

The COLORADO *Engineer*

MARCH 1975

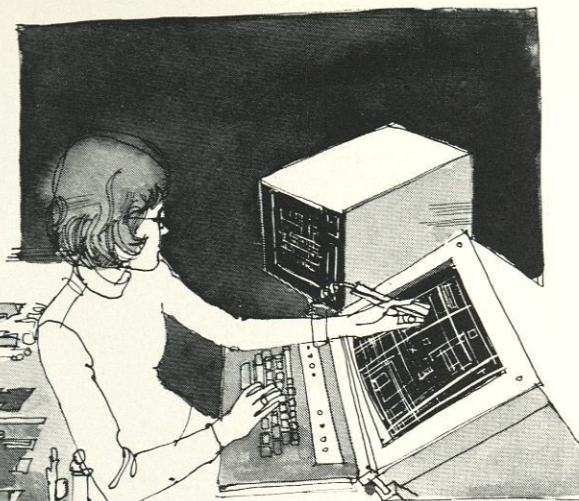


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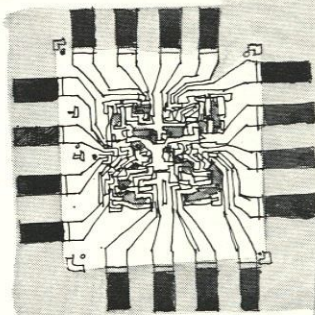
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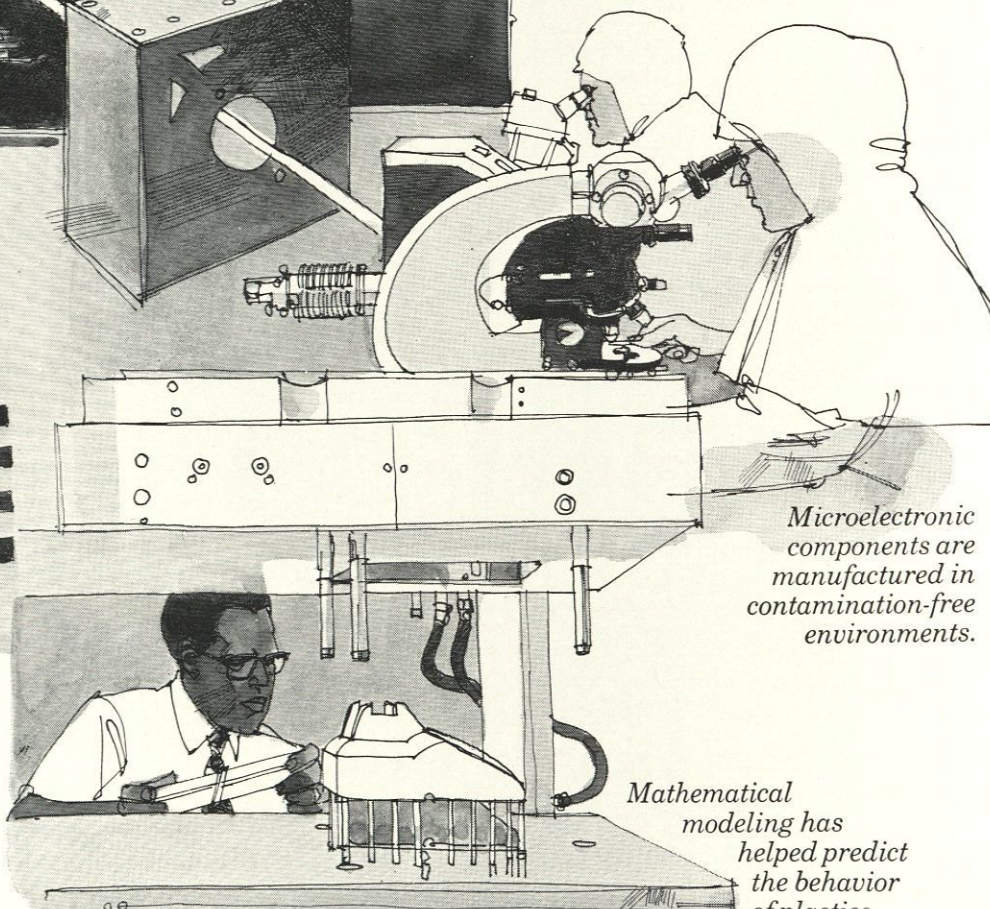
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IN THIS ISSUE:

- 3** Editor's Desk
- 5** News
- 5** Letters
- 7** Book Review
Scott Kempshall
- 8** The Community Development Act
and its Effects on the
Denver-Boulder Area
Don Brandes, Jr.
- 14** Ms. Engineer
Donna Edens
- 16** How to Succeed in Engineering
(In Spite of Yourself)
Rich Kendel
- 18** RTD: Still on the Move
Tim Doll
- 22** Bioengineering at C.U.
Bob Graham
- 27** Calculator Update
Gary Mills
- 31** E-days 1975
Eric Johnson
- 32** In the Final Analysis. . .
Setting courtesy Rogue's Gallery Restaurant

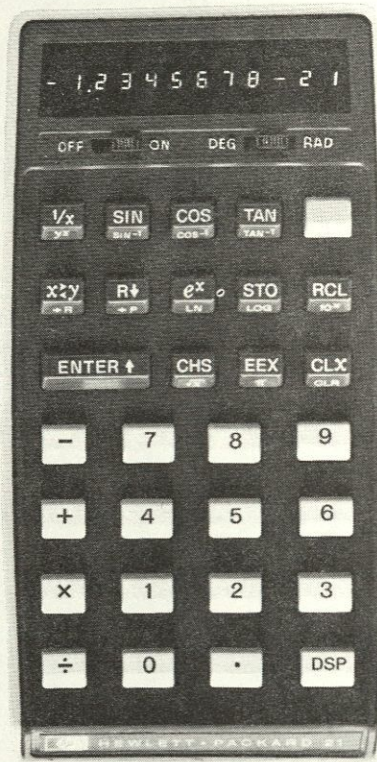
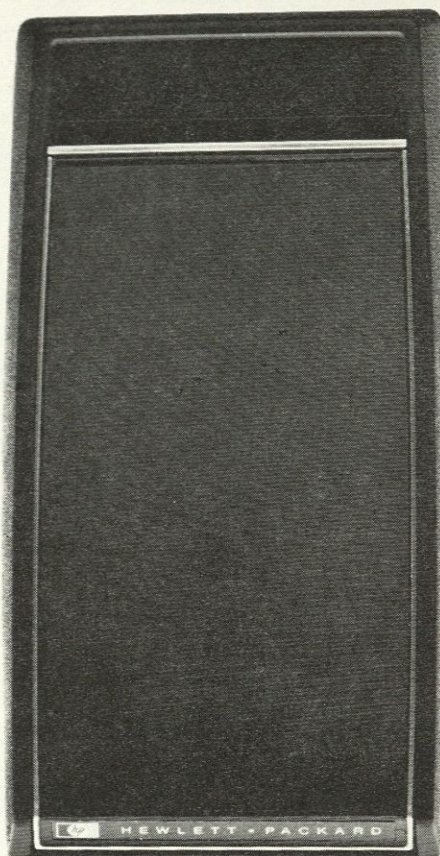
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Gary Mills

BUSINESS MANAGER

Kurt Olsen

PRODUCTIONDennis Wetterstrom
Scott Redheffer**COPY EDITOR**

Wes Jordan

ASSISTANT EDITOR

Bill Bernardelli

ADVERTISING MANAGER

Randy Clark

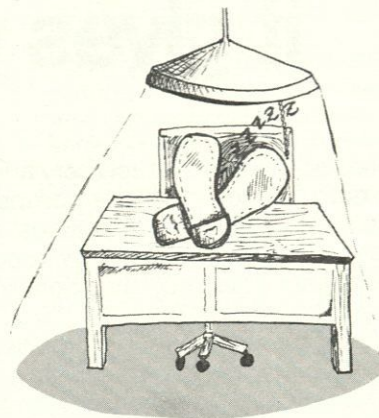
STAFF WRITERSWalt Cranor
Ruby Davis
Tim Doll
Donna Edens
Bob Graham
Scott R. Kempshall**PHOTOGRAPHY STAFF**Russ Brewer
Dave Sakaquchi
Darrell Howard**ART**Mark Almquist
Dennis Weingardt**SECRETARIAL**Elena Machina
Fran von Gerichten**FACULTY ADVISORS**Martin Barber
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TYPESET

New Morning Composition

Editor's Desk



Our cities. It has long been recognized that the urban environment in the United States has seriously deteriorated in the past half-century. In this issue we present two articles which describe how the urban environment in the Boulder-Denver area may be improved as the result of a federal law and a state administration. In his article, Don Brandes outlines the effects of the Community Development Act on our region and especially on Boulder. Tim Doll reports on the current status of the Regional Transportation District (RTD) as it tries to formulate a workable solution to the Denver areas's transportation problems. These articles serve to demonstrate the engineer's vital role in solving urban problems.

The wide diversity of problems that involve engineering is demonstrated by Bob Graham's report on the work of some engineering students and faculty in the field of bio-engineering. Donna Edens, the only woman writer on our staff, appropriately writes on the increasing role of women in engineering. This issue also contains an essay on the life of an engineering student by Rich Kendel, the popular Calculator Update and, of course, our Final Analysis on the last page.

In general, the staff of the *Colorado Engineer* is fairly pleased with this issue although we are disappointed that our advertising revenue has dropped off from our previous issues this year. It seems that advertising is the first thing that businesses cut when they experience a decrease in income. But on a lighter note, the staff of this magazine has added several new members and several other students have indicated an interest in working on the staff since the January issue. Their response has been gratifying and their help will be welcome. If anyone else would like to work on the staff or would just like to contribute an article or even a letter to the editor, the door to OT 1-7 is usually open and your assistance and contributions are welcome. Remember we still plan to publish a May issue and application for editor-in-chief and business manager for next year should be turned in by April 18. I hope you enjoy this issue and find it interesting and informative. If you do, or especially if you don't, please tell us so. It's tough operating in a vacuum. □

Gary Mills

A Request From the Staff. . .

We of the staff of the *Colorado Engineer*, in a continuing effort to upgrade the quality of this magazine, always try to be responsive to any helpful suggestions or sincere criticisms addressed to us. We believe that we *do* learn at least as much from our mistakes as we do from our successes.

This idea we feel to be central to the proper functioning of any body which has aspirations of being educational or instructive in nature, be it a magazine staff or a university faculty. It is our contention that any individual who tries to teach others must be responsive to the needs of his audience. This means being aware of one's own limitations as well of those of the persons you would presume to educate.

With this in mind, we would like to ask the students and faculty of the College of Engineering for their thoughts on the current teaching methods in the College of Engineering. In the past there have been attempts to prepare a course "evaluation", but we feel the results of those surveys to be, at best, incomplete, subjectively oriented, and not a great deal of help to either student or professor. While we are appreciative of the effort that goes into the preparation of those surveys, we would rather attempt to publish general observations and criticisms of teaching styles. We would hope that, rather than singling out a certain professor for a certain fault, we might encourage all professors to examine their own effectiveness as teachers without the need of pointed fingers. *Continued on page 7*

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FMC's business is machinery and chemicals, a combination which gives the company two billion dollars annual sales. And an unusual depth of capabilities in such fields as energy, food production, municipal services, construction, materials handling, and transportation.

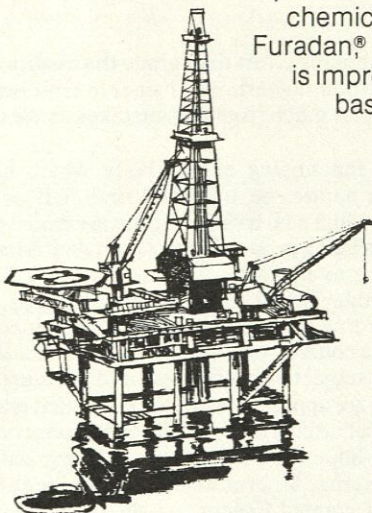
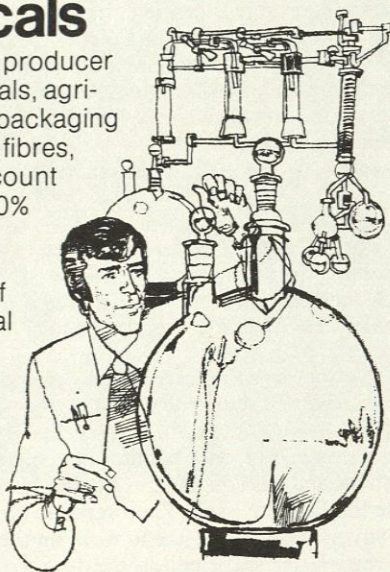
This wide variety of opportunities generates a need for an equally broad variety of professional skills, from business administration to major fields of engineering. Here are three examples:

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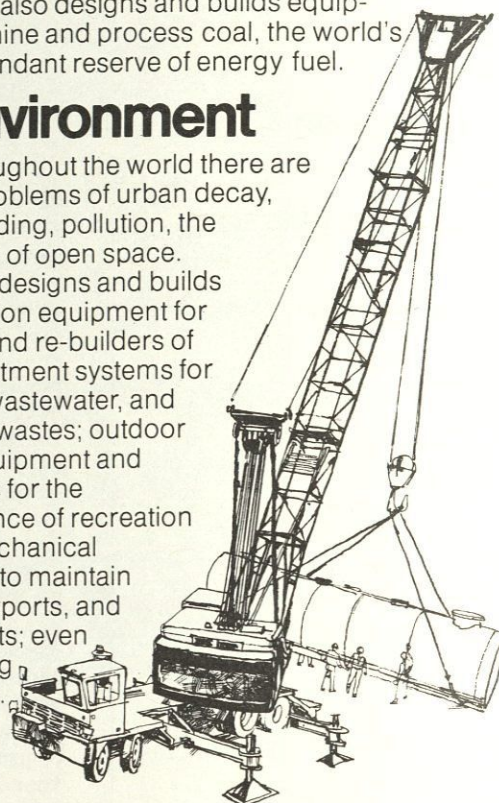
specialty equipment which FMC designs and manufactures. The products range from wellhead flow controls, swivel joints, and valves to mechanized loading systems and ocean-going vessels.

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Throughout the world there are urgent problems of urban decay, overcrowding, pollution, the shrinkage of open space.

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The opportunities

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NEWS

TEXTBOOK ON THERMODYNAMICS COMPLETED

Professor Herbert E. Johnson is wearing a well-deserved smile these days. After six years of careful preparation and revision, he has just published a textbook on "Principles of Thermodynamics and Power Systems" (Herbison Engineering Co. publisher). The massive 570-page volume presents the first and second laws of thermodynamics with a strong emphasis on the physical concepts and provides a variety of practically motivated examples to illustrate the application of the laws. Following a general discussion of the analysis of thermodynamic processes and cycles, Professor Johnson presents a number of specific examples covering displacement and turbomachine compressors and expanders.

Over 25% of the text is devoted to detailed analyses of the most commonly utilized cycles for power systems: Rankine cycle (including large-scale power stations); Brayton cycle (for stationary power generation and aircraft turbine-type engines); and the Diesel and Otto cycles so popular in conventional internal combustion engines. Contributing immensely to the value of the book are the 80 pages of tables, charts and graphs of the thermodynamic properties of common working fluids such as water, air and Freon. Most of these properties are presented in both customary and metric units, facilitating conversion to the SI system.

