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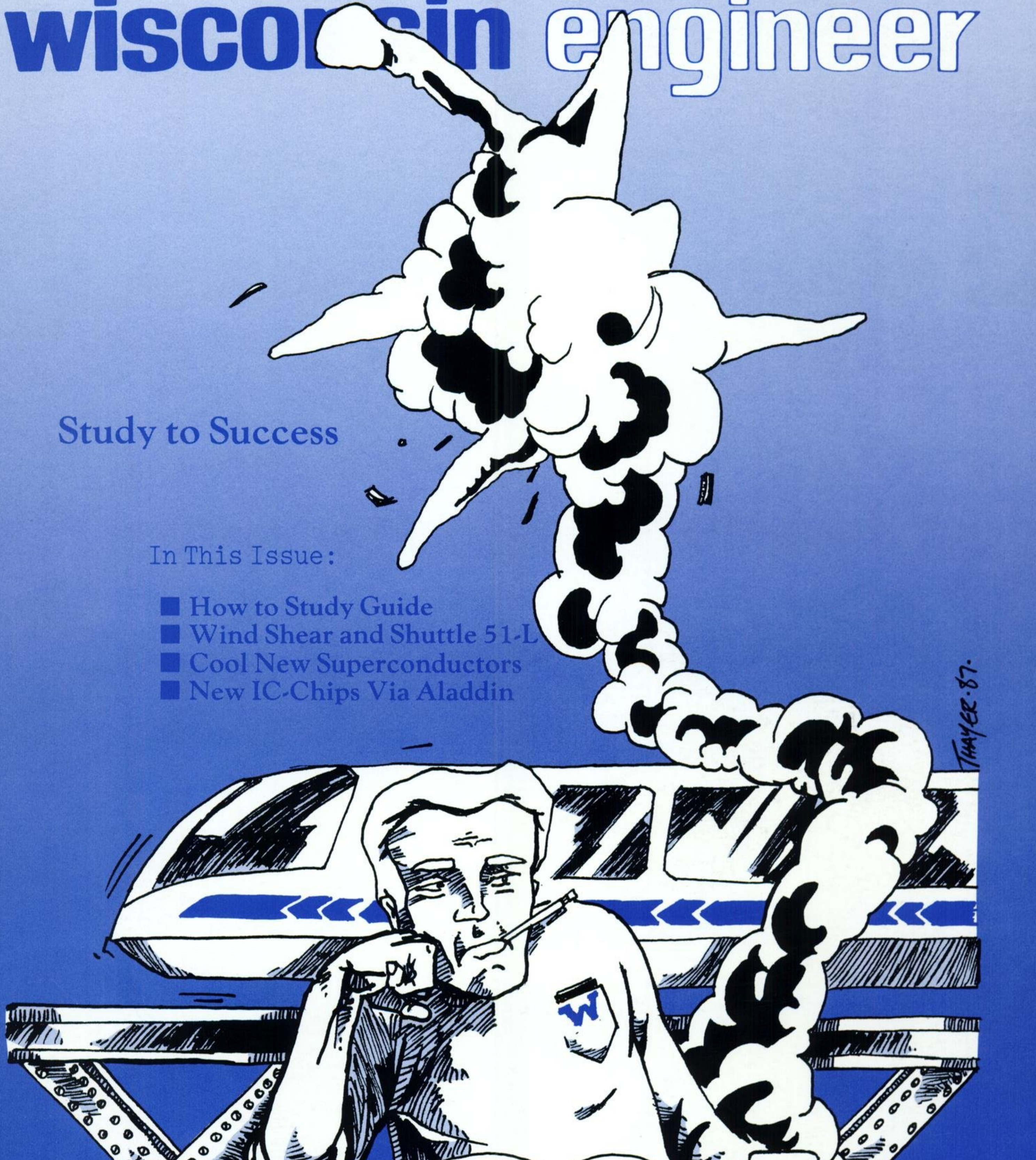

Study to Success

In This Issue:

- How to Study Guide
- Wind Shear and Shuttle 51-L
- Cool New Superconductors
- New IC-Chips Via Aladdin

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PUBLISHED BY THE ENGINEERING STUDENTS OF THE UNIVERSITY OF WISCONSIN-MADISON JULY 1987

Summer Issue

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The **Wisconsin Engineer** magazine is published by and for engineering students at UW-Madison, and is a charter member of the Engineering College Magazines Association. Philosophies and opinions expressed in this magazine do not necessarily reflect those of the College of Engineering. All interested students have an equal opportunity to contribute to this publication.

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Editorial

To Freshmen or Other Interested Parties

Why are you here? Is there a reason you came to the University? Was it to get a good job when you graduate, or to learn, or to make new friends, to party, etc.? I did not come here for any particular reason at all three years ago, except to go with a flow I entered much earlier. I did have, and have, a strong feeling that I was (am) going to have an interesting life, and that the only way to begin was to continue learning. I have come to understand that this is not the way to begin at all, but it is the way one must live to truly find life stimulating, or at least not boring.

I have also had to accept the first of the Buddha's "Four Noble Truths"—**Life is Suffering**. We all have classes that are absolute hell, more so in engineering I believe, but then I am slightly biased. The key to relieving the stress of painful classes is to accept the above Noble Truth, and to utter the phrase "No Big Deal," feeling it deep in your bones. Does that mean you can blow-off those hard classes? No, on the contrary, that means that sometimes you have to study ten hours a day for a week because you already blew-off five weeks, and even though it is hell, it's "No Big Deal." You must be able to buckle down when it is called for, or take Professor Grant's advice so buckling down is not necessary.

I have a problem disciplining myself, so occasionally I have had to write a strict schedule for a week, including 30-minute guitar or food breaks. Most of my problem with discipline stems from my inclination periodically to question every reason I have to study what I do, to learn these often boring subjects. Also, I am often lazy for no real reason, besides inertia possibly. I realize, however, that when I am successful at anything, I usually "enjoy" it, so more often than not I am able to provide the motivation to escape such traps and open up my books. But how do you know if you are studying what you should be studying? That is a real tough question. Honestly, I detest engineering half the time, but enjoy it enough to stay, at least for now, and to honestly say, "No Big Deal," about the painful parts. Usually. I must say that if you enjoy the subject no matter how successful you are at it, then by all means stick with it for a long while and give it a good shot. There are plenty of tutors to help you when you need it, and professors who generally will go out of their way for interested students. If you are like I am, and enjoy what you do well but do not have any strong feeling (yet!?) about what is right for you, then you must suffer along with most of us. It is not really necessary for you to berate yourself with stupid imperatives— "I have to pick a major," "I should like this subject;" or with interrogatives—"Will I ever, ever find anything that fits me," "Will I name my second-born Spanky X?" I have wasted much time doing that type of thing. It gets you nowhere, but does make your stomach ache. Go talk to a career counselor, your advisor, or whoever, and if that does not work, then it is time to sit back and relax, say (you guessed it!) "No Big Deal," and relish the fact that it is a provident universe, and that as long as you keep trying to learn, you will. The pieces always fall into place for those who expend effort, and keep the right attitude. That sounds truthful, I think. You must append your reason for being here to the best reason: personal growth.

This brings me to a major (however over-written) point of this little editorial, which is the importance of diversification for growth. Neither engineering students nor liberal arts students can grow in the broadest sense unless they experience as much of the "other side" as possible. I need my liberal arts classes to relieve the stress of the engineering curriculum— its sameness rather than its difficulty. I also have not yet found in my engineering textbooks any wisdom to help me understand other aspects of life that tend to pop up once in a while in school— love, loneliness, friendship, depression, etc. I am sure Humanities majors need a break as well.

I have found writing to be as good a stress reliever as it is a stress producer. If writing for class is stressful for you, buy a journal and empty your mind into it when you feel particularly frazzled and see how it helps. Then come to the **Wisconsin Engineer** and volunteer for the writing staff. I enjoy writing, and I think I might like to make a living doing it, but who knows? I am just plugging away here, confident that the pieces will fall because I am trying.

Well, this essay is looking for an ending, so I will finish with a few sentences about what I **really** feel about engineering, written by Saul Bellow, much better than I could—

A million years passed before my soul was let out into the technological world. That world was filled with ultra-intelligent machines, but the soul after all was a soul, and it had waited a million years for its turn and did not intend to be cheated of its birthright by a lot of mere gimmicks. It had come from the far reaches of the universe, and it was interested but not overawed by these inventions.

No Big Deal!

Quote:

Saul Bellow, "Literature in the Age of Technology," in **Technology and the Frontiers of Knowledge** (New York: Frank Nelson Doubleday Lecture Series, 1974), p. 22.

Dean's Corner

By Dean John Bollinger

One of the most exciting aspects of being a part of the College of Engineering is the fact that each year we see a new group of students that are interested in shaping their future. My faculty colleagues and I consider it at major part of our responsibility to enrich your education. We realize that we are here only because you want to be here. We expect that you will look to us for ideas and counsel; we will provide you with understanding, attitudes, sensitivities and tools that will contribute to your successful and productive career in the engineering profession.

I am sure that most of you who have thought about engineering and have made a commitment to pursue an engineering education already possess some of the attributes of future engineers. These attributes include the ability to place yourself in the right place at the right time, with the right goals and the right abilities to be a productive contributor. I will take four points— involving place, time, goals, and abilities, and break them down into the important elements and plans of action that will take you from point A to point B on a trajectory of minimum time, minimum distance, minimum cost, and maximum results.

First, consider place. You have chosen one of the best engineering colleges in the country. You will be taught by faculty with proven track records of national and world–wide recognition, not only in engineering, but in the sciences, mathematics, and humanities. They are not only devoted teachers, but they are researchers and entrepreneurs. By listening to them in the classroom and in their offices you will have an opportunity to hear a wide variety of opinions, facts and evaluative judgements that are a part of their experience. Not all of what you hear and see will agree with your point of view. Here is where the process of sifting and winnowing and philosophy–structuring must rest in your hands. Madison is on your side— it is a campus where freedom of thought is a strong tradition. It presents both opportunity for change, as well as responsibility to tradition, and you must weigh each wisely.

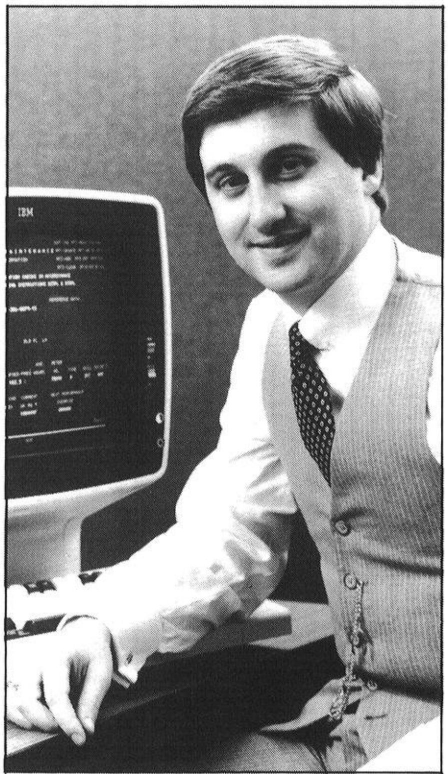
Time is the next element which you should consider. You can look at it as a resource that is packaged in finite, irrecoverable units. An hour used is an hour behind you and there is no turning back the clock. If it is not utilized well, it is wasted. Using any resource well is accomplished by management, and time management will be one of your greatest challenges. Time management does not infer that all of your time need be spent on work; everyone requires different amounts of time to accomplish different tasks. Some people need more sleep than others, some need more study time and still others appropriate more time for play. Each individual must seek the optimum combination of time utilization to meet his or her goals. Of course, this means having goals in the first place.

