The COLORADO Engineer

SUMMER 1980

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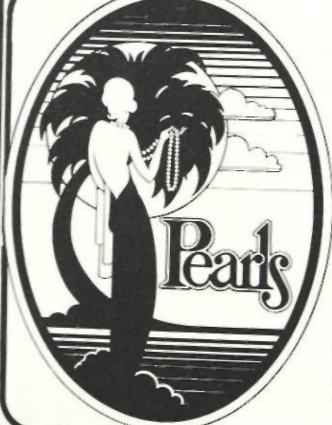

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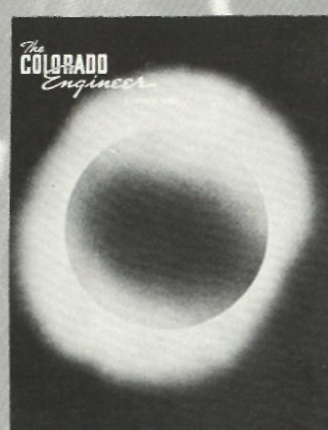
FEATURES

DEPARTMENTS



COVER

Our cover photo this month depicts a total eclipse of the sun. Under normal conditions, the sun offers an unending supply of energy. However, the photo indicates that the sun is not always shining, especially when the moon blocks it. For a continuation of our article, "Geosynchronous Satellite Power," turn to page fourteen. The photo was taken at f8, 29 secs.

published since 1904

The Editor's Outlook

On the Way Out

I think the toughest time of the year is right about now. The sun is shining, the birds are singing, and the hormones are shifting you into second gear with no place to go. But, alas, we must all trudge off to take our finals whether we like it or not. That is unless you are a senior. We all know how seniors have a way of squirming out of those last semester finals. But, don't feel too bad campers, we seniors get to sit through the eight hour PE exam. I guess it all evens out in the end.

Speaking of the end, at this time of the year, the *Colorado Engineer* magazine chooses its major staff positions for the fall. Naturally, this leaves all sorts of entry level positions open. So if you believe in, "Out with the old and in with the new," come and visit us in OT 1-8, and we will tell you all about magazine work. You will learn all about the business world and gain some friends that will last longer than those dorm acquaintances. It's fun work, and it is very gratifying to see your effort in print.

Now that the pleasantries are out of the way, it is time to get down to business. I am very disappointed in the state legislature for what they have done to this school. In just the four years that I have been here, I have seen the quality of my education drop down to rock bottom. I have seen some classes double in size, and I have witnessed some of the best professors I have ever had leave the school. It is in short, disgusting.

As the editor of this magazine, I honestly believe that the number of national recruiting ads we get is in direct proportion to the quality of this school and the quality of the magazine. The magazine was judged this year to be the second best magazine in the country, and we receive about thirty ads a year. The first place magazine receives about *sixty* ads a year. Of course there is some relation to school location and size, but this large difference can only be attributed to the advertiser and his opinion of our school. I'll let you put two and two together.

Perhaps I'm just a little upset about where the money goes in this University. Thank God that we have a multi-million dollar basketball arena and we didn't force those people to donate their money for lab equipment. Praise Heaven that we spend money to allow our Kampus Kops to roam around off campus instead of improving our athletic fields. Lastly, I'm just thrilled about the UCSU and the way they spend our money on full page ads protesting the draft.

Well now that I've had my say, I hope someone will take some action. It's about time that more alumni from this school take an active interest in the College of Engineering and direct it towards a brighter future. Once we have accomplished this, perhaps the college will get a little more recognition and we will get a few more ads.

Terry Clark

Staff

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Ski Lift Technology

The LSM 100 provides an effective way of increasing skier safety

By Paul Jurata

Technology for transporting skiers up the mountain has progressed considerably from the days of the early 1900's where a few rope tows pulled skiers up the mountain past rickety wooden towers to today, where high speed trams, like the one at Snowbird, can transport 125 skiers over 2900 vertical feet in less than 8 minutes.

Today's ski lifts are sophisticated, elaborately engineered electro-mechanical systems that can cost upwards of a million dollars and often transport over 8000 skiers a day. Yet as with any electro-mechanical system ski lifts are susceptible to failure, failures which can result in disaster. In the May 29, 1976 accident on Vail's Lionshead Gondola II, a failure in the lift system resulted in the deaths of four people and the injury of eight others, some seriously, as well as causing thousands of dollars in damages to the lift system equipment.

In an effort to improve ski lift safety and operation, Keystone Ski Area and the Electrical Engineering Department at the University of Colorado-Boulder have joined efforts to develop a new electronic monitoring system that will safely diagnose malfunctions and potential problems on ski lifts. The new system will identify a malfunction and automatically shut the lift down when necessary. In addition, it will provide the ski area personnel with a thorough and efficient means of testing the ski lift's operation.

Under the supervision of Dr. Frank Barnes, Chairman of the Department of Electrical Engineering, Paul Jurata and Tim Mills, both seniors in Electrical Engineering at the University of Colorado, embarked on the development of the lift safety monitoring system (the LSM 100) in May of 1979. During the development period, a close-knit working relationship was maintained with Keystone Ski Area and the system's designers.

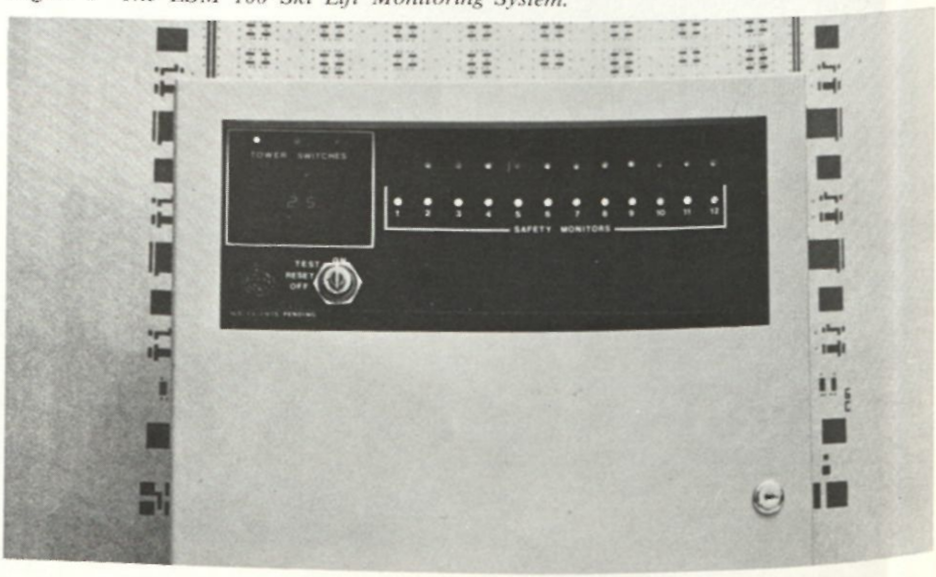
Supervised by Keystone's head engineer, Tom Lawrence, Keystone provided unlimited and invaluable input to the features and operation of the LSM 100. Keystone's input allowed Jurata and Mills to optimize the system for the exact requirements of the ski industry and the operating personnel. Keystone ultimately provided the testing grounds for the prototype and final designs. Presently, two systems are being field tested, one at Keystone Ski Area, and one at Arapahoe Basin.

The LSM 100 has two major functions: (1) derailment detection and tower identification; and (2) monitoring of safeties, the electro-mechanical subsystems whose proper performance is essential for safe operation of the ski lift. A derailment, or malfunction in any of the lift's subsystems, will be identified by the LSM 100, which immediately stops the lift and provides the operator with a visual indication of the nature of the problem. The LSM 100 was designed to be compatible with any type of new or existing ski lift whether a gondola, chairlift or tram.

Derailment Detection and Tower Identification

A derailment is probably the most serious malfunction that can occur on a ski lift. The load bearing cable is supported on towers periodically placed along the tower line. Two

Figure 1 *The LSM 100 Ski Lift Monitoring System.*



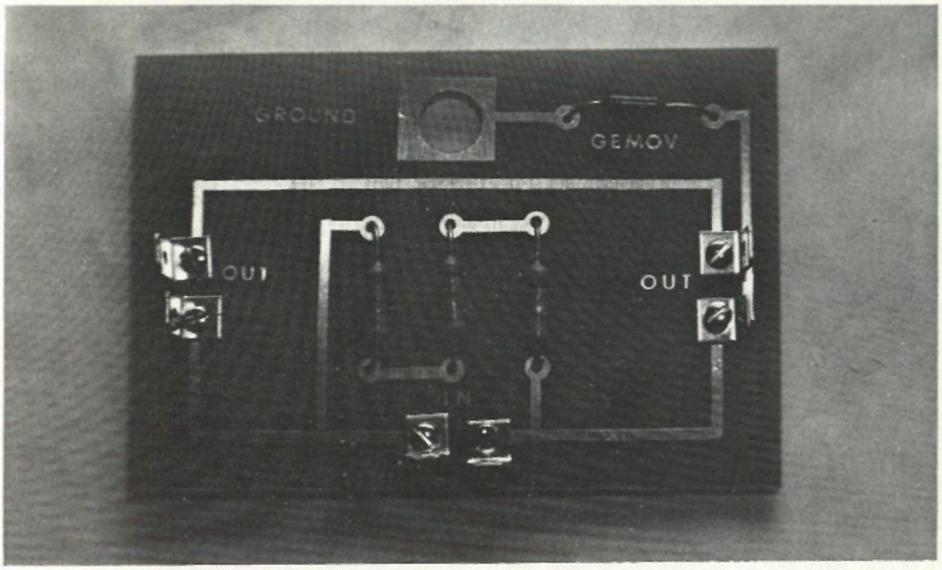


Figure 2 *A printed circuit board with a unique impedance is placed in each tower for identification.*

sets of pulley mechanisms, one for the uphill travel of the cable and one for the downhill travel of the cable, allow the cable to move freely over the tower supports. A derailment occurs when the cable comes out of either mechanism and falls into or completely off of the tower structure, possibly causing the passenger carrier to strike the ground. In either case, the derailment can result in death or serious injury, and may cause considerable damage to the lift system equipment.

