Rose-Hulman Institute of Technology
**Rose-Hulman Scholar**

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Fall 11-1967

# Volume 77 - Issue 9 - November, 1967

Rose Technic Staff
*Rose-Hulman Institute of Technology*

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# Rose Technic

November 1967

# Jobs that just might change the world

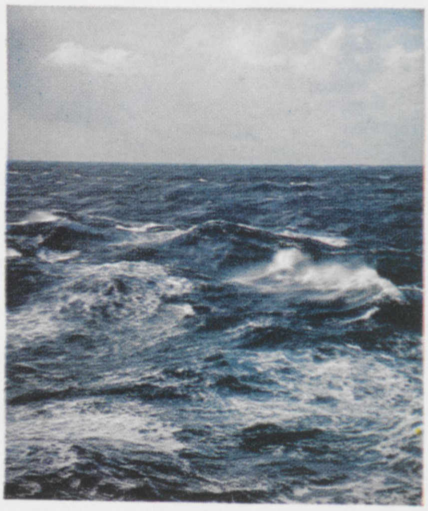
## Move people
through rush hours at 80 mph. Westinghouse built the experimental transit expressway in Pittsburgh. And we are building the computerized controls for the San Francisco mass-transit system that will be the model for others throughout America. We're looking for people to help us build equipment that will move people as they've never been moved before.

**These graduates needed:** Engineering, Physical Sciences, Social Sciences, Engineering Administration, Industrial Technology, Business & Liberal Arts.

## Tap the atom
with the company that started it all. Westinghouse supplies some of the largest nuclear generating plants in the world. We are building nuclear rocket engines. Our reactors power nuclear submarines. But this is only the start. We need people for some of the most fascinating projects we've ever attempted.

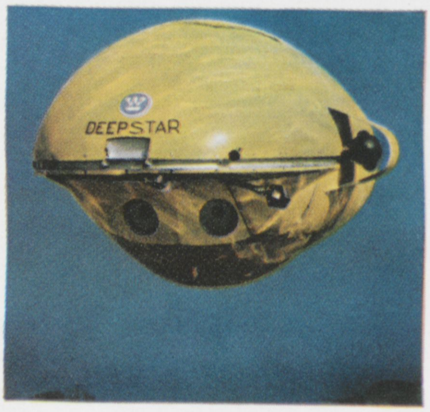
**These graduates needed:** Electrical Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Engineering Mechanics, Marine Engineering, Structural Engineering, Ceramics, Nuclear Engineering, Materials Science, Physical Sciences.

## Desalt the world's oceans
Westinghouse has 73 water-desalting units operating or on order around the world. Now we need people to help us design and build facilities that can desalt 150 million gallons a day—and solve some of the toughest water-supply problems we've ever tackled.



**These graduates needed:** Electrical Engineering, Chemical Engineering, Materials Science, Physical Sciences, Industrial Engineering, Engineering Mechanics, Mechanical Engineering, Civil Engineering.

## Take a dive
and explore the ocean 20,000 feet down. Westinghouse is developing a fleet of self-propelled undersea vehicles. In them we will dive deep, explore, salvage and probably discover more than any other single company in oceanography. We need adventurers to join the quest that has already taken us all over the world.




**These graduates needed:** Electrical Engineering, Mechanical Engineering, Chemical Engineering, Materials Science, Marine Engineering, Ocean Engineering & Science.

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Westinghouse has just purchased an embryo city. We're looking for people to help us rebuild many of the existing cities in America. We can do it—Westinghouse now provides more products, systems and services for construction than any other single company.

**These graduates needed:** Engineering, Physical Sciences, Social Sciences, Engineering Administration, Industrial Technology, Business & Liberal Arts.

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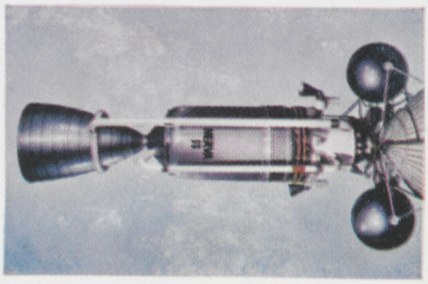
We are building the nuclear engine for voyages into deep space—to Mars and Venus and beyond. The jobs are exotic. We need more people to help us now.



**These graduates needed:** Electrical Engineering, Mechanical Engineering, Chemical Engineering, Materials Science, Nuclear Engineering, Aerospace Engineering, Physical Sciences.

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# How Union Carbide started a boom in Minnesota.

70 years ago, Minnesota's Mesabi Range was like a loaf of raisin bread. The raisins were pockets of rich, soft iron ore. The bread was a hard, low-grade iron ore, called taconite. It was a big loaf, about 110 miles long, three miles wide and 500 feet deep. So for fifty years, nobody bothered with the bread. They just dug out the raisins.

But 20 years ago, the raisins started to run out. And the miners were in trouble. Taconite is about 30 percent iron, so there was still enough iron in the loaf to last America's steel industry for at least 200 years. But you had to drill it and blast it—and taconite is harder than most steels, which made drilling almost impossible.

So Union Carbide invented the jet-piercer. Instead of a drill, it has a 4,000-degree flame. It heats the rock so fast it cracks away in small pieces that are blown clear. With a jet-piercer, you can make holes in taconite at up to 50 feet an hour. Then you can blast. And you've got a whole new industry on your hands.

Breaking down tough problems is Union Carbide's business. And there isn't much that we don't get into.

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## IN THIS ISSUE

Comets have always fascinated mankind. This month's cover story explains and examines comets.

Also in this issue read a prize winning article on tensor calculus on page 22. This paper tied for first place in the spring Pi Mu Epsilon Mathematics Paper competition.

The feature staff has come up with two articles which should be interesting to Rose men. The first, on page 6, examines Operation Catapult. The second concerns the convocation program and appears on page 8.

## COVER NOTE

This month's cover is a representation of the three wise men on their way to Bethlehem, following what, one modern theory contends, was a comet, rather than a star. Art work is by junior, Jim Coles.

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*November 1967*

# Rose Technic



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ROSE POLYTECHNIC
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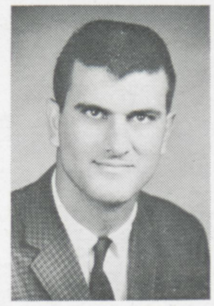
GUEST EDITORIAL:

# Studying Engineering Is Fine But There Are Other Things To Do, Too

By DR. HAROLD SABBAGH



Dr. Harold Sabbagh is an Assistant Professor in the Electrical Engineering Department. He received his B.S., M.S., and PhD. from Purdue where he graduated in 1964. Among his many activities Dr. Sabbagh is advisor to the IEEE branch at Rose and Triangle Fraternity.

Being an engineering student is about as full-time an occupation as a young person can undertake, short of soldiering. Still, there is some free time available, and the wise student is one who uses it well, wisely. We would encourage the student to diversify his activities so that he will not become stale doing the same thing (such as studying) all day.

Two types of activity come readily to mind: physical and intellectual. Each is important to a student, and, indeed, to non-students, as well. This writer has discovered that if he doesn't unwind by participating in some physical activity he becomes tense and unable to work effectively.

Fortunately, at Rose we have an excellent intramural sports program which offers students and faculty the opportunity to participate in physical competition. This raises another point—team competition. Certainly each student is individually in competition with his colleagues (regrettable as this may be). But what we have in mind is the value of belonging to a team and contributing to its success. Surely, this is one of the pleasant instincts we have retained from primeval days when man competed in order to survive.

Naturally, the non-athlete will look for other forms of team competition, such as debating, the glee club, a drama troupe, etc. These latter forms are "competitive" in the sense that a singer or actor strives to overcome errors ("opponent") in order to achieve a satisfactory performance ("victory").

In addition to active participation we would encourage the student to attend activities in which other people perform. Attend the convos, plays, concerts, football games, and the like. Do something! There's an education to be gained, a spirit of comradery to be achieved; there are lots of benefits to be had. But comrades and benefits are sometimes to be found outside of books.

## A NEW EXPERIMENT IN LEARNING:

# CATAPULT

by DICK SHALLCROSS
Soph. M.E.

In the August of 1962, Rose offered it's first pre-freshman summer institute program. Its success, coupled with the success of pre-senior programs across the country, led to Operation Catapult.

Plans for Catapult were begun in February of 1967. For the two previous summers Dean Moench had participated in the "Jesse" program at DePauw. and Prof. Headdy was familiar with the pre-senior Summer Science Seminar at Indiana University. It was their feeling that Rose could also offer a worthwhile and stimulating program aimed at students interested in science and engineering careers whether or not they were interested in attending Rose for their undergraduate studies.

After studying some of the other pre-senior classes in order to find their shortcomings, it was decided that a laboratory or project-centered program was the best. In March, a dinner attended by a number of high school science and mathematics teachers, was held in the Hulman Union for the purpose of seeking their advice on how Catapult might best help the high school student. Their opinion also favored a project and research orientation which would give the student some laboratory experience as well as exposure to equipment not available in most high schools.