The goals that brought you here to the campus must be constantly examined. They will change just as the view of a horizon changes as you travel. The goals farthest on the horizon are long–range goals. For example, some time ago your long–range goals included going to college. Now, this goal will change to obtaining a degree in engineering in a field where you find interest and excitement. Because the latter part of this goal may not be well defined at this time, you should have a short–range goal to explore different aspects of engineering to help determine more clearly what the nature of the long range–goal really is. In order to achieve the short–range goal you need to discover resources, develop understanding of situations, and evaluate alternatives. It is important to realize that achievement of goals is a relative matter. If you learn to evaluate your own performance, you can establish a percentage of accomplishment for each goal. That will help you to honestly assess how you should modify your program to stay on a target. There is probably nothing more personally devastating than to set unrealistic goals which are never met and never evaluated until it is too late to alter course.

The realization of one's own abilities should always be given high priority. Knowing your capabilities will help you set realistic goals, establish time management strategies and point you to being in the right place at the right time. Study is a fundamental element in developing your capabilities. You can develop your academic ability by going to class to hear and to see. You must then read and learn and finally inwardly digest the materials in your courses. Results can be assessed against your goals. If you skip a step, or deceive yourself in the process, you are likely to be dissatisfied with the results. There are no shortcuts in the process. Some people take less time than others to reach a desired level of satisfaction of goals. Some people find that their expectations cannot be met, regardless of time devoted.

Your job is to place all of these issues in perspective. You should draw upon the resources of the College of Engineering to assist you in finding your way from point A to point B in minimum time, travelling a minimum distance, at a minimum cost, and having achieved maximum return on your personal investment. When you can say that you are on this efficient track, then you are on your way to becoming an engineer.

Follow In Their Footsteps



After graduation, you will want to use your knowledge, skills and creativity in an organization that will provide opportunity for personal growth and advancement.

Oscar Mayer Foods Corporation, the leading meat processing company in the U.S., has such positions for talented young people. We need good engineers to develop better production machinery, improve our maintenance administration, help manage our plants, and to work in the many diverse engineering jobs that are so vital to our company. The young engineers featured on this page have found rewarding careers in keeping us No. 1 in our industry. We will continue to need good young engineers to follow in their footsteps as they advance through our organization. You could be one of them.

P. J. Samson
Plant Engineering Manager
Los Angeles Oscar Mayer Plant

P.J. *graduated in May 1979 from the Illinois Institute of Technology with a B.S. degree in Mechanical Engineering and entered our six month Engineering Management Development Program.*

P.J. has held a variety of positions in Maintenance Administration and Maintenance Supervision. In addition to these plant assignments, P.J. also works on our Corporate Engineering Staff in implementing an in-house designed, on-line computerized maintenance management system.

P.J.'s most recent assignment is at our Los Angeles plant as Plant Engineering Manager. In this position, he is responsible for all engineering, maintenance and powerhouse activities at this location.

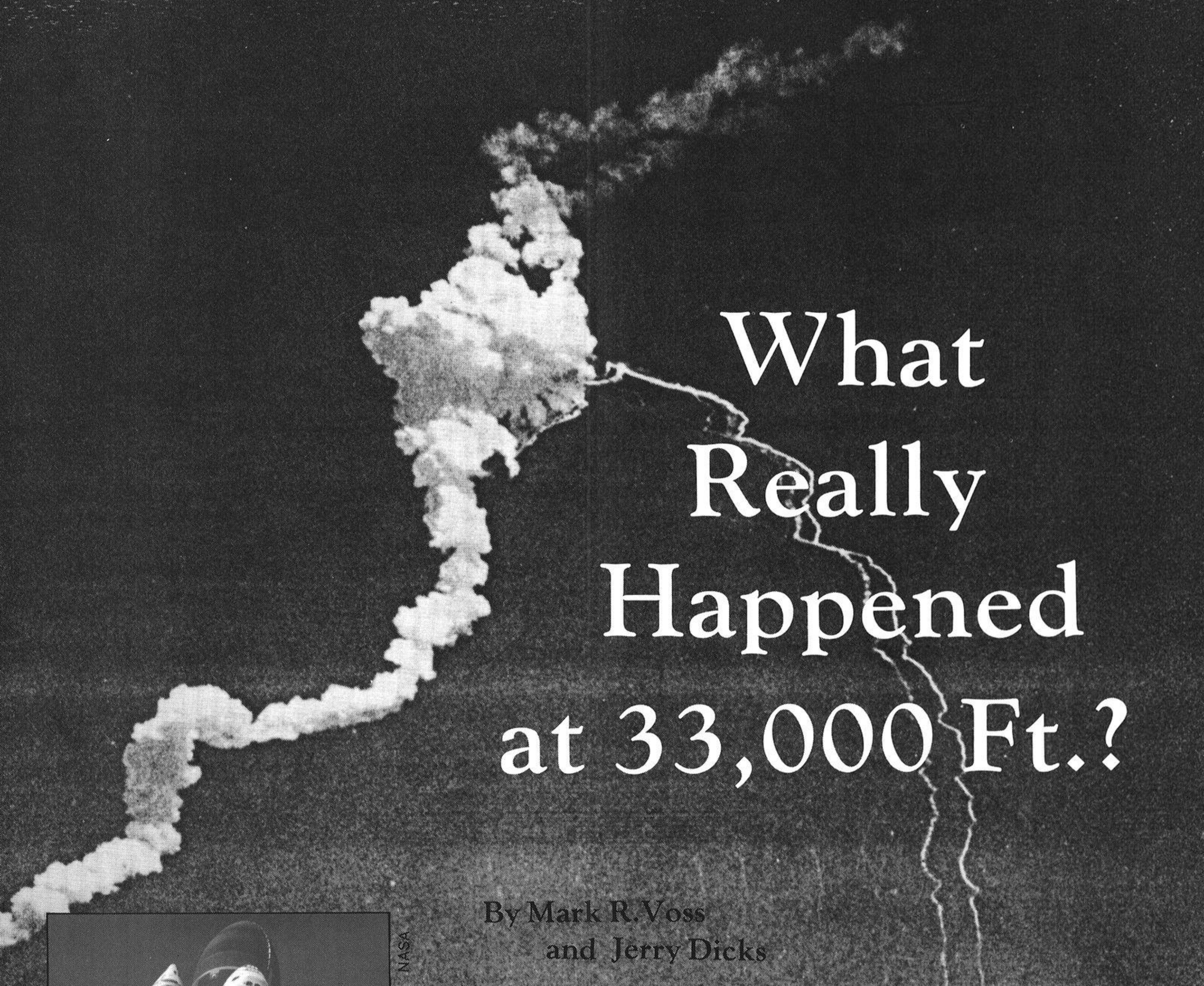
Oscar Mayer

Oscar Mayer Foods Corp.
Corporate Recruiting Office
P.O. Box 7188
Madison, Wisconsin
1-608-241-6897

Pat Molitor
Plant Engineering Manager
Davenport Oscar Mayer Plant

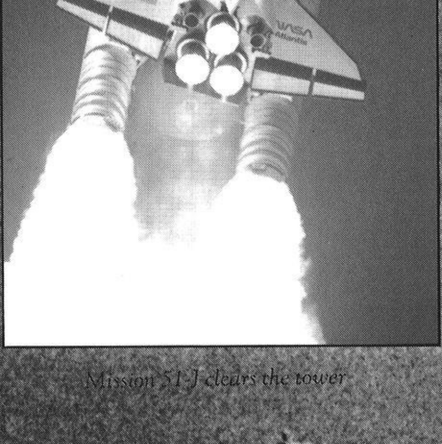
P*at started with the company in June, 1977, after obtaining a B.S. in Civil Engineering from the University of Wisconsin. He entered our six month Engineering Management Development program which provides the new engineer with a broad overview of the opportunities in the Engineering Division. The program also points out the significant role that the Engineering Division plays in the overall structure of the Oscar Mayer Foods Corporation.*

Pat has held various positions of increasing responsibility in the Maintenance Administration and Maintenance Supervision since graduating from the EMDP program. Pat's most recent assignment is Plant Engineering Manager at our Davenport facility. In this position, he is responsible for all engineering, maintenance and powerhouse activities at this location.



What Really Happened at 33,000 Ft.?

By Mark R. Voss and Jerry Dicks

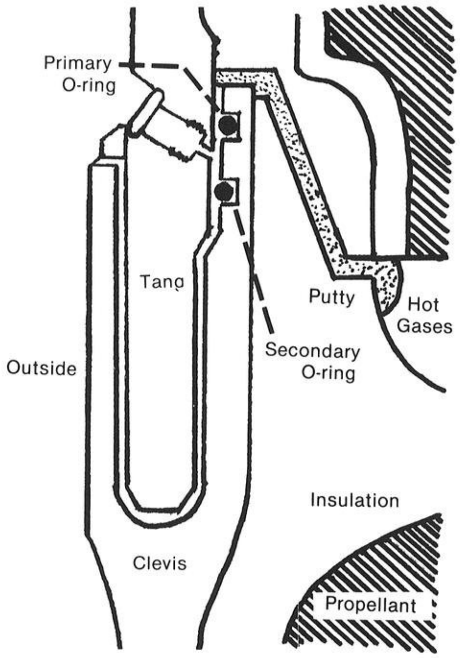


NASA

Mission 51-J clears the tower

All who witnessed the fiery disintegration of the Challenger in late January of last year remember the forked smoke trails that mapped the shuttle's end. Photos of the disaster were powerful images themselves, but they may also provide clues to the actual cause of the accident. What led to the explosion of the space shuttle? The current consensus is that joint rotation caused the destruction of the seals (o-rings) that are intended to prevent hot gases from leaking through the joint during the propellant burn. Thus, 58.7 seconds into the flight, a tongue of flame erupted from the right solid rocket booster, heating the shuttle's external tank and eventually causing the explosion.

FIGURE 1



The O–Rings

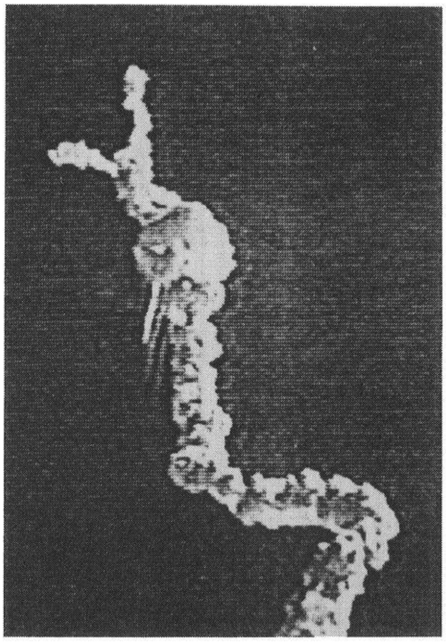
Before ignition, the booster's walls are vertical and both o–rings are in contact with the tang (see Figure 1). When the boosters ignite, internal pressure swells each booster section's case around its circumference. Because the joints are stiffer than the casing as a whole, each section bulges a little, so that its shape can be compared to a "frozen can of soda." The swelling causes the joint to rotate, so that the primary o–ring pushes into the gap between the tang and clevis, and the secondary o–ring is pulled away from the tang, where it is supposed to act as a seal.[1]

This situation is obviously undesirable. The action of the primary o–ring extruding into the gap violates industry and government o–ring application practices, which call for o–rings to seal by compression, not extrusion. Also, the act of lifting the secondary o–ring from its sealing surface eliminates the effectiveness of this o–ring as a redundant seal.[2] The Presidential Commission's Report on the disaster pointed to this problem with the o–rings as the primary cause of the Challenger disaster.

Smoke Trails

New evidence uncovered by the University of Wisconsin's own Professor William Birkemeier points to undetected wind shear as perhaps **the** major factor. Wind shear can cause incredible aerodynamic force on an aircraft when the wind velocity changes very abruptly with small change in altitude. In the case of the shuttle, wind shear occurred because of movement from a volume of fast–moving air to one that was essentially still. Excessive wind shear causes structural loads beyond those established as allowable for launch.