In order to safely deal with a derailment ski areas must be able to detect the problem and immediately stop the lift. According to Keystone engineers, failure to stop the lift within a quarter of a second might allow enough time for the chair to be severed from the support cable. Still another complication: even if the derailment is successfully detected and the lift is shut down, repair crews, and in some cases medical aid, must immediately be dispatched to the site of the derailment. The question still remains, where, on what might be close to a mile-long lift, has it occurred?

Present standard procedure for most ski areas is to have ski patrol ski the lift line and visually sight the derailment. The time it takes to have the ski patrol check the tower line may be the precious few moments required to save the life of an injured victim. Even if no injury has occurred the prolonged down time required to make repairs deprives skiers of the recreation they paid for, and quickly cuts into ski area profits.

A careful analysis of derailment conditions and the procedures required to efficiently deal with them was made by the designers and Keystone personnel. It was concluded that the LSM 100 would have to be able to detect a derailment, shut the lift down within 250 milliseconds, and provide the lift operator with the exact tower number where the derailment occurred. In addition to these requirements, derailment and tower identification had to be accomplished using a single two conductor circuit which would run the full length of the lift. The system would also have to be immune to the harsh weather conditions that occur in the winter and the severe lightning that often occurs during the summer.

. . . derailment can result in serious injury, or death, and may cause considerable damage to the lift system equipment.

Derailment and tower identification are accomplished by using an impedance sensing circuit. Mounted inside each tower is a small printed circuit board with a unique impedance representing the identity of that particular tower (see Figure 2). Potential for lightning damage prevented the use of more sophisticated electronics on the individual towers. Located on the pulley mechanisms of each tower are derailment sensors that detect separation of the cable from the pulley mechanism. Sensors from the two mechanisms are wired in series with each other and in parallel with the impedance on the printed circuit board in the tower. Thus when there is no derailment (an OK condition), the sensors will short circuit the impedance of each tower board and the detection line will appear as a closed loop with an impedance of 40 to 70 ohms. In an OK condition, a green status LED on the front panel of the LSM 100 will be illuminated (see Figure 3).

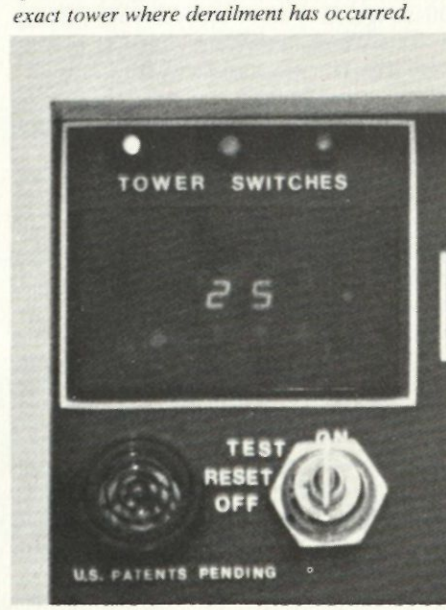
If a derailment occurs on a given tower the sensors shunting the impedance will open. At this point the sensing circuit would see the additional impedance of the specific tower where the derailment has occurred. The LSM 100 immediately shuts the lift down and by decoding the impedance, identifies the tower number and displays it on a digital readout. In the derailment condition a red status LED will be illuminated. The lift is then stopped and the lift operator can dispatch repair crews and first aid to the exact location of the derailment.

The harsh weather conditions that prevail during the winter often causes short or open circuits in the detection line which runs the full length of the lift. With the systems presently being used, a short or open circuit in the detection line may result in a derailment condition going undetected. Supervision circuitry within the LSM 100 readily detects open or short circuits in the tower line and notifies the operator.

A combination of the severe vibration that is present on the lift towers, and the changing weather conditions, may cause individual derailment sensors to develop intermittent malfunctions. On present systems these malfunctions can erroneously indicate a derailment and because of their intermittent nature are extremely difficult to locate and repair.

The LSM 100 incorporates a time window circuit which can indentify such intermittents before they are severe enough to shut the lift down.

Figure 3 *LED status indicators notify operator of a derailment condition. Readout indicates exact tower where derailment has occurred.*



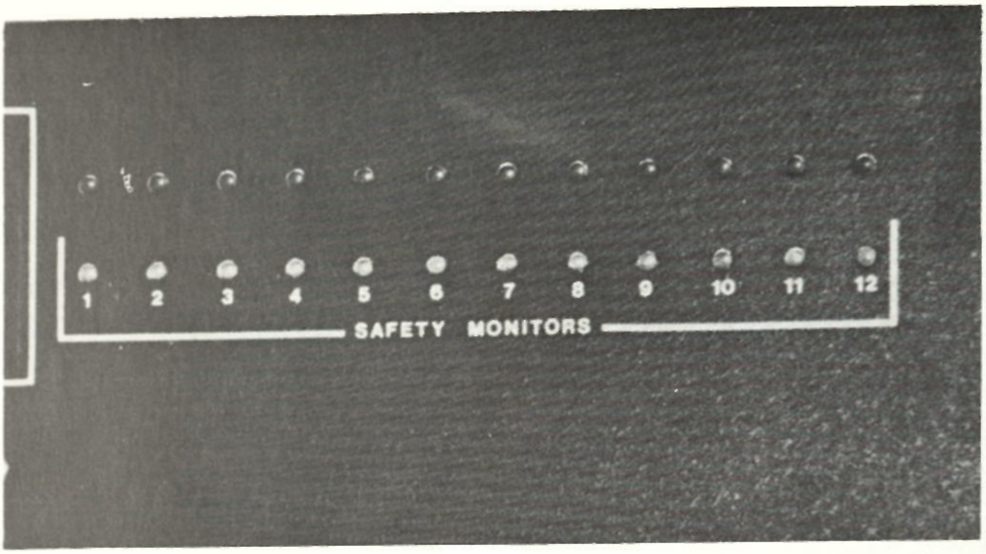


Figure 4 *LSM 100 has capability of monitoring up to 12 individual safeties. LED status indicators keep the operator informed of the status of each safety.*

Monitoring of Safeties

Monitoring of individual safeties constitutes the second major role of the LSM 100.

The safeties that require monitoring vary depending upon the specific lift system design, but almost all lifts will require monitoring of emergency brakes, safety gates, emergency stop buttons, motor temperature, AC-DC power conversion and cable tension. If any of these subsystems should malfunction the lift must be immediately stopped and the problem corrected. While the present monitoring systems at most ski areas will shut down the lift if a malfunction occurs, they cannot efficiently diagnose the nature of the trouble.

Through the use of CMOS logic the LSM 100 is capable of monitoring and identifying twelve individual safeties. Each is represented by a pair of green and red LED status indicators on the front panel (see Figure 4). When installed the LSM 100 is in plain sight of the operator running the ski lift.

When an individual safety is in an OK condition the corresponding green LED will be illuminated. The lift can only be operated when all twelve green LED's, as well as the green LED of the derailment and tower detection feature, are illuminated. If a malfunction of one of the safeties occurs the green LED goes out, the red one lights and the lift stops. With a glance at the front panel the operator can immediately identify the malfunction. When the problem is corrected the green LED will light and the operator will be able to reset the LSM 100 and start the ski lift. In this way operation can be resumed with minimal delay, and annoying down time is reduced.

The test circuitry of the LSM 100 allows the lift operator to thoroughly test out each safety, and test derailment and tower identification features, each morning before opening the ski lift to the public. When the system is in test mode the operator can walk around the lift equipment to test the different safeties. Because the operator may be out of sight of the front panel an audible tone is used to indicate the exact condition of the safety as it is tested.

The test mode is also useful to maintenance personnel who can, without the use of additional test equipment, check the performance of various sensors as well as verify the continuity of safety wiring throughout the lift.

Special Features

In light of the harsh operating environment that the LSM 100 would be subjected to, as well as the extremely high reliability required, several special features were included in the design.

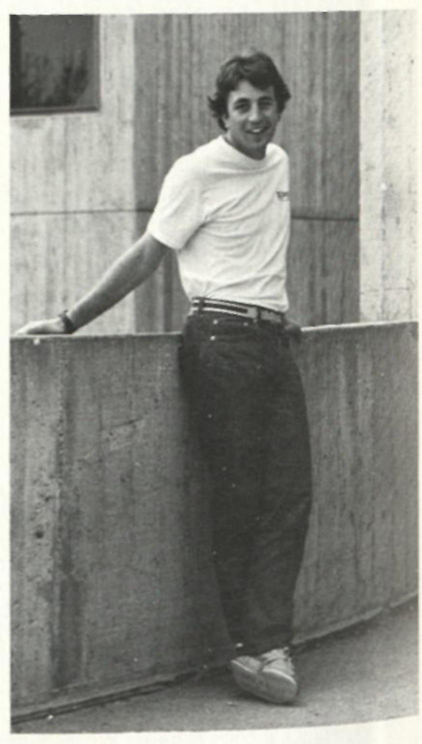
The safety monitor circuits, as well as the derailment and tower identification circuits, use high reliability, military standard components. These must meet the same rigid standards as the components in military weaponry, which includes an operating temperature range of -56°C to 125°C.

The summer months often bring severe lightning to the mountains. To protect the electronics of the LSM 100 from lightning as well as other voltage transients which may be caused by high voltage lines operating in the vicinity, metal oxide varistors were placed on all inputs and outputs. The field testing has proven this technique extremely successful.

If a power failure occurs almost all ski areas can operate their lifts with stand-by diesel engines. To insure uninterrupted monitoring of the ski lift the LSM 100 will automatically transfer to a stand-by lead acid battery and continue operating for up to eight hours. When power is restored the battery will automatically be recharged by a charge circuit. The 12 volt, 5 amp-hour battery, under normal conditions, will only need replacing once a year.