Although the book was developed primarily for undergraduate mechanical engineering students who need extended training in thermodynamics, Professor Johnson points out that it may also be used as a first-semester text for engineering students who wish to focus on the application of the principles of thermodynamics to practical systems. "There is a great advantage in presenting the principles of power system thermodynamics in a unified manner," Johnson says. "Now it is possible to combine a consistent treatment of the first law with valuable examples taken directly from modern industrial plants."

Scanning electron micrograph of an array of tungsten dendrites on the surface of a new experimental light-absorbing material developed by Jerome J. Cuomo, James F. Ziegler, and Jerry M. Woodall, of IBM's Research Division. (10 microns equals about 1/2500 inch)

SOLAR-ENERGY ABSORBING MATERIAL DEVELOPED

YORKTOWN HEIGHTS, N.Y., . . . The metal tungsten—fabricated with a special type of surface—has been discovered by scientists of International Business Machines Corporation to be highly efficient in capturing and holding solar energy. It may prove of interest to many researchers seeking alternative sources of energy.

The key advantage of the new material is its ability to hold its heat at high operating temperatures—in the range of 500°C (932°F). At this temperature, most solar materials lose a great deal of their absorbed energy by emitting infrared radiation.

A basic problem in development of high temperature solar absorbing materials is the construction of a surface which absorbs sunlight readily, but emits little infrared radiation, thus retaining a large portion of the absorbed energy. The problem is difficult to solve because normally the qualities which make a material a good absorber also make it prone to lose energy readily by emission. Conversely, a material which does not lose energy readily through emission does not usually absorb it readily either.

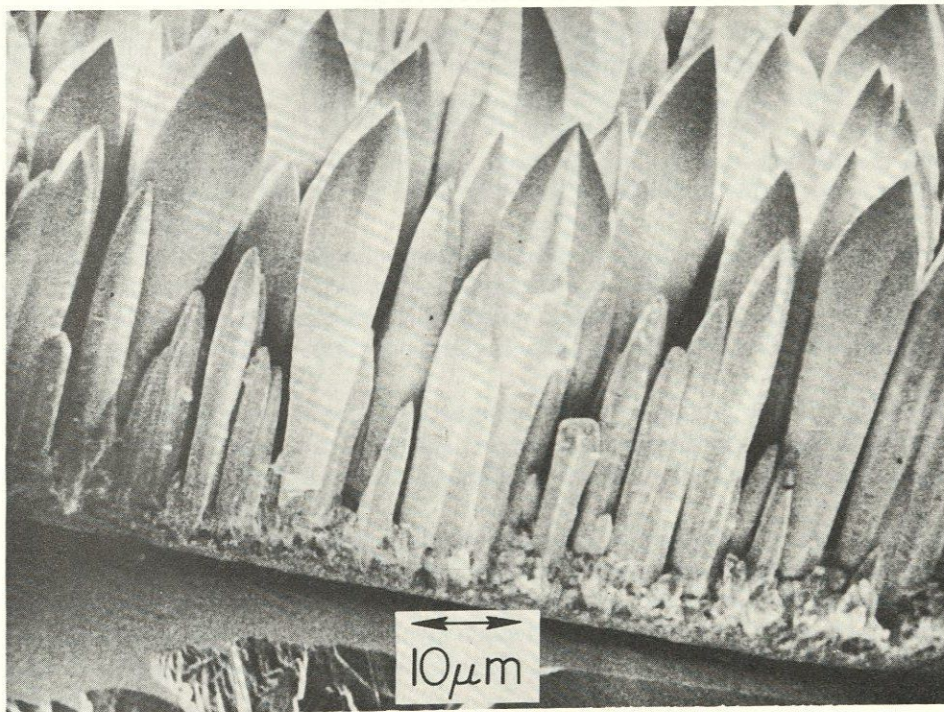
The new absorbing material was discovered during a semiconductor study in which IBM scientists were growing tungsten films. They noted that the top surface of the vapor-deposited tungsten was black, indicating that it was acting as a good absorber of light. The finding was

unusual, since tungsten is normally regarded as both a poor absorber and poor emitter of radiation.

Microscopic examination of the tungsten surfaces showed that they were covered with tiny vertical spear-like structures known as dendrites. Further investigation indicated that such a surface has promising absorption and emission characteristics in exploiting solar radiation to accumulate potentially useful heat.

In spite of "normal" tungsten's poor absorption characteristics, light striking the new material's surface at angles within about 15 degrees of the vertical axes of the dendrites bounces back and forth within a dendrite "maze" and is largely absorbed. The maze effect appears to be a consequence of the tiny size of the dendrites. Their diameters range from about 1/2,500 to 1/5,000 inch. Separation between individual dendrites is comparable to the wavelengths of light and may be as small as 1/50,000 inch. "Large" dendrites may be as tall as 1/500 inch, separated from one another on the average by about the same distance. Interspersed among them is a denser "underbrush" of smaller dendrites, ranging downward in height to approximately 1/2,500 inch.

Better than 96 percent of light from the solar spectrum is captured by the dendrite array. Heat is accumulated effectively because energy is emitted only via the same paths as it enters, within about 15 degrees of the dendrites' vertical axes. In contrast, a surface coated with carbon black, a very good absorber of radiation, emits infrared radiation hemispherically—in all directions from the surface. *Continued on page 7*



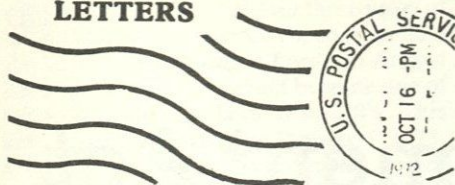
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LETTERS



'62

While I was passing through the lobby of the Engineering Center during the week of March 10, my attention was drawn to a stack of assorted *Colorado Engineer's* with a hastily scrawled note, "Where were you in '62?", placed beside them. Not being an engineer, I thought this to be a private joke. Right off hand, I could see no reason to think back to second grade. Being open-minded, however, I decided to follow the engineering mind and regress temporarily. I found nothing of formative value besides a fairly critical responsibility as tetherball monitor. Intrigued, I sat down to observe the reactions of the engineers to this display of memorabilia. A few casually thumbed through one or two issues, but by and large, 1962 wasn't a good year for anyone. Needless to say, I was somewhat relieved.

I came to the conclusion that the reason for such large numbers of back issues is the same as that for the large number of surplus issues today—isolation. Why not distribute the *Colorado Engineer* through other related departments such as Physics and Chemistry? Not only would readership increase, but even the perspective of the magazine has a good chance of broadening itself beyond the limits of '62.

Pam Nylander

NEWS

Continued

At low temperatures, most energy losses occur by conduction—through contact with the atmosphere, for example. It is only at higher temperatures that energy is lost in appreciable amounts through infrared emission. Because the paths of infrared emission of the new tungsten material are restricted to a cone-shaped volume, the material has a distinct advantage over hemispherically emitting blackbody absorbers at high temperatures.

Details concerning material preparation, structure, and behavior are available in a report, "A New Concept for Solar Energy Thermal Conversion," by Jerome J. Cuomo, James F. Ziegler and Jerry M. Woodall.

Continued from page 3

We know that all of you have opinions of how a professor might better present his material, hold your interest in class, or maybe just keep you awake during the early morning hours. Now is the time to let your ideas be known.

We do not intend to limit our attentions to bad habits either. We are well aware that there are many excellent professors in the College of Engineering and we would like just as much to hear your opinions of what makes a good instructor good as well as why a poor instructor is not.

Your response may take the form of a letter, an essay, or even a set of scribbled notes. (For obvious reasons we would prefer double-spaced typed responses, but we'll manage anyway if you can't.) What is important only is that you reply. Please mail or deliver these to the *Colorado Engineer* office in ECOT 1-7.

We are not sure of the format that this dialogue will follow; this is certainly largely dependent upon the response that we receive to this request. We are well aware that the variety of our efforts can only be directly proportional to the number of opinions we are able to elicit from you. Therefore, we hope that you take the time to let us know your thoughts. Any response you submit can only serve to make your professors more aware of your needs as a student and in the long run we feel this may yield beneficial results for all. □

Book Review

by Scott Kempshall



Engineering Education in Colorado The Colorado Engineering Dean's Council 49 pages

Compiled by the Colorado Engineering Dean's Council, a board comprised of the engineering deans of Colorado's four major engineering colleges (University of Colorado, Colorado State University, Colorado School of Mines and the University of Denver), this booklet is an analysis of the overall situation of engineering education of the State of Colorado, past, present and future. The report also contains references to the standing of Colorado with respect to the national situation.

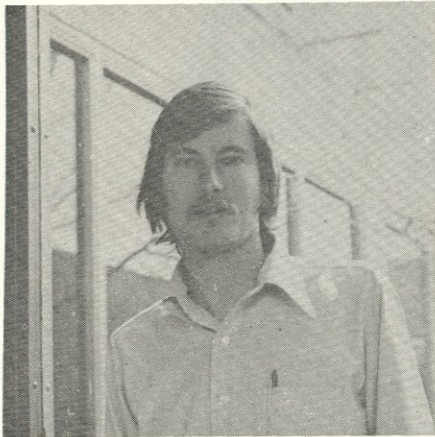
The analysis includes developments relative to engineering technology programs, response to former studies of engineering education in the state, the role of the individuals universities in providing continuing engineering education, and public service in the state, and predictions as to what will develop in the near future.

The booklet is most beneficially augmented by diagrams, charts and tables covering points such as, national high and low starting salaries and for undergraduate, masters and doctorate candidates, demand vs. supply of engineers nationally and statewide.

Every student of engineering should take the opportunity to examine the material covered, as it paints a bright picture for those of us looking forward to a career in engineering. The information here is interesting, well-written and very concise, and even though it will never make the best-seller list, it makes for some good reading. If you are interested, there is a copy in the office of the *Colorado Engineer*.

The Community Development Act and its Effects on the Denver-Boulder Area

by Don Brandes



Don Brandes, Jr. is the editor of Planning Resource News Review, a planning newsletter published through the Institute of Regional Planning, and is currently writing a report for the Planning Department in Broomfield, Colorado on the Community Development Act. He is a full-time student in political science at the University of Colorado, Boulder, and plans to graduate in May, 1975. Before transferring to CU he worked for over a year as an architectural-planning draftsman for Barber/Yergensen Architects and Planners in Colorado Springs.

Appendix A

COMMUNITY DEVELOPMENT BLOCK GRANT

(The following pages in this Appendix have been reprinted from the Federal Register)

federal register

WEDNESDAY, NOVEMBER 13, 1974

WASHINGTON, D.C.

Volume 39 ■ Number 220

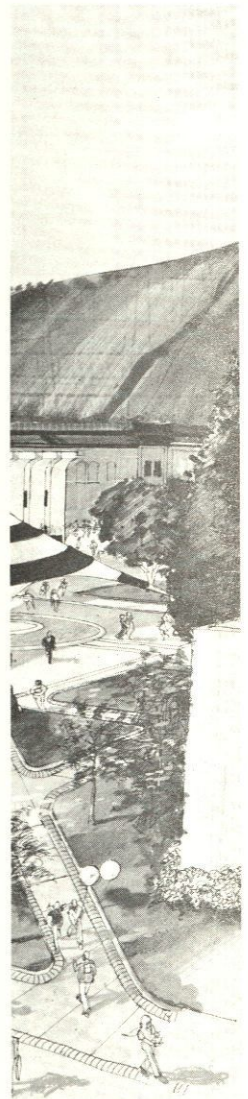
PART III



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Office of Assistant Secretary
for Community Planning
and Development

Community Development Block Grants



Signalling the end of over three years of negotiations between Congress and the Executive, President Ford, on August 22, 1974, signed what could become one of the most important laws of the 70's. This law, which took effect on January 1, 1975, is the Community Development Act of 1974. For University of Colorado graduating seniors with civil, environmental, or architectural engineering backgrounds the act may mean jobs involved with urban revitalization.

The Community Development (CD) program will allocate nationwide approximately \$2.50 billion for fiscal year 1975, and an estimated \$2.95 billion for both 1976 and 1977. This money is 100 percent grant with no local matching funds required. Cities such as Boulder, Denver, and Longmont "automatically" receive a share of CD money. Generally, smaller cities like Broomfield, Thornton, and Golden must "compete" for CD money. Most important, however, are the various projects the CD program funds. Among those eligible activities are: the construction of water and sewer facilities, pedestrian malls and walkways, parks, playgrounds, and neighborhood facilities. Other CD funded activities include the restoration or preservation of historic sites and natural resources, and programs of urban development. This list is extensive. With more than 20 percent of all construction workers jobless, a total of 54,700 people unemployed in Colorado, and several thousand graduating seniors soon to be searching for jobs, the CD program is certainly good news.

One problem with the CD program is that it is difficult to understand, as are most federal programs. However, to seek an understanding of the general intent of the CD program, as well as an understanding of how the program allocates money to cities, is nonetheless important. This article will briefly outline how the CD program is structured, and more generally, how the act will affect people living in the Boulder-Denver area.

The Community Development Act assumes that most local communities can best define their own priorities.

The Community Development Act (P.L. 93-383) assumes that most local communities can best define their own priorities. Thus the law is intended to revitalize local control. Past categorical grant programs such as Urban Renewal, Model Cities, Urban Beautification and others required multiple, lengthy application and review procedures. These procedures

were not only complex and time consuming but were also very costly to small cities who lacked sufficient staff and revenue to prepare worthy applications. The CD program, then, is a "block program" designed to replace the several categorical programs of the past. While CD grants replace existing grant programs, they do not replace grants already awarded under these programs.

The Department of Housing and Urban Development (HUD) has designated cities either "entitlement" or "discretionary." Basically, entitled cities have a population of over 50,000, while those of a lesser population generally fall into the latter category. But HUD also takes into account the city's extent of poverty (that is, the percentage of families whose incomes do not exceed 80 percent of the median income for the area), housing overcrowding (the number of housing units with 1.01 or more persons per room based on 1970 Census data), and population (also taken from the 1970 Census). In addition, if a city has had a history of Urban Renewal, Model Cities, or other HUD categorical programs which are being terminated as a result of the CD program, the city is termed "hold-harmless." A hold-harmless city receives at least as much as an average of the amounts it received from categorical grants over the five fiscal year period from 1968-1972. In other words, a hold-harmless city will be paid CD money based on an average of its past (68-72) categorical program funds for a three year period (75-77) beginning in 1975.

For instance, Longmont is entitled to \$883,000 per year for the next three years under the CD program because of an existing categorical Urban Renewal Authority. However, the Longmont Urban Renewal will cease to exist in March, 1975, and the City of Longmont community development program will take over. Longmont is an example of an entitlement city with past funding held-harmless.

Boulder is also an entitlement city. Boulder qualifies primarily because of its population size. As an entitlement city, Boulder expects to receive \$246,000 for 1975. Depending upon annual Congressional appropriations, Boulder may expect to receive an additional \$594,000 in 1976, and an estimated \$907,000 in 1977. Future entitlement for 1978 through 1980 is gauged at \$922,000 annually.

Broomfield and Thornton are examples of typical discretionary cities. A discretionary city has no predetermined allocation which it can expect to receive. These non-entitled cities must compete among other discretionary cities on the basis of poverty, housing overcrowding, and population. HUD will award discretionary money, then, if a city demonstrates urgent need.