Engineering Professor Birkemeier, who has specialized in radar wind analysis for 20 years, noted that the Cape Canaveral balloon data taken before and after the accident show no significant shear, but his analysis of the smoke trails and satellite images of them show considerable difference between NASA's balloon data and the actual speed and direction of the wind. Currently, there are two different opinions as to the severity of the wind shear conditions the day of the launch. NASA believes the wind speed changed over a 5000 foot gradient, but Birkemeier contends that wind shear ranged over a much smaller 500 foot gradient, making conditions far more dangerous.



Courtesy Prof. Birkemeier

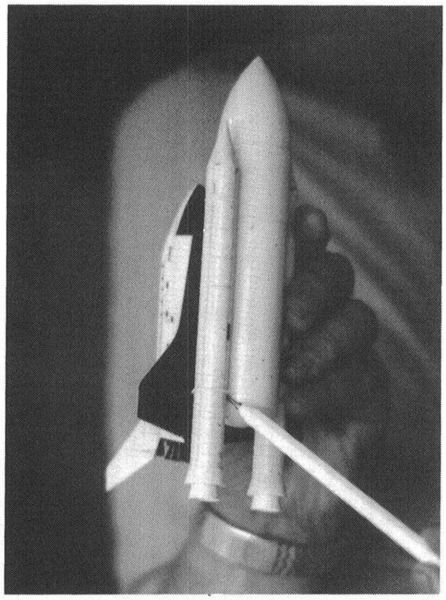
Video tape of smoke trail shows wind shear, clearly visible as sharp bend in the ascending trail.

Disaster

According to Birkemeier, shuttle 51–L met a strong northerly crosswind soon after launch, requiring the ship to fly with a large yaw angle, or a tilt in the direction of the oncoming wind. In addition, the right SRB (solid rocket booster) engine required a gimbal angle of 2.5 degrees, the largest angle yet recorded on the motors to correct for the roll forces produced by the wind.

Already, the Challenger had stiff wind conditions to deal with, but it could not be prepared for what happened around 58 seconds into the flight, at 33,000 feet. Birkemeier's smoke trail analysis indicates that the wind from the north increased to 100 feet–per–second at 57 seconds, and then dropped to zero at 58.5 seconds. A sharp downward spike in NASA's graph of the craft's lateral acceleration denotes the first change in wind speed, but just after, at the time of the shear, NASA's graph shows a gap in the data. Birkemeier believes this is so because the real data is off the scale in the other direction.

...the shuttle could not be prepared for what happened at 33,000 feet.



Birkemeier holds shuttle model, pointing to the joint on the right SRB that spewed flame. It is also the point of connection to the external tank, subject to great stress, especially in the case of wind shear.

In the space of 500 feet (a few shuttle lengths), wind speed dropped from 100 feet–per–second to zero, according to Birkemeier. The shuttle was flying yawed (slightly sideways) to compensate for the crosswind when it plowed into calm air. The sudden shock of not having its nose into the wind sent the shuttle rolling 11 degrees, the largest roll ever. The roll is noted by NASA in the Presidential Commission's Report, but according to Birkemeier, it is an indicator of a much larger shear than what NASA described. The violent deacceleration that produced the roll, combined with the lateral force on the right SRB due to its gimballed nozzle, would have been enough to cause failure at the joint, said Birkemeier.

Coincidentally, and unfortunately for the Challenger that day, the shear happened to occur 58.5 seconds into the flight, at 33,000 feet. According to Birkemeier, this corresponds to the "Max–Q" point, the altitude where the shuttle normally encounters the greatest aerodynamic forces due to its speed and the atmospheric density.

Engine #1

Birkemeier has suggested that there is additional evidence for wind shear as the cause of the shuttle disaster. He notes that video tapes show the apparent failure of main engine #1, the shuttle engine closest to the tail fin. It is the engine furthest from the center of rotation of the shuttle, and subject to the greatest "whiplash" stress. At 59 seconds, its nozzle throat appears to spurt a jet of flame. Pictures of the shuttle's ascent from several angles seem to show the flame as a bright glow superimposed on the right OMS (Orbital Maneuvering System) engine pod. The Presidential Commission's Report explains the glow on the pod as a reflection of the SRB exhaust.

The tail fin recovered from the waters off the Cape shows deep grooves that seem to radiate back into engine #1. Birkemeier points to traces of titanium in the grooves, and the fact that the lines converge back toward the #1 main engine (whose nozzle contains titanium), as evidence that the engine failed. The NASA report's explanation is that the booster leak eroded the fin and that part of the booster swung by the fin after the lower attachment failed. Birkemeier doubts this because the direction of the blow–torch created by the leak does not coincide with the tail, and there is no titanium in the booster rocket. The failure of one of the main engines would have been catastrophic even if the right SRB had not leaked.

Assisted by grad student T.S. Lee and Professor John Beetham, Birkemeier is now working with computer simulation programs which convert wind profiles into debris trails to increase the accuracy of his analysis. There are many puzzles yet to be worked out, like the report of an airline pilot who was flying a half–hour before the shuttle flight, at 33,000 feet, about 50 miles northwest of the Cape. He described a huge shear—a wind speed change of 283 feet per second in a few hundred vertical feet. Birkemeier has not found proof for a shear that large, but the pilot's claim matches his calculations better than NASA's. He firmly believes he will find all the missing pieces and will fully explain the tragedy. He is staying in touch with NASA, and they expect to use his findings in simulator runs at the Johnson Space Center to learn how such winds affect the climbing shuttle.

Although Professor Birkemeier has spent many long hours already puzzling over the discrepancies between NASA's theory and his own, he does not plan to quit until the job is done. Good is bound to come of his work— more sophisticated methods for dealing with wind shear may prevent such catastrophe in the future, and could finally provide meaning for the Challenger disaster. □

Notes

[1,2] **Spectrum**, Volume 24, Number 2 (February 1987), p.43.

Special thanks to Professor Birkemeier for his editing help.

How to Study

By Hiram E. Grant
Professor Emeritus
Washington University, St. Louis

No one can educate you. Neither the lecturers nor the texts, the most capable professor nor the best organized course in the leading university in the world can accomplish this. You have to do the hard work of thinking through and comprehending the subject matter placed in your path.

How you handle yourself regarding your time, your attitude towards studying and the way you study (called work habits), and how you cope with sundry diversionary forces and outside activities will affect your whole professional life.

If you succumb to the jibes of your fellow students about intensive studying, you will always remain weak. When you do a superb job of learning you are unintentionally showing up and embarrassing students who are not conscientious. Will those who coast through their courses finish college? Or, if they do, will they be successful in their careers? Do you chose to duplicate their lives? The choice is yours.

Unintentionally? —ed.

SATISFACTION IN STUDYING

There is **real** satisfaction in mastering a subject. Why do you like one subject more than another? Is it not because you have more basic knowledge in the area? As an undergraduate I became afraid of a required course considered to be difficult. However, I worked exceedingly diligently the first six weeks, built a firm foundation, and before the semester was over found it to be quite easy. Mastering the fundamentals rather than being the victim of them made the difference. You can do the same— will you?

There was, as is to be expected, a real sense of satisfaction in having made a difficult course rather easy. Also, the fear of failing formulated an organized work habit helpful not only in this instance but in other situations encountered in the future. Once good work habits are acquired, they are not arduous. They become a normal effort taken in stride.

DEVELOPING GOOD HABITS OF STUDYING

Good habits are not developed quickly, so consequently you may become discouraged or even frustrated. However, persistence is rewarded. In time the new habits will become routine. As a result, you will become more efficient. You will find you can use your time more efficiently and you will acquire new learning more readily. The latter is due not only in great measure to increased mental training, but also to the greater interest you will take in your subjects because you are mastering them.

Disciplining oneself to develop good study habits and to discard poor ones can be compared to weight lifting. The strain experienced when one starts to work with the unfamiliar gradually lessens as one becomes accustomed to it.

To avoid confusion, I point out that Professor Grant did not intend to suggest "SERFing" instead of studying. —ed.

STUDY HABITS

There is ample time for study, for participation in extracurricular activities and play, but they should not be mixed. Organizing one's time and refusing to deviate from the plan is essential. Wasting an hour here and another there indicates that one is disorganized. If you do not like to have the term applied to you, recognize your shortcomings and organize your way of life.

Acquiring good work habits permits a more satisfying way of life and brings the attainment of one's goals within the realm of possibility. Good study habits will enhance your learning and prepare you to take advantage of opportunities once in your career. Poor study habits produce a minimum of learning, lower your ability to solve professional problems, and cause frustration.

Mastering the fundamentals rather than being the victim of them made the difference.

A positive mental attitude toward studying— wanting to learn rather than forcing oneself to learn— is a significant timesaver. Studying with a sincere desire to master a course determines how well you study and learn.

Good study habits:

1. Use intervals between classes to study.
2. Select a quiet, adequately lighted, well-ventilated place to study.
3. Avoid turning on the radio while studying. You may not realize it, but it is a distraction, not an aid.
4. Occasionally take short exercise breaks to prevent fatigue caused by slowed blood circulation.
5. Make an outline of each assignment for review purposes. The mere making of the outline is learning. Outlines and notes may be put on 3x5 cards or in a notebook. Put your questions on cards, and add the answers later.
6. Learn to read the problem questions twice to get the full impact of what is called for. You will then be less apt to misread exam questions and answer unasked questions or become so confused you fail to answer a question.
7. Plan to arrive at the first meeting of a course early. This will permit you to secure a seat in the first row and avoid sitting among the disinterested students in the rear where they hope they will not be noticed.
8. *Pretend that you enjoy the lecture, the professor, as well as the text. Who knows? Brownie point here, brownie point there... —ed.*

Along with increasing your ability to learn you will be formulating an organized pattern for your professional life. This does not mean your life will be regimented; it is an intelligent approach to conducting yourself in an efficient rather than haphazard manner, which is an insult to your intelligence. The former reveals a mature adult, the latter an immature adult.

WHEN TO STUDY

Regardless of whether the next scheduled meeting of the course is a lecture or a discussion class, the assignment should be studied thoroughly before attending. One of the purposes of the class is to resolve the remaining unclear thoughts, not to serve as a substitute for studying. The professor should **refuse** to slow down the progress of the class to accommodate those who do not come prepared. Such refusal is a refusal to lower the standards of the university. Did you seek a college with low standards? If not, then do not expect the standards to be lowered to accommodate you if your interest in learning is low.

The professor will have time to add material not found in your text if the students are fully prepared when class starts. She will give a different perspective than that offered by the author, and a different way of deriving the same formulae. She will fill in the gaps in your knowledge pattern, and either answer your questions or ask questions that will enable you to reason the solution to the problems.

Students who have not studied usually ask questions of little help to themselves or anyone else in class. They ask the "I didn't study" type questions, not in-depth questions resulting from having studied.

An assistant professor of Stanford University told of studying conscientiously late at night, yet consistently receiving poor grades. He said it finally dawned on him that "the accepted practice of studying when least mentally prepared to study was my problem." He decided to go to bed three hours earlier and rise three hours earlier, wash his face in cold water, and then study while he was refreshed and rested. He soon found he could **learn more in less time** and have a better understanding of what he had learned. Why not give it a fair trial for a month?

Obviously, "Stanford" didn't know about Letterman or free delivery until 1:00 a.m. —ed.

STUDYING THE ASSIGNMENT

Those who read an assignment once and feel they have absorbed most of it are doing themselves a grave injustice. Needless to say, this is a poor learning habit. There is too much in each sentence and paragraph to be acquired in one reading regardless of whether one has been previously exposed to the subject or not. Try sitting through a movie twice to see what was missed the first time. Read a story twice. Do you not have a greater understanding of the characters than you did the first time?