Installation and servicing by ski area personnel has been greatly simplified by the implementation of easily accessible plug-in circuit boards throughout the design, as well as clearly marked input and output terminals. The LSM 100, which is housed in a steel cabinet, can be installed and tested on an existing lift, or a new lift where the wiring is in place, in approximately six hours.

While many long hours were spent in the lab and at the drafting table, the successful development of the LSM 100 may be attributed to the invaluable input by Keystone. Keystone provided Jurata and Mills with the insight into the exact needs of the ski industry as well as the needs of the people who operate the lifts. The development of the monitoring system is one more step in providing ski areas with means of operating safe ski lifts.



Paul is a senior in Electrical Engineering and worked with the Keystone engineers as part of an independent study project. Besides skiing and circuit design, his interests are obviously many and varied, since he is never at home when you call him.

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The Constant Quest for Money

Alumni funds prove invaluable to the College of Engineering

By Karen Curlander

If you ask a College of Engineering student where the funds come from to support the College and provide him with an education, you might hear the answer, "industry donations." Another student may reply, "tuition," and still another might say "state support." Each of these students would be correct, because all three of these factors are important sources of income that help the College function. But there is a fourth notable source of funds that you probably could get very few students to come up with, because most students are unaware of its significance. This is the funding provided by the alumni of the College of Engineering. Without the support of the alumni, the College would have great difficulty maintaining its program.

The largest contribution made by alumni is the provision of faculty positions. The state does not give the College enough support to provide new faculty jobs; in fact, the state has been reducing these positions. Therefore, alumni support has been the major source of this financing. Glenn Murphy, a 1929 graduate, bequeathed his ranch land south of Boulder to the College of Engineering. At his death in 1978, this resulted in nearly one million dollars, providing CU's first fully endowed faculty chair. The Croft family has also provided over $200,000 to fund three professorships in the College of Engineering. Professors Geller, Ramirez, and Chang have come to CU as a result of the Croft donation.

A major factor of alumni support to the College of Engineering is the Dean's Club. All alumni are invited to join, and each member pledges $100 per year donation to the College. The Dean's Club currently has 285 members. The Denver campus has an organization similar to the Dean's club, called the Century Club.

The University runs an Annual Giving Program, in which letters are sent out to all alumni giving them the opportunity to donate to any of the departments of the University. The money raised from this program is mostly used for faculty travel. The state provides less than $100 per year per faculty member for travel, so this must be supplemented by outside sources. Alumni support enables professors to go to technical meetings, and travel in search of government funding.

Student scholarships are also provided by alumni. More than $40,000 is available at the undergraduate level for scholarships, and graduate fellowships are also donated. The $200,000 Giroux scholarship fund provides $15,000-$20,000 annually for fellowships.

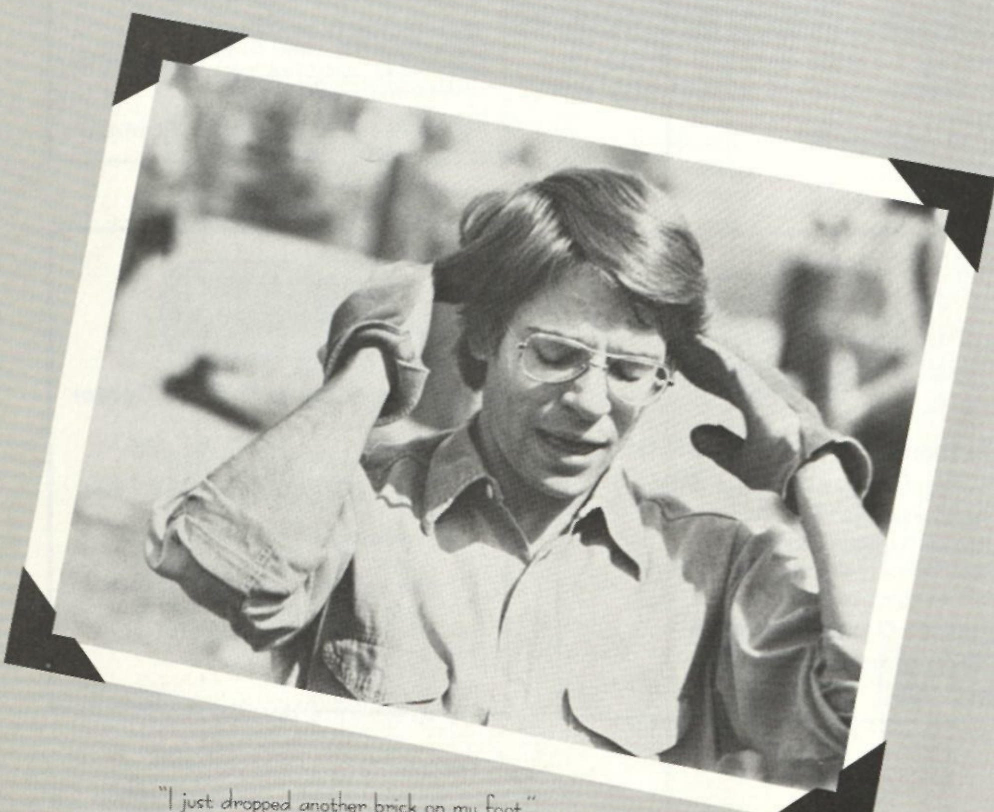
Additional uses of alumni funds are varied. Some contributions are used for faculty recruiting, and help pay for moving expenses for new faculty members. Alumni also contribute lab equipment, and other donations are made directly to the individual departments to be used at their discretion.

In short, it can be seen that alumni funds are put to a wide variety of uses. They keep the College endowed with excellent professors, help needy students and deserving students pay for their education, and in general help keep the schooling up to date. So, the next time someone asks you where the money for an engineering education comes from, don't forget to mention the alumni. Let people know how valuable they are.

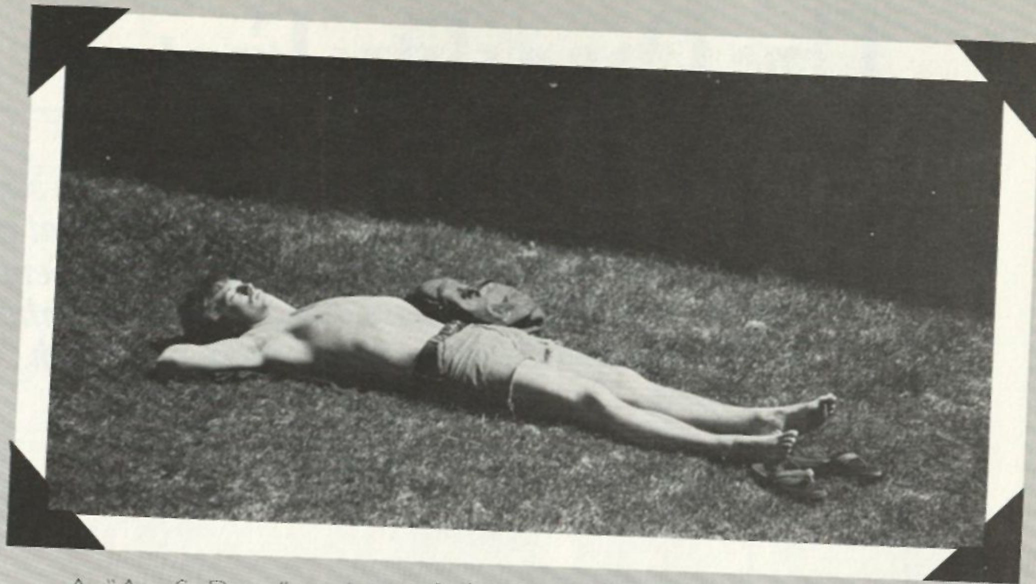
"We're going to have to find larger nuggets than this; I heard tuition's going up again."

"Just three more years and I'm up for parole!"

Spring



"I just dropped another brick on my foot."



An "Arts & Parties" major boning up for finals.

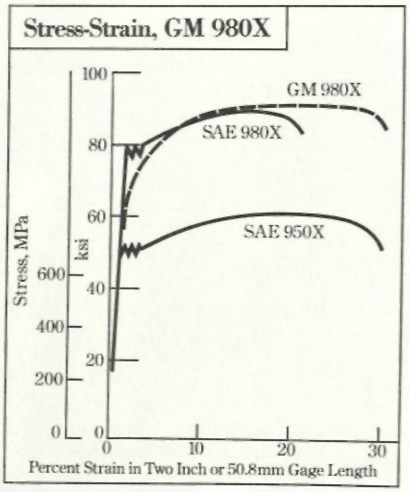
Scenes

"And even in the quietest moments. . ."

As study pressures increase, students take to climbing the walls.

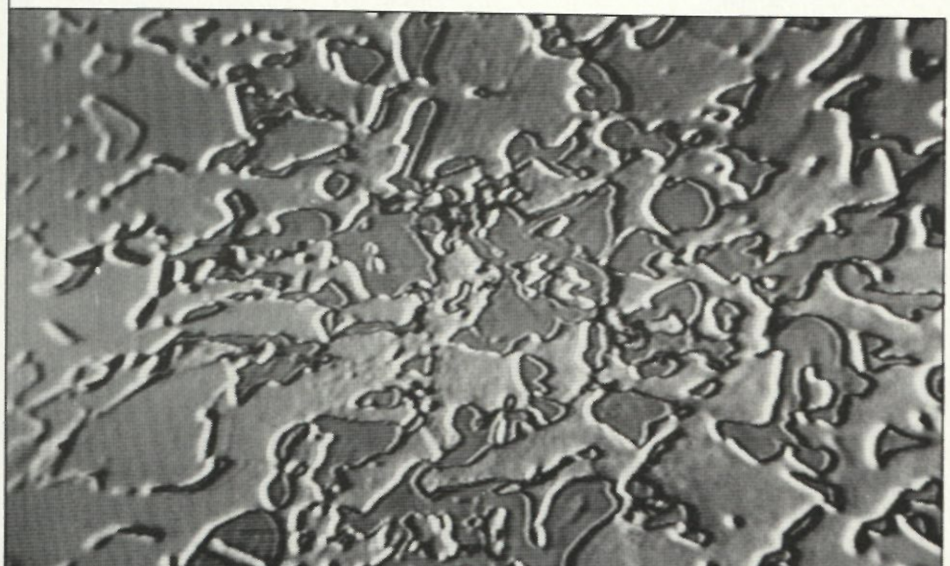
The Ductility Factor

The use of high strength, low alloy steel has been severely limited, due to its low ductility. Now, a simple heat treating and controlled cooling process, developed at the General Motors Research Laboratories, has successfully enhanced formability properties without sacrificing strength.