In the Denver-metro area there are ap-

proximately 16 discretionary cities. The estimated sum of discretionary-competitive funds in metropolitan Denver is \$648,000 for 1975. The estimate of 1976 discretionary funds is \$2,213,000. This substantial increase can, in part, be accounted for by the total national increase in appropriation from 1976.

As an entitlement city, Boulder expects to receive \$246,000 for 1975.

With all this money becoming available to cities, the prospect of being employed by future CD funded activities becomes imaginable. The list of eligible activities for which an entitlement or discretionary city may apply for CD funds includes:

- acquisition of real property which is;
 - blighted, deteriorated, deteriorating, or inappropriately developed
 - appropriate for rehabilitation and conservation activities
 - appropriate for preservation and/or restoration of historic sites; urban beautification; conservation of open space, natural resources or scenic areas; provision of eligible public works, facilities and improvements, or for other public purposes.
- acquisition, construction, or installation of public works facilities, or other improvements, including:
 - pedestrian malls and walkways
 - recreation facilities
 - historic properties
 - foundations for air rights sites
 - senior centers
 - neighborhood facilities
 - streets, streetlights, and utilities
 - water and sewer facilities
 - parking, solid waste disposal facilities, and fire protection services and facilities, if such are located in or serving designated community development areas.
- code enforcement in deteriorated or deteriorating areas in order to arrest the decline of the area.
- special projects to remove material and architectural barriers restricting the elderly and the handicapped.
- clearance, demolition, removal and rehabilitation of buildings when incidental to other program activities.
- payment of the cost of completing an urban renewal project.
- relocation payments and assistance.
- payment of reasonable administrative costs and carrying charges related to the planning and execution of activities.

Ineligible activities include:

- public facilities (which are ineligible

unless they are specifically mentioned under eligible facilities):

- ☐ schools
- ☐ hospitals
- ☐ stadiums, theatres, cultural centers
- ☐ buildings for the general conduct of government.
- political activities.
- new housing construction.
- operating and maintenance expenses.

On January 13, 1975, the 16 member Boulder Citizen's Committee on Housing and Community Development (CCHCD) recommended to City Council the following project appropriations of the total \$246,000 to be allocated for 1975: \$175,000 to the new downtown mall project (plus \$475,000 to be spent on the mall in 1976); \$25,000 for planning and administering the CD program; \$40,000 to provide for physical improvements in existing city housing projects, including conversion of units for handicapped, and the addition of ramp and handrails in elderly projects; \$5,000 for the Retired Senior Volunteer Program (RSVP), a program which provides transportation services for Boulder senior citizens; and \$1,000 to be used for tree-planting and general landscaping in the Goss/Grove neighborhood. All of the first year projects CCHCD recommended cannot begin, however, until the CD grant application has been approved by HUD. Funds may be expected for the Boulder projects by May 15, 1975. Incidentally, the Boulder City Council has already given their approval to the mall project which will begin as soon as HUD funds are received.

It is interesting to note that since the early 60's Boulder has been conscientiously examining the possibilities of a mall. Perhaps the first plan considered by the city was prepared by Gruen Associates of Los Angeles in the late 60's. Gruen proposed the "Boulder Tomorrow Plan" which concentrated on basically four design areas: superblock concept; transportation improvements; parking facilities; and a civic and cultural center. Using Gruen's recommendations as a foundation, Carl Worthington and Associates, in 1974, reworked the mall concept, and determined that a downtown plan still appeared worthwhile for Boulder. Today, the principal design coordinators for the mall are: Everett/Zeigel Associates, Boulder architects and planners; Sasaki Dawson DeMay Associates of Watertown, Massachusetts, landscape architects and environmental planners; and Communication Arts Incorporated, a Boulder firm specializing in graphic and industrial design.

The key to the mall design is the separation of vehicular traffic from the pedestrian. After closing Pearl Street between 13th and 15th Streets a public plaza will

then be constructed in front of the Boulder County Courthouse. The design team claims that the downtown mall will revitalize the Boulder core area, and eventually lead to an improved tax base.

Preliminary cost estimates for the Boulder project are \$1.3 million. As mentioned earlier, the city plans to allocate \$650,000 of CD funds towards the mall by the end of the second program year. Whether Boulder expects to finance the entire \$1.3 million mall cost through future CD funds is not known. In any case, Boulder's downtown mall will soon become one of the first real signs of Community Development actions in Colorado.

Future discretionary projects in the Boulder-Denver area are still in the application review stage. HUD still has to determine which, among these discretionary cities that have applied, will be funded. One of those who has applied for discretionary

funds is Lafayette City Manager Jane Williams. Williams has applied for a \$225,000 CD grant. The grant would be used to enlarge a portion of the water transmission line and the water treatment plant, and to add an additional chlorination station. Williams claims that Lafayette has lost up to 50 percent of its water through leaks in its transmission lines. That is, Williams says, the city has pumped one million gallons of water a day and Lafayette residents were billed for only half that amount. Williams did not indicate exactly how Lafayette determined the 50 percent water loss. Presumably, the city based its residential water usage on local meter readings, and then checked this total against the total gallons pumped per day.

Hydrotronics Incorporated, a water engineering firm, has developed a procedure for detecting leaks in water transmission lines, and may be retained by Lafayette in

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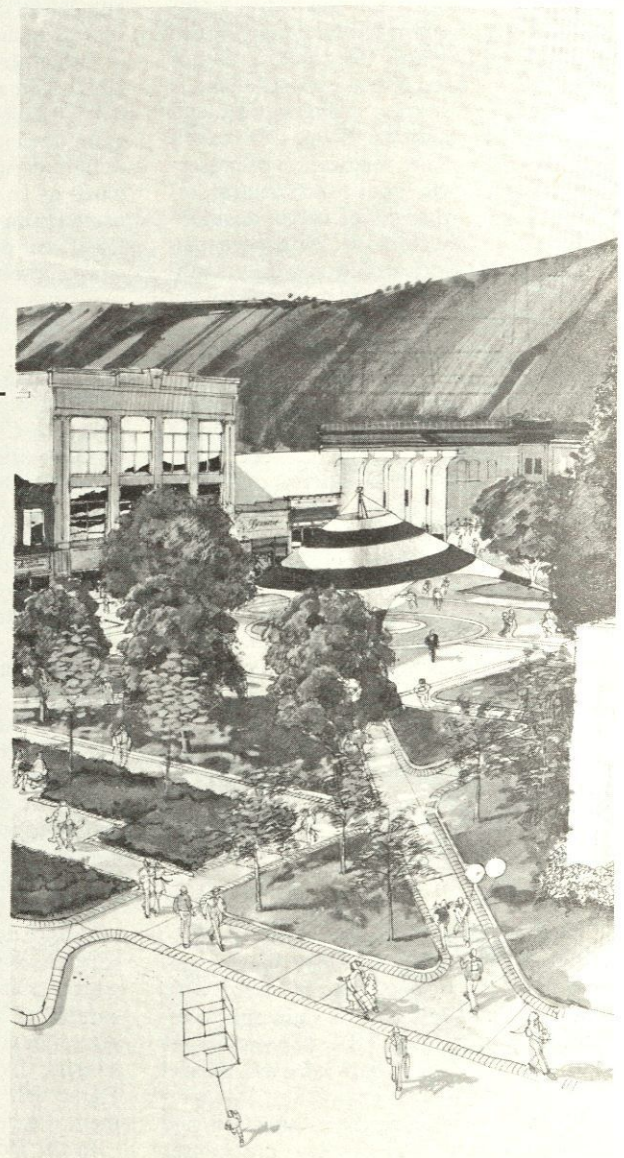


PART III

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Office of Assistant Secretary
for Community Planning
and Development

Community Development Block Grants



an effort to solve its water leak problems. The technique used by Hydrotronics engineers is to attach sensors at different locations on the pipeline which will broadcast soundwaves to a mobile unit in the case of a leak. A similar study was performed by Hydrotronics for the city of Georgetown, Colorado.

The possibility of Lafayette receiving some of the \$648,000 does not appear to be that remote. Since 1970, the town's population has grown from 3,498 to more than 7,000. Because of this rapid growth the

In Broomfield, the population has more than doubled since the 1970 Census. The current population of more than 15,550 is expected to rise to 30,000 by 1980; 50,000 by 1985; and 80,000 by 1990. The rapid growth in Broomfield has, according to Broomfield Planning Director, Tim Heins, brought about the need to examine the effects of this growth upon the maintenance of a healthy natural environment, and its effect on city revenue and expenditures, police and fire protection, schools and the full range of municipal services. In Heins'

the air. We hope to get additional water from Denver then." But he said the city would face "the price of water rights going up dramatically." Broomfield would also appear likely to benefit by applying for discretionary funds.

Louisville City Administrator, Leon Wurl, has joined with Lafayette and Broomfield in expressing his concern over rapid growth. In Louisville, Wurl says, "We've tried to develop innovative things (concerning growth), including builders supplying funds before annexation to study how new developments will affect the community as a whole." The 1970 Census listed Louisville's population at 2,560; the latest estimate is 3,500 residents. Though Louisville has a relatively low, but growing population, it nonetheless qualifies as an entitlement city because of a history of urban renewal. Surprisingly, Louisville is one of the few examples in the Denver-metro area where a small city is assured of receiving CD money. Louisville is entitled to \$200,000 for 1975.

Other discretionary cities in the Denver-metro may decide not to apply for a share of the estimated \$648,000 fund, but will instead wait until 1976 to apply for a part of the estimated \$2,313,000 fund. The

The key to the mall design is the separation of vehicular traffic from the pedestrian. After closing Pearl Street between 13th and 15th Streets a public plaza will then be constructed in front of the Boulder County Courthouse. The design team claims that the downtown mall will revitalize the Boulder core area, and eventually lead to an improved tax base.

sewer and water systems are near the limit of capacity. However, Lafayette will be competing among other Denver-metro discretionary cities having similar, if not more critical problems.

own words, "Broomfield has, with the combination of our own supplies and the additional water from Denver, enough water supply to allow continued growth for the next five years. After that we're up in

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reasons a discretionary city may choose to wait until 1976 or 1977 are quite simple: money and time. Application procedures, while streamlined by the CD program, are still long, complex and costly. The smaller city, which employs only one or two planners, cannot afford to risk spending time and money on the CD application unless the city is fairly certain of being awarded funds. Planning departments for entitled cities usually have the advantage of a large planning staff. The irony is that a small city with only one or two in its planning department may have problems as severe as the entitled city with eight to ten planners.

The task of completing the CD application prior to receiving CD funds is the city planning department's responsibility. All CD applications require the following information:

1) A summary of a three-year plan which identifies community development needs and objectives developed in accordance with area-wide development planning and national urban growth policies, and which demonstrates a comprehensive strategy for meeting those needs.

2) A one-year CD program which:

- a) takes into account the effect upon the environment
- b) is designed to eliminate or prevent slums where such conditions or needs exist
- c) indicates activities to be undertaken to meet community development needs and objectives
- d) indicates resources expected to be available for meeting needs and objectives.

3) A Housing Assistance Plan

- a) surveying the condition of the community's housing stock
- b) specifying an annual goal for the number of units or persons to be assisted, including:
 - i) the mix of new, rehabilitated and existing units
 - ii) the size and types of housing projects and assistance best suited to the needs of the community's lower income persons.
- c) indicating the general locations of proposed lower income housing with a view toward:
 - i) furthering the revitalization and stability of neighborhoods
 - ii) promoting greater housing choice and avoiding undue concentrations of lower income persons
 - iii) assuring availability of adequate public facilities and services for such housing.

4) Certifications of:

- a) compliance with Civil Rights Acts
- b) adequate citizen participation
- c) A-95 review of application (done through the Denver Regional Council of Governments)

d) annual performance report

Because the CD application is so detailed and demanding, several entitled cities in the Denver-metro area have had to pay outside consulting firms to gather required data in order to complete the CD application. For instance, the Longmont City Council hired George C. Perkins and Associates of Denver to prepare a housing assistance plan. Perkins is now conducting a study of the exterior physical condition of houses, and a socio-economic survey. Perkins' study will cost Longmont \$30,000. Indeed, as previously mentioned, the small discretionary city is forced into a distinct financial bind during the application process.

Aside from the abbreviated mechanics of the CD program as herein described, several cities in the Boulder-Denver area will be receiving a large amount of money. The

economic effect of the CD program in Colorado will amount to \$26,789,000 in 1975 alone. Within the Boulder-Denver area a total of \$17,796,000 will be divided among the following entitlement cities with each receiving the amount shown.

Denver	\$15,827,000
Boulder	246,000
Longmont	883,000
Louisville	200,000
Littleton	197,000
Lakewood	232,000
Aurora	211,000

The civil, environmental, or architectural engineering student cannot ignore the economic impact of the CD program. Hopefully, some portion of CD money will open up new prospects for engineering, construction, and an improved urban environment. □



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x^2	yes	yes
$\sqrt{x}$	yes	yes
$\sqrt[y]{x}$	yes	no
$1/x$	yes	yes
$x!$	yes	yes
Exchange x with y	yes	yes
Metric conversion constants	13	3
% and $\Delta\%$	yes	yes
Mean and standard deviation	yes	yes
Linear regression	yes	no
Trend line analysis	yes	no
Slope and intercept	yes	no
Store and recall	yes	yes
Σ to memory	yes	yes
Product to memory	yes	yes
Random number generator	yes	no
Automatic permutation	yes	no
Preprogrammed conversions	20	7
Digits accuracy	13	10
Algebraic notation (sum of products)	yes	no
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Fixed decimal option	yes	yes
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Constant mode operation	yes	no



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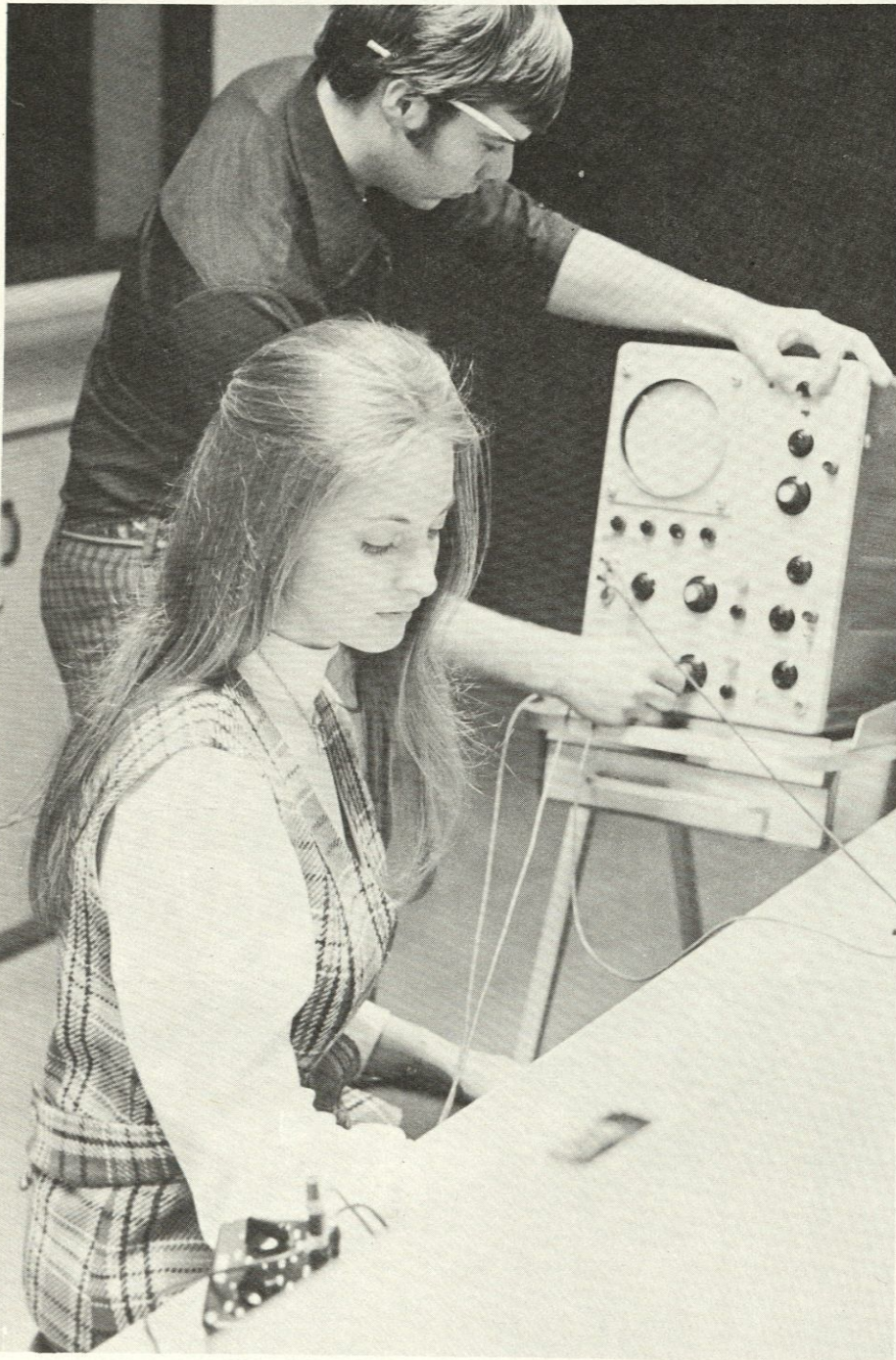
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Ms. Engineer

A look at women engineering students

by Donna Edens



It would seem that in the past the physical strength required to handle heavy machinery evolved into a 'prerequisite' for a bachelor of science degree.