To obtain a general concept of the assignment, read it quickly the first time. Then read it carefully two more times, trying to understand the author's thoughts as completely as possible. This will require a generous amount of time in the first part of the course because you are acquiring a substantial amount of basic knowledge. After the first six weeks, additional knowledge will be acquired more readily and the amount of time spent studying can be reduced. To have read the assignment only once is egotistically and falsely saying, "I can assimilate whatever thoughts and ideas an author can put into writing in a single reading."

It might also be saying, "This is ridiculously boring!" —ed.

Questions will undoubtedly come to mind as you study. Put them on 3x5 cards, noting page and paragraph, and when you obtain the answers in class or professor's office, add them to the cards.

LECTURES

The basic purpose of lectures is to amplify, to integrate knowledge, and to give aspects of knowledge not included in the text. Those who foolishly come to lectures without having studied the assignment invariably miss much of the pertinent material being offered without realizing it. They cannot take concise notes because they are not prepared to assimilate the material presented. What is missed in the lectures is **lost**. Assignments can be read a number of times; lectures are given only once. Any lecture which can be fully or reasonably well understood without studying the assignment in advance is a **poor** lecture. It is too much to expect one's mind to grasp new information completely in the short time of a lecture.

Promptly after lecture, while it is still fresh in the mind, enlarge upon the notes taken. The lecturer spends a great deal of time giving thought to and preparing for each lecture in order to include as much "meat" as possible. Because lack of time prevents you from including all of the lecture material in your notes when it is given, it is essential that you rewrite them immediately.

Don't forget, you have fifteen (15) minutes between classes. —ed.

ORGANIZING NOTES AND THOUGHTS

Taking notes in lectures and later organizing them are skills useful in all of life as well as college. Perfecting your ability to outline is also a worthwhile endeavor for your career.

Note-taking, outlining and organizing will pressure you to evaluate the material presented, and when practiced throughout college, these techniques become mastered and integrated as a normal part of life. They are developed through conscientious effort year after year rather than "I can do it when I feel like it." Has anyone ever won an Olympic medal on that philosophy?

Finally, use light colored accent marking pens to accent important words and sentences in the text, and write in the margins. Writing in the margins serves as remainders for later use when studying, indicating "I've got to get back to this...explore this further...reread this...and so forth."

NO DOODLING! —ed.

NOISE

You are kidding yourself if you think you can study more easily when the radio or stereo is on. It may be soothing, but it is not conducive to learning. Scientists, philosophers, and authors who produce outstanding results do not have stereos on when they are concentrating because they recognize that they are hindrances. Do you feel that you have greater understanding of learning and thinking than they? Try using ear plugs if you cannot control noise any other way.

CRAMMING

A football coach would not let his players take it easy until the day or two before the game and then expect them to learn all of the plays. He would not urge his players to stay up late the night before a game to master the plays nor would he give

them a stiff workout up to the minute of play. Yet many students regularly and foolishly do these very things to prepare for an exam, in what seems an almost deliberate attempt to lower their grades. It is astounding! Students rationalize that if they do not cram, they will fail, never considering that by needlessly allowing themselves to become tense and tired, they will not be able to think clearly.

The tension and nervousness created by cramming subsides shortly after the exam, and then the correct answers come to mind. Instead of having acquired knowledge, the student who has crammed has mastered only the dubious ability to transfer some facts from a text to an exam paper. Such ability is worthless in a career. Would you want to rely upon a doctor, lawyer, or airplane designer who obtained his education by cramming?

It must be pointed out here that veteran crammers feel little nervousness —ed.

As a rule, knowledge obtained by cramming is lost as quickly as it is gained. How many of those who cram could pass an exam covering the same subject matter a month later? Cramming can be expected to cause you to become confused, frustrated, and tired due to inadequate sleep— at a time when you **should** be relaxed and confident. Cramming cannot possibly compensate for improper and inadequate study habits.

How will you solve the problems you will encounter in your career? The answers will not be found in texts. You will have to mold and adapt the fundamentals you have acquired into pliable solutions as you seek to solve problems unheard of when the texts you used where written. Cramming cannot prepare you for those solutions.

NERVOUSNESS DURING EXAMS

Nervousness during exams is caused by a lack of self-confidence. Even students who have adequately studied sometimes have this shortcoming. For those who have studied thoroughly daily but still cram the night before and study up to the moment the exam papers are handed them, it is a needless lack of self-confidence. But those who are lax in their study habits and rely on memorization, cramming, and cheating techniques have good reason to be nervous. Unfortunately, the habits they have acquired are as detrimental to their professional careers as they are to their college careers. What is the price of nervousness? Here is a good example. A capable student who always studied until the exam paper was handed him failed every exam including the midsemester. His professor said, "You have failed badly every exam so far. How about trying my way for passing them?" He was advised to do his reviewing prior to the day before for the remainder of the exams, to go to an early movie the evening before, to do no reviewing the day of the exam, and to come to class not caring whether he passed. He did this and received high grades. He passed the course with a good grade. Even a well prepared student needs the proper mental attitude towards being tested as this student discovered. It was poor mental attitude and not his ability that failed him for half a semester.

Are you professors listening to this? —ed.

The exams of the classroom are one form of the exams of life. The meetings with your superiors, the conferences in which you will participated, and the sundry times you will be asked for your opinions will all be exams of your career. Will you be prepared for them, be relaxed so you can "pass" them, or will you be nervous due to lack of self-confidence? Your decision will be influenced by your attitude toward education and your willingness to adopt proper learning processes.

COPYING DAILY ASSIGNMENTS

Some students avoid the arduousness of learning by copying daily assignments supplemented with a brief cookbook-type explanation from another student. They foolishly think they have learned when they copy. The copier has only deluded herself. Who is going to do the thinking and reasoning later on for her in her career? Friends who solved the problems did the hard work of digging for knowledge, but gave only commentaries about what was learned. One cannot build a physique by receiving verbal instructions. You have to follow a vigorous training routine.

MEMORIZING IS NOT LEARNING

One can memorize and repeat some material in a foreign language, yet not understand a word. Memorizing a definition, an explanation of a fundamental, or a formula without a sound understanding of its meaning or derivation is of little value. If you forget a key word or an item of a formula, you will be stymied.

Memory is a fine facility to utilize to remember faces and names, meeting appointments, keeping certain data in mind, etc. But it must be recognized that memorization cannot be a substitute for understanding. It also must be recognized that for many things memory is short lived. Unlike a computer, memory has a built in capacity to forget. If you were to recall all of the small details of your life, the unpleasant and pleasant alike, you would welcome the forget factor of memory.

Memories, human or computer, do not think, innovate, create, analyze, reason, or mold knowledge to new situations. Thus, memorization offers little either to you or your employer. If you believe otherwise, why not tell job interviewers on graduation that you memorized your way through college? Furthermore, if memorization were such a valuable tool, it would not be necessary to go to college. The texts already exist— you could purchase them and memorize.

Employers will not hire you or keep you on the basis of amount of memorized knowledge you can retain like a computer. Rather, you will be hired for your ability to mold and adapt, to innovate and create solutions to previously unsolved problems.

WHY HAVE EXAMS?

As unenjoyable as they are, exams are necessary adjuncts to the learning process. The basic purposes for giving them are as follows:

1. To evaluate the student's progress in learning.
2. To pinpoint weaknesses as well as strengths in the students progress.
3. To furnish the "push" towards one's potential that many need.
4. To remove the conceit which says "I understand that" from keeping one from studying assignments fully.
5. To prepare for the "exams" of life— the ability to think, work under pressure and with a time limit.
6. To indicate to the professor the effectiveness of his teaching methods. If the conscientious and struggling students cannot answer well then he is ineffective and needs to improve his techniques.
7. To determine whether the students can creatively mold and adapt the fundamentals to meet other than straight-forward problems— the problems of life.
8. To show crammers and memorizers the ineffectiveness of their learning techniques.
9. *To show crammers and memorizers that, yes, once again, they have beat the system! —ed.*

The faculty do not enjoy preparing and grading exams any more than students enjoy taking them. Nevertheless, both should recognize their importance and utilize them well for the student's benefit.

OPPONENTS OF EXAMS

Some argue against the concept of exams. In so doing they are trying to avoid having their ability to acquire knowledge tested. They rationalize that they are being hampered in learning. Yet, everyone needs yardsticks with which to measure their learning. Some faculties likewise argue against exams, but for a different reason— to avoid having to prepare and grade them.

Several professors told of having countered student arguments against exams by asking their classes if they preferred relying on professorial judgment for their semester grades, to be based solely on the final exam, or on an oral exam. These alternatives to several exams during a semester had no appeal. Which do you prefer?

PREPARATION FOR EXAMS

Preparation for exams is definitely not a project for the night before nor the hours before the exam. Preparation for exams should start the first week of classes by acquiring the basics of each course. Studying on a daily basis, listening attentively and asking pertinent questions in class is the real preparation for exams. Such thorough preparation makes it possible to absorb, assimilate, and understand the subject matter rather than have it float on the surface of the mind.

A professor told of the method he used in Europe in preparation for exams. He would work up a discussion group which would meet a few days before the exam, not the night before. Each student was asked to prepare mock questions for each to answer and to question each other's responses. Those students gained the ability to answer and to defend their own viewpoints and to understand the viewpoints of others as well as to learn of their weaknesses in reasoning. They were stimulated to a better understanding of the subject and became better able to acquire the thought processes needed to produce the best answers. This method is far superior to going over old exams for it involves delving into the subject to find the questions, and learning from different versions of the answers. Why not give it an honest try?

It must be pointed out here that the quickest, least painful way to pass exams with absolute minimum work is to study old exams intensely. Further, grades such as **BC** *can be easily attained this way, as my most recent transcript attests. Why not give it an honest try? —ed.*

REVIEWING FOR THE EXAMS AND THE FINAL

An intelligent approach allows knowledge to become imbedded in mind for a better understanding of it. The poorest times to review are the night before and during the day of the exam. Last minute pounding in of knowledge short-circuits the learning process. It creates nervousness from wondering whether or not the information will be remembered long enough to last through the least question. It creates unnecessary tiredness and jeopardizes your self-confidence in understanding the material. When allowed to be developed normally the learning that is gained becomes a real and valuable part of your knowledge and ability. Opting instead on memorization shows ignorance of the value of the learning process. It is saying, "What is to be learned from the course is useful only for taking exams." If this is true, it also implies, "College is useful only for obtaining the degree."

Reviewing should be like clinching the nail after it has been driven through the boards. In other words, proper studying of daily assignments should begin the first day of class and continue throughout the semester, ending with the first review.

One way of approaching study and review is this: Organize the course as it is acquired, and then learn the course as if you will be teaching it the next semester.

Reviewing for a regular exam two or three days previously allows one to discover the important details, and allows time to improve on weaknesses. Reciting aloud, writing out your thoughts and explaining your thoughts to others as well as listening to theirs clarifies a subject far better than "silent" learning. Even explaining your understanding to a less capable student aids materially the learning process. It makes one conscious of what is needed for a full understanding of a fundamental. This is a regular part of the learning process for the professor, for she is discovering some of the finer points when she is helping a struggling student. This is not true, however, with the lazy student who merely wants answers.

Reviewing should be like clinching the nail after it has been driven through the boards.