The specific objectives set up for the 1st Operation Catapult were fourfold. First each student was to gain training and experience in the "scientific method". This was to be done through work on 18 different projects. such as weighing the earth, verification of the earth's average density by use of artificial satellites, and interpretation of lissajous figures on the screen of the oscilloscope. Through these various studies it was hoped that the student would formulate his own theories.

The second goal was to provide some experience in communication skills. This was to be accomplished by instructing the student in the use of charts, graphs and tables, as well as exposing him to written and oral presentations of technical material.

The third objective was to provide at least a glimpse of areas of study outside the field of engineering and physical science, such at art, Meteorology, bio-engineerisg, astronomy and city planning. This was done so that the student might see why anyone is interested in such fields and possibly have his own curiosity aroused.

The fourth objective, as a result of the first three, was to provide a motivation for serious studying during the student's senior year, and to instill a growing desire in the student to enter the science and engineering field.

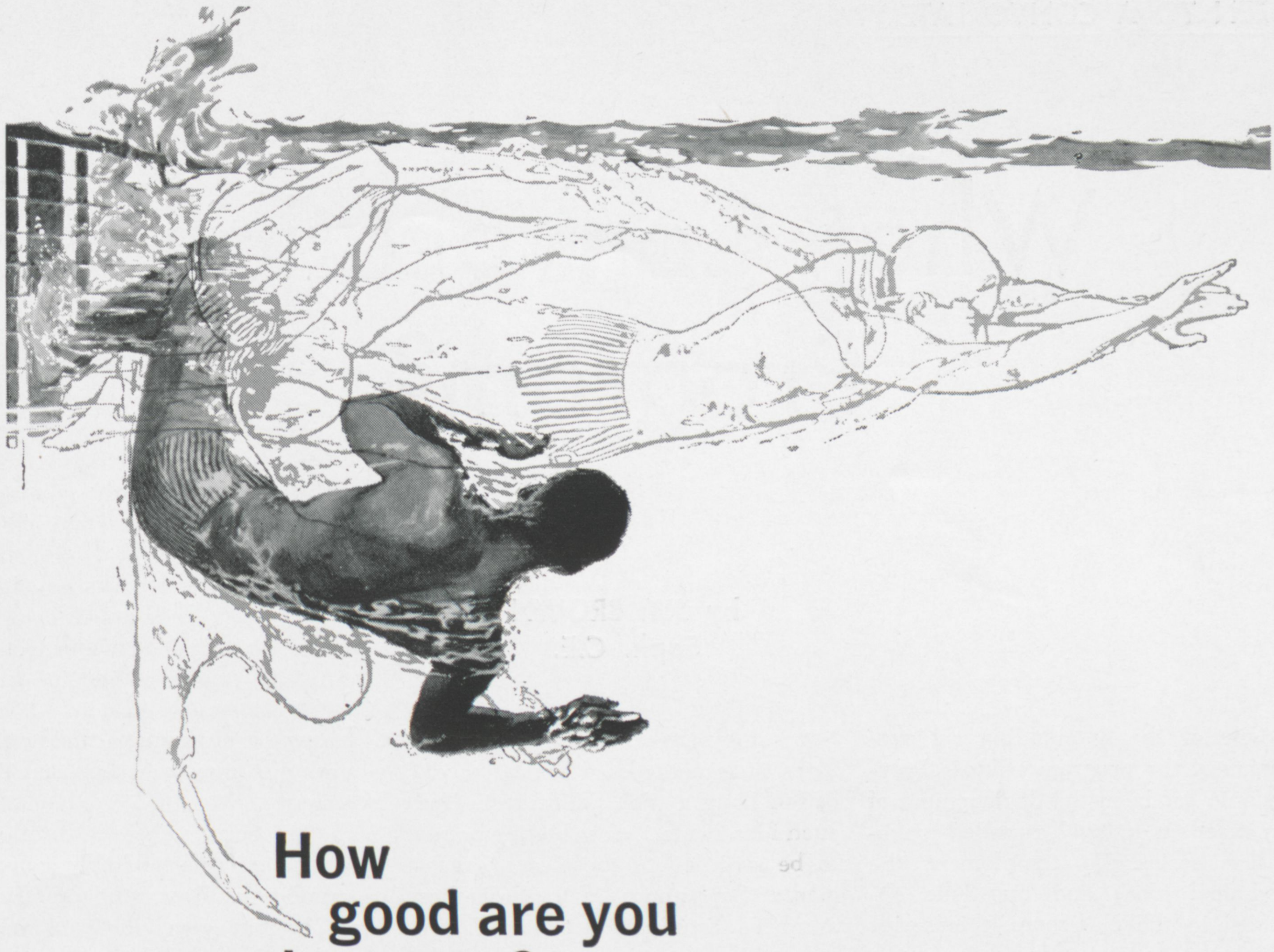
Various high schools were contacted around April 1 and notified that Rose was planning a summer program to run from July 9 through August 5, 1967. Originally, the program was planned for forty students, but favorable response pushed the enrollment up to 67. Admission was not restricted to only the "gifted" students. Rather, it was hoped Ctapult would attract a cross-section of students which might be more nearly typical of the Rose student body. Criteria for admission were three units of mathematics, three units of English, one unit of physical science, one unit of social science, and one unit of foreign language. Since the applications received were, in mos cases, for 5 semesters of work, i was necessary to rely heavily on th recommendations of mathematics an science teachers and the counselor

The scheduled academic part c the program consisted of 108 hour which included 60 hours devoted t group projects, 9 hours to compute instruction and 13 hours to lecture The projects were to involve funda mental principles without Calculu or higher mathematics and withou a pre-requisite of physics. Thes projects were planned to avoid th typical "Science Fair" spectacula type of display, but rather to con centrate instead on projects an equipment which could be unde stood by all of the students in th group. The format called for 52½ hours for working on the projec 1½ hours for 5 minute oral progre reports (by group) on the thir Monday, and six hours of 20 minut oral group reports on the differer projects.

The computer instruction wa handled by Mr. William D. Schinde a Rose Math Major of the class c '69. Mr. Schindel prepared a set c mimeographed notes for the studen entitled *Introduction to Compute and Programing*. The emphasis i this class was first on the nature c a computer and machine languag Students were also instructed in th use of the key punch, line printe mark sense unit, and sorter. Onc the students were familiar enoug with the Fortran language an Rose's IBM 1130, they were e couraged to write programs.

The lectures were designed t give the student insight into u familiar areas of study and wor

(*Continued on Page* 27)



# How good are you on the turns?

A strong stroke isn't enough to win in freestyle swimming. Experts say: "Watch the turns."

"A champion won't touch with his hand," they tell us. "He begins his overhead tumble with a downward stab of his right arm, twists as his feet hit, then explodes forward with a powerful pushoff."

Their conclusion: "Experience and smart coaching develop a championship turn."

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# What Convocation Program?

by JIM BROWN
Soph. C.E.

One of the outstanding achievements of the program at Rose Polytechnic has been the development of an excellent and well-rounded convocation series. To complement the technical ideas and questions obtained in the classroom, this series is almost entirely devoted to the humanities and social sciences. Classical music. artistic displays and lectures, discussions of American ideals, and a myriad of other topics all contribute to an educational experience that cannot be found in the laboratory. It is this type of experience that will be of great value in facing the realities of life, and it is this type of experience that results in a better adjustment to society and self. It is a terrible tragedy that the students of Rose do not support the program to the fullest extent. Attendance at the majority of the convocations is almost to the point of embarrassment: embarrassment for members of the convocation committee who invited the speaker and embarassment for the guest speaker who is speaking to an unfilled auditorium.

Why? Each year the faculty examines the convocation programs, suggests changes and improvements, and attempts to promote greater student interest. With good intentions, they have developed many ideas and methods to make convocation hour a time of interest. One such idea made it possible for points to be awarded to the class (Freshman or Sophomore) with the higher number of students attending. However, this plan was met with little enthusiasm although it still remains in effect. Recently, the faculty proposed to obtain its guest lecturers from relatively distant areas, hoping that a change in manner and personality would cause some enthusiasm. This idea has been put into effect but its consequences are yet to be seen.

The convocation committee has done much to strengthen the program at Rose. It has been noted that in many colleges and universities convocations have been a requirement, and attendance has been mandatory. However, the committee feels this is not the method that should be employed. The convocation program is meant to be a supplement for the student, and the Rose student should be allowed to have a free choice in deciding which lecture interests him. Thus, the program becomes apparent: it is up to the student, to decide whether convocation should be attended, but it is the responsibility of the faculty to present a program to the student whereby he may gain non-technical experience.

The reasons for absence from convocations are very probably as many in number as Rose students. However, certain psychological factors contribute extensively to these absences. Apathy and laziness are certainly two key factors; a student just does not care about working an extra hour by listening to another lecture. Free time, nevertheless, is most probably the greatest reason. Convocation hours mean just two hours to escape from the pressures of the classroom, to write letters. leisurely studying, or a short nap. Most people usually end up in the congested area of the main hall.

