wrote these words in 1902, as part of *Vesalius in Zante,* she was unaware that she was describing the ways that our modern calculators, digital watches, and personal information products show their results. Light-emitting diodes (LED's) and fluorescent-tube displays generate their own light, while liquid-crystal displays (LCS's) depend on the ambient light to create the symbols representing numbers or letters.

Since fluorescent-tube displays, at least in calculators, are a vanishing breed, this article will concentrate on LED's and LCD's.

Although both LED's and LCD's have been available for calculator use only recently, their underlying principles have been known for decades. In 1907 H.J. Round touched wires from a battery to a silicon carbide crystal and was greeted by yellow light given off at the junction of one of the wires. Eventually Round's discovery became the basis for today's LED.

Some of the properties of liquid crystals were known even earlier; in the late 19th century experimenters noted that these complex organic substances behaved like liquids, but their molecules also aligned themselves into crystalline lattices. Later, scientists discovered that the lattices of some liquid crystals to be affected by an electrical field, and that these lattices could also alter the transmission of light.

The Light-Emitting Diode

Any ordinary semiconductor diode, even the old geranium "cat's whisker," gives off a small amount of infrared light when the proper voltage is applied. But most commercial LED's are made of gallium arsenide (GaAs) or gallium arsenide phosphide (GaAsP) since they emit visible light and because they are fairly efficient as such light sources go.

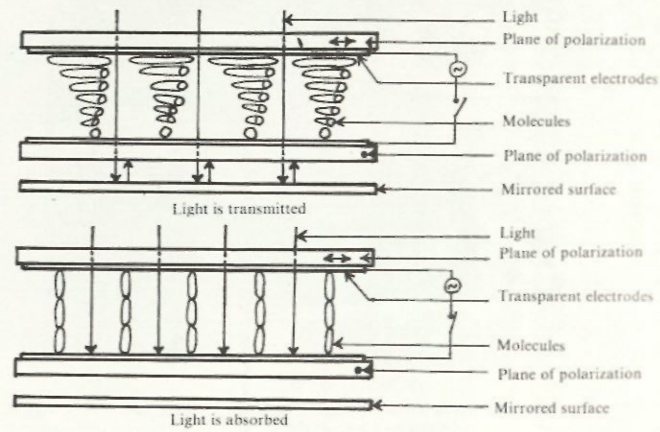
Like any diode, the LED consists of two regions of similar material, an *n* region, whose molecules have excess electrons in their outermost shells, and a *p* region, whose molecules have a deficiency of electrons (or "holes") in their outer shells. When the proper drive voltage is applied, electrons in the *n* region migrate to the *p* region. As they recombine with the "holes" in the *p* region that give up energy, and in the LED this energy is emitted as light.

Unlike an ordinary light bulb, the LED does not require a vacuum, and it generates light without much heat. In addition, even the small segments used in calculators are tough and shock-resistant.

The Liquid-Crystal Display

The *field-effect* display, used in many calculators, employs polarized light. When two polarizing screens are arranged so that their planes of polarization are the same, light is transmitted through the screens. If one of the screens is rotated 90 degrees, light polarized by the first screen is absorbed by the second, and the screens appear black.

In the twisted nematic field-effect display, a thin film of liquid crystals is sealed between two sets of polarizing screens and transparent electrodes, after the opposing plates have first been chemically treated so that the molecules align themselves with their long axes at 90 degree angles, as in the figure. This alignment causes the polarized light from the first screen to be rotated before it reaches the



second screen, and the light is transmitted completely through the display.

When an electric field is applied, the molecules untwist and they no longer turn the light, which is then absorbed, causing the display to appear black. When power is removed from the electrodes, the molecules realign themselves and light is transmitted again.

This type of display acts like a camera shutter, passing the light or cutting it off. If a manufacturer wants clear digits on a dark background, all that is needed is to rotate one of the screens so that both polarizing planes are the same. This way, light is passed only when the field is applied.

LED vs. LCD

Both types of displays have their advantages. There are differences in performance and application that should be noted.

One difference is the matter of light and dark. An LED display, being a light source, is easier to read the dimmer the ambient light is. The light-emitting diode is bright and distinct on even the darkest of nights.

The LCD, on the other hand, uses available light; the more ambient light that strikes it, the darker and more distinct the display becomes. This can be an advantage outdoors and on a bright sunny day, but in a normal classroom situation both types of displays are easily read.