Engineering has too long been considered a stronghold of unquestioned male dominance. It would seem that in the past the physical strength required to handle heavy machinery evolved into a "prerequisite" for a bachelor of science degree. But the majority of engineers today work at desk jobs and employers place more importance upon a high level of technical competence than upon mere physical ability. Many engineering jobs require no more physical exertion than it takes to push the buttons on a calculator. This realization has thus allowed many women to consider engineering as a possible career choice.

At first, women were reluctant to enter this traditionally masculine field. They encountered the disapproval of family and friends and alarmed many of their professors and fellow students. But the prejudice against women engineers has been declining steadily and now women are discovering that they are not only accepted, but welcomed into most engineering colleges.

The University of Colorado was among the first to graduate a woman from the College of Engineering. She was Minnetta E. Frankeberger and she received her degree in 1903. (By the way, the first woman engineer on record is Edith Julia Griswold who established herself in patent office drawings in 1886.) By 1900 there were less than 100 women engineers in this country. But the outbreak of World War I created a demand for trained engineers and thus more women began to enroll in engineering schools.

The contributions made by these early women engineers have been significant. Edith Clarke contributed to symmetrical-component theory, circuit analysis, and long-distance power transmission. Dr. Lillian Gilbreth was a pioneer in the field of motion study, while Dr. Irmgard Flugge-

-Lotz is an internationally known figure in the field of theoretical aero-dynamics and automatic control. More recently we find women engineers involved in the development of sounding rockets and the supervision of ground and airborne surveillance radars surrounding Cape Kennedy. A woman also holds a patent on a process used in manufacturing the type of printed circuit found in transistor radios.

These women have more than proved themselves capable engineers but they have also helped open the doors for even greater numbers of women engineering students. Female enrollment in engineering universities across the nation is enjoying an upward trend and we find the situation at C.U. to be no exception. The number of women students enrolled in the College of Engineering has increased from 58 to 107 in the last year alone and one now finds women represented in all departments. Of these 107, 19 are enrolled in chemical engineering, 18 in applied math, 17 in electrical engineering, 16 in civil engineering, 13 in architectural engineering, and nine with undetermined majors. In other departments the numbers drop to four each in aerospace engineering, mechanical engineering, and engineering design and economic evaluation. Only three women are enrolled in engineering physics. There are five women graduate students and two women professors.

"Increasing female enrollment is partially a by-product of Women's Liberation," suggests Ms. Anne DeVore, a counselor in the C.U. College of Engineering. The Women's Liberation movement is responsible for encouraging young women

"There's nothing inherently feminine about mixing a given batch of materials, exposing it to a definite temperature for a definite time and producing a cake. There's nothing inherently masculine about mixing a given batch of materials, exposing it to a definite temperature for a definite time and producing iron casting-s."

to reassess their attitudes towards traditionally male occupations. Male-female role distinctions are gradually diminishing. "There's nothing inherently feminine about mixing a given batch of materials, exposing it to a definite temperature for a definite time and producing a cake. There's nothing inherently masculine about mixing a given batch of materials, exposing it to a

definite temperature for a definite time and producing iron castings," states engineer Rebecca Sparling.

Women engineers of high achievement have had the least trouble with discrimination. Technical accomplishment is admired and surpasses any existing prejudice. This view is confirmed by Professor Beck, who is with the Engineering Design and Economic Evaluation department. "I have had relatively little discrimination in my professional life," she says. "It was the thing I wanted to do and I felt no external pressure. The pressure was competing with myself."

Anne DeVore believes this self-competition to be the number one problem of women engineering students. "These women are very achievement oriented. They tend to take grades too personally. If they get a 'C' in physics, they think it means that they shouldn't be an engineer. What it really means is that they got a 'C' in physics. Everyone has their mediocre areas."

"Women engineering students are very bright," Ms. DeVore continues. "Their problems are not with the course work; it's a role problem. Many engineering students have at most two or three women in the class. These women feel very isolated. It's a big problem." However, this feeling of isolation is created by society in general and does not stem specifically from the attitude of male students. In the words of Ms. DeVore, "Male engineering students are very objective; they have an open mind. If you can do the work, you're okay."

One way to alleviate this feeling of isolation is to bring women engineering students together professionally as well as socially. The University's now defunct SWE (Society of Women Engineers) is in the process of being re-established due to increased interest. The SWE is a non-profit, educational, service organization dedicated to making known the need for women engineers and encouraging young women to consider an engineering education. The aim of the society is not to segregate women engineers; they are encouraged to belong to their own professional engineering society as well. The SWE offers the opportunity for women with common interests and ambitions to meet.

Women engineering students are becoming involved in engineering-related activities. For the first time in C.U. history, AES (Associated Engineering Students) has a woman president, Carolyn Hime. Ms. Hime stated that being a woman has not hindered her in any way. She feels that a woman president has an advantage: "Being a woman can help recruit participation." This statement is perhaps indicative of a great versatility to be found in a woman engineer.

According to 1968 statistics, women were nine percent of all professors; nine percent of all scientists; seven percent of all physicians; three percent of all lawyers; but less than one percent of all engineers.

It has not been easy for women aspiring to be engineers—they have met with discrimination all along the way. But one hopes that as the need for engineers increases the negative attitude towards women will diminish. According to 1968 statistics, women were nine percent of all professors; nine percent of all scientists; seven percent of all physicians; three percent of all lawyers but less than one percent of all engineers. Despite this fact statistical studies indicate that a greater percentage of women will be entering engineering as a profession due to the increased acceptance of women's capabilities. The last bastion of male domination on the college campus is coming down. □

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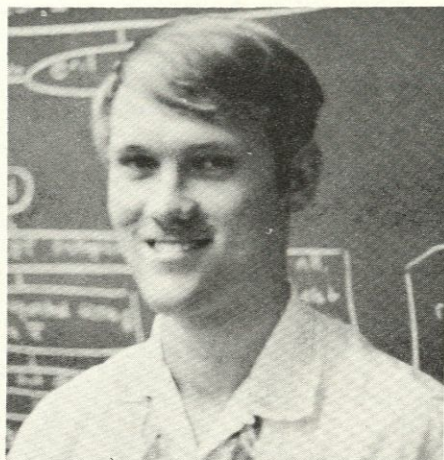


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How to Succeed in Engineering

by Rich Kendel



Rich Kendel, otherwise known as "Rotc Rich," is a senior majoring in Aerospace Engineering with a minor in Latvian studies. Rich's career goals are to fly in the Air Force after graduation, and then to go on to recreational engineering. His hobbies include study breaks and waterskiing.

There are, in my opinion, four basic ways to get accepted in the School of Engineering: by being a minority, by being the son and/or daughter of the Dean, by being lucky, or by being smart. Of these, only the lattermost really does you much good once you're in, but then to me, being smart takes all the fun out of it. How anticlimatic it would be to go the four year distance without once wondering if you'll be among the two-thirds that bites it.

For myself, I was one of the "lucky" (or the cursed, depending on how you look at it). When I started three years ago, I was unanimously voted by the computers as the one in our class "least likely to succeed in engineering." The electronic deities figured that I would transfer out and they probably would have been right, except they forgot to program in one important variable—the 3-year language requirement. Many are the times I've ogled the Arts and Parties' course outline, but only to be turned back, aghast and defeated, by a shortage of French conjugates in my two

year high school repertoire. So, I accepted my fate of lowering class curves and, armed with eighteen years inexperience, set out to meet my destiny.

My first task, after having established the fact that I was doomed for going into engineering, was to decide which field of engineering to major in. Studying the viscous effects of defecation through a pipe didn't appeal to me, so civil was out. I can't change a lightbulb without an instruction manual so that eliminated mechanical, and electrical engineering is only for masochists. So, I continued to narrow down the choices until, to me, the *least* impossible of the majors seemed to be aerospace. And besides, I figured if I was going to learn how to be unemployed, I might as well go all the way and enter a field that had already proven itself.

That momentous decision accomplished, the initial steps in my indoctrination to engineering consisted of a series of physical adjustments. First, I established residency within the inner depths of the Engineering Center, which necessitated the need to wean my stomach from food and onto vending machines. I didn't really kick the habit "cold turkey" (so to speak) for I have previously conditioned myself by having eaten in a dorm. But, while the two may reek of similar quality, I still suffered from withdrawal and varying degrees of the "D.T.'s" (dead taste) buds. Even now I have daily flash backs to hallucinations of green professors and fatal error print-outs.

Also among the acclimations necessary in my development as an engineer, was the all-important ordeal of giving up sleep. Infidels will tell you it can't be done, but to the true believer, all is possible. For this is the time-honored secret of obtaining the engineering state-of-mind — that of being able to walk around in a trance-like state with symbolic dark, mystic moons about the eyes. It is not an easy task to undertake, but once surmounted it represents the overcoming of the last real barrier that might prevent one from joining the engineering cult.

Now that you are an engineering student, you will find that your classes consist



of two types: those that are boring and, at the other end of the spectrum, those that put you to sleep. Boring classes are those of all variety which are basically unintelligible. It helps if the professor can't speak English and teaches from a text translated from Latvian into Latin.

The classes that put you to sleep, on the other hand, are (usually) taught by older professors (the type that were born before life as we know it began). This is because it takes many years of experience to master the arts of the hypnotic technique. However, with the aid of 8 a.m. classes, windowless rooms, and careful supervision, even the lowly T.A. can condition his class to fall asleep at the simple command of "good morning."

Outside of classes, the bulk of your time

ring (In Spite of Yourself)



is committed to studying, but there are ways to ease the pain. For example, calculators are a nice means of saving time, though a math major will do almost as well. In fact, every engineer should own one, preferably one that is quiet (i.e., floating decibels), easy to shut off, and programmable.

Now in engineering there is no such thing as "spare time," but to the cagey student it's amazing what you can get away with under the pretense of "study breaks." A good example is sex. Contrary to popular belief, calculators and slide-rules do not qualify as sex substitutes. (However, it is interesting to note that this is not the case in the relation between a math major and his sheep-skin covered CRC.) Another common phallixy is that one can lengthen

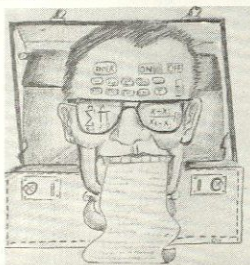
"game time" by reciting mathematical tables to preoccupy the mind. While some types may find math tables exciting, engineers tend to be more interested in the problem at hand and derive little pleasure from the tender exchange of hyperbolic functions.

The truth of the matter is, sex is a good, concentrated form of relaxation, exercise, and relief (not necessarily in that order). It can even be beneficial the night (or hour) before a test provided one drinks a glass of milk the following morning to renew strength and replenish precious bodily fluids.

The social contacts of the engineer usually fall into two categories. First, you have the pre-exam get-together known as the "study party," where individuals of common intellectual tribes gather around the ceremonial coffee pot and chant four-letter word offerings to the almighty Test God.

Also, there is the engineer's post-exam celebration when the same individuals meet again to pay homage for the blessings bestowed upon them by the Test God over the preceding period. Here one may find a variety of rituals, ranging from the somewhat bizarre practice of burning strange herbs, to the more common practice of drinking strong potions. Examples of potions indigenous to the University of Colorado vary from the Math Major's Micky (a hot glass of milk with a jigger of cream) to the ever popular Harry Buffalo (a glass of Everclear with a nitro chaser).