A comparison of the stress-strain behavior of GM 980X, SAE 980X, and SAE 950X steels. GM 980X offers greater ductility at the same strength as SAE 980X, and greater strength at the same ductility as SAE 950X.

Scanning electron microscope micrograph of dual phase steel at a magnification of 2,000. The matrix (background) is ferrite; the second phase is martensite.



FOR SOME TIME, automotive engineers and designers have been faced with the challenge of building cars light enough to get good gas mileage, but still roomy enough to comfortably transport four or five passengers. One technique which has proved fruitful is materials substitution.

Lighter materials, such as aluminum alloys and plastics and high strength, low alloy steels (HSLA), are being phased into new vehicle designs to replace certain plain carbon steel components. Each, though, has displayed inherent problems which limit its utilization.

Unlike plastics and aluminum, however, HSLA steels have the same density as plain carbon steel. Weight reduction is achieved because thinner sections (less volume) can be used to carry the same load. Since the formability (ductility) of most high strength steels is poor, though, it has only been possible to form simple shapes from it. This has severely limited the widespread use of HSLA steels (such as SAE 980X) for auto components. New hope for the increased utilization of HSLA steel has arisen, however, with the development of a new dual-phase steel, GM 980X, at the General Motors Research Laboratories.

General Motors is not in the steel business, and GM 980X is not a brand of steel. GM 980X is the designation for a type of steel displaying mechanical properties similar to those of the samples first formulated at the General Motors Research Laboratories. "GM" in the designation indicates that the steel is a variation of the conventional SAE 980X grade. In the standard SAE system for material identification, "9" designates that the steel is HSLA. "80" is the nominal yield strength of the metal in thousands of pounds per square inch. The "X" denotes a micro-alloyed steel—one containing on the order of 0.1% of other metals such as vanadium, columbium, titanium, or zirconium as a strengthening agent.

GM 980X displays the same strength, after strain hardening, as SAE 980X steel, but has far more ductility. This characteristic allows it to be formed into various complex shapes which were previously thought to be impossible with HSLA steels. The superior formability of GM 980X has substantially increased the utilization of HSLA steel in the manufacturing of automotive components such as wheel discs and rims, bumper face bars and reinforcements, control arms, and steering coupling reinforcements.

Dr. M.S. Rashid, discoverer of

the technique to make GM 980X steel, comments, "I was working on another project using HSLA steel, when I noticed that if SAE 980X steel is heated above its eutectoid temperature (the temperature at which the crystalline structure of metal is transformed) for a few minutes, and cooled under controlled conditions, the steel developed significantly higher ductility and strain-hardening characteristics, with no reduction in tensile strength."

FURTHER experiments proved that the key variables to make GM 980X are steel chemistry, heating time and temperature, and the rate at which the steel is cooled. Specimens of SAE 980X were heated in a neutral salt bath, then cooled to room tem perature with cooling rates ranging from 5° to 14°C/sec. (9° to 26°F/sec.). Dr. Rashid notes, "We found that the maximum total elongation resulted when the cooling rate was 9°C/sec. (16°F), and the lowest total elongation resulted from the highest cooling rate (14°C or 26°F/sec.)."

GM 980X steel has a high strain-hardening coefficient or n value, accompanied by a large total elongation. The n value gives a measure of the ability of the metal to distribute strain. The higher the n value, the more uniform the strain distribution and the greater the resistance of the metal to necking (localized hour-glass-shaped thinning that stretched metals display just prior to breaking). Tests have proved that GM 980X distributes strain more uniformly than SAE 980X, has a greater resistance to necking, and thus has far superior formability.

"The superior formability of GM 980X compared to SAE 980X steel appears to depend on the nature of two microstructural constituents, a ferrite matrix (the principal microstructural component) with a very high strain-hardening coefficient, and a deformable martensite (the other crystalline structure) phase. In the SAE 980X, failure occurs after the ferrite becomes highly strained, but when the GM 980X ferrite is highly strained, strain is apparently transferred to the martensite phase, and it also deforms.

"Therefore, voids leading to failure do not form until after more extensive deformation has occurred and the martensite phase is also highly strained. Obviously, the exact nature of these constituents must be important, and any variations in the nature of these constituents could influence formability. This is the subject of ongoing research."

Dr. Rashid's discovery represents a significant breakthrough in the area of steel development. His findings have opened the door to a new class of materials and have completely disproved the commonly held belief that high strength steel is not a practical material for extensive automotive application. "At GM, we've done what was previously thought to be impossible," says Dr. Rashid, "and now we're hard at work to find an even stronger and more ductile steel to meet the needs of the future."

THE MAN BEHIND THE WORK

M.S. Rashid is a Senior Research Engineer in the Metallurgy Department at the General Motors Research Laboratories. He was born in the city of Vellore in Tamil Nadu (Madras), India, and attended the College of Engineering at the University of Madras–Guindy. He came to the United States in 1963 and was awarded a Ph.D. in Metallurgical Engineering from the University of Illinois at Urbana-Champaign in 1969. After a three year Post-Doctoral Fellowship at Iowa State University, he joined the staff of the General Motors Research Laboratories.

Dr. Rashid is continuing his investigations into the development of even more ductile high strength, low alloy steels. When not in the lab, he enjoys relaxing by playing tennis and racketball with his wife, Kulsum.

GM **General Motors**
People building transportation to serve people

Geosynchronous Satellite Power: Baseload Solar Electricity for the Future?

Part II

By Clark C. DeNevers

This is the second part of this article. The first part was published in the Spring 1980 issue of The Colorado Engineer. *The reader is encouraged to look it up for an introduction to this discussion, as well as the Photovoltaic and Nuclear concepts.*

—Editor's note

THE final concept of orbital power generation involves the use of collected and concentrated sunlight to drive a closed-loop fluid power cycle. The principles and applications of fluid power cycles are well known; the challenge to an SPS program is to develop a system with high mass effectiveness, i.e., maximize the parameter kW/kg.

The two fluid power cycles being considered are the Rankine and Brayton cycles (see your favorite thermo text). The main difference between the two is that in the Rankine cycle the working fluid undergoes vaporization and condensation during each pass through the cycle, while in the Brayton cycle the working fluid remains entirely in the gas state. The Rankine cycle enjoys the advantage of requiring less internal work to compress its working fluid than is required by the Brayton cycle to compress its working fluid. This extra internal work (per unit of work output) requirement forces the Brayton cycle to be more efficient and/or capture more incident radiation, resulting (by the Second Law) in more collector area or a higher turbine inlet temperature. A typical thermal SPS design is shown in Figure 12. Table II compares parameters for a number of possible thermal SPS designs.

In general, closed loop fluid power cycles draw heat from a heat source and transfer it to a heat sink, extracting work along the way. The heat source for the thermal SPS is sunlight concentrated on an absorber; the heat sink is geosynchronous space.

A number of absorber concepts could be applied in an SPS system. The leading design focuses the incident radiation on the interior of a spherical cavity (hence the name "cavity absorber") where heat is transferred to a fluid (the working fluid or a heat transfer fluid) circulating in tubing close to the inside wall. Most cavity absorber designs are capable of 98% absorption of incident radiation.

The main concentrator designs fall into two categories: inflatable parabolic (dish) or multifaceted. A parabolic reflecting dish is normalized to the sun continuously by rotation relative to the SPS mass axis, and several may be employed in series to concentrate the radiation on a smaller absorber. A multifaceted concentrator consists of many flat reflecting surfaces which must be articulated individually to "see" both the sun and the absorber.

The predominant mode of heat rejection to a geosynchronous heat sink is radiation, since interplanetary space contains only about 10^9 molecules per cubic meter (versus 10^{25} at STP), and convection is insignificant. The leading heat rejection technologies are heat pipes and condensing fluid radiators. The heat pipe is a common technology in past and present space use, while the feasibility of condensing fluid radiators has only recently been demonstrated. Most current

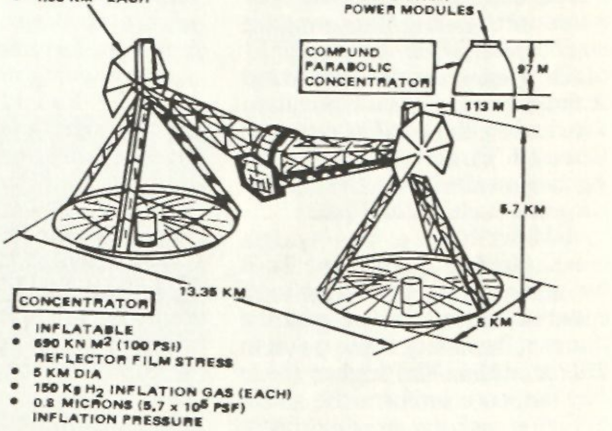


Figure 12 *Typical 5GW thermal SPA layout. Concentrator system is inflatable parabolic, with two in series ahead of the absorber. The standard microwave antenna is shown on its rotary joint between the radiators.*

Basic parameters for candidate 5GW thermal SPS designs. Minimum Kg/Kw corresponds to optimum design from a mass standpoint. Generator size corresponds to one of several hundred independent power modules.

thermal SPS designs call for a mix of the two technologies. A heat pipe is shown in Figure 13.

Temperatures in the radiator loops will range from 100-1000 degrees C, which poses problems in the selection of suitable heat transfer fluids. Organic fluids degrade above 350 degrees C, and steam is relatively corrosive, so for the higher temperatures, a pumped NaK (liquid sodium-potassium) system is currently favored.