Another difference is in power consumption. Most of the power in a calculator is usually used by the display. The LED can consume many milliwatts of power, while the LCD can get by on a few microwatts.

Next?

Researchers at Bell Labs have developed a clear film of an iridium compound, which changes color when a short electrical pulse is applied. The film remains opaque for hours with no energy applied, and switches back to clear with a short pulse of opposite polarity. The switching speed is as good as that of LCD's, and cost is expected to be low due to the simple support circuitry and the small amount of iridium. So be on the lookout for "ID's."

"PEOPLE WHO READ THE COLORADO ENGINEER ARE IN A CLASS BY THEMSELVES"

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News News

HOW ETHICAL ARE ENGINEERS?

NEW YORK—How ethical are today's engineers? Since chemical engineers face ethical situations every day and their decisions have a direct bearing on the public, their ethical stances are important. *Chemical Engineering* magazine, a McGraw-Hill publication, reports in its current issue the results of a survey showing that engineers are concerned with ethics in their jobs, but that a need exists for a better code of ethics, improved ethics education and more corporate involvement in solving the ethical problems of engineers.

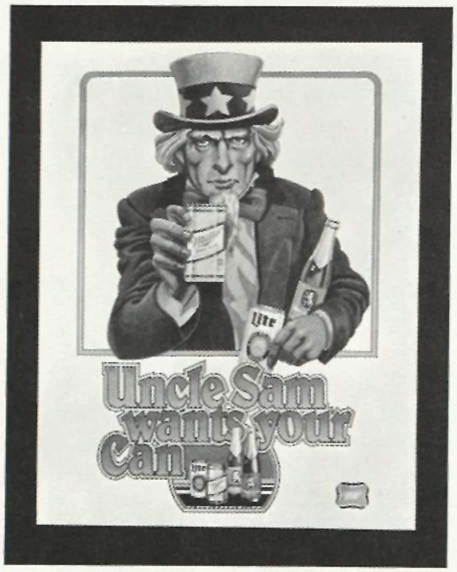
Chemical Engineering's ethics survey presented nine hypothetical cases—such as whether to add recognized poisons to food products—and asked the magazine's engineering audience to identify the most ethical course of action in solving each problem.

An unprecedented 4,348 responses were received from engineers worldwide. The voluminous response and the diversity of answers prompted *Chemical Engineering's* editors to recommend these actions to improve ethics in the engineering profession:

- Revision of ethics codes to reflect the fact that most engineers work for corporations, not as independent consultants.
- Inclusion, in any code, of guidelines for the application of the code's principles.
- Provision of a hierarchy of code principles, so that an engineer can tell which take precedence when there is a conflict.
- More corporate involvement in solving the ethical problems of employee engineers. Not only would this help the engineers, but it might help corporations in coping with problems of legislation and product liability.
- Further education of both engineering students and engineers.

Although the *Chemical Engineering* survey shows diversified points of view, it is encouraging to note that most engineers will not keep quiet about oil spills or add harmful materials to products.

And how ethical are engineers compared to other professionals? *Chemical Engineering's* readers were also asked to rate the ethics of other professional groups. The results show that engineers think that clergymen and chemists are the "most ethical" professionals, while ranking politicians and TV reporters the lowest on ethical conduct.



WE WANT THAT BEER CAN

MILWAUKEE—The Miller Brewing Company has added a weekly cash payment provision and increased the value of the prizes awarded in its 1980 College "Pick 'Em Up" reclamation program, Thomas B. Shropshire, Senior Vice President and Treasurer has announced.

Shropshire said: "The change should stimulate further competition among college groups and result in a record number of recycled cans and bottles. It will further enhance Miller's commitment to a clean environment by stimulating interest in our collegiate reclamation program."

Since its inception in 1973, students participating in the program on campuses around the country have collected more than 33 million pounds of aluminum cans and 17 million pounds of bottles.

The Miller Brewing college program, which began at three universities, is now conducted on over 350 campuses, with many of these participating in the popular "Pick 'Em Up" program. The program is part of Miller's overall effort to help reduce litter and conserve energy. The company and more than 700 of its distributors operate reclamation centers which, in 1979, collected more than 33 million pounds of aluminum beverage cans.

Miller's Pick 'Em Up contest is open to any recognized campus organization in states where the program is legal. Groups are awarded one point per pound of bottles collected and 10 points per pound for aluminum cans collected each week. Points are accumulated at the conclusion of the contest, which ends one week before final exams. Groups participate in two divisions—one for fraternities and the second for sororities, dormitories and other campus organizations.