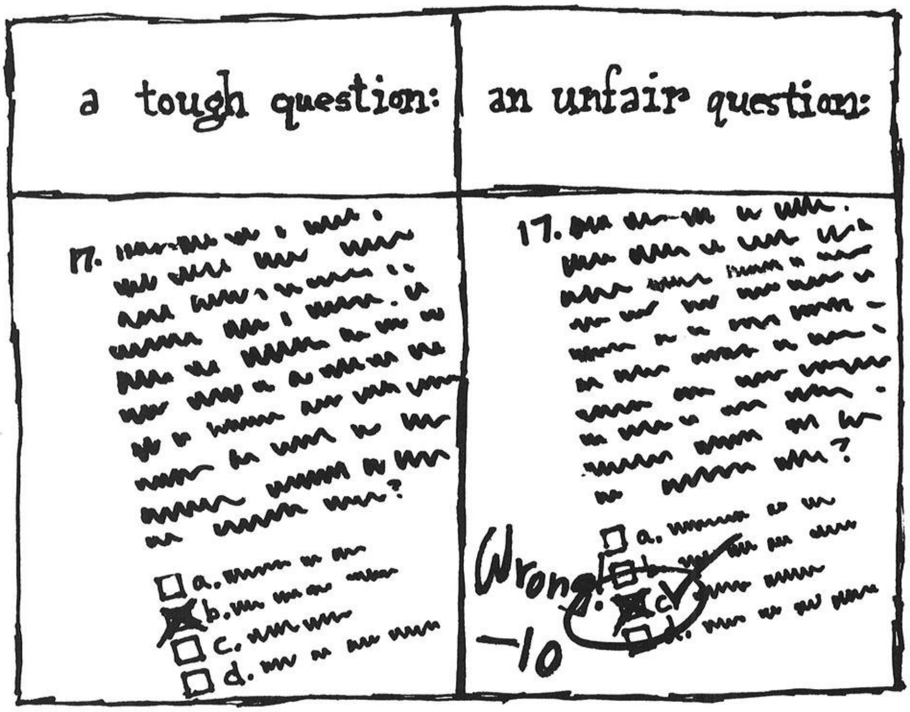
This earlier reviewing combined with a good night's sleep the night before is the best preparation for an exam, as it makes you relaxed and self-confident. Knowing that "I've studied well and I can put down all I know" allows you to solve the problems and questions in the same relaxed, self-confident manner as if they had been given as a daily assignment. To "go to pieces" or say "I had a mental block" answering questions that you could have answered at any other time shows a distinct lack of emotional control and a lack of self-confidence. This condition is only aggravated by cramming. Strengthen yourself by not doing it.

Begin the final exam reviewing at least two weeks ahead of time. Make a list of notes and questions. Label paragraphs not fully understood and make an appointment with the professor. He will admire this approach (he gets little of it) and will extend himself much more than to those who go unannounced or with the attitude, "Teach me the course well enough to get through the exam."

If you do not know the subject by the night before the exam, it is too late to begin to take the course seriously. You will fail any exam other than those with questions answerable by memorization. Such questions indicate the professor was lax in his teaching and may be compensating for it by asking easy questions.

EXAM QUESTIONS

There is no point in asking questions on those aspects of a subject everyone understands. Exam questions should pinpoint areas where knowledge may not be as well grounded. Exams are intended to expose weaknesses so that they may be strengthened by further studying. The conscientious do this. Those who do not strengthen their weak areas compound their problems in later exams because of a weak base of knowledge. Every weakness exposed by an exam question should be strengthened, not only for future exams, but for life's work. Letting weaknesses remain unimproved makes for mediocrity in a career.



THOSE "UNFAIR" QUESTIONS

Admittedly, exams are imperfect, but so is life. They cannot entirely evaluate all of your capacity for learning, capability to think in-depth, accumulation of knowledge, and ability to mold and adapt it to your will.

The president of a large corporation who had taught a couple of years before going into business had this to say: "According to those who are experts in the learning process, memorization represents the lowest level of the process. The next level is comprehension, or understanding of the material. Next comes application, or the ability to use the material. Then comes analysis, or the ability to break the material down so it can be better understood. Next is synthesis, the ability to put parts of the knowledge together to form a new whole. At the highest is evaluation, or the ability to judge the value of material for a given purpose. The conscientious teacher will attempt to prepare her examination questions to require the students to progress to higher levels of the learning process. The student is the one who profits, even though at times she may feel the teacher is being deliberately 'unfair'."

There are students who complain about questions for which answers cannot be found in a totally straightforward way in the text. The precise answers to the problems of life usually cannot be found in texts either, or for that matter, in any other place to which one can refer. It is poor thinking on part of the faculty to present in exams only questions to which precise text answers can be given.

"Unfair"questions are often those which require one to "mold"and otherwise "adapt" a concept or principle to meet a particular situation rather than to put square pegs in square holes and round ones in theirs.

Unfair questions can also be poorly thought out, lame attempts by a professor to finish creating a boring exam. Let's not be unfair to the professors. —ed.

In your career you must expect the questions and problems often to be ill defined. Facts, figures, and other materials and information that are totally irrelevant to the question or problem are frequently intermingled with those that are relevant. The irrelevant must be recognized as such and discarded in the quest for the solution. The "unfair"and tough questions posed in college exams usually train you to deal with similar problems in your career and life. The classroom, not your career, is the arena in which to find out whether you are sufficiently competent to cope with the tough problems of life. When you have a firm grip on the basics of a subject and understand how to mold and adapt them, career experiences enable you to handle increasingly difficult situations. Does the student who successfully answered the "unfair"questions say they are unfair? Tough, yes, but not unfair.

In the "exams"of your career, silence will be the equivalent of not being able to answer a question on an exam and will be "graded"accordingly. In contrast, monopolizing a conversation or a meeting will be like covering up on an exam by using a lot of words but saying little. A good answer or presentation of an idea does not need to be verbose. Cleverly trying to divert the discussion to an area in which you are better informed will alert those who do think clearly to analyze such maneuvering for what it is— a diversionary tactic to cover up a lack of knowledge. Once in your career expect to experience some of these diversionary tactics.

TAKING THE EXAM

First read, then reread the instructions and questions for a clear understanding of what is required. Learn to respect the individual words in a question, be it an essay, multiple choice, true-false or any other type. Expect there to be key words which will better define the meaning of questions.

It is highly advisable to jot down in the margin or on a piece of scratch paper details of an answer before starting to write. These details may be otherwise forgotten while writing. Take a few moments to organize your thoughts before attempting to express what they are.

Solve the easier questions first rather than always in the sequence given. Having read the tougher questions, your subconscious will be working on them while the easier ones are being solved.

This really works! —ed.

Human nature shortcomings, when combined with time pressure, can often undermine the power of reason. For example, it is foolish to stubbornly plug away at a seemingly difficult problem while leaving easier ones unsolved. I once took a final exam sheet from a student who was red in the face, who stubbornly refused to go on to the next problem though advised to do so. The sheet was taken from him. He cooled off and finished the remainder of the exam. The sheet was returned to him. He received a 99 instead of a very low grade.

If you have not bothered to organize your daily assignments, expect your essay exams to be even more disorganized due to the pressure of time. Irrelevant material will enter unintentionally making it more difficult for the professor to properly evaluate your answers. A poorly organized answer with poor handwriting will receive a lower grade than a concise, easily read answer.

A problem-type question, such as in mathematics, physics, and engineering, needs a well organized series of steps with none of the steps omitted. When you omit steps and make an error it is much more difficult to give proper partial credit.

A few items about exam-taking follow:

1. If rushed for time at least itemize in statement form or outline how you would have solved the problem or question.
2. Do likewise for the problem in which you find you made an error but do not have time to correct it. Professors are interested in whether you know how to solve the problem rather than the answer itself.
3. Check your watch occasionally to avoid spending 40 percent of the time on a 20 percent question. Lay your watch on the table.
4. Be neat. Sloppily prepared exams are not easy to grade. Neatness has its way of psychologically getting better results.

Be Neat!

5. Leaning over a desk for an hour or two in a cramped manner means inadequate breathing,and it, in turn, means insufficient oxygen to the brain for it to function properly. Oxygen is the brain's food. Practice good breathing: periodically straighten up, lean back, force your shoulders back, take several deep breaths, and then return to the exam.
6. Take a brief, but brisk ten minute walk just prior to an exam to add to your blood circulation.
7. *If you don't know a thing and feel like freaking, slam your pencil down, walk up to your professor with your exam and state in a loud, confident manner, "This exam is an insult to my intelligence!" then leave. —ed.*

EXAM RESULTS

All too frequently students do not restudy those areas of indicated weaknesses as if those bridges will never be crossed again. Failure to strengthen your weaknesses undermines your ability to understand more complex subject matter fully. Not restudying those proven weak fundamentals weakens your ability to pass the final exam.

GRADES

There are those who sulk and refuse to learn conscientiously when they do not receive the grades they feel they deserve. Grades should be given solely in accordance with the quality of the daily assignments, themes, term papers, reports and so forth rather than on the amount of effort expended or the length of the endeavor. The same is true for exams.

There are those who sluff their learning when they do not like their professor. What will they do when they have to work with or for someone they do not care for? To ever not do your best even in most unpleasant situations is doing more damage to yourself in the long run.

SUMMARY

The student who studies superficially and relies upon the help he receives from his fellow students to solve problems will invariably perform poorly in any exam for which original thinking is required, be it in the classroom or in a career. He has learned only the mechanics of how to solve problems but not the thought process and he can expect that his performance in his career will be no better than his performance in his exams.

The following study guide is an aid in preparing yourself to meet the new and different problems which will occur daily in your career.

1. Study each assignment three times, going over it quickly the first time and then carefully the second and third times. Only after the third time will you approach mastery of the assignment. Thoroughly studying the assignment does not take additional time; it actually saves time because it enables you to solve the problems more quickly.
2. Underscore, use accent pens, and add notes to texts freely.
3. A part of the learning process is acquiring confidence. Except for tables, the text should not be used while the daily problems are being solved. Learn to rely on your understanding. Mastering the fundamentals creates confidence and eliminates nervousness.

Being afraid to ask questions in class or of the professor in his office is definitely cheating yourself. No reward is ever given for being bashful.

4. Courses are difficult when you do not know the fundamentals. If you will work as hard to learn the fundamentals during the first six weeks of a course as you usually do the last three weeks, you will find you have mastered the course and the rest will be relatively easy. The basics of many courses are not exciting to learn, but they are exciting to apply because you will have then acquired sufficient understanding of them to know what you are doing. Nervousness, frequently caused by insufficient studying, invariably disappears as confidence is acquired.
5. To obtain the maximum from a lecture or discussion section, study well before you go to class. As you study, make notes on cards to which you can refer during discussion in class or with the professor. See your professor regularly, but be prepared to ask specific questions. Thoroughly studying the assignment will enable you to do this. Being afraid to ask questions in class or of the professor in his office is definitely cheating yourself. No reward is ever given for being bashful.

This is just semantics, of course, but to be exact—don't most grade schools give out "shyest"or "most bashful" awards? Just trying to avoid the lawsuits. —ed.

6. Too frequently a student expects a professor to merely give him the answer to the problem, which in itself is relatively unimportant. It is much more important that the professor aid the student in reason-

ing out the solution by asking a series of questions that the student can answer, thereby stimulating him to analyze the problem and develop a solution. A student who uses this method (developed by Socrates 2300 years ago) to help a fellow student who is having difficulty will find that the student has improved there own ability to analyze and understand the fundamentals.

7. Since far more can be learned in less time when one is fresh than when one is tired, try going to bed a few hours earlier than usual and rising a few hours earlier the next morning. Why study late at night when you are tired just because others do?

8. Studying the night before and the day of any exam is too late. If the fundamentals have been mastered as they were assigned and then reviewed a few days before the exam, last-minute cramming will not be necessary. It is far better to go to an early movie the night before, get a good night's sleep, and be relaxed for the exam. Cramming creates nervousness and is an admission of previous failure to learn. Athletes do not train up to the last minute; they train (learn) ahead of time and relax before the big event.

9. Reviewing for final exams should start three weeks before the end of the semester. Make notes of paragraphs and equations you do not understand and seek help from the professor. By allowing an adequate length of time for review and help, you will be able to come to the final exams rested, relaxed, and confident because you are adequately prepared.