For an outsider, convocation gives a bad image, but it is not because Rose students are irresponsible or that they believe convocations to be unimportant. Most students realize the knowledge that can be gained, but they just don't possess enough inertia to keep them going through the convocation. If, the Rose man can just realize more fully the new dimension that convocations supply, if he can just *make* the time to attend, then convocations can continue as an integral part of the Rose tradition.

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Depends on the giant. Actually, some giants are just regular kinds of guys. Except bigger.

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Complete testing facilities to prove out better ideas.

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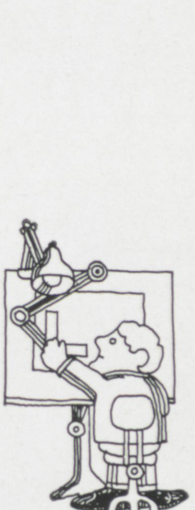

EDITORIAL

## Ask Anybody, He Will Tell You

What advice Just ask, someone will tell you what to do. Why not? The advisee does not have any more involved than the time. After all in seeking this advice, isn't one just gathering opinion to buffer one's personal choice?

If one needs help in making a worthy decision, he seeks the facts that bear on the situation not opinions. Opinions are not binding and motivating. Far more accomplishments are the result of doing rather than telling.

Separating the chaff from the wheat or fact from fiction may become a more significant task than making the decision. In developing this necessary skill, what better background is there than problem solving. Isn't problem solving in the classroom, really impartial experience in decision making?

Even after deducing the essence of the problem, the solution may not be obvious. What may be right for one person is probably wrong for another. Therefore the best decision is a personal choice based on one's own principles.

Regardless how one arrives at the decision, he has to bear the blame or reap the harvest of that choice. Friends may encourage him, but he must withstand the trials of decision alone.

*F M N*

## Dissatisfied?

It is truly obvious when a person is unhappy. Bu
how many of us really stop to realize how often w
could be happy? It seems that many students becom
preoccupied with being unhappy rather than realizin
how fortunate they are to be obtaining the educatio
and job opportunity they themselves decided upon. I
a student is dissatisfied with his curriculum, then h
has only himself to blame! He decided upon it!

If engineering is your desired vocation, preoccup
yourself with satisfaction that college is your oppor
tunity to learn to think and become acquainted wit
ideas. Appreciate the courses that expose you to idea
and professors who can make you think and even com
up with your own ideas.

If you're going to be an engineer, why not be th
best your abilities will enable you to?

Its easy if you develop a good attitude. Comm
yourself to doing your best and you will be able t
enjoy learning and thinking in college. Then you wi
also be in the habit of doing a good job when yo
graduate and will naturally top your competition jus
as you did in college.

*D E N*

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COVER STORY

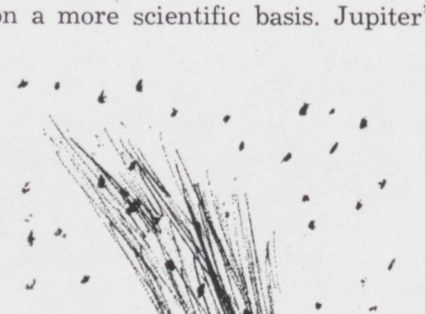
# Analysis of

By Mike

In ancient and medieval times, comets were regarded with superstitious dread. They were thought to be forewarnings of war, pestilence of famine. Attempts were made to incorporate these heavenly bodies into the general picture of the star filled sky. Most of the mystery consisted in their general appearance. Comets are not spherical, well-defined objects of light, but diffuse regions of light, having no distinct boundaries. Also, they show at times, a distinct tail of varying brightness. At these early times, the motions of the comet in the sky remained a mystery, and they were definitely unpredictable. They appeared as bright objects in the sky for a short time, then disappeared.

With the discovery of the law of gravitation by Newton, it was made possible to accurately determine the orbits of some of these comets. It was discovered that comets moved around the sun in paths having forms of conic sections. Methods were developed for calculation of orbits, especially by Halley (1656-1742) and Olbers (1758-1840). With the contribution of these ideas, a whole new approach to the study of comets was available, that of celestial mechanics.

Celestial mechanics flourished in the nineteenth century and it provided a means for studying comets on a more scientific basis. Jupiter's



"family of comets" was discovered, among other things. Bessel and Bredichin developed theories on the formation of comets tails. The brightness of comets and comparison of magnitudes was studied. Subsequent developments have shown that comets are examples of cosmic space; a vast physical experiment occuring before our very eyes and useful for examination.

The return of Halley's comet in 1910 and the appearance of other comets in later years have afforded us with a chance to apply modern experimental techniques to the study of comets. Cometary research has been greatly enhanced by this opportunity.

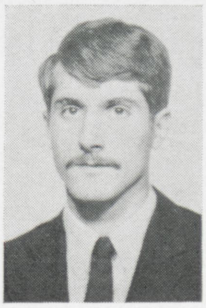
*Origin and Formation of Comets*

The proposed process of formation of comets is that of accretion of interstellar dust through the gravitational action of the sun during its journey through galactic clouds.

The presence of an obscuringmatter in space was first recognized by the scientist Barnard and that it exists in the form of fine dust particles was established by Slipher. Many other observations have confirmed this fact. The occurrence of dark patches in space, gives evidence of a highly obscuring material. The more finely divided a material is the more area it can screen, so long as the finely divided particles do not fall below the wavelength of the light in size. An example of this is

# A Comet

Hanley



Mike Hanley is a senior Physics major from Louisville, Kentucky. He is a member of Tau Beta Pi, Pi Mu Epsilon, Sigma Pi Epsilon, and past scholarship chairman of Theta Xi fraternity.

smog, where these finely divided particles can practically cut off sunlight totally.

There is also the well-established effect of reddening of the light of distant bright stars brought about by selective absorption which indicate the presence of a dust. This fact also permits an estimate of density distribution.

Now that we have established the existence of interstellar dust, it is generally believed that the dust originated from explosions of supernovae, during which process huge chunks of material, probably heavy elements, were ejected into the surrounding regions and later condensed into small, solid particles.

The distribution of the dust is irregular, but it is concentrated into clouds of complex form. No definite size can be assigned to these clouds, but the dimensions in some instances may be many parsecs.

When collision occurs, some of the kinetic energy of motion will be transformed into heat, and some disruption of particles may occur, and the conversion of material into liquid or gas. Now consider two particles which collide at the axis. They will both have the same radial component of velocity along the accretion axis, and their transverse components perpendicular to the axis, will be equal and opposite. These transverse components give the relative velocity of collision. Thus the gravitational action of the sun changes the relative velocity of the particles from near zero at large distances from the star, to large values near the star, and then gradually diminish with increasing distance along the axis.

If the two particles were of the same mass, and since the collision would result in a loss of kinetic energy due to the relative motion, and the resultant velocity would just be the formen common radial component away from the sun along the axis.

The actual process, instead of two particles colliding from exactly opposite direction, will involve a large number from all directions colliding more or less uniformly around the axis. It can be shown that the radial components will all be the same and equal to the original speed of approach of the cloud. Thus, the effect of the collisions will be just as if the particles were converging from all directions at right angles to the axis.

At first smaller particles will collide more likely, because of the large cross-sectional area; but after such a stream of particles has begun to form, further collision probability is greatly increased.

Those particles which collide at great enough distances from the sun, will have a radial velocity after collision, that is great enough to exceed the escape velocity from the sun at that distance. These particles then will move away from the sun and and eventually escape altogether. Oppositely, those particles that collide sufficiently close to the sun, the resultant radial velocity will be less than the escape velocity, and eventually will be drawn back by the sun's attraction. What actually happens is that the stream at the axis builds up to a certain density, and the velocity in this stream is always toward the sun out to a certain distance, called the neutral point, and always away from the sun beyond this distance.