The random impingement of meteoroids on the SPS is a cause for concern to SPS designers because of the hazards posed to fluid conduits as well as inflated concentrators. Due to the mass lifting requirement, the actual cost of replacement fluid might be significant compared to the cost incurred due to system shutdown. In the design process, meteoroid impingement will be modelled (probably by the use of a Poisson statistic) and protective systems optimized with respect to mass. The leading approaches for protection of a fluid conduit in space are bumper shielding and redundancy. Protection for an inflatable concentrator would probably consist of compartmentation. In both cases a thermal SPS will require a major backup supply of the various fluids and a repair capability with a quick response time.

	BRAYTON	RANKINE	RANKINE	RANKINE
WORKING FLUID	HELIUM/XENON	CESIUM	CESIUM/STEAM	POTASSIUM
AREA (REFLECTOR) KM^2	24	30-32	23	30-32
ηOA %	15	12	18	12
CYCLE η %	45	36	47	36
TURBINE INLET TEMP °C	1379	1038	1038	1038
GENERATOR SIZE MW	30	30	30	30
SAT. ORIENT	Y-POP, X-IOP	Y-POP, X-IOP	Y-POP, X-IOP	Y-POP, X-IOP
RADIATOR AREA KM^2	2.35	1.35	2.2	1.35
SYSTEM SP. WT. KG/KW	8.85	8.35	6.9	11.0

Table II

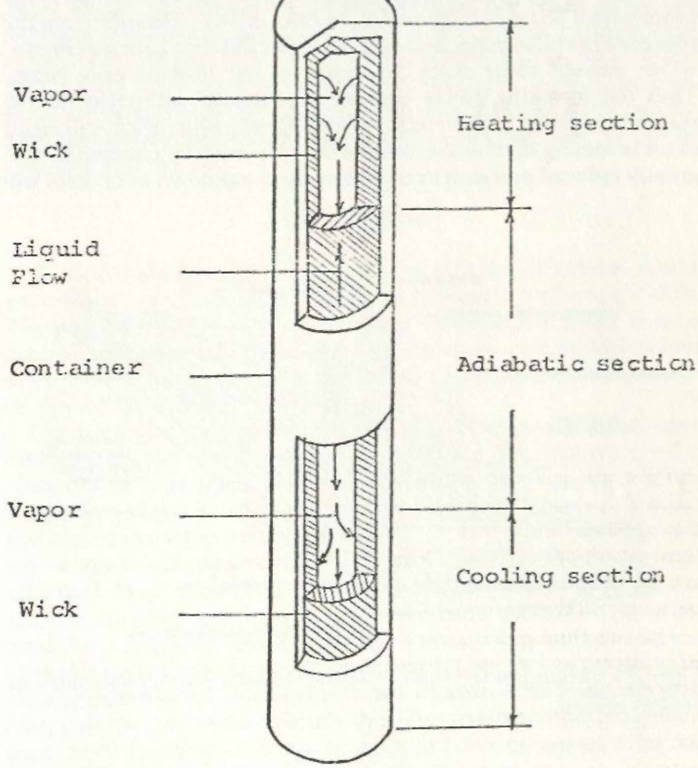


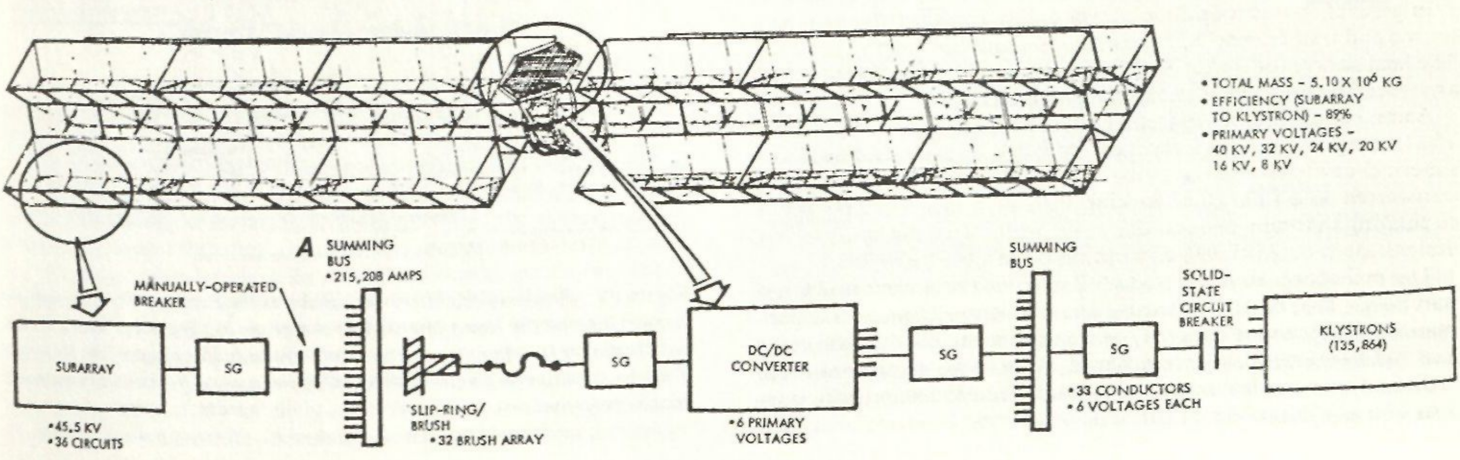
Figure 13 *Typical heat pipe configuration. Long used in space applications, a heat pipe requires no external work and can operate reliably at a range of temperatures. The transport of condensed working fluid through the capillary wick is the result of surface tension forces and is impervious to gravity, or lack of gravity. The adiabatic section is generally insulated. From Master of Science Thesis by Syung Hoon Chung, Univ. of Utah, 1970.*

Microwave Power Transmission

A typical power distribution system for a photovoltaic SPS design is shown in Figure 14. The diagram follows power generated at a subarray through summing, conversion to six required klystron voltages, and delivery to many thousands of klystrons in the transmission antenna. Power transfer from subarray to klystron is expected to be about 90% efficient, with much of the loss arising in the main busses due to I^2R effects.

At the transmitting antenna, the input DC power is converted to RF waves in the microwave region, which falls between 10^9 and 10^{12} cycles per second. Microwave radiation is nonionizing, unlike nuclear radiation, and is widely employed in radar, communication, and cooking roles. The DC-to-microwave conversion can be carried out by an amplitron or a klystron, both of which are beyond the scope of this article. Put simply, a klystron generates a stream of electrons by cathode/anode interactions. The electron stream is then bunched into pulses of the appropriate frequency by the action of cavity resonators, which are driven by the primary voltages supplied by the power distribution system. The electromagnetic field which surrounds the electrons will reflect their wave characteristics, and

Figure 14 *Power distribution system for a photovoltaic SPS design. From summing bus A on, the system is essentially identical for photovoltaic, thermal and nuclear satellites, although a rotating slip ring would not be needed for the nuclear system.*



input of electricity to the klystron will cause it to emit microwave radiation. The waves emitted by the klystrons are directed appropriately by slotted wave guides at the antenna surface. The power density of the emitted waves will vary across the radius of the antenna in a normal (Gaussian) distribution, with a tenfold reduction in power density from the center to the edge. An integrated klystron module and a microwave power transmission antenna are shown in Figures 15 and 16, respectively.

For optimal utilization of incident microwave radiation to the earthbound rectifying antenna (rectenna) site, the incoming waves should be as coherent (in phase) as possible. For this purpose, a pilot beam will be generated at the rectenna site and directed at the SPS/NPS transmitting antenna. Individual klystrons will receive the beam with a phase corresponding to their relative distance from the source of the pilot beam, and each klystron will then generate microwaves phased to be exact conjugates of the received pilot beam. Thus the incoming power bearing microwaves will arrive at the rectenna in phase. Conversely, the absence of a pilot beam will result in an incoming microwave beam with only random coherence, and greatly reduced power delivery. Thus the breakdown of control will not result in a "runaway death ray," and presumably the point of coherent impact could not be readily changed by overt action of terrorists or the like.

The microwave beam reaching the rectenna is profiled in Figure 17. The "no-pilot-beam" value of 0.003 mW/cm^2 can be compared with the values in the figure. Data from laboratory studies indicate that a six minute dose of microwave radiation at an intensity of 100 mW/cm^2 will kill a mouse. Human beings are probably less resistant.

The in-phase microwave radiation incident on the rectenna site impinges on a series of row-on-row arrays angled normal to the beam. The arrays will be composed of dipole antennas equipped with diode rectifiers. The arrays will convert the incident RF energy to direct current which will be transferred to a power station a short distance from the rectenna farm. At the power station the DC will be converted to AC in phase with the local grid and released thereto. The result is heat and work for electric utility customers.

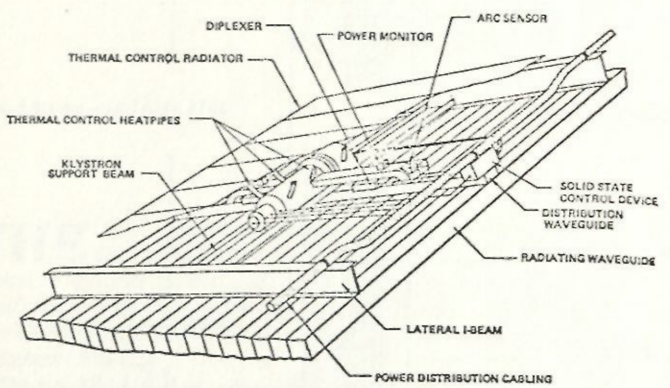


Figure 15 *Klystron unit combined with waveguides and thermal solid state control systems.*

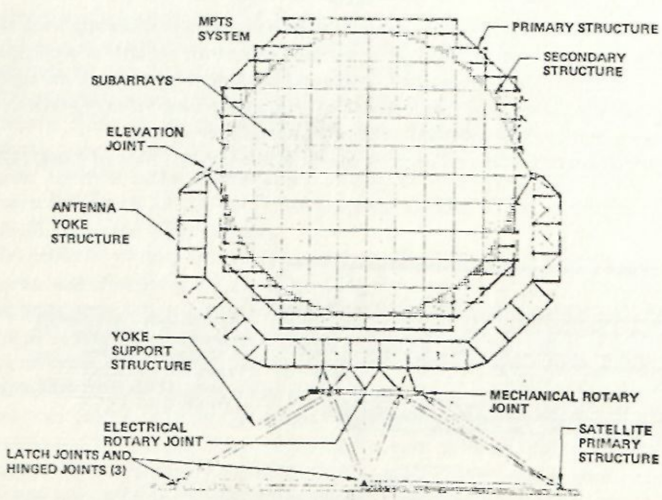


Figure 16 *Microwave power transmission antenna as incorporated in one SPS design. The circular transmitting area is about one kilometer in diameter; the klystron density increases from the edge to the center by a factor of ten. To keep the beam properly directed at the rectenna, the antenna circles the rotary joint. Further aiming can be effected by articulation of the elevation joint and altering the altitude of the whole SPS.*

Environmental and Safety Concerns

The proposed SPS/NPS programs will create a whole new set of environmental and public safety questions, in addition to some rather old ones. Brief discussions of some major points follow.