Participants in the current contest are eligible to receive such prizes as a wide-screen television, a deluxe stereo component system or 12-piece bar set if they accumulate 7,500 points; a video cassette recorder, component stereo system or color television if the group accumulates 3,000 points; and a washer and dryer, microwave oven or icemaker if the group collects 1,500 points.

In addition, groups will receive the current cash value for aluminum turned in, Shropshire said.

A HYBRID ELECTRIC FOR THE 80'S

General Electric Company has organized a team of leading automotive and technology firms from the U.S., West Germany and Japan to produce two advanced hybrid automobiles for the U.S. Department of Energy (DOE).

The experimental vehicles, to be ready for testing late in 1982, will have both a gasoline engine and an electric motor under the hood. They will run part of the time on gasoline, part of the time on batteries, and—when needed—on both simultaneously.

The GE Research and Development Center, Schenectady, NY, is prime contractor for the $8 million project, which will see construction of a pair of four-door sedans seating five adults.

This contract is part of an overall DOE

program aimed at stimulating commercialization of electric and hybrid vehicles as a means of reducing U.S. petroleum consumption. GE's hybrid design, for example, is expected to consume from 40% to 55% less petroleum than a conventional car of similar size over an 11,000-mile annual driving mission.

GE will provide expertise on the electric propulsion motor, the electronic controls for the motor, and the microcomputer controls for the entire hybrid system. Last year, the company delivered to DOE the Electric Test Vehicle-1, the nation's most advanced experimental electric vehicle.

Major subcontractors are Wolkswagenwerk, AG, Wolfsburg, West Germany, which will design and build the specially modified gasoline engine; Globe-Union Inc., Milwaukee, WI, which will develop the 12-volt lead-acid batteries that will power the electric motor; and Triad Services, Inc., Madison Heights, MI, which will design and fabricate the body and chassis.

Both Globe-Union and Triad worked with GE previously, in similar roles, in developing the ETV-1, as well as the GE-100—an electric test car built in 1978 from off-the-shelf components.

Daihatsu Motor Co. Ltd., Japan's leading manufacturer of battery-powered vehicles, will serve as a consultant on the project.

"The hybrid car is designed to minimize trips to the gas station and maximize the use of the wall plug for the typical American driver," Dr. Roland W. Schmitt, GE vice president for corporate research and development, pointed out. "Its major advantage is that it burns less gasoline then conventional cars, but offers a much greater range than all electric vehicles," he added.

The hybrid's 40-horsepower electric motor and 80-horsepower gasoline engine will operate separately or in parallel. The electric motor will primarily be used for speeds from zero to 30 mph and the gasoline engine for most highway driving. In situations where both the electric motor and the gasoline engine are needed, such as in passing, the load will automatically be shared. A microcomputer will control overall vehicle operation.

GE engineers estimate that the experimental hybrid auto will accelerate from zero to 50 mph in 12 seconds and will look, perform, and handle like conventional vehicles that will be marketed in the mid-1980s. Its design is planned to be suitable for mass production in the mid-1980s at a consumer price of about $7,600 (1978 dollars).

VOLCANIC DUST GETS GLUED DOWN

BELLINGHAM, WASH.—Some 4,500 square miles of Pacific Northwest land impacted by fine volcanic dust from Mt. St. Helens provided a dramatic demonstration of dust control with diluted lignin.

State and other officials using liquid lignin donated by Georgia-Pacific Corp. here "to help settle the problem" praised results as they attacked up to seven dry tons an acre of fine dust which blinded and halted traffic and killed machinery in some of its worst concentrations.