10. Leaning over a desk during an exam compresses the lungs, restricting the supply of oxygen to the brain. Nerves get on edge, and tension mounts. To obtain relief, straighten up during the exam, take several deep breaths, then try to relax by slumping in your chair and letting your arms dangle for a few moments. It should take about one minute of time. Have you ever thought of a mistake on an exam shortly after turning in your paper—when you were no longer leaning over your desk? It was due to being relaxed and your brain getting its normal amount of oxygen once again.

11. Seeing someone else's solutions to problems is the quicksand of learning. You think you understand, but you do not. The lack of understanding shows up when another problem involving a rearrangement of the same facts must be solved. The person who solved the problem without help acquired the real learning, not you.

12. The diploma is only the end of the beginning. You are not a "finished product" when you graduate, but are merely on the right road toward becoming competent and successful in your career. You must continue studying at the graduate level and/or on your own.

13. Try hard in school. If you screw up, those are the breaks. Mom still loves you. Try again—if you screw up, those are the breaks, Mom still loves you... —ed.

Now that you have read this explanation on How to Study do you plan to discard it? If so you are indeed in need to learn to discipline yourself. You cannot hope to fully digest this treatise in one reading any more than you can an assignment of text. How well do you think you would do on an exam of this advice on only one reading? Most likely poor.

Keep this— you just might find it wise to refer to once you get some low grades and want to learn how to improve on them. The sooner you recognize that college IS different and much harder than high school the quicker you will adjust to the higher standards. The "water" is a lot deeper and you are on your own to learn how to "swim" in it for furthering your life's career.

I couldn't let Prof. Grant have the last word— if he was here, I doubt he would let me. What I have to say is simply this: try very hard not to let school pressure control you. Everything will fall into place whether or not you have anything to do with it. If you are honestly serious about this place, Grant's sagely advice will at least help avoid one form of pressure. Don't you think? —ed.

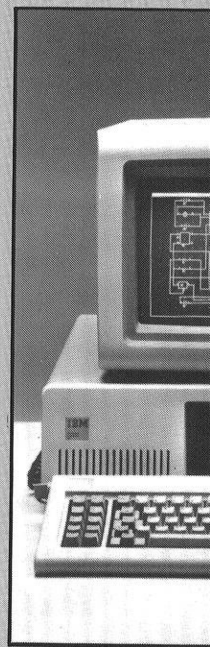
—The End—

THE ENGINEERING
BE A PART

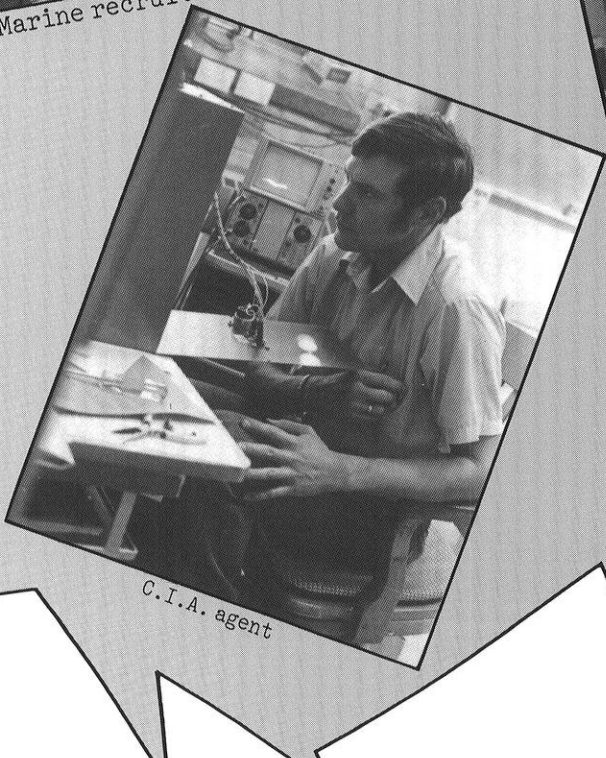
Studying is not all we do!

Just a few guys lookin' kinda' funny and standin' in line

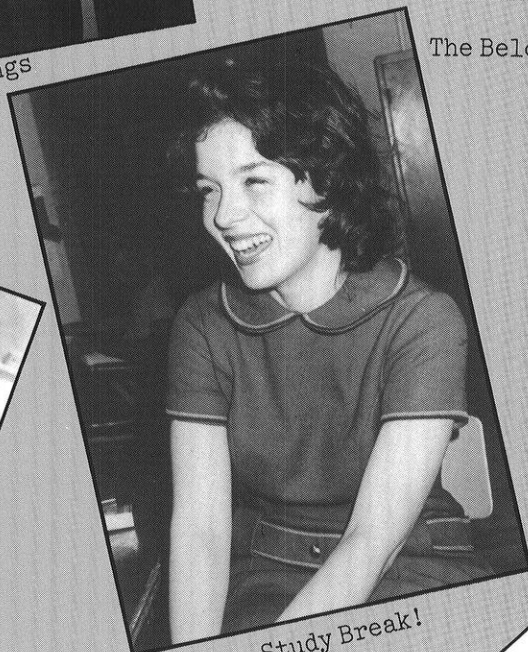
or, Marine recruitment after the Contra hearings



The Beloved ob

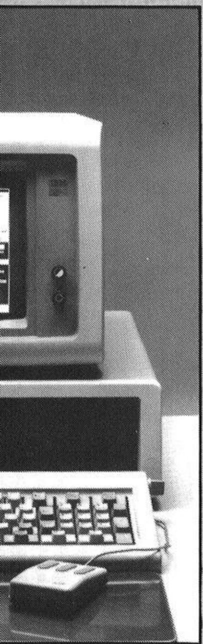


C.I.A. agent

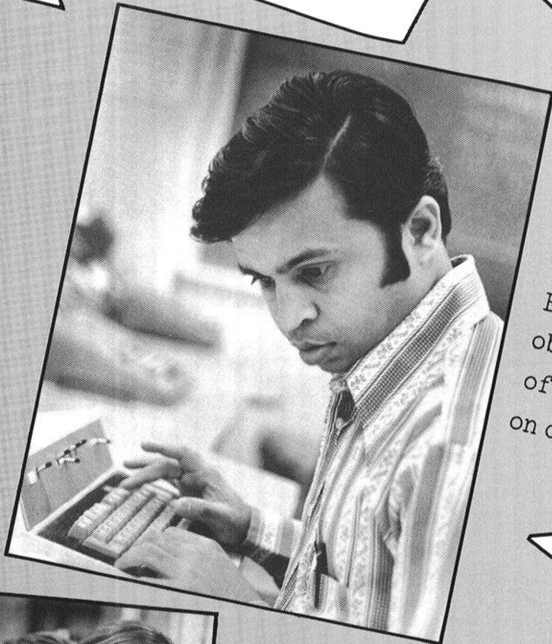


Study Break!

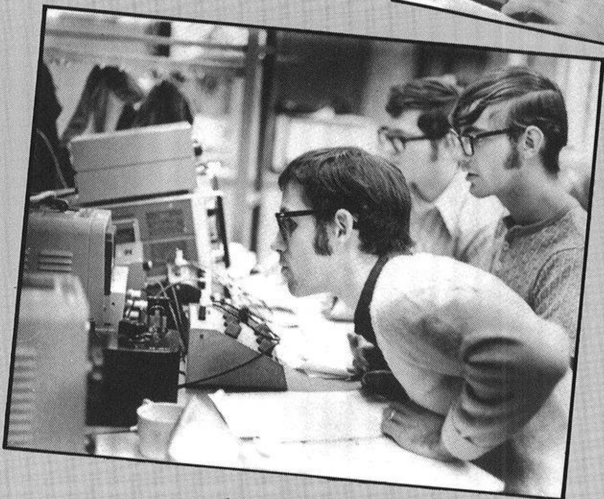
Experience:
of It!



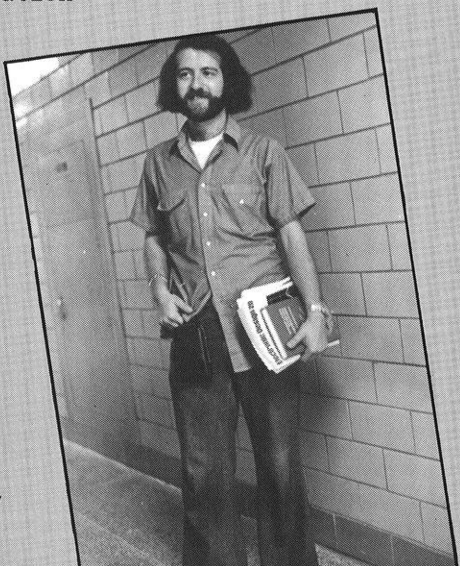
Cathectation



Engineer observing behavior of cockroach on computer ''mouse''

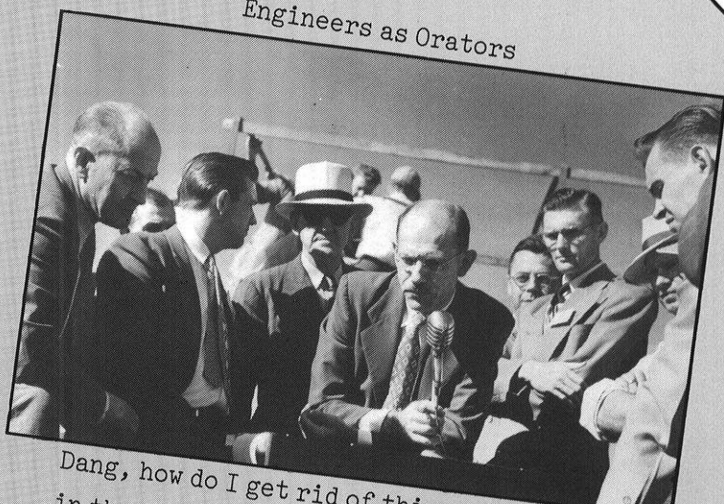


Engineers ignoring personal hygiene for the greater benefit of humanity



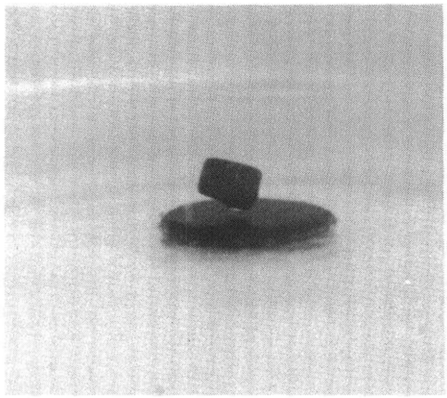
The Engineer's attire or ''Hi, my name's Rick, and I'm just standing here looking sorta funny.''

Engineers as Orators



Dang, how do I get rid of this guy behind me in the weird glasses?

A Word About the New SUPERCONDUCTORS



An ordinary magnet sets up a circulating supercurrent in the superconductor below, creating an opposing field that floats it.