The accident statistics of the first generation Space Shuttle will be history in ten years. The next generation Space Shuttle (on an SPS scale) will probably be safer, and NASA's past record is an excellent mark to shoot for. The environmental impact of a Space Shuttle accident would depend on the nature of its cargo and the range of dispersion of debris. The major environmental impact of the Space Shuttle/SPS program might not result from accidents but from normal "safe" operation. The typical estimate for a 10GW SPS is that 800-1500 Shuttle flights will be required for all the necessary materials for construction. Further flights would be required for construction bases as well. Needless to say, the total mass lifted would well exceed that of all previous space exploration. The impact of all the expended propellant material added to all the various layers of the atmosphere might be substantial, and certainly some study is in order for the near future.

The recent and well publicized "reentries" of Cosmos 954 and Skylab into the atmosphere will immediately call to question the

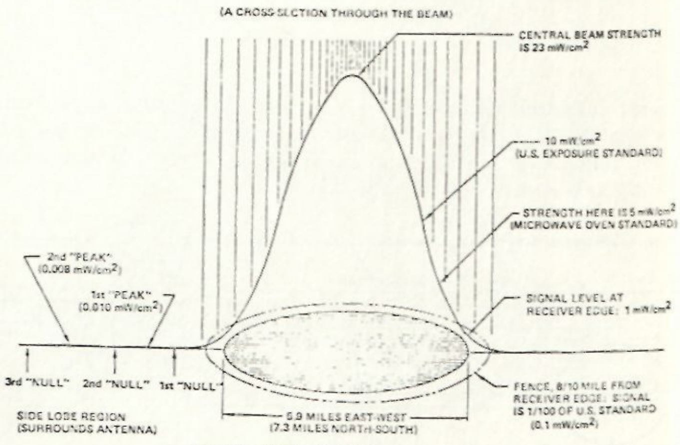


Figure 17 *Profile of the Microwave Beam at the Rectenna Site. The anticipated value of the beam intensity in the event of pilot beam loss is 0.003 mW/cm^2, far less than any of the noted standards. The shape of the rectenna farm becomes increasingly elliptical at higher latitudes, while at the equator it would be a circle.*

merits of putting even larger structures (including nuclear material ala NPS) in orbit, where they might pose a related threat to the safety of all of Earth's inhabitants. This question can be broken down quite easily by a glance at the orbital decay times contained in Table III. Cleary a deployed SPS/NPS in GEO poses very little hazard of fall. Therefore the hazards of falling SPS/NPS materials will arise in LEO construction, which will probably occur at an altitude of about 500 km, and the transportation system below that.

The hazards to humans involved in space construction and operation of deployed satellites will be estimated from past space experience. The potential hazards will be clearly spelled out for persons interested in SPS/NSP work, since the legalities thereof should be quite compelling to the various organizations involved. The passage of large microwave beams through the atmosphere will create a number of possible problems. To date, the picture is not complete.

The operating frequency of klystrons is that set aside by international convention for industrial, medical, and scientific use. All users of this band must accept interference, so SPS operation should not pose a problem. Klystron design efforts are underway to minimize noise outputs.

The cylinder bounded by the SPS microwave transmission antenna and the rectenna will contain a cross sectional area of about 50 square miles. This area could be encroached on by all types of aviation, lower orbiting satellites, and numerous airborne and ground animals. The effects of the nontrivial power density of the microwave beam on these encroachers (and vice versa) will have to be studied and appropriate restraints implemented.

The microwave beam, in passing through the atmosphere, will be unaffected by cloud cover and local weather patterns. The converse effect of the beam on the atmosphere is currently the subject of serious study. The main region of current interest is the ionosphere, which runs from 85-500 km above sea level. Although the ionosphere is continuously bombarded (variable with solar flare activity) by UV and X radiation, the concentrated microwave beam from a SPS/NPS system will be a new effect. Microwave heating of the lower portions of the ionosphere may exceed the local cooling capacity, resulting in thermal runaway, and in the upper ionosphere an effect called thermally induced self-focusing can create local striations in the Earth's magnetic field. The threshold microwave beam intensity for both of these effects is believed to be $25mW/cm^2$, and the implications of these effects are still being studied.

The biggest environmental impacts and safety hazards of an SPS/NPS program may well arise not in orbit or in the upper atmosphere, but on Earth, in the establishment and operation of the support industries for the extensive fabrication of SPS/NPS components. The nature of the support needed will vary from one concept to the next, but even so the majority of the energy and manhours required will be expended on Earth, with subsequent pollution impacts and industrial hazards.

Current Development Work

NASA and associated contractors are carrying out a number of programs directly and indirectly associated with development of the SPS/NPS.

The Space Shuttle itself will be extensively studied with an aim to reducing the cost of lifting cargo into orbit. Experiments planned for Space Shuttle implementation will demonstrate the use of electric ion bombardment thrusters, the assembly of structures in space, and the properties of materials in an orbital environment. These experiments won't necessarily be aimed at SPS development, but the lessons learned will be useful to SPS designers. Other proposed Space Shuttle projects include graduated scale photovoltaic array demonstrations beginning in 1981, leading up to a small scale SPS demonstration (1 GW) as early as 1988. The various small scale projects will demonstrate increasing levels of structural advancements and microwave control.

Earthbound work on photovoltaic cells is continuing unabated, with new approaches as well as old. Microwave Power Transmission has been demonstrated on a small scale, and further work will lead up to full scale demonstration.

One recent development in the orbital solar energy field is a new concept put together by a NASA group, which is called SOLARES. The concept calls for the placement of reflectors in orbit (probably at GEO) which would simply reflect sunlight to a ground site, where the nearly continuous supply of solar radiation could be converted by photovoltaics, fluid collectors, or agriculture. Some eclipsing would occur at local midnight, but overall storge for a baseload solar power plant would be reduced by a factor of five. The really intriguing aspect as set forth by the proponents of SOLARES is the reduced orbital mass requirement, 1 kg/kw, versus 6 to 8 kg/kw for a typical SPS design. This "passive" concept is immediately interesting; however, it has yet to survive the relatively detailed analysis of current SPS proposals, and the claims of its proponents have yet to be critically scrutinized.

Conclusion

Work in progress has shown that a number of orbital power generation concepts should be technically feasible by the mid 1990's. The economic outlook of any of these concepts will result from a tangled web of component costs, energy costs, and pollution and safety costs. One of the major cost drivers for all of the concepts will be that of lifting mass into Earth orbit.

Orbital power concepts will have to compete with a variety of other available energy sources at some decision point. Parameters for comparison might include energy payoff time (3-10 yrs for a SPS), design life (30 yrs for a SPS), production energy requirement, capital and operating costs, estimated deaths per kW (from realistic risk assessment), and environmental impact (pollution costs or other measure). With these parameters (and perhaps others) in hand, the decision to implement an orbital power program can be taken by whatever mechanism may be in force. It is hard to predict the nature of that mechanism ten years hence, and it is hard to predict the relative significance of the various parameters. The framework of energy decisions is continuously changing; the world has become a huge "hard hat area." At least we needn't worry about a falling SPS/NPS. The sky will probably fall first.

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2. NASA Fact Sheet; *Space Solar Power*; Release #77-30, April 1977.
3. Technology Review, August/Sept 1979, pp. 76-77.

3. *Technology Review*, August/Sept 1979, pp. -77.

Acknowledgment: Figures taken from 1978 Intersociety Energy Conversion Engineering, Vol. I.

Table III

Initial Altitude (km)	Decay Time (estimate/yr)
742-926	1000
1482-1852	10^6
35929 (GEO)	infinity

Clark has been working since March for Hercules Aerospace near Salt Lake City, Utah. He spends a lot of time wondering about "the nature of that mechanism," and collecting Confederate money, just in case.