Here, then, are but some of the "secrets" behind the life and times of the engineer. Others may knock our "conservative style," but when 92% of us get jobs after graduation (at an average starting salary of \$14,000 per year) we can cry about it all the way to the bank. □



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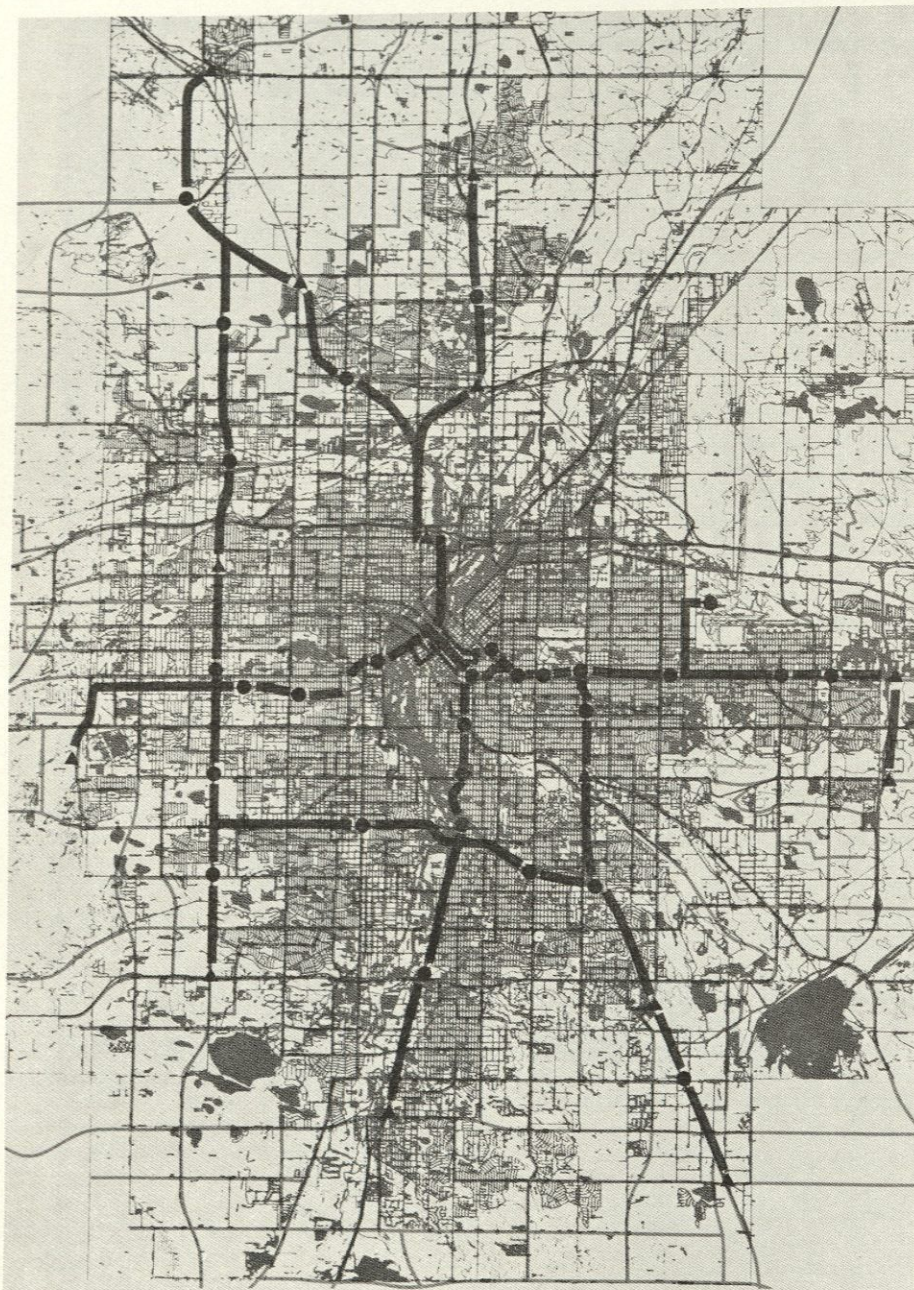
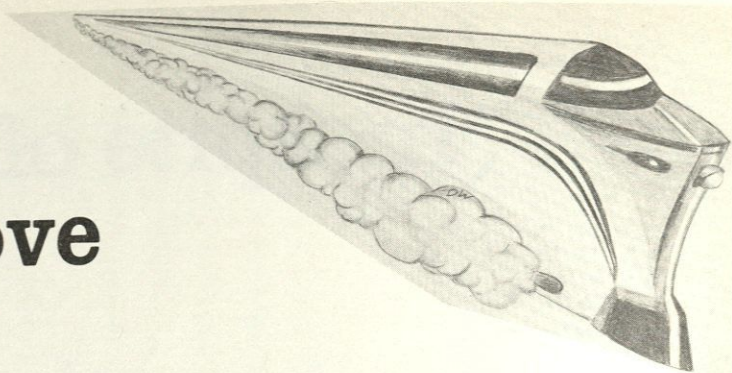
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Remember RTD? It's. . .

Still on the Move

by Tim Doll



DENVER

Map of the Denver area showing the RTD's proposed bus (light bold lines) and PRT routes (heavy bold lines).

In 1969 the Colorado General Assembly formed the Denver Regional Transportation District (RTD) to plan and implement a comprehensive public transportation system for Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties (Metro Denver Area.) During the next three years the RTD mapped out an extensive transportation plan for this area, one which would cost over an estimated \$1.6 billion.

In September of 1973 the RTD presented this plan to the people of the Denver area. The plan called for the sale of \$425 million in municipal bonds, financed by a 1/2 percent sales tax, to pay for the project. The remaining \$1.2 billion was to come from federal grants. After a highly controversial campaign, the RTD plan was approved in the six county area, and since then administrators have been busy implementing the first part of it.

The "Early Action Plan" (as the first phase of the plan is known) is an effort to improve the Denver area bus system. Toward this end, the RTD set out to buy the six separate bus systems which serve the Metro Denver Area. By the end of 1974 the RTD had purchased the Evergreen Transit Company, the Longmont Mini, the Denver Metro Transit, the Englewood-Littleton-Fort Logan Bus Company, the Northglenn Suburban Bus Company, and the Boulder Bus. The RTD also opened highly controversial negotiations on possible purchase of the Denver Boulder Bus Company. This controversy centers around the fact that the DBBCo was the only privately owned bus company making a profit in the Denver area. Opponents of the purchase say that because the DBBCo is making money is must be doing a good job and should therefore be left alone. They claim that if RTD took over the DBBCo the service would actually get worse instead of better. The rates would probably go up as well, they say, due to inefficiencies in the RTD methods of operations. This controversy has yet to be resolved.

The RTD is now looking to complete an integrated bus transit system in the Metro Denver Area. It is also revising the rate schedules, eliminating "zone" fares on

local routes, and generally equalizing the different bus fares. On the current integrated system a person can ride from Castle Rock to Longmont, from Evergreen to Aurora, or from and to nearly anywhere in between on public transportation. During the height of the energy crisis last winter the RTD was able to lease twenty five additional buses to serve the Denver area, taking an estimated one thousand cars out of the Denver rush hour traffic and saving untold thousands of gallons of gasoline. It is not surprising that ridership on the Denver area buses has gone up over 15 percent since RTD took over. It has also added several thousand miles of new routes to the system, serving people that were never before served by public transportation. Last year RTD contracted to buy 120 new buses, ranging from 47 passenger express buses to 25 passenger "mini" buses. RTD plans, as well, to install over 100 bus passenger shelters by the end of the year. Also instituted is a comprehensive bus service for the elderly, blind and otherwise handicapped: during 1974 RTD purchased 12 special buses equipped with elevators (for lifting wheelchairs), extendable low level steps for the elderly, and even seats with room for a seeing-eye dog. These buses do not run regular routes, but instead run special subscription door-to-door service.

Unfortunately, buses do not provide a long term solution to the Denver transportation problem. Denver is one of the fastest growing cities in the nation. The Metro Denver population, already 1.35 million, is expected to swell to over 2.35 million by the year 2000. Urban sprawl is threatening this once beautiful area with the same problems that now confront Southern California. Even now the Denver area has more autos per household than any other major urban area in the United States except for certain areas in California. Thus Denver has one of the most serious air pollution

... in the long run buses cost more to operate than most mass transit systems. The long term solution is a rapid transit system.

problems in the nation. Its high altitude coupled with an abundance of sunny days simply aggravate this problem. Over 90 percent of the photochemical smog in the Denver area is caused by pollution spewing automobiles. The U.S. Environmental Protection Agency air quality standards call for a 31 percent reduction in auto miles traveled in the area by 1977. This is a difficult request for an area that is growing at an annual rate of nearly 5 percent.

Buses are unable to meet this challenge. Buses are slow (the average speed of a bus

in a metropolitan area is only 10 to 12 mph), inefficient, and generally uncomfortable. In addition, although buses have low initial capital costs, in the long run buses cost more to operate than most mass transit systems.

The long term solution is a rapid transit system. Thus, as part of its long range plan, the RTD included a billion dollar Personal Rapid Transit (PRT) system to serve the needs of the Metro Denver Area. PRT is to be a system of small, elevator like, vehicles running with high frequency on a concrete guideway. Most of the proposed guideways were overhead, with some short sections in downtown Denver being subways. The system would operate much like an

... the RTD is going to have to provide an alternative means of transportation that is at least as fast and nearly as comfortable as privately-owned vehicles.

elevator, being demand controlled by computer. The cars would travel at about 30 to 40 mph and being electrically powered would create no pollution. These cars would have the utmost in modern conveniences including carpeted floors, upholstered seats, special lights, and climate control. They could be dispatched at 15 second intervals, thus making long waits for cars almost non-existent. Also, due to the personal nature of the cars, they could generally go to the passenger's chosen destination with few intermediate stops, thus making the system quite convenient for all. During peak hours, however, the PRT car would stop at two or three stations to fill the car with commuters headed for the same destinations. Since cars would pull completely off the guideway to stop, other cars would be able to pass through stations unimpeded, even though the car in front may have stopped. In addition, the computer controlling the system could "learn" the habits of commuters and anticipate where to send cars before they were actually called. The system could also be programmed to send special cars to places such as Mile-High stadium where great demand might be created by such things as sporting events.

The RTD also made special mention of the low initial cost of the proposed PRT when they chose it to meet the needs of the Denver area. Projected construction costs of the PRT complete with stations and cars were about 10 to 15 million dollars per mile, as compared to 15 to 30 million dollars per mile for most rapid transit train systems and approximately 30 million dollars per mile for a four lane highway through a metropolitan area.

However, the PRT plan has run into problems. A government test of the project in Morgantown, West Virginia proved to

be a complete disaster. Construction costs have skyrocketed due to unforeseen major technological problems. Basically, the project seems to be overly automated. The computer that is supposed to direct the cars to their destinations is suffering frequent malfunctions. Consequently, one finds many cars sitting idly on tracks far from stations and, in some cases, cars are sent to the wrong location. These problems are similar to those experienced by other highly automated rapid transit systems, such as the BART system in San Francisco. Some experts predict that construction costs for a workable PRT could go as high as \$50 million per mile. Influenced by this, the Urban Mass Transportation Administ-

ration (UMTA), an organization supervised by the U.S. government, has withdrawn funds for a PRT test track in Broomfield, Colorado and has asked RTD to reassess the economic viability of the PRT.

The Federal Government has appropriated only \$7.825 billion to cover mass transit for the next six years. There are over twenty-five metropolitan areas clamoring for that money. In order to decide who gets that money UMTA has placed a great deal of emphasis on the so called "cost effectiveness" of a system. In order to make sure that Denver reaps at least its share of the money, the RTD has awarded a \$4.9 million contract to TRW, Inc., a systems management consultant, to evaluate five different systems for cost effectiveness and their practicality in the Metro Denver area. The five systems are; an advanced bus system, a light rail system, a conventional rail system, a fully-automated fixed guideway system, and last, the PRT.

The advanced bus system would use the present bus system as a base, expanding it to meet future needs. This would mean the expansion of bus fleets to even greater numbers than is now currently planned, using "Superbuses" and "Transbuses." Both these buses are about one foot lower than conventional buses and their outside noise levels are over 50 percent lower while the inside noise level is 75 percent lower. These buses would also have such passenger conveniences as wider seats, more leg room, improved air conditioning and heating, comfort designed suspension and even stereo music. They would also have two way communication systems to allow advance warning of delays and emergencies. Some of the Superbuses are designed with a flexible center portion for easier turns. The Advanced bus system would

also make use of exclusive buslanes to make service faster and more reliable. This system would have the advantage of a low initial cost, but it would ultimately suffer from the same shortcomings of the present bus system.

An alternative is the Light Rail Vehicle (LRV). The LRV is much like a modern streetcar and it has already been approved for use in San Francisco and Boston. The

... the computer controlling the system could "learn" the habits of commuters and anticipate where to send cars before they were actually called.

Boeing Corporation, the prime contractor for the LRV's to be used in San Francisco and Boston, is expected this spring to deliver LRV prototypes to the Department of Transportation Highspeed Ground Test Track (located in Pueblo, Colorado) for

evaluation and testing. The cars being constructed for Boston and San Francisco are 73 foot long articulated (they bend in the center) models with 68 seats and a maximum capacity of 219 passengers. The LRV's are considerably faster than buses, displaying average speeds of 30 mph. They have a top speed of 60 mph. They would use their own right-of-ways in the central city, and provide ground level service in less congested areas allowing for fewer unnecessary stops. They use less energy per passenger than buses, and since they are electrically powered they produce no air pollution. The LRV's are also less expensive to maintain and operate than buses, and have a longer useful life. The capital expenditure required for these vehicles would be the lowest of all tracked transportation forms. LRV's can use existing abandoned rail road right-of-ways and by using pre-emptive signals, many surface crossings may be tolerated, eliminating the need for large numbers of expensive overpasses and underpasses. The LRV may also be used as a subway in high density

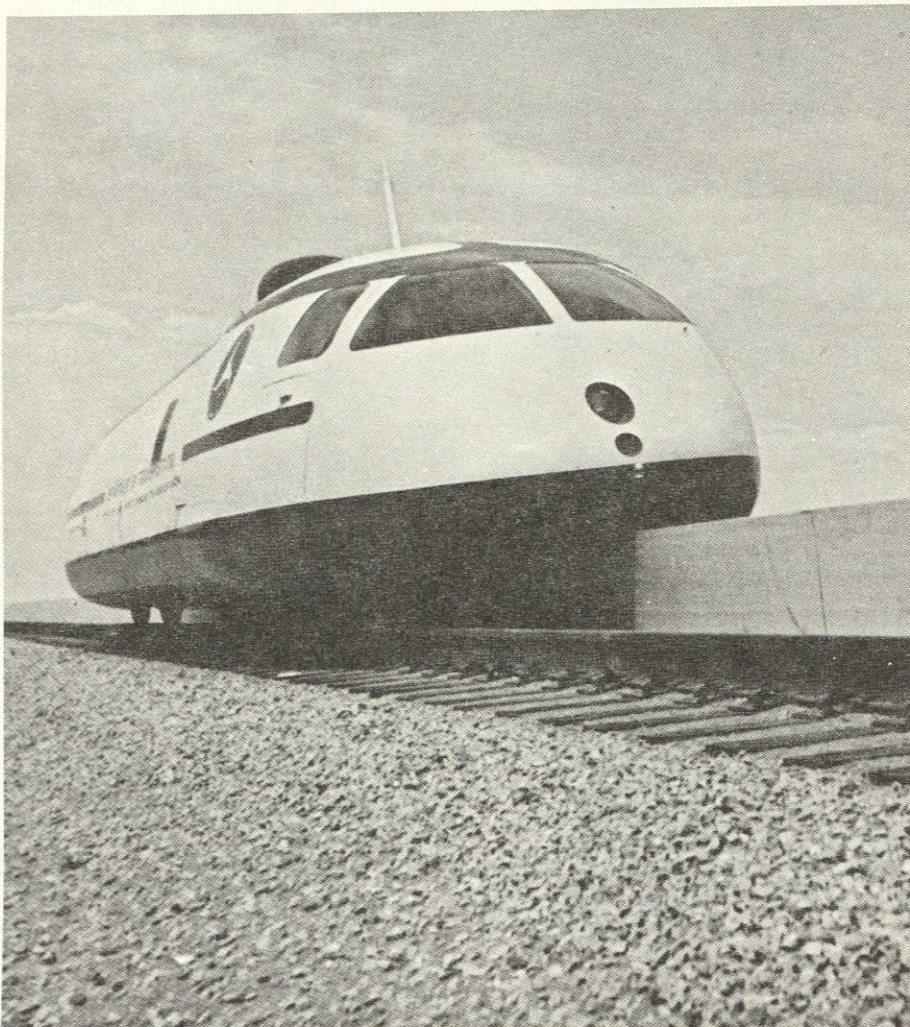
areas. They can be equipped with the latest in comfort and safety features, such as air conditioning, upholstered seats, tinted safety glass, diffused fluorescent lighting, acoustical insulation, carpeted floors, and stereo music. They are also designed so that they may be used on completely automated systems. Since the Boeing LRV's are modular in design, the vehicles may be constructed to the exact needs of the municipality in which they are to be used. Taking all of the aforementioned into consideration one thus finds the LRV a very attractive approach to public transportation and it is therefore being carefully examined by TRW and RTD.