*General Data*

Comets discovered in any one year are designated by letters, a, b,

(*Continued on Page* 18)

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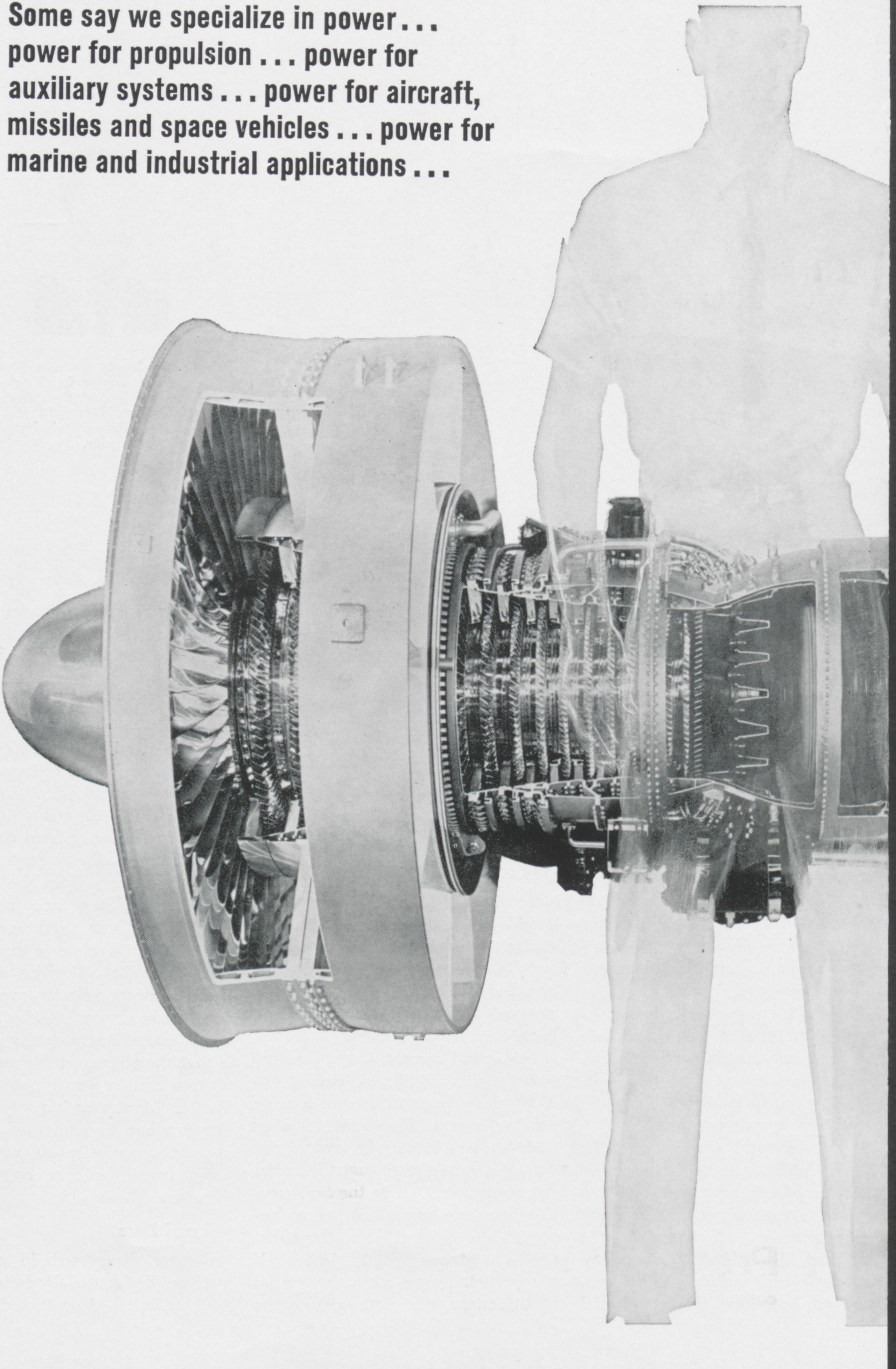

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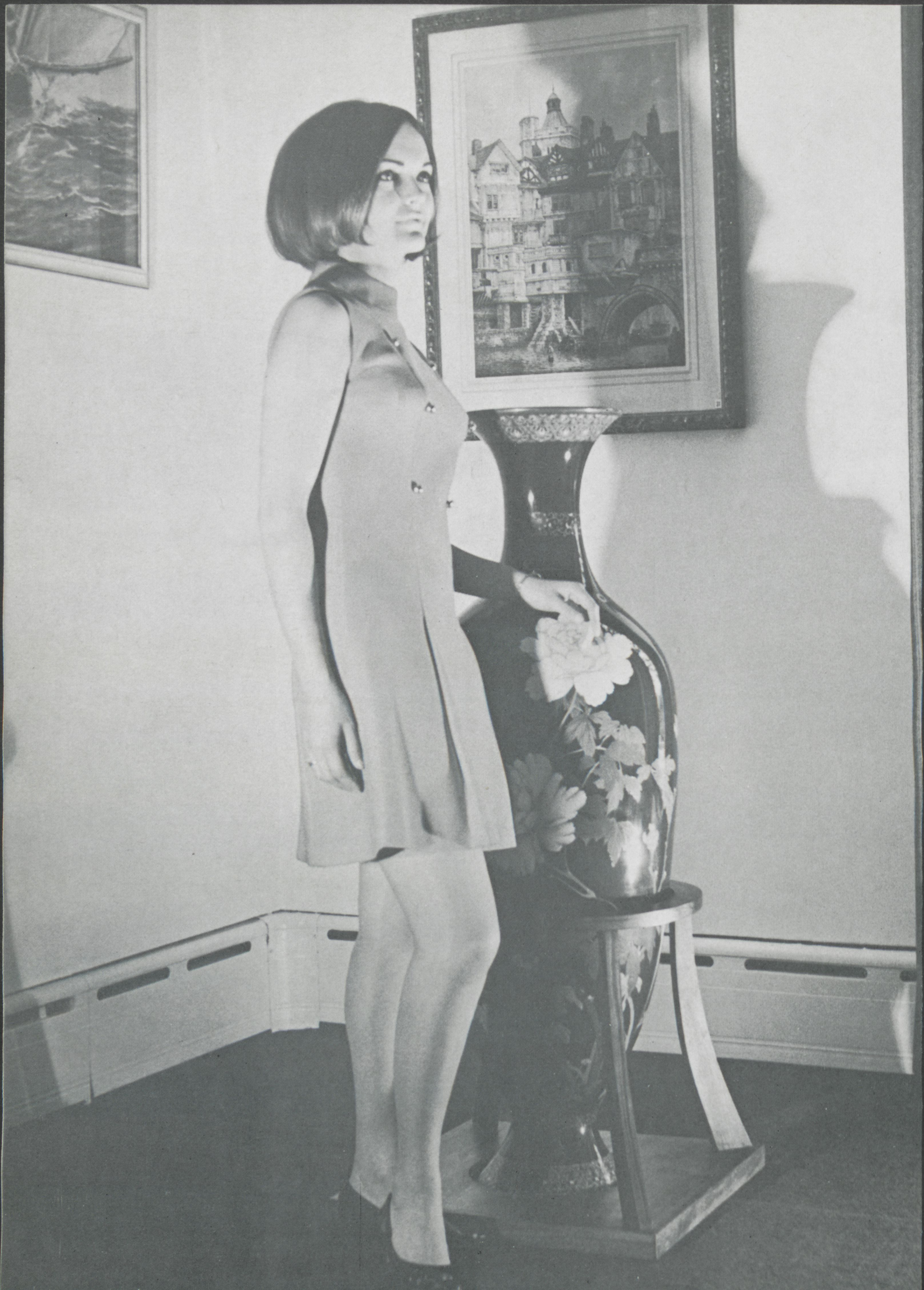

# MARIA HUNSICKER

# November Miss Technic

Miss Technic for November is Maria Hunsicker. Maria is a freshman at Indiana State University, where she is a pre-law major. Maria is from Cloverdale, Indiana. Her extra-curricular interests include modeling and swimming. Maria is a 5′ 4″ brunette with green eyes.

## COMET

(*Continued from Page* 13)

c, etc., in their order of the discovery, together with the year number and the name of the discoverer, unless some particular person has done some significant work on calculations of orbit or some other aspect. The comet discovered by Morehouse in September, 1908, was first known as "Comet 1908d Morehouse", as it was the fourth comet discovered that year. If there are two independent discoverers, both names are used. The permanent designation used is the year followed by a Roman numeral of the time of perihelion passage. Thus, Comet 1908d became "Comet 1908III Morehouse", since it was the third comet to pass perihelion in that year, although fourth in the order of discovery.

The greatest amount discovered in any one year was 14, in 1947. On the average, five comets have passed perihelion each year, counting old and new ones. Approximately one thousand comets are known.

Comets are the largest animals of the solar system. The diameter of the head, which consists of the coma, and nucleus varies from 29,000 kilometers to 1,840,000 kilometers in the comet of 1911. As the comet approaches the sun, the coma at first expands, but near perihelion it becomes smaller again.

The nucleus, the bright point in the center of the coma, is relatively small and varies greatly in size from one kilometer to one hundred kilometers. Sometimes the nucleus is not visible and other comets have multiple nuclei.

The tail is the longest part of the comet. Lengths range from zero to $1.5x10^{11}$ kilometers. In large comets the tail begins to form when the comet is about twice our distance from the sun. At or after perihelion passage the tail achieves its maximum length. Rapid development of the tail is often accompanied by signs of great activity within the head of the comet.

The orbits of comets were originally thought by Kepler to be straight lines and wander through space from star to star. After Newton's law of gravitation was developed orbits were able to be calculated. So, if the attractive forces of the planets are ignored in comparison with the great gravitational effect of the sun, the path of comets must have the form of a conic section, namely ellipses, parabolas, and hyperbolas.