Computer Games

To avoid studying, go hunt the Wumpus

By Peter Amstein

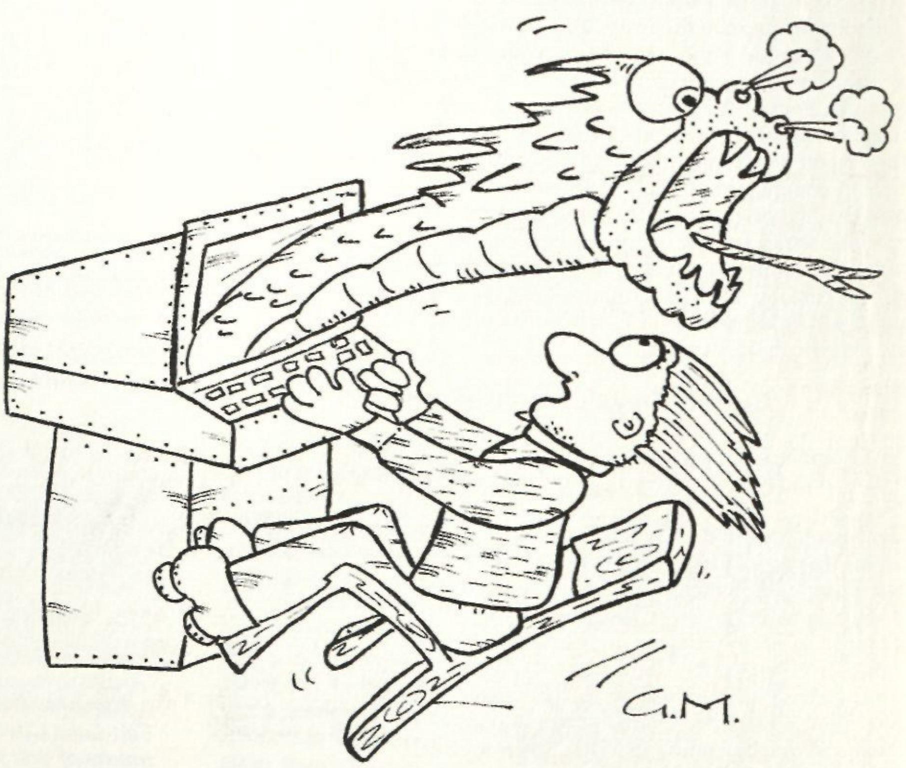
You parry a lightning thrust and lunge with your sword. You miss and the troll swings his axe and gets you right in the side—ouch! Another furious exchange and the troll takes a final blow, disappearing in a cloud of greasy black smoke. A quick diagnosis reveals that you are lightly wounded; another serious wound and you'll be informed that "you seem to have gotten yourself killed. Would you like me to patch you?" Many go through this harrowing experience daily, but with quick work at the keyboard, most will survive. Hundreds of feet of teletype paper later, a few emerge victorious—grand master adventurers.

The scene is, of course, another round with a diablolical computer game. For almost every game known, there is a computer version somewhere. They range from simple-minded tic-tac-toe (which you can never win) to chess, for which there may never be a computer grand master. There's Monopoly, including even a version for programmable calculators. Some games are educational, like Wharton. Wharton is a U.S. economy simulator, but he is a bit unrealistic. After I had brought inflation to 200 million percent annually, and the long term interest rate to 250 million percent, Wharton told me that "because of my mismanagement the people are restless." Only restless? Well, perhaps because my unemployment rate was only 2.1 percent.

A classic game is Star Trek. Star Trek has many fans at semester's end, when the last program is turned in and there are still a few dollars left in the computing account. As many versions of this game abound as do computers. All let you play the roll of Captain Kirk, navigate outer-space, and battle Klingons while worrying about your shield energy and photon torpedo supply.

Where does one go to get so immersed? The computer center has a rich stock of games accessible to anyone with funds to burn up. Your friendly local microcomputer dealer has demonstration models with great examples of game programming, many in full color with wound effects and quick video action. Several companies maintain free (bless them) game files for their employees to play during non-peak times on the company computer.

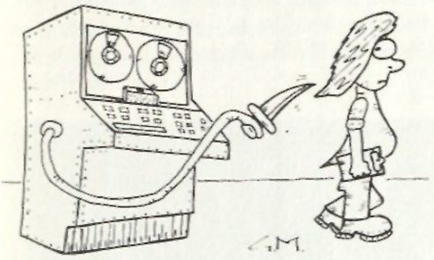
The best games are those which involve creeping about in miles of imaginary underground tunnels and caves, encountering unthinkable horrors and scenes of astounding beauty, all the while collecting treasure for your horde. A vivid imagination is the key to your enjoyment. As grades slip and home-



work goes unfinished, new passages are discovered, the thieves' lair is finally found and excitement mounts. For the addict, nothing takes precedence.

The original adventuring game is in fact Adventure (written in Fortran if you ever wondered). Adventure allows simple commands like "get keys" and "throw knife." You can spend hours investigating the deep caverns or wandering about in the "maze of twisty little passages all alike." A grand master is finally carried away to his reward on the shoulders of cheering dwarves, and all of adventuredom salutes him. Another version called Adventure IV (written in Pascal) is waiting for those ready to start again in a whole new set of tunnels and rooms.

Dungeon is a more sophisticated refinement of exploration games. The parser allows complex commands like "walk through the south wall." You must push buttons and plug leaks. An improper command may elicit the comment "you must supply an indirect object." Dungeon refers to the



player as a "cretin." When you try to break down a granite wall the response is "I think you are taking this thing for granite." Everywhere you explore, the game has a similar smart remark for you.

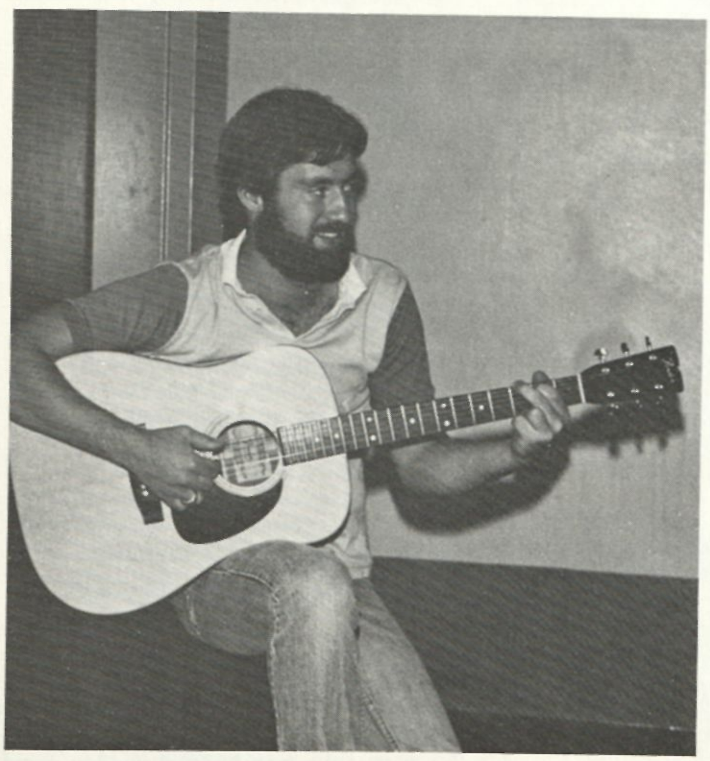
Dungeon was inspired by the popular Dungeons and Dragons game. It also borrows freely from Adventure and from games like Hunt the Wumpus, which pits you against bats and arms you with arrows for your hunt. When the dreaded beast is near you are warned with the message "I smell a Wumpus."

This addiction is dangerous though. Recently my source of computer time for Dungeon dried up. My roommate, a fellow addict, now plays long hours of solitaire. I sit and watch—withdrawal is painful indeed. Still, we can look forward to new advances in technology which may open even greater possibilities in this area, certainly one of the most enjoyable applications of the computer.

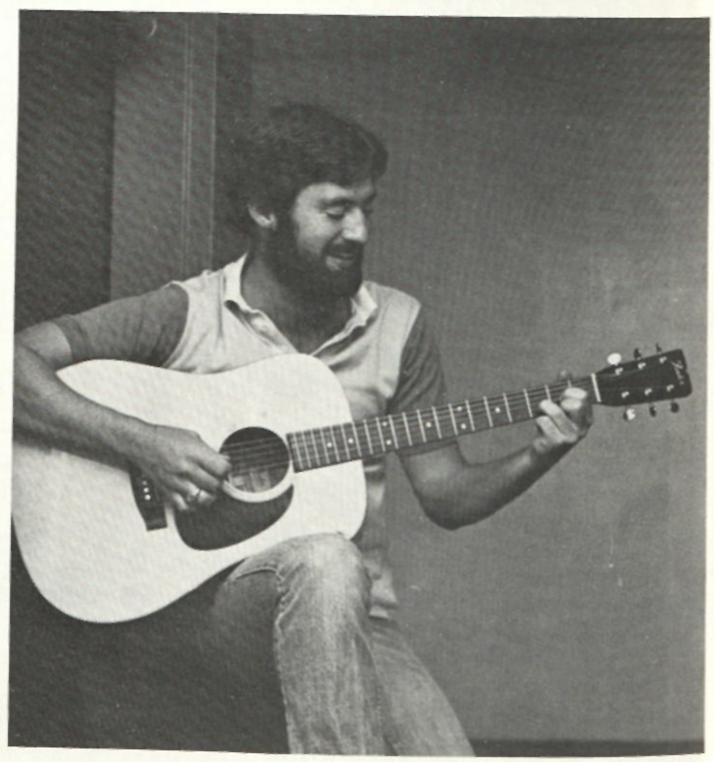
PHOTO GRAPHY

Article and Photos by John Pohle

Shedding some light on the subject



This picture was taken in a poorly lit hallway, as an "album cover" of guitarist Chris Conner. The flash was attached to the top of the camera and aimed directly at the subject. This produced the shadows behind the subject and caused the reflections off of the guitar face.



The same picture as the one on the left but with the light bounced off of the ceiling. This softens the light and causes the shadow to disappear from behind the subject. It also adds more depth to his face.

Light is to the photographer as paint is to the artist. To create successful pictures or paintings, one must have extensive knowledge of the medium. The term photography, coined by Sir John Herschel, is derived from two Greek words meaning "writing with light." To successfully utilize light, the photographer must understand its effect on every object and scene.

Quality and direction are two characteristics of light which give rise to shadows, form, texture, and highlights. Quality refers to the type of light source. Harsh intense light yields crisp shadows and creates a very small range of tones and a high degree of contrast. Soft light causes faint shadows, and a large range of tones. An example of soft light is a slightly overcast day or the shade of a tree on a bright sunny day.

The direction of the light influences the appearance of texture and the shape or form of the subject. Back lighting causes an object to be seen as a silhouette, and light directed from the front allows very little texture or tone to appear in the photograph. A harsh light from the side can create large shadows. These shadows can exaggerate the texture of an object and distort its form, can add a large amount of contrast, and can allow for very creative photographic effects.