FIGURE 2

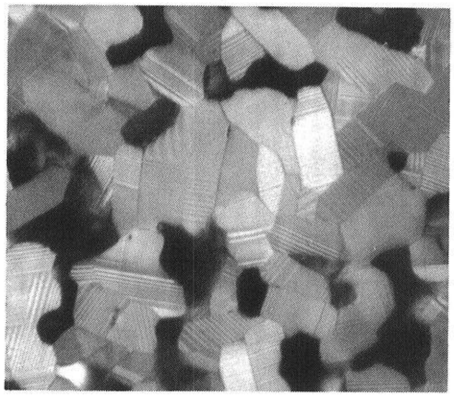


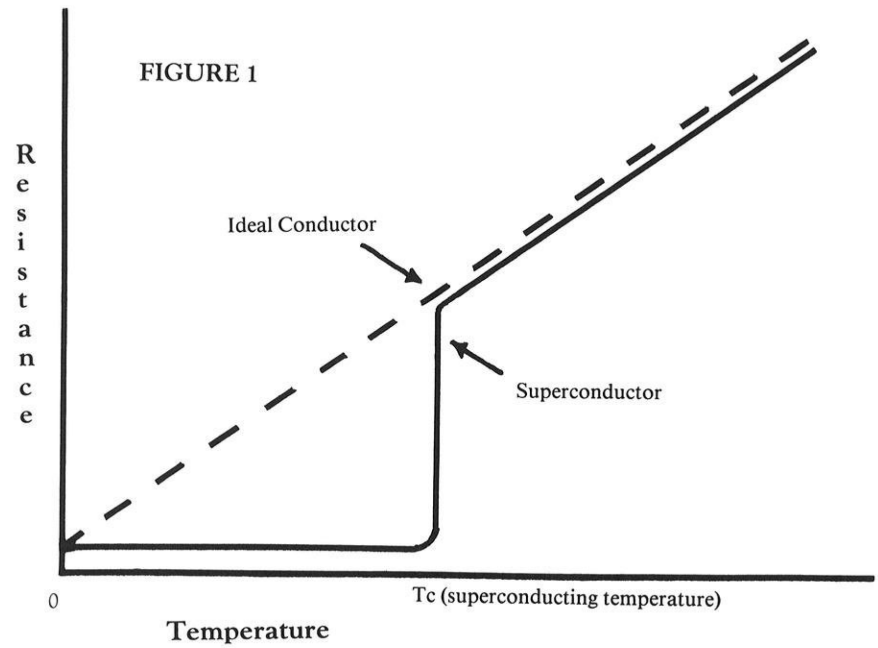
Photo by Jeff Seuntjens

Magnification of the oxide shows grains clearly visible. The grains are volumes of the same molecular orientation, and are the key to understanding the physics of the material.

By Rick Rutherford

Ever since the discovery of superconductivity in 1911 by Kamerlingh Onnes, physicists have dreamed about the possibilities that widespread, readily available superconductor technology could provide. One of the obstacles blocking the realization of these dreams has been partially removed by the discovery of a new material which exhibits superconductive properties above the cooling temperature of liquid nitrogen, around 90K. Room temperature is around 295K. Originally, Onnes used liquid helium (boiling point 4.2K) in his experiments with tin and lead, and he found that cooling the materials to so low a temperature caused their resistance to electricity to suddenly drop to zero. It makes logical sense that lowering a material's temperature will lower its resistance, since the atoms will lack the energy supplied by heat to oscillate and block electrical flow. It was a new phenomenon to see the resistance actually decrease to **zero** however, and it is this amazing property of matter that allows current to flow indefinitely (Figure 1). No additional electric energy need be applied to run a superconductive circuit that is operating because no energy is wasted by conversion to heat. This property of superconductivity was recently found in an oxide of yttrium, barium, and copper—$YBa_2Cu_3O_{7-y}$. The number of oxygen atoms is uncertain because the number of vacancies in the crystal structure is not yet known.

FIGURE 1



The compound is formed at about 900C, and it must be carefully treated in oxygen at about 500C to get the best properties. The exact oxidation state is very important to the superconducting properties. The oxide is created by firing a mixture of metal oxides or carbonates, producing a black, brittle, brick-like solid, containing many tiny grains (Figure 2). The grains are volumes of atoms with the same molecular orientation, with misorientations occurring at the grain boundaries. The key to understanding the new material seems to be in understanding exactly what occurs at the boundaries. Presently, a perplexing characteristic of them is that they do not appear to permit supercurrent flow. Extremely high supercurrent densities appear to flow within the grains (1000–10,000 A/mm^2), but only 1 to 10 A/mm^2 can flow from grain to grain. This is a major obstacle to high magnetic field applications of the new materials, and researchers are working fervently to come up with solutions. Development of large areas of the same molecular orientation might solve the problem, but at present it is not known whether the weak connection at the boundaries is due to the highly directional nature of the superconductive properties of the material (i.e. supercurrent moves only in one dimension through lines of CuO), or if it results from the lack of correct chemical composition in the grain boundaries.

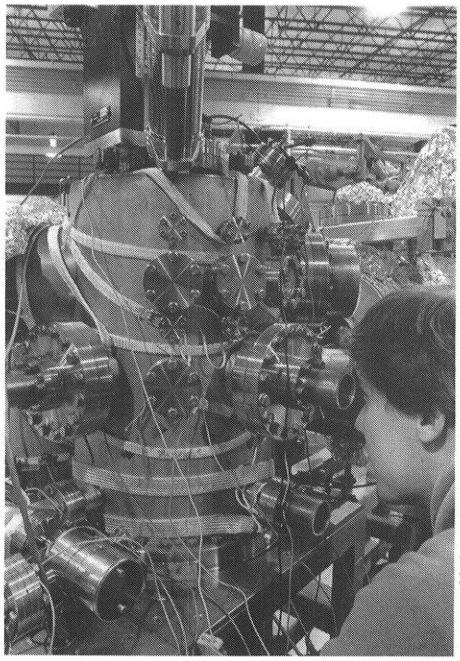
Researchers are quick to point out that it is not a new technology that has been found, but a new material...

The most visible advantage of the new materials is the operating temperature, since liquid nitrogen is very cheap when compared to the cost of liquid helium, and it is available in large quantities. Also, the radical difference between the specific heats of different materials at 4.2K and of the same materials at 77K allows for greater stability within the cooled system, because there is less tendency for small temperature differences in the entire system to send the temperature of one material high above the others.

No matter how much this discovery seems like a revolution within the field of superconductors, researchers are quick to point out that it is not a new technology that has been found, but a new material that can be used with existing technology. The most exciting applications of the new superconductors are in the production of large magnetic fields, possible because of the immense currents that can flow in them. Such fields are necessary for nuclear fusion research, particle accelerators, and floating trains, but it is too soon to tell the role the new materials will have in producing them. Advances in microelectronics are more reasonably expected. Superconducting circuits eliminate resistance (heat), allowing for closer spacing of components in a circuit and thus speeding up operations. The Josephson junction, a switch made possible because of the physics of superconductors, is faster by a few magnitudes than silicon transistors, and its use will greatly increase computer speed.

Professor David C. Larbalestier of the Applied Superconductivity Center here at the UW suggests that even though the new materials are exciting, there is as yet no reason to change the present use of the technology in magnetic resonance imaging, particle accelerators, and laboratory magnets. However, the new materials do offer the prospect of many new and relatively cheap applications, such as motors and transmission lines. Professor Eric Hellstrom, a ceramist at the UW, states that it must first be demonstrated that profits can be made within a short time period (i.e. 10 years) for private industry to show a great deal of interest. Only the U.S. government—most notably the Department of Defense— will continue to support researchers over a long period of time while the fruits of their labor are not yet applicable to the modern commercial world. It seems very unlikely, however, that nothing new will be gained within the next decade. Engineering professor James Nordman simply said that we can not at all be certain of the results of the research currently in progress. After all, he says, when semiconducting materials were first discovered, who would have dreamed that they would eventually be used to make digital wristwatches?□

The Leap to a New IC Technology



University News Service

A researcher adjusts instruments on one of Aladdin's beam lines.

By Jeff Gregory

**Science Writer
University–Industry
Research Program**

When one thinks of Wisconsin, beer and cheese probably spring to mind. But the dairy state is also becoming known as a research center for a new process that could produce more powerful computer chips. The process is called X-ray lithography.

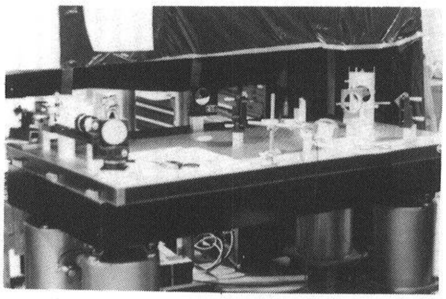
"I think we are in a beautiful position for basic research in this field," says Henry Guckel, director of the Wisconsin Center for X-Ray Lithography.

Guckel, UW-Madison professor of electrical and computer engineering, says the university has a distinct advantage because of Aladdin, one of the country's few electron storage rings capable of producing the synchrotron radiation needed for the lithography process.

Housed at the Synchrotron Radiation Center (SRC) in Stoughton, Aladdin produces a powerful beam of soft X-rays that can be used to imprint incredibly small silicon-based integrated circuits (ICs). Using this method, researchers hope to produce circuit patterns several times smaller—and therefore denser and faster— than those currently in use.

But while this looks good on paper, notes Guckel, the reality of an economical, Aladdin-produced IC is some distance in the future.

"There are many things that need to be solved before industry can make money on this sort of thing in a big way," he says. "But on the positive side is the fact that we can do X-ray lithography at all in Wisconsin. There are only two or three other places besides UW-Madison that can do that."



A mirror and lens system used to take advantage of the beam produced by Aladdin.

Guckel adds that it's difficult to assess the exact status of American X-ray lithography because research conducted by corporations is often proprietary. But with five of Aladdin's 36 beam ports permanently assigned to X-ray lithography research, he hopes to see some major progress made at the Wisconsin facility.

A Shining Lamp

The Synchrotron Radiation Center and its electron storage ring—built with funds from the National Science Foundation, the Graduate School, and the State of Wisconsin— play key roles in the activities of the Center for X-Ray Lithography. The latter center was launched four years ago with a $1.25 million grant from WARF (Wisconsin Alumni Research Foundation). WARF also provided recent funding that enabled scientists to enhance and refine Aladdin's performance.

Aladdin's entry into full operation, and the Synchrotron Radiation Center's receipt of a major new grant from NSF (almost $9 million over three years), was celebrated last October at a formal dedication of the ring.

"The machine is up to power and ready to go," said Franco Cerrina, UW-Madison professor of electrical and computer engineering and associate director of the center. "But we're still defining the role of the center with industry."

Cerrina notes that while currently the SRC and the lithography center welcome only industry research that will be published and made public, future proprietary research will probably be accepted on a "payback" basis with users covering the energy and labor costs of conducting their experiments.

Some of Aladdin's ports have been assigned to industrial or university researchers for basic research. Although industrial interest in the facility has been high, says Guckel, the IC industry is financially strapped at present and funds necessary for

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Inside the Synchrotron Center— workers surrounded by advanced technology.

running experiments have simply not been available. The downward trend of the home computer and computer games market in the last few years is cited as a major cause for the industry-wide slump.

The Microchip Gap

This is unfortunate, says Guckel, because foreign competition is heating up in the X-ray lithography field. Guckel is concerned that U.S. efforts to win this race may be hurt by the substantial aid that overseas programs are receiving from their respective governments. Germany and Japan in particular have heavily subsidized private-sector development of X-ray lithography and research for the next generation of microchips. Indeed, says Guckel, the major Japanese program is entirely government organized.

It is not in the best interests of the U.S. to have our IC sources of supply in other countries...

"But if the U.S. puts together a concentrated organized effort, we *are* going to catch up because we have all the necessary skills and resources," he adds.

Guckel characterizes the IC industry position as a catch-22. The amount of money available for X-ray lithography research is extremely limited by the current slump; but such research and its attendant investment may be necessary for industry growth in the long run.

The Department of Defense also feels that bolstering the U.S. IC industry is essential for national security, says Guckel. Many of the increasingly technological weapons systems produced in this country depend on foreign-made, or at least foreign-assembled, silicon chips. Such dependence is not in the national interest, he says.

According to a recent statement by the D.O.D. Defense Science Board task force, there is a "microchip gap" between U.S. and more advanced overseas producers— a situation they declared would require a \$1.7-billion remedy over the next five years.

David Huber, director of the Synchrotron Radiation Center and associate director of the Center for X-Ray Lithography, is sensitive to the role that Aladdin could play in closing that gap.