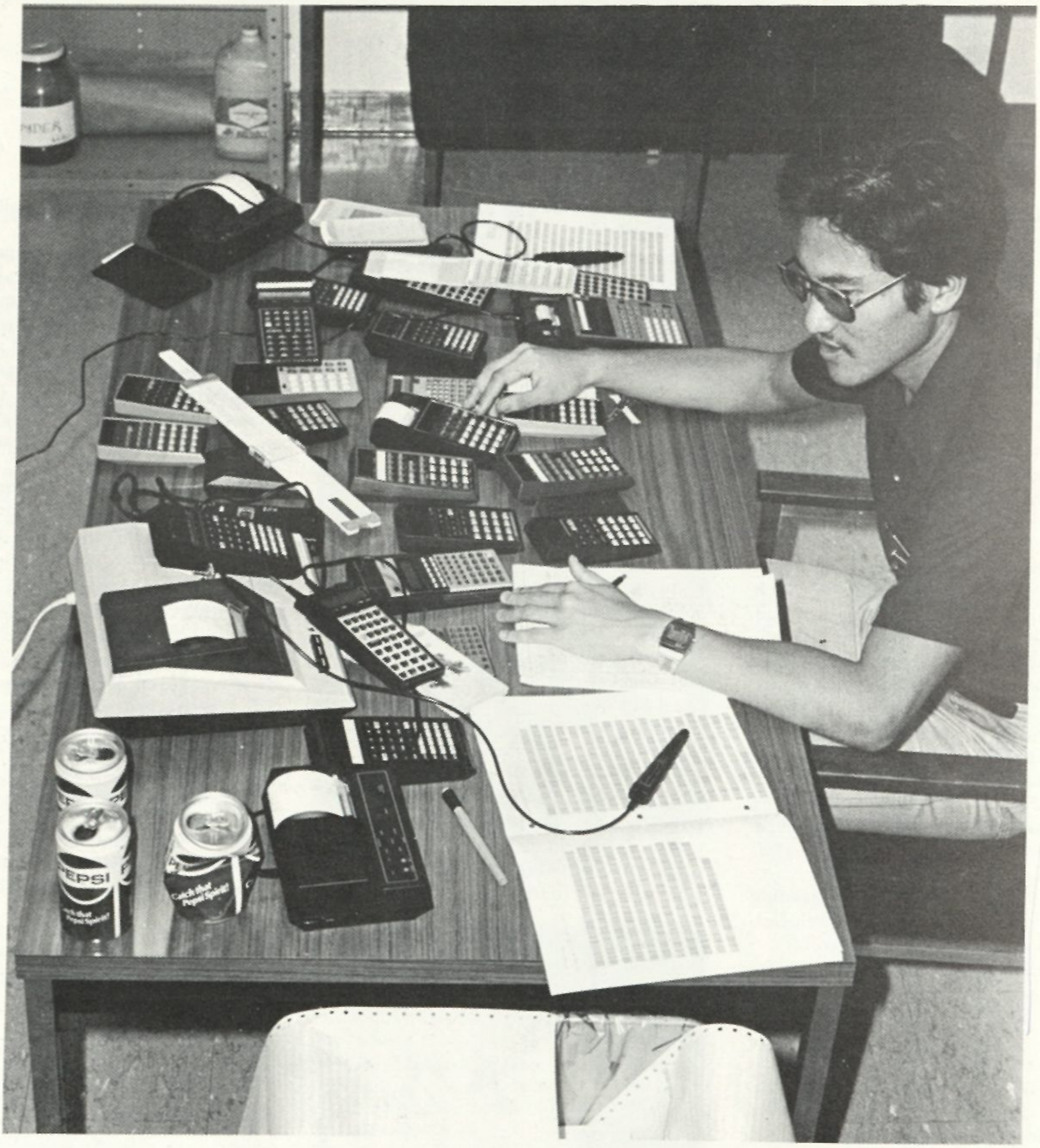
Lignin, the "glue" which holds cellulose fibers together in wood, is freed in the paper pulping process and has been employed for years for road binder as well as other beneficial uses. G-P volunteered "up to 100,000 gallons" gratis to the state, which, when diluted would make 200,000 gallons for dust arrest.

Initially G-P readied shipment of 10,000 gallons each to the four hardest-hit highway divisions, transported by company trucks. The state had up to 1,500 miles of highway shoulders, gullies, equipment storage yards and rest areas it wanted to treat quickly. The Port of Portland, Portland, Ore., also received 10,000 gallons of free lignin from G-P to lay dust in its ship repair yards and other active areas.

Both the State of Washington Department of Transportation and the Port of Portland have told G-P that the use of lignin has now been included for purchase in their standby emergency plans for response to any future eruptions of Mt. St. Helens or other latent volcanos in the Cascade chain.

GOT A FUNNY STORY?

The Colorado Engineer magazine is looking for amusing anecdotes and stories from engineering labs and classes. They are to be published in the Oil Can Society pages. Bring or send yours to the Colorado Engineers editorial offices, ecot 1-8. You can save a stamp if you use campus mail.



" I told my professor I didn't need to use the computer!"

FINAL ANALYSIS