When allowance is made for the presence of planets, the paths are highly three-dimensional curves, because the system of forces will now contain additional contributions. At any instant, a so called osculating orbit can be defined and are close

approximations to the actual path. Eventually though they gradually change and represent the real path for only a limited time.

The reason for the difficulty in determining the orbit of a comet lies in the great eccentricity. Most comets are not discovered until they are near both the sun and the earth, and after they pass perihelion, they usually are difficult to follow much beyond the earth's orbit. The small potrion of their total path which lies in the earth's orbit may be very much alike for a long ellipse, parabola, or hyperbola, and therefore exact observations are necessary for determination of the orbits.

Despite their overall dimensions and volumes, the masses of comets are quite small by other astronomical standards, and it is assertedthat even the very largest comets can not have masses comparable with a moderate sized asteroid. The masses themselves have not been determined dirctly, since the only criteria for being able to be determined is for them to undergo some kind of gravitational encounter with another body of comparable mass. Since there are no such bodies in the solar system, the evidence of extremely small mass is shown by the absence of perturbing effects by the comets, for instance, on planets. To cite an example, in the year 1770, Lexell's comet passed very close to the Earth and some change in the Earth's orbital period might have been expected; but no such observance was detectable which established that the mass of the comet would not have been even one ten-thousandth of the Earth's mass.

*Spectroscopic Data*

The spectra of comets are very complex. They give both a continuous spectrum and an emission of bands and lines. The continuous spectrum is believed to come from reflection of sunlight from the nucleus or from dust in the near area. The proportion of such reflected light appears to be greatest in the nucleus and least in the tail. Another part of the continuous spectrum is due to the intrinsic light of the comet, but is not as great as the reflected sunlight. However, comets with very faint nuclei, like Enke's comet, may at times fail to show any continuous spectrum.

At certain wavelengths, the spectrum appears as numerous bright bands due to molecules. Identifications of several bands have been made and reveal that this emission is due to compounds of carbon, hydrogen, nitrogen, and oxygen, and the presence of such molecules as CH, $CH^1$, $CH_2$, CN, $C_2$, NH, $NH_2$, OH, and $OH^+$, has been established. Also in the tails, $N_2$, $CO^+$, $CO_2$ have

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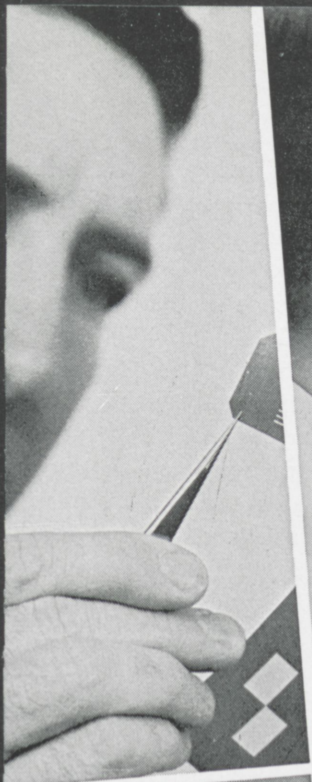

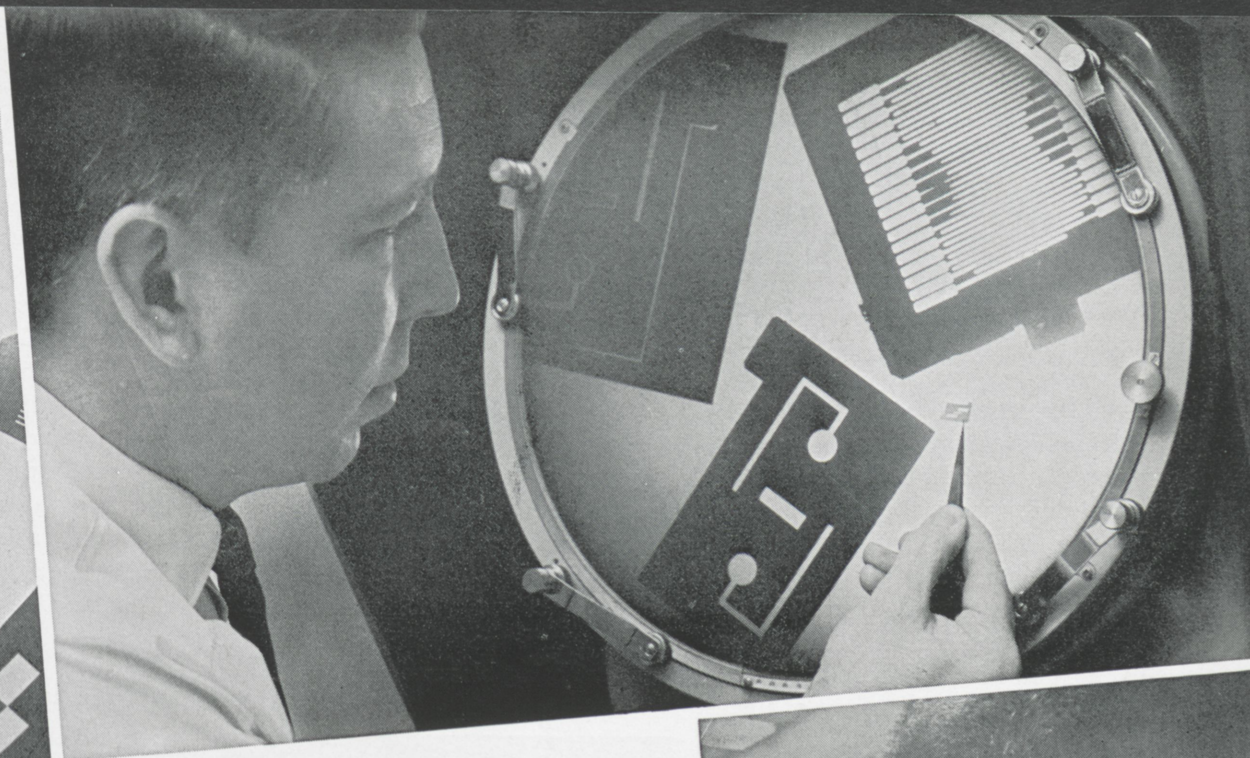


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## COMET

(*Continued from Page* 18)

been observed. Comets near the sun have also shown sodium lines, and there have been claims for the presence of magnesium, iron, and nickel.

The spectrum of comets varies with heliocentric distance, and in general, the bright bands are much more intense when the comet is near the sun. Metallic lines are visible only near the time of perihelion. This variation may be caused by the variation in the discharge of electrified particles from the sun as well as the variation in the amount of ultraviolet light given off by the sun. Very distant comets show only CN in their spectrum at a distance of approxximately 3 Au. . As they come closer, $C_3$,$NH_3$, appear, and inside 1.5 AU, CH, OH, NH, $CO^+$, $N_2$, $NH^+$ appear.

Comets have such peculiar spectra, that it is doubtful whether all the phenomena observed can be included in one simple theory. This field has been somewhat neglected, despite the interesting and important problems awaiting solution. Much more data is needed before any really definite conclusion can be made about the theory of spectra.

*The Nucleus*

The nucleus is the bright point of light in the coma. Some comets have no nucleus at all, while others have multiple nuclei, although these conditions are rare. It often has the appearance of a star-like point of light condensed within the coma, not necessarily in the center. The nucleus is usually displaced to the sunward side of the coma. In some comets this is very obvious, but in others it appears at no more than a general tendency of increase of brightness at some part of the coma. The nucleus affords a convenient point to center on in measuring the position of a comet for the purpose of computing its orbit. The nucleus often can only be seen when the comet is near the sun. It may well be that the nucleus is no more than an apparent phenomenon, possibly some kind of changing contraction of small particles. One model of the nucleus is the sand bank model, where the nucleus is thought to be a swarm of solid particles, separated from each other by about a meter, and each weighing a few milligrams. This concentration of particles can account for the spectra of reflected and scattered sunlight that is observed. However, with this model, it is very hard to account for the observed gases in the coma from solid bodies. Also, it is wondered whether this collection of particles would be able to withstand the nearness of the sun without being blown apart. For these

reasons the model is not generally accepted.

The other model of the nucleus that is proposed is the so-called icy conglomerate model, suggested by Whipple. He imagines the nucleus to consist of a conglomerate of meteoritic materials with "ices" consisting of gases such as $H_2A$, $NH_3$, $CH^+$, $CO_2$, $C_2$, $N_2$, solidified under the lower temperatures of interplanetary space. The structure has some tensile strength, and the ices are generally poor conductors of heat. Solar radiation will vaporize some of the gases, leaving an outer matrix of poorly conducting material. The ices mentioned here are a better source of the gases than are the dust particles.

There is also a cloud of particles in the immediate vicinity of the nucleus, from which the continuous spectrum arises. As the solar radiation heats up the surface layer and the molecules sublime, a surface dust structure remains. This process of heating, sublimation, and escape is a rather complicated one.

This model, with its structural strength, will be able to stand some perturbing forces. Eventually though, all the ice sublimes and there is left just dust spread along the comet's orbit, by which the meteor stream is formed.