"We're making a very serious effort to get industry interested in X-ray lithography," he says. "It is not in the best interests of the U.S. to have our IC sources of supply in other countries."

The Main Challenges

To help industry make the leap to a new technology, researchers at the Aladdin facility are working on problems at the leading edge of X-ray lithography research, according to James Taylor, professor of chemistry and an associate director or the Center for X-Ray Lithography.

Two of the main challenges to a practical system of X-ray lithography, he says, lie on the receiving end of the process— in the masks, or stencils that carry the chip pattern, and in the photoresists, light-sensitive chemicals that are applied to silicon wafers to control the X-rays' etchings.

According to Taylor, masks are composed of areas of "X-ray absorbers," usually made of metals such as tungsten or gold, and transparent areas made of various substances. Like a common stencil, the clear ares of the mask allow the X-rays to pass through and expose the photoresist in the pattern defined by the absorber.

The process becomes more complex, however, because an IC requires more than one exposure. Each chip is made up of several levels, or layers, sometimes partially overlapping. Like a multistoried building, each floor or layer of the chip has a different floor plan. A different mask must be positioned with an accuracy of one tenth the dimension of the smallest line of the circuit pattern being printed.

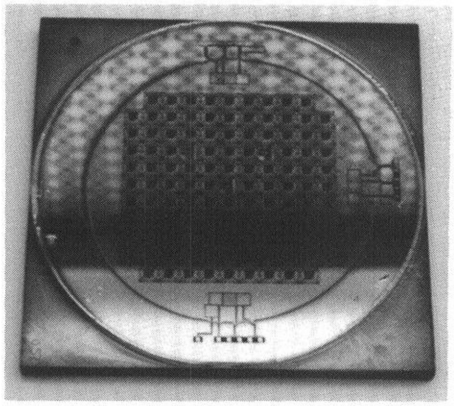
The challenge is to make masks that are fine enough to transfer a submicron size pattern, but that are tough enough to resist warping from the heat of the lithography process. Although the soft X-ray's wavelength is short enough to expose minute areas, the IC is only as good as the mask from which it is made. New and possibly tougher mask substances, such as silicon nitrides and aluminum oxides, are currently under investigation, according to Taylor.

The challenge is to make masks that are fine enough to transfer a submicron size pattern, but that are tough enough to resist warping from the heat of the lithography process.

This research will draw heavily on the expertise of UW-Madison professor of electrical and computer engineering John Wiley and his colleagues in the Materials Science Center. Selecting materials for masks and resists and understanding how they work together is a major element of the X-ray lithography effort. Wiley, also an associate director of the Center for X-Ray Lithography, is another contributor to what Taylor sees as the necessary interdisciplinary make-up of the effort.

The last major challenge of creating practical X-ray lithography lies in the development of the optimal photoresist. This material, according to Taylor, is the light-sensitive polymer that coats the silicon chip.

"Some of the truly new and promising candidates are derived from a family of synthetic polymers, called polysilanes, which were originally produced by chemistry professor Robert West at UW-Madison," says Taylor. One frustrating development, he adds, is that chemicals that accept an X-ray-imprinted pattern with high resolution tend to be relatively insensitive to the X-ray's energy, thus forcing a longer exposure time.

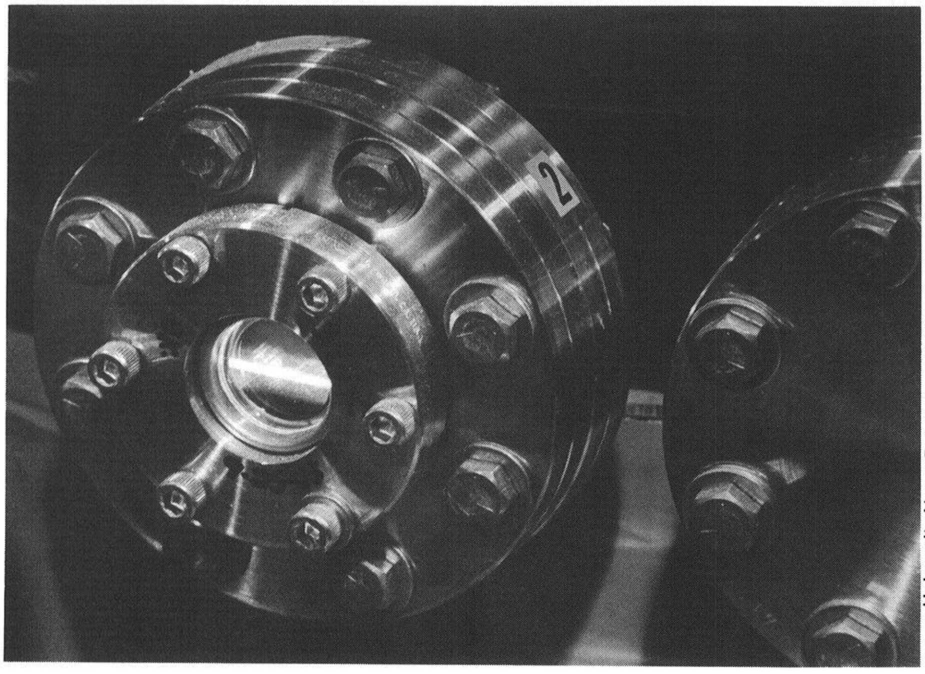


The mask, used to delineate the shapes on the IC-chip that will describe its function.

Taylor estimates that although there are at least several hundred commercial photoresists available on the market, only 20 to 25 of them are suited for X-ray lithography. Most were developed for optical or ultraviolet lithography, older techniques with poorer resolution that X-ray lithography researchers hope to replace.

The center is now moving quickly to assume its role as a collaborator with industry, say Taylor, and has recently submitted a $1.5 million proposal to a national consortium of integrated circuit companies called the Semiconductor Research Corporation. With the aid of this requested support over the next three years, the center will seek a number of ways to improve mask and photoresist technologies.

"We have the ability to accommodate American industry now," says Guckel. "In the IC industry, what you can do today, as opposed to tomorrow, is very important." □



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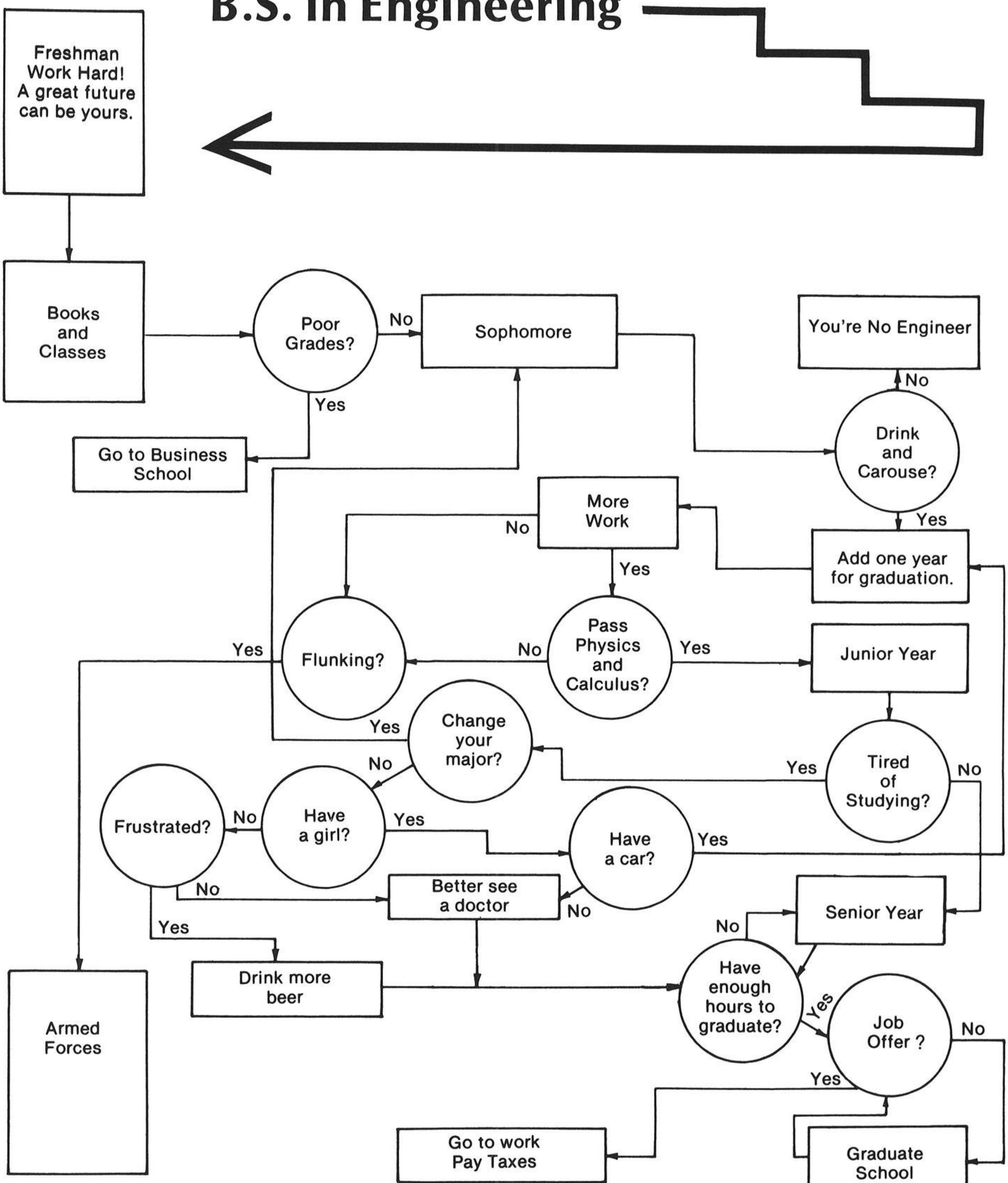
As electrons are accelerated around the Aladdin ring at near-light speeds, they produce a beam of radiant energy (shown here) that is rich in the soft X-rays needed for X-ray lithography.

Jeff's article was first published in the May 1987 issue of the **Research Sampler**, *of the UW-Madison Grad School.*

B.S. in Engineering



—Reprint from USC Engineer

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A Social Fraternity of Engineering and Science Students

Welcome to the University of Wisconsin-Madison! You've made an excellent decision as to where you'll be spending the next few years. The UW has much to offer its students, but it can be difficult to discover and enjoy all of these opportunities. It can be quite an impersonal place, especially when you're one in 45,000. There is a good way to get involved -- by joining an organization that is involved. TRIANGLE FRATERNITY is one such organization.

TRIANGLE FRATERNITY is located at 148 and 144 North Breese Terrace, across from the engineering campus and Camp Randall football stadium. We are a social fraternity of men interested in engineering and related majors, dedicated to our brotherhood, and making the most of our years here at the University of Wisconsin- Madison **both**academically and socially.

TRIANGLE FRATERNITY was founded on the Madison campus in 1913, making it one of the older fraternities in Madison. TRIANGLE has been involved in many activities in its years on campus, including the bi-yearly Engineering Exposition and, more recently, "Greek Week." TRIANGLE members live in two houses on Breese Terrace: 148, the oldest stone building on the street, and 144, the newly acquired house next door, giving us a total capacity for 31 in-house members. Living at TRIANGLE has many advantages, including a full kitchen and meal plan, an Apple computer system, an extensive exam file, and the opportunity to live with people having similar interests.

Technical majors are difficult enough when you're one in 45,000. By joining an organization that's involved, you can make the best of your years here in Madison both academically and socially.

Sincerely,
TRIANGLE FRATERNITY
Pieter Kreunen
Rush Chairman

FALL RUSH EVENTS

Freshman Registration Help	Thursday, Aug. 28	All Day
Rush Party	Friday, Sept. 11	9:00 p.m.
Rush Dinner	Wednesday, Sept. 16	5:00 p.m.
Rush Party	Friday, Sept. 25	9:00 p.m.