The third mentioned system under consideration by TRW is the conventional rail system. A conventional rail system could be any of several different systems, from the very conventional train to some very unconventional tracked vehicles. The government's High Speed Ground Test Track is currently testing some of the "Trains of the Future." These high speed ground vehicles all have one thing in common, they are all

There is just not enough incentive at present to get people to leave their cars at home and ride the bus.

powered by linear induction motors. The linear induction motor is an advanced electrical motor that magnetically pulls itself along the track, using the track itself as part of the "engine." Since this propulsion system is not impeded by friction as is the conventional rail system, the linear motor is thus capable of much higher speeds than present trains. The Pueblo facility is currently testing the Linear Induction Motor Research Vehicle (LIMRV) which is capable of speeds in excess of 250 mph. (This vehicle, by the way, holds the world speed record for tracked rail vehicles.) Also being tested is the Tracked Levitated Research Vehicle (TLRV). The TLRV is designed to test magnetic as well as air levitation principles and is reported to be designed for a top speed in excess of 300 mph. Both of these research vehicles have self-contained turbine powered generators to power the vehicles, since conventional third rail and overhead wire power sources vibrate excessively and will not operate at speeds in excess of 150 mph. Hence, also under development at the test track is a third rail power source that will operate at speeds of up to 300 mph.

The main advantage of the conventional rail system is its high speed. Since current rail vehicles are capable of speeds up to 150 mph, and future vehicles may be capable of speeds up to 300 mph, the conventional rail



Linear Induction Motor Research Vehicle making a test run at the Pueblo test track.

is ideal for long trips between cities or suburbs. For example, a conventional rail system between Denver and Boulder could turn the now tedious drive into a 10 minute milk run. This system would also have the advantage of a very high peak capacity, in excess of 30,000 people per track/per hour. This compares with 24,000 per track/per hour for a light rail vehicle, and 8,000 people per lane/per hour for a bus system. Due to the high cost, and since the high speed is of little use in a metropolitan area, the conventional rail system is not well suited for Denver's overall needs. It might become very useful, however, as a connector between the several suburbs of Denver.

The last system to be evaluated by TRW, the Fully-Automated Fixed Guideway System, has quite a bit in common with the PRT. The idea of the FFGS is to reap all the benefits of a PRT after having eliminated most of the disadvantages. The FFGS would use mid-sized vehicles (about 20 passengers) instead of the personal (six passenger) vehicles of the PRT. During rush hour the FFGS would run scheduled service, but during the slow periods the system would have demand responsive service just like the PRT. The FFGS would also have the ability to bypass stations even though the vehicle ahead was stopped

at the station.

In all probability, the RTD will not pick a single system to serve the Denver area, but instead will use a combination of two or more of the systems mentioned herein. For example, the RTD might use a conventional rail system to connect the distant suburbs such as Boulder and Castle Rock and have this feed into a light rail system to serve the central area. In this way the RTD hopes to provide a maximum of service at a minimum of cost.

Getting a little closer to home, the RTD does not have many actual plans for the Boulder area. Boulder was not even included in the Early Action Plan because the Boulder Bus had already been upgraded to the specifications set forth for the RTD bus system. Also, before the RTD original plan was voted on, the Boulder City council decided that the six and one half mile PRT system designated for Boulder would not meet Boulder's needs and they therefore rejected it. RTD has *no plans* as yet to provide Boulder with any type of rapid transit system. Also, due to the possible resulting population growth, the RTD does not plan to connect Boulder to any of the other surrounding cities by rapid transit. This connection with the surrounding areas is vitally important as can be experienced by driving the Boulder Turnpike during the

rush hour.

Instead of introducing rapid transit to the Boulder area, RTD simply plans to expand the Boulder Bus service. While improving the bus service may help, it certainly will not be a final solution to Boulder's traffic problems. There is just not enough incentive at present to get people to leave their cars at home and ride the bus. While much can be said for the Boulder Bus, especially when compared to other bus systems, it is nonetheless slow and inefficient. It takes an average of twice as long to travel somewhere in Boulder on the bus as it does to drive. People simply will not give up driving their cars unless they are given an equally attractive alternative, and right now the bus does not meet this requirement.

If the RTD hopes to convince people to leave their cars at home it is going to have to provide an alternative means of transportation that is at least as fast and nearly as comfortable as privately owned vehicles. If the RTD fails to do this, then, the only people riding mass transit will be those who are unable to drive cars, and if this becomes the case, then RTD will have accomplished nothing. □

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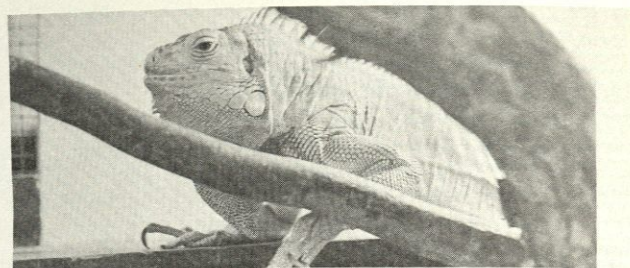
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Bioengineering at C.U.

by Bob Graham



Bioengineering draws on the strengths of two seemingly unrelated fields—biology and engineering. From biology comes a qualitative approach to generating basic knowledge of life systems. A biologist may research the effects of a drug; a bioengineer will research how many molecules of the drug will react with how many body cells to produce how strong a response.

It is the engineering background of the bioengineer which allows him a unique approach to the study of life. It is this background which allows him to develop a computerized heart monitoring system which stores electrocardiograph signals through the use of Fourier coefficients or allows the bioengineer researcher to bombard fish eggs with high energy microwave radiation and to examine quantitatively the resulting effects in the egg protoplasm.

Dr. Igor Gamow, professor of aerospace engineering, said he thinks it is the task of the bioengineer to combine his mathematical skill, and his skills in dealing with the physical universe, with biology to find viable answers to problems.

But to Gamow the philosophy of the engineer is perhaps as important as the training. "Biologists are limited by not understanding how the system works. They don't (we don't either) understand how the brain works, they don't understand how the heart works, they don't understand how the eye works—nobody understands the basic mechanisms of biological systems.

"But the engineer attacks the problem like an engineer—he wants to find an answer. To get answers you usually gather data to establish parameters, and use mathematics and computers for analysis. The engineer, because of his background, is more suited to find these answers."

Dr. Marvin Luttges, also an aerospace engineering professor, said he thinks bioengineers are in a position to make significant contributions to the study of life systems. "Whether it is a deserved reputation or not, engineers have historically been looked upon as those people who are responsible for solving some of our real world problems. Put that together with the

fact that most of our urgent problems are medical kinds of problems such as environmental or food problems and I think we have a bright future ahead for bioengineering."

Neither Gamow nor Luttges holds an engineering degree. Luttges' academic background is in biology; Gamow, however, also holds a master's degree in basic science.

"The underlying philosophy," Luttges said, "was that presumably the aerospace engineer, more than most engineers, had to become more aware of the requirements of the biological system. After all, they had to create not only propulsion vehicles to get people into space, but they had to have some realization of what the people had to have once they got there."

But aerospace engineers are not simply limited to the design of spacecraft, nor is interest in biological problems limited to the aerospace department. Research in bioengineering is carried on throughout the College.

Dr. Robert Christopher of the Department of Mechanical Engineering said, "the discipline of bioengineering requires working with the medical doctors and using engineering techniques to help them solve their problems—they have to define the problems so we know what to work on."

Working upon this foundation and primarily in the field known as bionics (development of mechanisms that imitate nature), two of Christopher's graduate students are working on a fluidic-controlled pump for the heart-lung machine. This may virtually eliminate the time factor now so critical in open heart surgery.

Another of Christopher's graduate students has recently begun research on incubators for premature babies. It has been observed that many of these children are later found to be deaf. There is reason to suspect that the incubator in which they spend their early life acts like a drum, that is, magnifying the surrounding sounds and thus causing the child to go deaf.

Students working under Dr. C.H. Suh, chairman of EDEE, are mathematically modeling the functions of the human skeleton. This research is breaking much new

ground in the compilation of qualitative data never before available. For example, there has been much study of how the human spine responds to violent dynamic loads such as those it encounters in auto accidents. There has been very little quantitative data gathered upon its response to the slow displacements of common back ailments. Chiropractors consider such displacements to be the key cause of many ailments. M.D.'s put less importance on them. Both agree that pressure on a nerve can cause pain symptoms—but neither have much quantitative data upon which to base opinions. Bioengineers at CU are gathering quantitative data upon both, and already have some impressive new knowledge about nerve injuries.

Gamow said the level of biology a bioengineer needs is dictated by his research. "I can imagine a bioengineer knowing very little biology. Maybe he's working with artificial intelligence, for example: it really isn't necessary for him to know basic physiology or even basic biochemistry. If you get a curriculum that goes completely biological, you are not training bioengineers—you're training nothing but biologists."

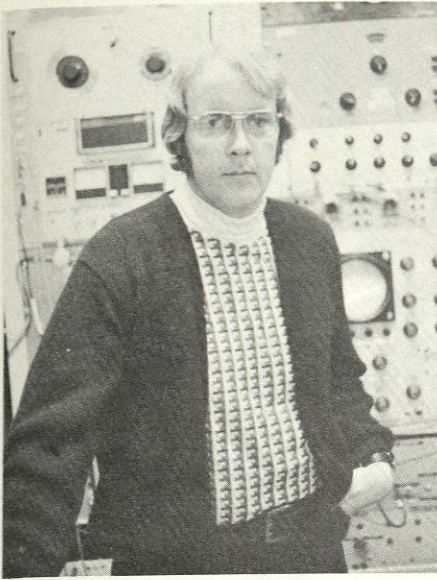
Luttges, however, takes the other view. While not wanting to see any of the traditional engineering courses dropped, he nonetheless feels that the bioengineer needs a much stronger education in biology than is normally provided.

"Today you have a situation where the so called bioengineers are trained by other engineers trained by other engineers and the amount of biology they get is atrocious. You're talking about first year medical school level of biology if you're lucky."

To Luttges, bioengineering implies more than simply working with doctors or computers. Bioengineers, he said, must be more than "engineers dabbling in biology."

"I think for bioengineers to become better recognized they really have to get a better grasp of not only their engineering, but also of the biological subjects."

Bioengineering as a formal science is in its infancy and, according to Luttges, the



Dr. Marvin Luttges.

future of bioengineering depends on today's students.

"I think we're in the formative stages where a lot of the future of bioengineering depends on what the products being turned out here do in terms of how visible they are—how good their contributions are. M.D.'s or research people might look at the contributions of bioengineers and say those fellows are a little naive for not being able to go out and generate that last bit of data which would be necessary for their model."

But, as Dr. Luttges further states, there may be a reason for this naivety.

"I think one of the basic sciences that has been left out of the engineering curriculum is biology. After all, engineers aren't creating things in a vacuum. They're doing it presumably in the service of man and it's a shame the engineer has to have defined for him what the service of man is—that he can't recognize it for himself because he doesn't have the background."

The term "bioengineer" may be recent, but the discipline itself is not. Biomedical engineering as a formal science, Gamow says has been around for 10 or 15 years. "Our program is unique because we emphasize the basic principles and do not just train engineers to work for doctors."

Several universities have recently initiated bioengineering degree programs, but there is solid resistance to such a move at C.U. The key goal of the bioengineering professor at C.U. is defined to be that of giving each engineering student a grasp of how technology affects man and his environment. For this reason, bioengineers and bioengineering courses are distributed among all of the six engineering departments, not concentrated in just one. Hind-

sight has also shown that it is much easier to market a standard engineering degree than a degree in bioengineering.

Luttges' main area of study is neurophysiology. This expertise in nerve functions is reflected in the work of two of his graduate students on electrophysiological and neurochemical correlates of the central and peripheral nervous systems.

Doug Groswald has B.S. and M.S. degrees in aerospace engineering. He is currently working on his Ph.D. in aerospace under Luttges. His Ph.D. research includes the study of the degeneration of nerves. Groswald literally tortures nerves by cutting, pinching and reducing the diameter of nerve fiber axons.

"We're investigating degeneration in peripheral nerves," says Groswald, "and we're trying to characterize the degenerative changes in nerve proteins using electrophoresis (the movement of molecular particles dispersed in a fluid through an electrical field). The degeneration is induced by trauma—trauma induced by cutting the nerve, ligating it (taking a piece of surgical thread and pulling it taught) and by reducing the diameter of the nerve. All these different traumas produce some form of degeneration to different extents."

"Along the axons there's a continuous flow of a material called axoplasm transport. This flow is believed to be responsible for replenishing the axons and the ends of the axons with materials that are necessary for it to carry on its normal functions. We're also interested in finding how the interruption of this transport material affects the axons down stream. There are different changes in rate and quantity of degeneration in the peripheral nerves and we're also trying to characterize these changes mechanically and with elec-

trophysiology."

Groswald is using a system known as sodium dodecyl sulfate, polyacrylamide gell electrophoresis. The resolution of this system was greatly improved by a former C.U. aero student as part of his Ph.D. work. SDS gell allows for the separation of proteins by their molecular weight and allows for high resolution photographs.

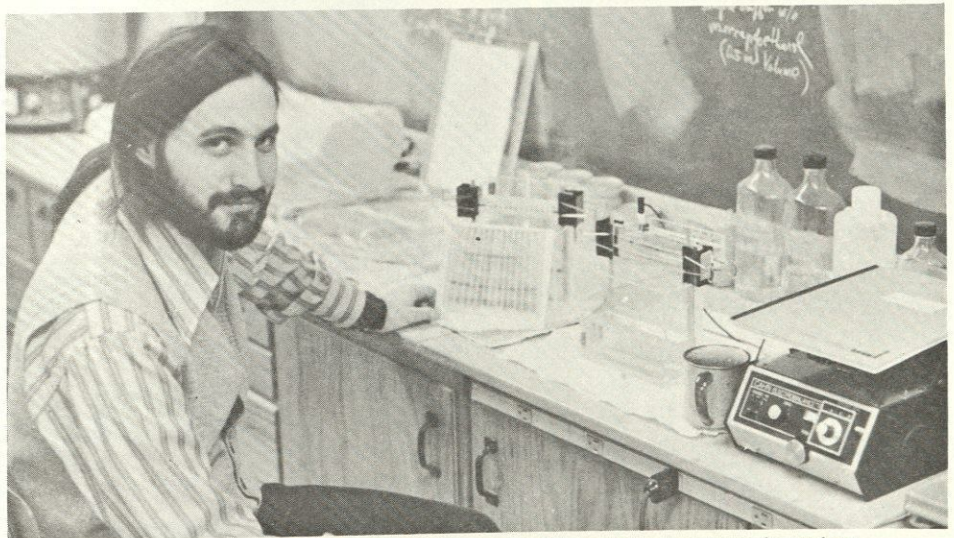
Rick Gerren is working toward his masters degree in aerospace engineering and occasionally helps Groswald with his research.

In recently completed research of his own, Gerren studied the electrical properties of the nervous system by attempting to correlate electrical conduction velocity through the nervous system with nerve damage. Gerren also uses a toxic substance, triethyl tin, to produce other anomalies in nerves of mice. These toxic effects are used as other tools for better understanding some of the occurrences associated with nerve degeneration.