The solar radiation heats the side of the comet facing the sun. If the nucleus is rotating there is a considerable time lag due to transferring heat to the interior. This constitutes a force on the comet and causes an increase in the velocity of the comet. This in turn will cause an increase in the semi-major axis of the ellipse. This hypothesis is used to explain the acceleration in the motion of Comet Enke.

*The Coma*

The coma is the principal part of practically all comets and has the appearance of a faintly luminous cloud with an angular size sometimes of several minutes of arc. Its shape is roughly spherical ( but fan-shaped comas are reported, although they are far from regular. One of the most striking properties of the coma is that it always contracts as the comet approaches perihelion. It appears to be a more or less continuous haze of light, though its intensity may vary considerably. The coma and nucleus together are referred to as the head of a comet.

The coma consists of molecules which have sublimated and evaporated from the dust layer on the nucleus. The molecules evaporate and then by the ultraviolet radiation from the sun they are photodissociated into simpler particles. This implies that comas are a gaseous phenomenon, but dust comas have been found. Sometimes these are characteristic of new comets which have recently been observable.

*The Tail*

Finally, but not the least in importance, is the tail, from which the name given to comets derives. For the most part the tail of a comet is pointed away from the sun so that on approaching this body, the tail follows the nucleus, while on receding from the sun the tail precedes the nucleus. Occasionally, a comet may have more than one tail and the extra tails may make a considerable angle with the line pointing away from the sun. The general rule is that at different parts of the orbits, the tail is always streaming away in practically the opposite direction to that of the sun, so that while the tail lies in the orbital plane, the angle between the general direction of the tail and the direction of orbital motion of the comet varies considerably.

Basically, there are two types of tails. Type I consists of ionized particles such as $CO^2$, the principal particle, and $C_2+$, $CH+$ and $CN+$. The tails are straight, and make an angle of a few degrees with the radius vector in the direction opposite to that of the comet. Type II tails are strongly curved, homogeneous, and do not possess a fine structure. Observing the spectra from these tails, one finds that it is mostly reflected sunlight which strongly suggests dust particles. The sizes of the dust particles are approximately ½ micron.

Type II tails are essentially flat structures and confined rather closely to the plane of the orbit. Type I tails are very complex and poorly understood. They have fine structure. The matter in these tails is concentrated into streamers which make up the tail ray, which appear to be ejected from the nucleus in the sunward direction. The tails ions, which are mostly $CO+$, exist in tubes which extend up to the nucleus. Ionization of CO is probably due to a charge exchange with a hydrogen ion.

Light pressure effects on the tail vary with the area of the particles involved while gravitational effects depend on the mass and vary as the volume. As particles get progressively smaller, the sun's light pressure decreases less rapidly than its gravitational effect until, at certain values for the diameter, the light pressure greatly exceeds gravitation. Of course, if the particles are smaller than the wavelength of the light, involved, gravitation assumes control again.

Another factor is involved in the formation of tails. Whenever the tail shows structure and individual parts can be recognized in a series of photographs, the motion of these parts away from the head is not uniform and the velocity is often much greater than light pressure could produce. Therefore we must assume that other forces coming from the sun, possibly electromagnetic in character, play a part in tail forma-

(*Continued to Page* 25)

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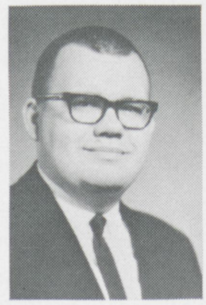
## PI MU EPSILON ESSAY

# An Historical Peek at Tensor Calculus

By DAVE GROVE



David Grove is a 1967 graduate from Rose where he obtained degrees in Math and Physics. He was active in Sigma Pi Sigma, Pi Mu Epsilon, MAAA and AIP while an undergraduate at Rose.

Harold Jeffreys in 1891 said, "The tensor method . . . has the great advantage that it is not a new notation, but a concise way of writing the ordinary notation . . . " Perhaps a good starting point from which to examine this notation would be with Gauss. In the early part of the nineteenth century, about 1820, the great mathematician Gauss turned his attention to geodesy and surface theory. His work in this area involved quantities called "quadratic" forms.

In his study of quadratic forms Gauss used curvilinear coordinates. The most common example of these coordinates would be

$$x=r \cos \theta, \; y=r \sin \theta$$

where r=constant and $\theta$=constant determine a system of curvilinear coordinates in the xy plane. Gauss proceeed in 1820 to express the linear element ds in a quadratic differential form, viz.

$$ds^2 = E\, du^2 = F\, dudv + G\, dv^2$$

He did not stop here, but went on to state his "theorema egregium" which said that the total surface curvature depended only on E. F and G and their derivatives. This made $ds^2$ an invariant for any particular surface. It was this theory of invariants coupled with the theory of differential geometry that was the starting point of the theory which was later to become known as the tensor theory.

Around 1854, Bernard Riemann published a paper on the foundations of geometry in which he applied intrinsic coordinates to n-dimensional manifolds. In another paper, he presented some work on the relativity theory of gravitation in which he introduced the now famous Riemann-Christoffel tensor. This work resulted in the preparation of two other papers: one by E. B. Christoffel in 1869, in which the Christoffel symbols were introuced and some work on transformation of quadratic forms was presented; and the other by R. Lipschitz, in 1870, which dealt with differential parameters and which greatly influenced the Italian mathematician Beltrami.

In order to trace the rest of this development we must move to Padua in Italy. In the early 1880's Gregorio Ricci Curbastro, a professar at the University of Padua, became interested in this work which was being done on the transformation theory of invariants. In 1888 he published a book, *Delle derivazione covariante e contravariante,* in which he presented a complete theory of invariant transformations.

It is interesting to note that the mathematics of general relativity was available one year after the Michelson-Morley experiment. Ricci's work (1887-1896) was primarily a new symbolism for this invariant theory. He was primarily interested in applying it to the transformation theory of partial differential equations. However, his work also fitted the transformation theory of quadratic differential forms. One of his students, Tullio Levi-Civita, became interested in this theory and together with other students of Ricci suggested the preparation of a general account of the whole subject. At this time Felix Klein invited Ricci and Levi-Civita to prepare an article on the general theory of th
absolute differential calculus whic
appeared in 1901 in Vol. 54 of *Math
Ann.* This paper was not read b
many at this time and so didn't at
tract much world-wide attentio
among mathematicians. Levi-Civit
later wrote a book entitled *The Ab
solute Differential Calculus* whic
is the classic text in the theory o
tensor calculus.

M. Grossmann of Zurich becam
interested in this subject, mastere
it and taught it to one of his stu
dents, Albert Einstein. When Ein
stein later became interested in ty
ing together Maxwell's electrody
namics and Newton's gravitationa
theory he realized the need of a ne
theory to unify the theory of th
universe. This resulted in his publi
cation in 1905 of the special theor
of relativity which is based on tw
postulates. Einstein realized h
needed some new kind of vecto
algebra which could express his dif
ferential equations of relativity i
a covariant form. He found what h
neeed in the theory of tensor alge
bra and later in his general theor
thhe tensor calculus. This new ca
culus was not taken seriously b
physicists and mathematicians unt
the predictions of the theory wer
experimentally verified.

In a rather naive historical wa
we could say that Tait's quaternion
were replaced by Gibb's vector a
alysis in an attempt to find a mor
practical applied algebra. After 191
with the advent of general relativit
several special branches of vecto
analysis were replaced by the tenso
calculus.



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# R&D: Laser Ray Gun

by ROBERT B. MONTGOMERY
Public Relations Representative
Model 747 Program

Laser is an acronum for light amplification by simulated emission of radiation.

Laser beams, like light beams, are versatile. They can be friend or foe. At various intensities the laser can cut diamonds and metal, may help locate points on the Earth, measure the shape of ocean surfaces, and "spotweld" retinas on the human eye.

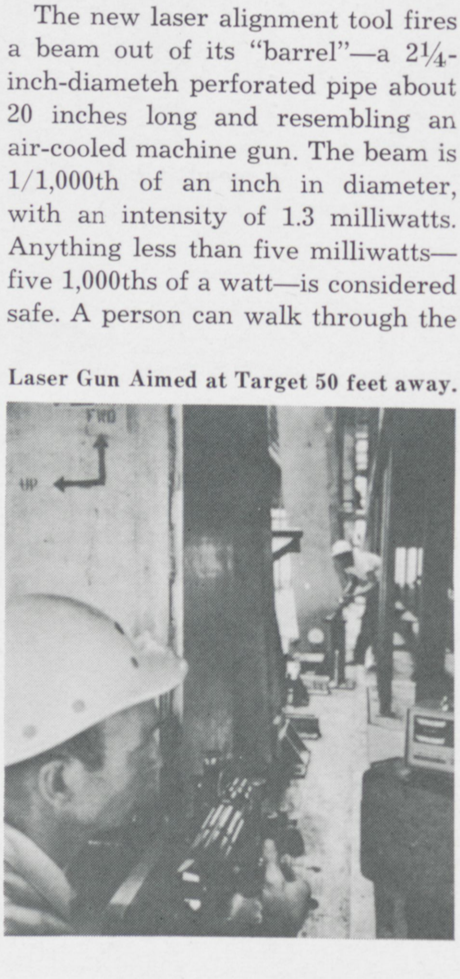
One new use of the laser at Boeing's Everett, Washington, plant, manufacturing site for the Model 747 jet transport, is extending the range of tool alignment. Tool fabricators use the laser to align precisely wing-panel jigs—huge holding fixtures on which the 747 superjet's wings are built.