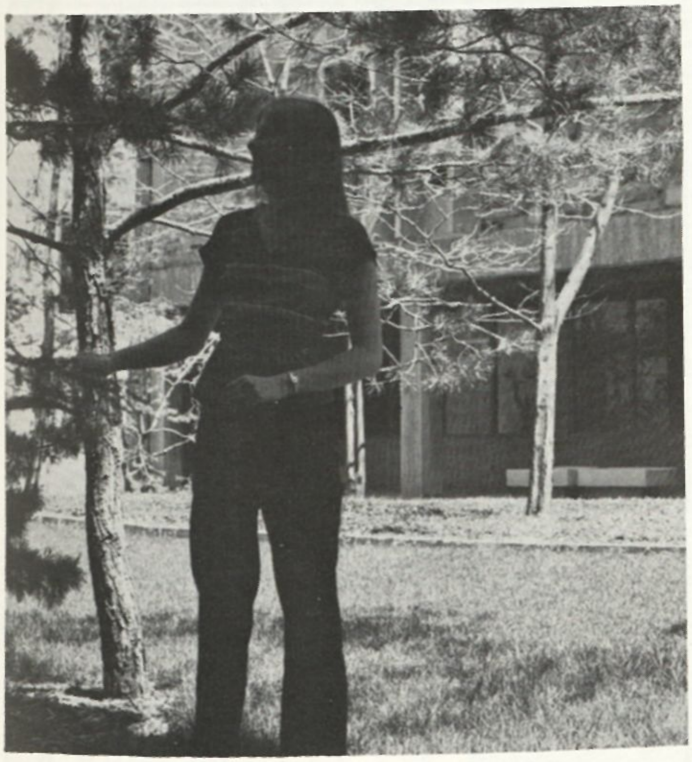
When making portraits, soft light is more appropriate since it creates various tones and lends relief to the face. Harsh light will make a nose dominate a subject's face or cause shadows that look like black eyes. Sometimes it may be desirable to use harsh lighting to bring out the texture of an object. Texture adds an unusual effect to a photograph because it allows the viewer to relate tactile sense to the picture.

In many situations the available light is not adequate for the intended photograph, sometimes due to an extremely fast motion which can only be captured by a fast shutter speed. A flash provides a solution to this problem. An electronic flash emits light for about 1/1000 of a second, which used with the synchronized shutter speed of 1/60 or 1/125 second still yields an effective speed of 1/1000 second. There are strobes on the market fast enough to "stop" a bullet.

In some outdoor photography there is ample light for a picture but the light source is behind the subject, causing shadows in the foreground. A flash or another artificial light source can be used in this situation to "fill" the foreground with light. This gives some relief to the object in the picture. Whenever a flash is used, one should keep in mind that the amount of light is proportional to the square of the distance from the subject: if the light source is moved twice as far away, the subject will receive one-fourth of the original dose of light.

When using a flash to photograph people or objects indoors, try to bounce the light off the ceiling. This will soften the light and change its direction, adding relief to the subject and improving tone quality. It also prevents the background from being shadowed by the object in the foreground. The aperture should be opened 2 to 3 f-stops to account for the light which is absorbed by the ceiling. Bouncing the light also helps to prevent reflections from glass or other shiny objects. If the light cannot be bounced, try removing the flash from the camera and holding it off to the side.

In outdoor photography, the direction of the sun is a major factor in the blending of tone and texture. Most people take pictures with



This picture of our production manager Kathy Curlander was taken on a sunny day in the shade. Because the background is very light Kathy's face remains slightly shadowed, caused a partial silhouette of her body.

By using a "fill flash," the foreground has been illuminated, causing the features of her face to appear. Because there is some available light the face has some tone. Tone is the areas of transition from shadow to highlights.

The star pattern of the sun is caused by the leaves of the iris, which creates the aperture opening. There are five leaves in the iris of the canon 50mm lens used to take this picture. The smaller the opening the more pronounced the rays.

the sun at their backs whenever possible. If some of these pictures were taken with the sun from another angle the subject would show up in more detail and interest would be added. The resulting darker background draws more attention to the intended subject.

These are just a few of the many techniques and theories of lighting. Every photographer has his or her own habits and preferences. The best advice—try your own ideas. The way light is used can make the difference between an award winning photograph and a picture worthy of only the trash can.

News News

LATEST ELECTRIC CAR

An advanced four passenger, subcompact experimental electric car, known as the "Electric Test Vehicle-One" (ETV-1), has been unveiled by the Department of Energy (DOE).

"Although this vehicle is still in the experimental stages, it shows that a functional, safe and stylish electric car can be built," said Acting DOE Under Secretary John M. Deutch.

The $7 million contract under which ETV-1 was built called for the development of a totally new electric car that would increase consumer and industry acceptance of the electric car by accelerating technical advancements.

It also called for a test car with maximum consideration for the consumer with respect to driveability, comfort, and styling. Additionally, the program required that attention be given to energy efficiency, utility, safety, ease of production and cost.

ETV-1 is a test car and not commercially available to the public. However, in order to assure that it represented a practical car, ETV-1 was designed so that it could be mass produced for about $6,400 (1979) dollars by 1985.

The life cycle cost of the ten year life of the car, including electricity for recharging, is estimated to be less than 18 cents per mile of which 2 cents would pay for scheduled maintenance. This is comparable to existing internal combustion engine cars.

"250" CLUB HAS FUNCTION

The smallest and least known university organization, the "250" Club, raped, pillaged, and burned the Engineering dorm, Aden. A club spokesman said the action was taken because the dorm was a public nuisance.

When questioned, the Boulder Police Department, FBI, CIA, and ASME all linked the organization to the Hell's Angels due to thermodynamic reasons. The leader of the organization, a man known as RAC, was quoted as saying that their next project will be larger. The service oriented club plans to push over the Williams Village towers utilizing small two-stroke vehicles.

TURNING IN THE BREEZE

The world's largest wind turbine is now generating 2,000 kilowatts of electricity for the Blue Ridge Electric Membership Corporation's power grid.

Built by the General Electric Space Division for the U.S. Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA-Lewis), the milestone aerogenerator stands atop Howard Knob, which rises approximately 1,000 feet above this mountain town in northwestern North Carolina.

The wind turbine, dedicated in July, 1979, operates whenever the wind blows between 11 and 35 miles per hour. It can produce electricity for 300-500 average-size homes at wind speeds of 25 miles per hour. Gargantuan in every respect, its two 100-foot long steel blades weigh nine tons each.

Concealed in a 34-foot long nacelle are rotor shafts, gear train and the generator. The nacelle sits some 140 feet—10 stories—above the ground on a truss-type tower structure.

This largest of all wind turbine generators weighs 350 tons, including the support tower. The generator is computer controlled by equipment at the base of the tower. Wind direction is monitored so that the rotor is properly aligned with the wind. The control then varies the pitch of the blades in order to maintain a constant 35 revolutions per minute (rpm). A synchronous AC generator is driven at 1800 rpm by a high speed shaft.

ANHEUSER-BUSCH "UNNATURAL"

Three expert nutritionists who advised the Federal Trade Commission in connection with the proposed rule on "natural" advertising for food have concluded that the "natural" campaign used by Anheuser-Busch, Inc., in the advertising and promotion of its principal beer brands is "false and deceptive."

According to the expert testimony, the Anheuser-Busch "natural" campaign for its four beers—Budweiser, Natural Light, Busch and Michelob—is inaccurate, deceives consumers, and is the kind of abuse of the term that led to the necessity of such a rule.

Dr. Little, of the University of California, Berkeley, described Anheuser-Busch as "one of the worst offenders" in the abuse of the term "natural." "In fact," said Dr. Little, "the beer sold to the consumer by Anheuser-Busch is far removed from anything identified as natural by scientists and consumers."

In defending itself, Anheuser-Busch has offered its own definition of "natural" as an alternative to the objective standard in the FTC's proposed "natural" advertising rule.

AB claims that "natural" should mean "produced only with natural ingredients and using traditional processes."

But, said the memorandum, AB's beers could not meet even its own definition.

Miller cited as AB's non-natural and non-traditional proceses:

* Using the additive tannic acid produced by a chemical solvent extraction process in its beers as a chillproofing agent (to prevent haze). Tannic acid has been recognized in scientific literature as serving three distinct functions: chillproofing agent, anti-oxidant and antimicrobial preservative.

* Using chemically treated beechwood slats during the fermentation of Budweiser;

* Mechanically injecting carbon dioxide into its beers (a technique AB itself has called "artificial");

* Employing the modern technique of "high gravity" brewing for Budweiser, Busch and Natural Light; that is, brewing beer "too heavy" for commercial consumption, and then diluting it with carbon dioxide-injected water;

* Shortening the brewing cycle for Budweiser by nearly 25 percent in recent years.

This electric car is plugged into the electronics revolution.

The electric car you see here is one of a pair of experimental vehicles GE is developing for the Department of Energy.

With a projected range of 100 miles at a constant 45 mph, it's so much better than previous models that there's hardly any comparison.

What's made this big difference is electronics. A GE-designed microcomputer manages energy flow throughout the propulsion system, regulating power demand to extend the car's range.

The power-conditioning unit contains another major GE innovation: special high-power transistors.

They're the world's most efficient high-power transistors, capable of switching 400 volts and 350 amps on or off in less than a millionth of a second. Yet the silicon chip that contains them is less than half the size of a postage stamp!

These high-power transistors have three important functions.

They regulate the speed, torque and acceleration of the car's DC motor.

Their high-frequency characteristics also make them ideal as components for the car's overnight charging system.

Finally, the transistors play a big role in the car's regenerative braking system. They help change the motor automatically into a generator, supplying braking power to the wheels and producing current to partially recharge the batteries.

What's coming down the road after this advanced vehicle? GE engineers are developing one that's even more advanced. It's a hybrid that will burn far less fuel than an all-petroleum-powered car and have even greater range and power than the all-electric. It too will feature microelectronic controls...but of even greater sophistication.

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

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

If you are interested in engineering opportunities at GE, check your Placement Office or write to: Engineering, Bldg. 36, General Electric, Schenectady, New York 12345.

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