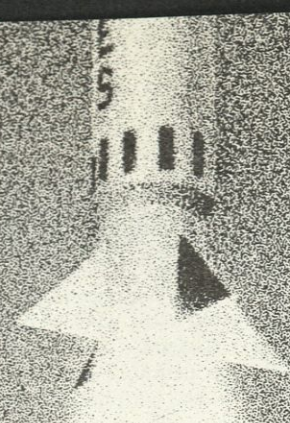
"I'd put a stimulating electrode in the proximal portion of the nerve (the area closest to the cell body) that has received damage from different drugs or different types of damage. On the distal part of the nerve (the area further away from the cell body) I'd put recording electrodes and look for differences in conduction velocity between nerves."

Gerren's research showed larger diameter nerves (those with the lowest threshold) tend to be most easily damaged, thus slowing the response time of the nerves.

Also working in the Luttges lab, Darrell Jones, an aerospace Ph.D. candidate is working on the development of a computerized heart monitor. He explains that every function of the heart has associated with it an electrical impulse which can be monitored on an electrocardiograph



Graduate student Doug Groswald displaying his gell electrophoresis project.



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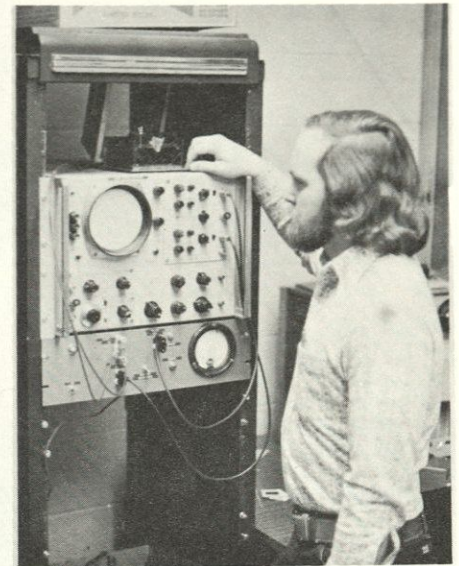
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Dr. Igor Gamow with a boa constrictor in his laboratory.



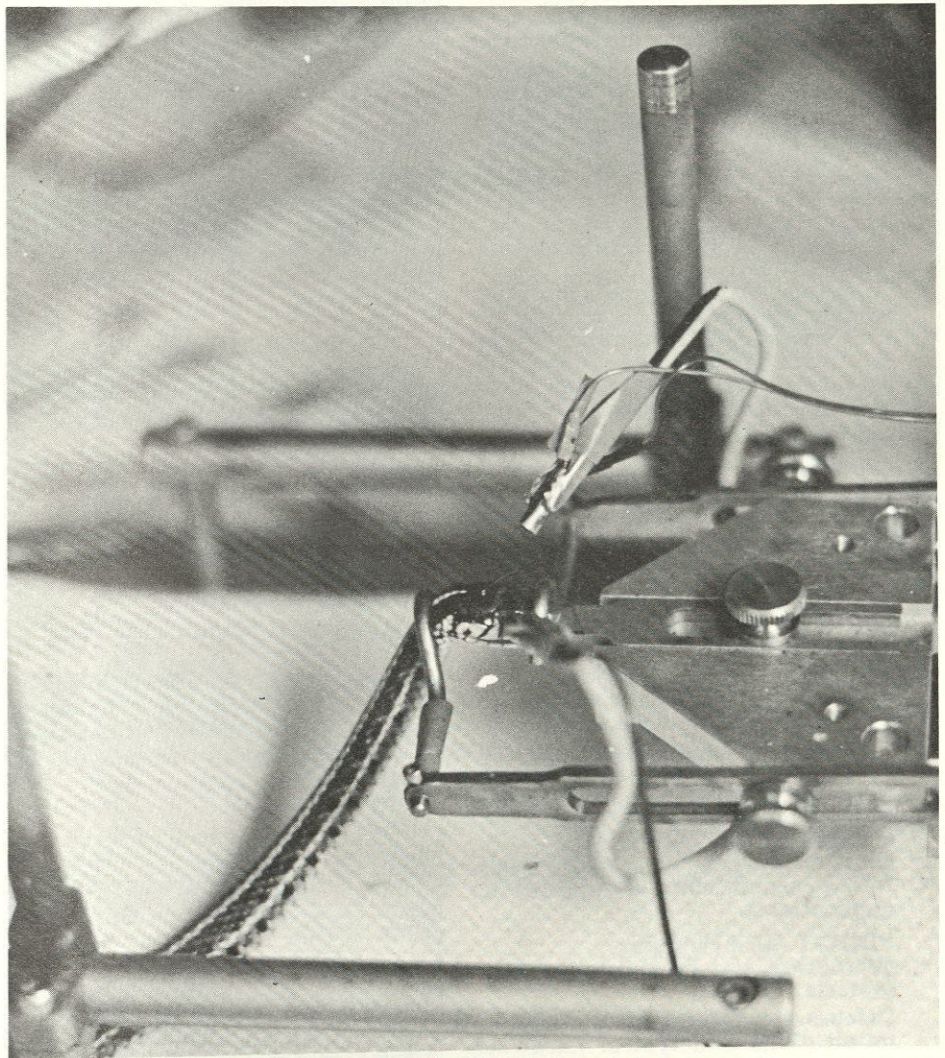
Darrell Jones adjusting the oscilloscope to cut down on background "noise" in the mouse heartbeat he is monitoring.

(EKG). The EKG waveform is comprised of P, QRS complex and T waves. Jones is studying the P-Q interval, a measure of the synchronization of the ventricular and atrial portions of the heart.

"There are many heart monitoring programs," Jones said, "but what makes this one unique is that it does not depend on a normal waveform. We take an average of what the heart beat looks like and store this waveform average through the use of Fourier coefficients. The computer compares two waveforms and sees if they match or not. If they don't correlate, this non-correlation value can be used as an indication of the P-Q spread."

The computer apparatus used by Jones can detect a five percent spread in the waveform. Such a spread is an indication that a heart attack may be imminent. By using the computerized systems, doctors can have a lead time of up to 30 minutes before the actual heart attack.

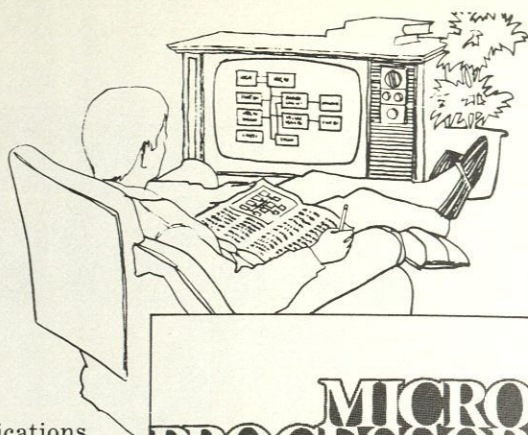
By taking a waveform average and not correlating individual waveforms, more patients can be monitored by one computer and the chances of a "false positive" are reduced. "It's not critical that we catch every heart beat," Jones said, "because the changes of conduction velocity in the heart are a gradual type thing that occur over periods of hours. That's what makes this monitoring system more effective than some of the ones that are currently used. A lot of the current heart monitoring systems essentially examine every beat and are subject to a lot of false positives from patient movement, coughing, etc. If you have this average type data, heart variation due to one single event such as inspiration disappears on an average, but the spread won't disappear."



Micro-electrode recording of brain cell activity in a garter snake.

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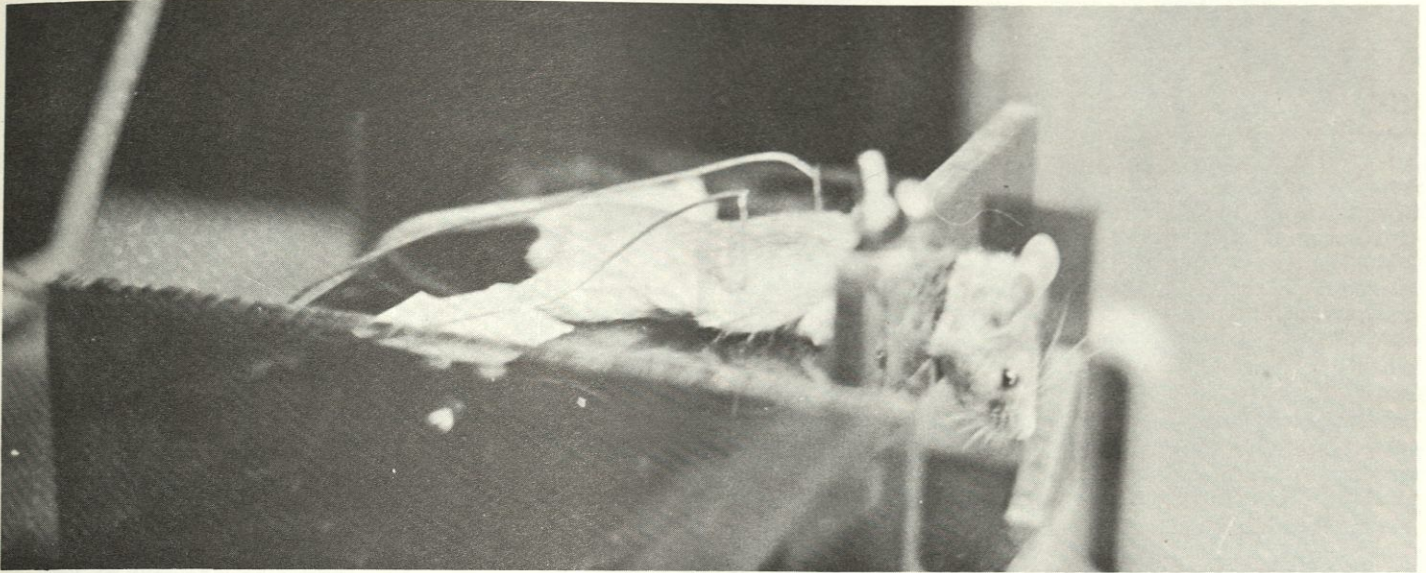
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A mouse with electrodes attached to monitor its heartbeat.

In more theoretical research, Jones is trying to train mice to control their QRS spread by stimulation of the mice's medial forebrain bundle and lateral hypothalamus, the pleasure centers of the brain. If the mice can be trained, it is possible by using biofeedback techniques, man could also learn to control the functions of his heart.

"There's no a priori evidence that we shouldn't be able to get them (the mice) to do that, but on the other hand, there's probably not a whole lot of a priori evidence that they will either. It's really theoretical at this point."

Jones said his engineering background has enabled him to take a different approach to heart monitoring research than would be normal for the mere biologist: "Engineers have a different outlook on how to attack problems. They view the biomedical problems differently from the people who grew up in biology and psychology. My applied math background allows me to do a more rigorous mathematical analysis."

Joseph Ortega, also an aerospace Ph.D. candidate is working with Gamow on the mechanical properties of the one cell plant *Phycomyces*. Using the Mechanical Engineering tension-compression machine, Ortega has found mechanical changes in the cell wall of the *Phycomyces* when it is subjected to light stimulation. This has provided insight into the way this primitive plant grows.

According to Gamow, Ortega's work is a perfect example of the kind of things a person in bioengineering can do as a result of understanding both fields. "This is really fairly simple engineering and very simple biology but it results in sophisticated answers to biological problems."

Another example of bioengineering research at C.U. is a project in electrical engineering concerned with microwave radiation—high energy, short pulse radiation such as is associated with radar. Sandra Pyle, an electrical engineering graduate student, is bombarding fish eggs with microwaves during different stages of their embryonic development to study possible bombardment related abnormalities. Current research is aimed at correlating cellular damage with the stage of the fish egg's development.

Eggs from tropical zebra fish are collected from breeding tanks and placed one at a time into a device which bombards the eggs with microwave radiation for a specific period of time at specific frequencies and intensities. Some of the eggs are allowed to develop and malformations of the newly-hatched fish are studied. It has been found that small malformations in the embryo are magnified if the incubation is carried to term.

Earlier research has attempted to study the mechanism by which microwave radiation destroys cellular material—that is, whether it is the heat, or perhaps an effect related strictly to the electrical field which causes the destruction.

Rob Schwartz, an electrical engineering graduate student, and David Joffe, an undergraduate math major, are developing an optical interface which will allow doctors to take Polaroid photographs from internal body viewing devices currently in use by the medical profession.

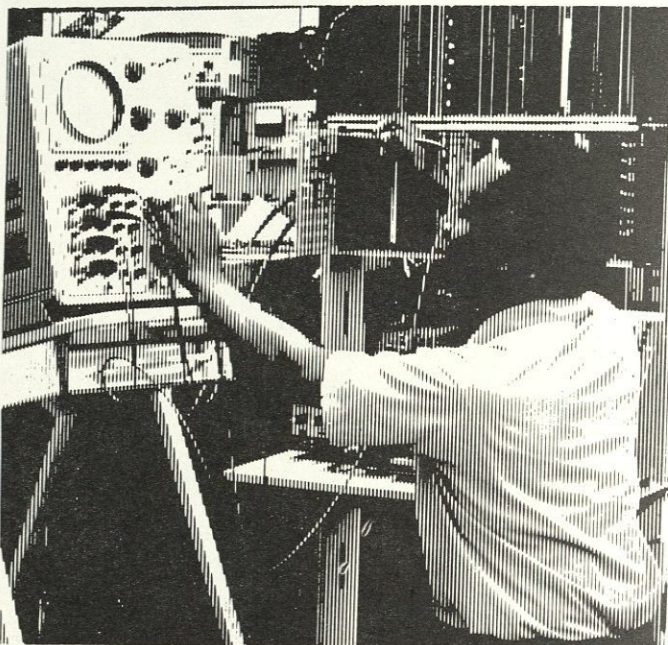
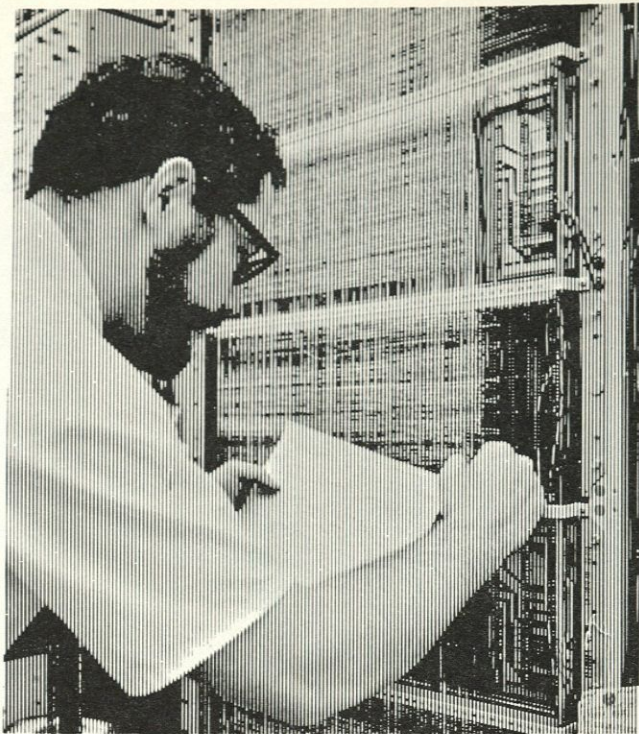
A gastroscope is a device which is inserted through the urethra and allows doctors to visually study the bladder wall. A cystoscope consists, among other things, of a long tube which is swallowed and al-

lows doctors to study possible stomach problems. Despite the fact that the optical interface seems to be a rather trivial engineering design problem, Schwartz and Joffe said there is not a device currently available to allow doctors to take instant pictures using these devices.