Wing jigs and other permanent manufacturing fixtures must toe a straight line. Any deviation from the line more than 10/1,000ths of an inch will result in an imperfect airplane part. The conventional alignment depice—an optical tool—resembles the telescopic sight on a rifle. The operator, peering through a scope, lines up a small target in the center of the cross hairs. The target is u sually no more than 50 feet away.

Wing panel jigs for the Model 747 are 120 feet long and at such distances a man's eye is less efficient; optical tooling, less precise. The 747 jigs must be aligned to an accuracy of less than 10/1,000ths of an inch over the 120-foot length. It is doubtful that the optical tool can do it. The laser can.

The new laser alignment tool fires a beam out of its "barrel"—a 2¼-inch-diameteh perforated pipe about 20 inches long and resembling an air-cooled machine gun. The beam is 1/1,000th of an inch in diameter, with an intensity of 1.3 milliwatts. Anything less than five milliwatts—five 1,000ths of a watt—is considered safe. A person can walk through the beam with no sensation whatever.

**Laser Gun Aimed at Target 50 feet away.**




Use of the laser on the win-panel jigs involves aligning the "headers" —flat vertical steel supports 1½ inches thick, 20 inches wide and 11 to 20 feet high. There are 19 such supports along the length of the upper panel jig and 18 on the lower paney jig. All of them must be lined up in a precise military row.

Header alignment is determined by first placing a laser transmitter on the inboard end of the jig and lining up a small target at the outboard end 120 feet away. When the beam hits the target, the other headers are aligned along the same line-of-sight.

Over distances of 50 feet or more, laser alignment devices are about twice as accurate as conventional optical means. After the first 50 feet traditional methods allow a tolerance of about 1/1000th of an inch for every 10 feet of distance. Laser accuracy after the first 50 feet is 1/1000th of an inch for every 20 feet of distance.

When their work on the wing panel jig is completed, the laser crews will use their new equipment on spar tools and other long-distance alignments. They expect to be using the laser eqquipment at least until the end of the year.

## COMET

(*Continued from Page* 21)

tion and structure.

The orientations of comet tails are very important for the study of comets. It also supplies information relative to the study of interplanetary gas. Type I comet tails appear to be only influenced by the solar wind, that is, the solar wind determines the direction of orientation of the tail. The problem is purely geometrical and will not be discussed further.

Type II tails are much more dicficult to understand. Repulsive forces of a ttraction within the comet form the shapes and regulate the orientations of the tails. The strength of the hypathetical repulsive force is taken as being proportional to $r^{-2}$, and it is defined in such a way that the solar mass, which is unity, is r egarded as being replaced by a hypathetical mass $\mu$=1-R, where R is positive. The quantity R=1-$\mu$ then represents the repulsion of the sun and indicates by how much this exceeds the gravitational attraction. With certain assumptions it is now possible to calculate the amount of this repulsion, and direction of motion of a partical. The relevant equations have been formulated by Bessel and Kopff extended them later.

Much more reliable results on this subject can be obtained it is it possible to establish directly the orbits of isolated particles, or of cloudlike condensations within the tail, on a photographic exposure, such procedure having been followed by many investigators.

The important conclusion that can be drawn from the works of some of the investigators of the tails are: (1) different clouds observed simultaneously in the same cometary tail show very different repulsive forces to be present; (2) the repulsive forces can attain, on the average, a value some 100 times greater than solar gravitations; and (3) the initial velocities of the tail particles agree well with the value of one km/sec that would be expected on the basis that the molecules are produced by evaporation and photodissociation from solid parent substances.

There exists some evidence that shows that Type II tails do not go off into the radial direction from the nuclueus. This result stems from the fact that dust particles in the vicinity of the nucleus are carried along by the fairly dense concentration of gas there. The orientations are in order with this hypothesis and with the expansion velocities of the gas gas which determine the orientation of the gas tail.

This, then, gives a general picture of the situation concerning the theory of comets, and their physical properties. The initial hypothesis of the theory is somewhat believable, for the existence of the dust clouds is an established observational fact and therefore a legitimate starting point. The journey of the sun through the clouds is a very reasonable hypothesis. Although tests relating to the hypotheses are mainly order of magnitude calculations, the degree of agreement reached is at least as close as could be expected.

In view of the fact that most if not all stars must from time to time pass through dust clouds, and since a high percentage of stars are double, it is seen that the theory implies that comets probably form the most numerous class of celestial objects in the universe. The process of accretion, here applied to interstellar dust, is equally effective for a gaseous cloud in so far as addition of mass to the sun and stars is concerned. This accretion of mass as stars move through interstellar hydrogen is one of the main factors in determining their growth and course of evolution. Such evidence is provided directly by the phenomenon of comets.

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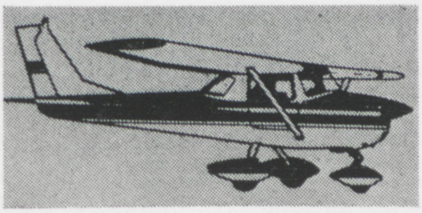

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## SPORTS

# You Too?

by DON RILEY
Sr. E.E.

How many times have you said to yourself "That referee needs new glasses" or "Hey ref, you're missing a good game"? I venture to say more than once. I'm not condemning anyone for I'm just as guilty as the next fellow. But let's play a game called "You too can be a referee." We'll play this game on the campus of a small midwestern Engineering School—Rose Poly.

The first thing we must do is choose the players of our game—the referees. At Rose Poly, they have an intramural-interfraternity league for various athletic events of which football, basketball, and softball are the most important. These three events require referees so that the games can be played in a realistic manner. Having no referees would disrupt the continuity of these games. But, who are these referees? Simply, they are members of the student body who have chosen to give of their spare time so that others might enjoy the competition. They receive a minimal wage for their services and yet, these forces which consistently bicker with the referees seem to expect the impossible from them.

The second stage of our game shall be to set up a game situation and let you view for yourself what a referee does and why he usually becomes the center of vehement arguments. Here we go. Assume it is third down and five yards to go for a touchdown for Team Alpha. Team Bravo needs this game to clinch the IM football trophy. Team Alpha has broken the huddle and is now lined up on the ball. The ball is snapped and Joe Dokes, offensive right tackle, slips and falls in front of the defensive linebacker who decided to shoot the gap. The defensive man trips over Joe Dokes and immediately claims that Joe left his feet on a block. (In the IM league, no person can leave his feet on a block in the interest of safety). But the ref doesn't throw the flag, the play continues and Team Alpha scores the winning touchdown just as time runs out. Team Bravo is enraged and the ref is surrounded by a horde of players. But he won't change his mind.

This play could have been called either way. It was purely a referee's decision. But had he called it the other way, Team Alpha would have argued. So, the referee didn't have a chance to escape the wrath of either team.

Now, let's finish our game. The IM league is definitely in need of more referees. This has been the case for some time now. Students are apathetic and don't wish to become involved. They are content to play the games and leave the rough work up to others. And then, when "the others" make a "wrong" decision, everyone cries "Get a new ref". If more people would respond to the requests of Coach Carr and referee a few games a week, then maybe the caliber of referees would improve in the eyes of the vehement arguers.

You, too, can be a referee!

## OPERATION CATAPULT

(*Continued from Page* 6)

The topics were chosen with as much diversity as possible within he list of available speakers.

The non-academic program withn Operation Catapult was designed irst, to provide some broadening experiences not directly related to he main goals of Catapult and econdly, to provide wholesome receation and relaxation. This phase of Catapult consisted of fieldtrips to various plants within Indiana and movies three evenings a week, as well as softball and vollyball during he day.

At the close of the four weeks, students were asked to evaluate the worth of Operation Catapult. The esponse was overwhelmingly in avor of its continuation. The only hing that the students expressed lispleasure about was the selection of movies presented as part of the ecreational program.

The success of the first Catapult program is largely due to its handlng by the staff. Dr. McMillin, direcor of the program, and Mr. Harry Johnson of the Vigo County School Corporation did much to stabilize the program. Dr. Knudsen of the Chemstry department, Prof. Schmidt of he Mathematics department, and Dean Moench of the Electrical Engineering department all added tremendously in their respective areas o the success of the program. Mr. Leo Kelly, school counselor and ead tennis coach at Rose, did a fine ob in the recreational area and elped to make Catapult a fun experience as well as a learning experience.