The main problem encountered in this two month old research is how to get enough light to the stomach or bladder to take a picture. Several different means of light propagation have been explored, but a continuous light propagated along a light fiber seems to be the answer.

At present, bioengineering at C.U. is in a period of evolution and change. The faculty and students working in bioengineering are trying to determine what kind of problems they should be working on and what kind of philosophy the education of bioengineers should follow. In the words of Dr. Luttges, "When you start to build a program you don't build it on narrow kinds of things. You try to get people well versed in basic kinds of things so they can go out and say, 'alright, here's a problem. Maybe I don't know all the peculiarities of it, but I do have a firm enough grasp of the basics so maybe I can do something significant with it.'"

"I think really and foremost we want to train a first generation of bioengineers who are competent—competent both as engineers and as biologists." □



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Calculator Update

by Gary Mills

Since our January 1975 "Calculator Update" the pocket calculator industry has continued with its past trend: steadily lower prices and introduction of new models. Recently, however, both Hewlett-Packard and Texas Instruments have apparently developed a new marketing strategy which is demonstrated by the introduction of relatively inexpensive models that virtually replace earlier models. Examples of this trend are the Hewlett-Packard HP-21 and the Texas Instruments SR-16. The HP-21 is a smaller, lighter, cheaper version of the HP-35, the first pocket calculator with slide rule functions, which was introduced in January 1972 at a price of \$400.00. The HP-21 has all the functions of the HP-35 and is presently priced at \$125 (See the Hewlett-Packard ad in this issue). According to a Hewlett-Packard dealer, the HP-21 is the first of a whole line of lower priced calculators which will probably replace HP's current models. Hewlett-Packard's incentive for introducing the HP-21

is the competition such as that from Texas Instruments who have been making serious inroads into HP's calculator market with the SR-50 and SR-51 which were priced much lower than equivalent HP models. Texas Instruments however is fighting back by lowering their price even more on the SR-50 and by introducing the SR-16 which has most of the important transcendental functions (except for trig. functions) at only \$90.00.

It will be interesting to watch the continuing price/feature battle between H.P. and T.I. over the next several years until prices eventually stabilize. At what point will prices stabilize? That is a question which will require a more detailed analysis in a future Calculator Update but this author feels that for lower priced scientific calculators such as the SR-50 and the HP-21 the prices will not change more than 20% over the next year. But my guess is probably not much better than yours. Happy calculator shopping. □

CALCULATORS AND FEATURES

All prices — lowest Boulder retail.

	Type of Display	Number of Display Digits	Scientific Notation	Places in Operational Stack	Number of Addressable Memories	Programmable	Trig Functions	Hyperbolic Trig	Polar/Rectangular Coordinate Conversion	Log/Ln	e ^x	y ^x	A ⁿ	Square Root	%	n!	Standard Deviation	price March 10, 1975
Berkey 4030	Liq-Xtal	8	●		1		●			●	●	●						125
Canon F-5	LED	8		2	1		●		●	●	●	●		●				170
Casio FX-10	Liq-Xtal	8					●			●	●		●	●				80
HP-21	LED	8	●	4	1		●		●	●	●	●		●				125
HP-35	LED	10	●	4	1		●			●	●	●		●				195
HP-45	LED	10	●	4	9		●		●	●	●	●		●	●	●	●	245
HP-55	LED	10	●	4	20	●	●		●	●	●	●		●	●	●	●	395
HP-65	LED	10	●	4	9	●	●			●	●	●		●		●		795
HP-80	LED	10	●	4	1									●	●			395
Keystone 108	Liq-Xtal	8			1									●	●			125
Keystone 2050	Liq-Xtal	8			1		●			●	●	●		●				195
Rockwell 61R	Liq-Xtal	8			1		●			●	●		●					100
Sharp PC-1801	Liq-Xtal	8			1		●			●	●			●				119
Sinclair Scientific	LED	5	●				●			●								70
Texas Inst. TI-2500	LED	8	●												●			45
Texas Inst. SR-11	LED	8	●		1									●				20
Texas Inst. SR-50	LED	10	●	2	1		●	●		●	●	●		●		●	●	125
Texas Inst. SR-51	LED	10	●		3		●	●	●	●	●	●		●	●	●	●	225
Texas Inst. SR-16	LED	8	●	2	1					●	●	●		●				90

Come to E-days 1975

No, E-days has not passed you by this year. . . yet. Once again, a large number of engineering students (and Prof's) will raise _____, well, they'll have a great time the week of **April 20th** (get a load of some of the action last year!)

This year you will have a chance to use your highly-developed skills in such things as a softball tournament, bike rally, egg drop contest, concrete canoe race, and beer can stomping contest(?). In addition, you will have a chance to get funky at a dance and to get loaded at a picnic. Join in and have a great time!

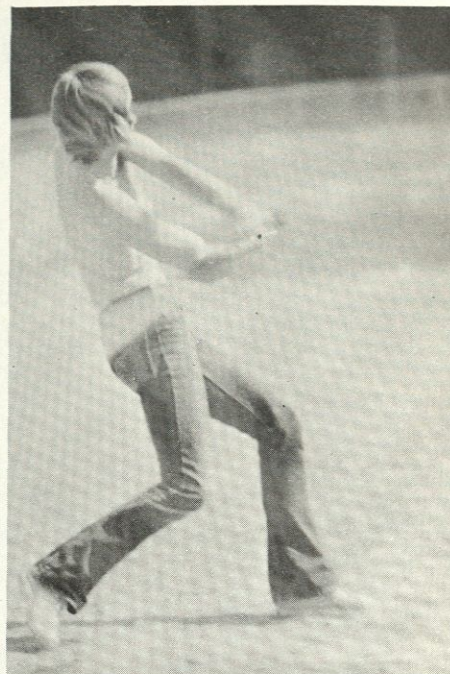
Watch for a program and more information in April.



Finishing work on the ill-fated *Titanic II*.



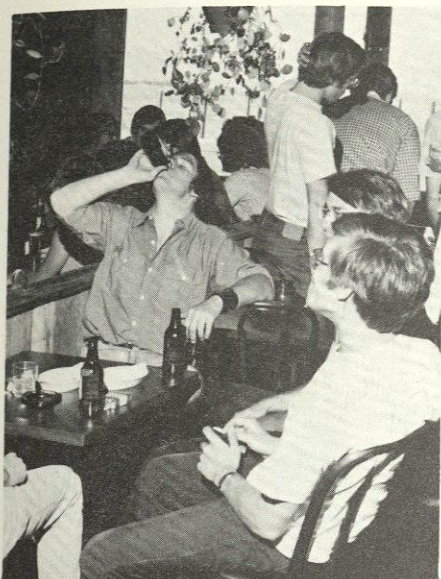
The *Mudineer* heads out while the *Titanic II* heads down.



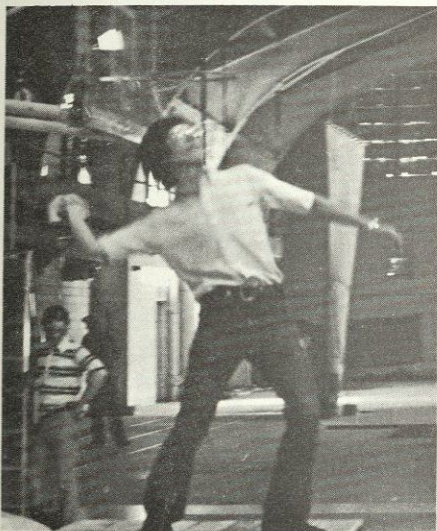
Fast action on the softball diamond.



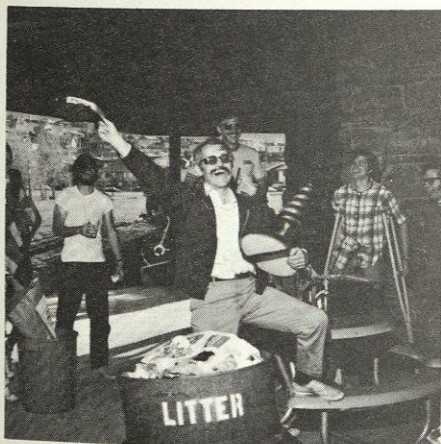
An avid concrete canoe race fan.



Getting it down at the F.A.C.



Dave Sakaguchi winning the paper airplane contest.



Professor Oswald proudly displays his "Meanest Professor" purple screw award.

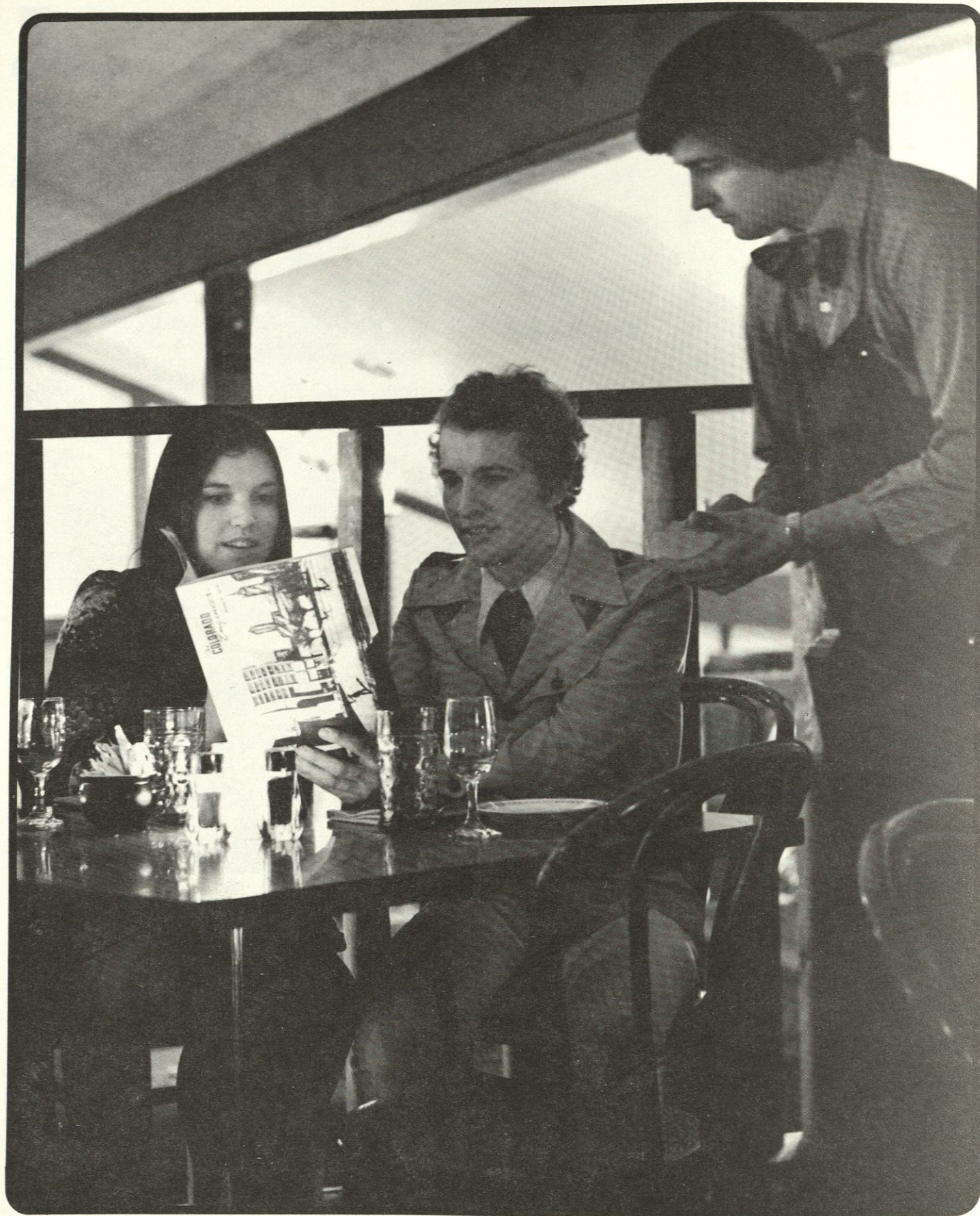


The crowd engrossed in the high drama of concrete canoe racing.



Good music and good times at the picnic.

In The Final Analysis...





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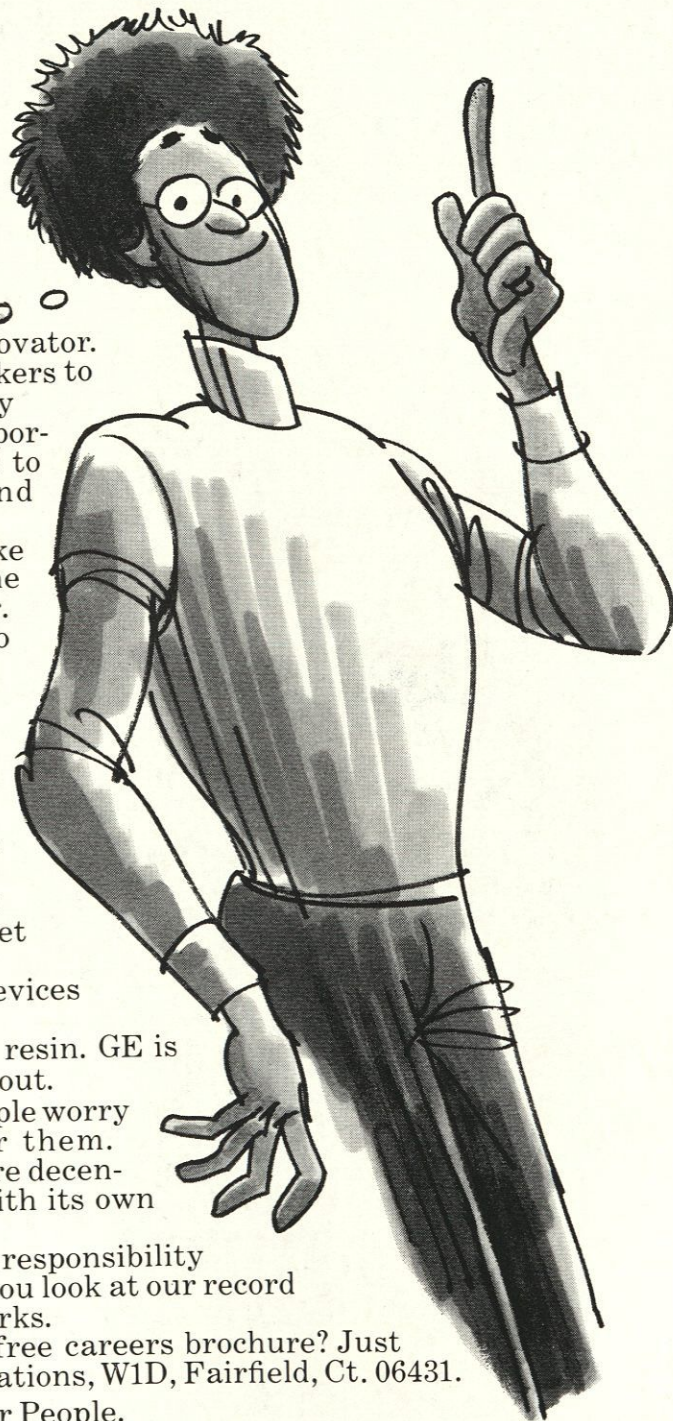
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