Because of the success of the first Catapult, next year there will be wo Operation Catapults, each four weeks long. It is interesting to note hat out of 67 participants in the st program, 35 of them have already pplied for admission to Rose at the ime this article was written. Some f these would probably have applied Rose regardless of their participaion in Catapult, but even those now ave a clearer understanding of why hey want to attend Rose.


# Some of our best engineers are still students.

Take the head of one of our Systems Sections. He puts in a workcrammed week riding herd on the development of AC's new Ship's Self-Contained Navigation System (SSCNS). But come Tuesday nights, he's down at the university (he'll have his Ph.D. next June). He's one of our top engineers. Still a student. He's typical of our moonlighting "student" engineers who spend their workdays on advanced projects like Apollo, LM, Titan III, MAGIC series on-board computers, Carousel IV (AC's inertial navigator for Boeing's new 747 jet), a fire-control system for the Main Battle Tank (a joint U.S.-Federal Republic of Germany Program).

Then there's another kind of student engineer. He's in college somewhere completing his degree. He strives for the top grade in his class. And usually makes it. He has no intention of calling his education quits when he graduates. He's got his feet on the ground and his eyes on the stars. He, too, may one day be one of our best engineers.

Could we be talking about you?

We try to make self-improvement easy at AC Electronics—where we specialize in research, development and production of guidance, navigation and control systems for military, space and commercial applications.

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If you're completing your B.S. or M.S. in E.E., M.E., Math or Physics, ask your college placement officer about a General Motors/AC on-campus interview for positions at all three AC Electronics locations—Milwaukee, Boston and Santa Barbara. Or write directly to Mr. R. W. Schroeder, Director of Professional and Scientific Employment, AC Electronics Division, Milwaukee, Wisconsin 53201.

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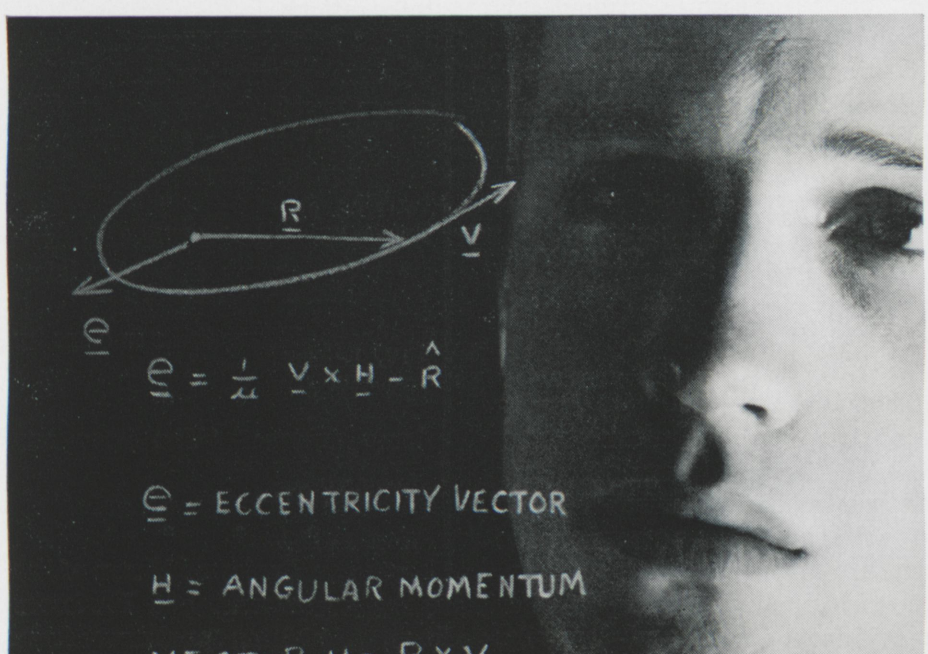
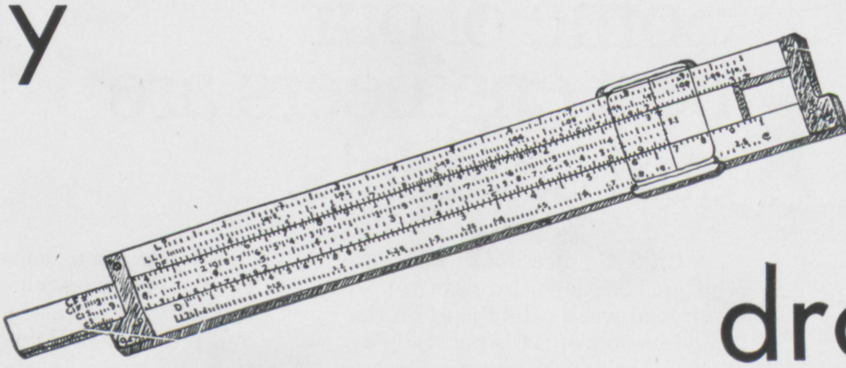


# sly droolings



**Stolen by Gary Kelm, Soph, M.E.**

A pair of newlyweds had tipped the porter generously on boarding the train to keep the fact a secret. The next morning, noticing the many knowing looks cast in their direction, the angry groom called the porter to account for his treachery.

"Lawdy, boss," he replied, "I didn't tell 'em; they asked me if you was just married and I sez 'No, they is jus' very good friends."

* * *

**Question; Since pro means the opposite of con, can you give an illustration?**

**Answer: Yes, Progress and Congress.**

* * *

Prof: "How many revolutions took place in France during this period?"

Engineer: "Four."

Prof: "Enumerate them."

Engineer: "One, two, three, four."

* * *

**Drunk: "Shay Lady, you know you got two very beautiful legs."**

**Girl (snapping): "How would you know?"**

**Drunk: "I counted 'em."**

* * *

The Coed, excited about having been pinned by a fraternity man the night before, dressed hurriedly and was walking towards campus when she came upon a group of male friends. Stopping in front of them, the girl proudly thrust out her chest and commanded happily, "'Look!"

But in the excitement, she had forgotten to wear the pin.

* * *

**The Engineer's Psalm**

**Professor Rogers (Meeks, Schmidt, etc.) is my instructor, I shall not pass.**
**He maketh me to exhibit mine ignorance before the whole class.**
**He telleth me more than I can comprehend;**
**He lowerth my grade.**
**Yea, though I walk through the corridors of knowledge,**
**I do not learn.**
**He tries to teach me;**
**He writeth the equations before me in hopes that I will understand them.**
**He bombardeth my head with integrations,**
**My slide rule doth freezeth,**
**Surely math and physics shall stump me all the days of my life,**
**And I shall dwell in the College of Engineering forever.**

* * *

Angry Father: "What do you mean bringing my daughter home at this hour of the morning?"

Engineer: "Have to be in class by eight."

* * *

**Army doctor: "You have any physical defects?"**

**Selectee: "Yes, sir, no guts."**

* * *

Last year, Professor Mason of the physics department and Professor Dixon, a visiting professor from Scotland, were overheard talking in the physics lab.

Said Mason to Dixon: "Well, we have to draw a line here somewhere."

* * *

**And then there was the freshman who thought a logarithm was a forester's song.**

* * *

A housemother complained to the dean of women that the boys in the fraternity house next door never close their blinds and that it embarrassed the girls. When the dean went to the room of the particular girls who had made the complaint, she looked out the window and said, "Why, I can't see in their window from here."

The girls said, "Oh, you have to stand in that chair."

* * *

**Reader: "Rumor has it that you have a rather wierd sense of humor. After reading some of your jokes, I have concluded that the rumor is correct. It seems you laugh at just about anything. Do you have any comment to make about this?**

**Editor: "Ha, Ha, Ha!"**

* * *

"So your husband is one of the big guns of industry."

"Yes, he's been fired eight times.

* * *

* * *

First Drunk: "Shay, do you know what time it is?"

Second Drunk: "Yeah."

First Drunk: "Thanksh."

# What's a good engineer like you doing in a local Bell Telephone Company?

Well, here are a few things you can do:

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# "Traffic is terrible today!"

*". . . Accident in the left hand lane of the Queens-Midtown access ramp. Right lanes moving slowly. Fifteen minute delay at the Brooklyn Battery Tunnel. Lincoln Tunnel backed up to the Jersey Turnpike. Extensive delays on Route 46 in the Ft. Lee area. That's the traffic picture for now, Bob."*

However, technical people at GE are doing something about it. Development and design engineers are creating and improving electronic controls and propulsion systems to guide and power transit trains at 160 mph. Application engineers are developing computerized traffic control systems. Manufacturing engineers are developing production equipment and new methods to build better transportation products. And technical marketing specialists are bringing these products and systems to the marketplace by working with municipal and government agencies.

Young engineers at GE are also working on the solutions to thousands of other challenging problems—products for the home; for industry; systems for space exploration and defense. When you begin considering a career starting point, think about General Electric. For more information write for brochure ENS-P-65H, Technical Career Opportunities at General Electric. Our address is General Electric Co., Section 699-22, Schenectady, New York 12305.

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