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IN THIS ISSUE

On page 10, Bioengineering, Rose's newest department, is analyzed as a rapidly expanding area of modern technology.

“Athletic” minded Rose students should find the article on page 8 concerning muscle contraction informative.

On page 22 the winning essay of the fall Tau Beta Pi pledge class is presented, courtesy of John Burke.

COVER NOTE: This month's cover depicts, via montage, some of the many elements of the rapidly expanding field of bioengineering. Art work is by junior electrical, Jim Coles.
Guest Editorial ........................................... Dr. Oran Knudsen

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An Eruption in Bioengineering .......................... Ed Green

State of the Congress .................................. Ken Burkhart

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Miss Technic

Sports

Sly Droolings

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opinions expressed by its contributors.
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(b) In the case of a taxpayer other than a corporation, the amount allowable as a credit under this section for any taxable year shall not exceed:

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2) $500, whichever is less.

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Development Office
Rose Polytechnic Institute
Terre Haute, Indiana 47803
GUEST EDITORIAL:

IMAGINATION

A TV viewer of football is continually reminded that Imagination and Imagineering are important in solving the technical problems of our complex world.

In 1874, S. H. Van’t Hoff, at the tender age of twenty-two, shocked the scientific world of Chemistry when he published a paper stating that "the geometry of atoms in a molecule could account for some of the chemical properties of matter." He followed this paper with others relating the osmotic pressure of dilute solutions to ideal gases and discussing the importance of equilibrium in the physical, biological and chemical universe. After each paper Van’t Hoff was berated, by the "so called authorities" in the field, as a young dreamer who didn't know enough about any field to discuss it intelligently. Yet, Van’t Hoff was the first Nobel Laureate in Chemistry for these same ideas. He was ahead of his day.

Einstein as a young man tried to imagine what a "traveling wave front" might look like if he were traveling at a comparable velocity with the wave. Out of this rather "foolish dream" he developed the concept of relativity and was awarded the Nobel Prize.

Tyndall wanted to find out during his studies on fermentation what happens if the air which comes in contact with the fermenting substance, is altered by freeing it from "those floating small dust particles which can be shown to be present by means of a light beam." He removed the dust particles very simply by covering the inside surface of the box with glyceral. After some time even the smallest dust particles "stuck to the walls, like flies on a tar-covered fence."

Michael Faraday wrote a letter to a friend in which he says of himself, "Do not suppose that I was a very deep thinker, or was marked as a precocious person. I was a very lively, imaginative person and could believe in the 'Arabian Nights' as easily as in the 'Encyclopedia.'"

Helmholtz describes his invention of the ophthalmoscope as follows, "the thought occurred to my mind to place between both eyes of the patient a small mirror with a small aperture in such a way that a lateral light beam would fall in the subject's eye which now can be observed through the aperture."

Van’t Hoff has summarized the part that imagination plays in an investigation as follows:
1. In the choice of the moment or the object of observation.
2. In the finding of aids, which facilitate observation.
3. In the observation of a correspondence or dissimilarity with other phenomena.
4. In the setting up of an hypothesis.

He continues by saying:
"The individual who possesses all these qualifications will nevertheless remain without any significance if he lacks the irresistible drive to make use of these abilities, and this compelling drive which manifests itself as enthusiasm and subsequently as perseverance is frequently the pursuit of an idea which exists only in the mind of the investigator and consequently represents the result of imagination. Such creations of imagination have brought about miracles."

Do not be afraid to develop your imagination. Here is something to ponder:
The earth is composed of about $10^{50}$ atoms. There are about $10^{55}$ "earth masses" in the known universe. In the complex DNA molecule the atoms could be arranged in $10^{1200}$ probable arrangements - but only one of these arrangements would have the properties that makes DNA important to living organisms.

Lastly imagine yourself a success. Here are some guidelines to use:
- Do something you enjoy.
- Don't expect something for nothing.
- Do more than is required.
- Have high expectations.
- Don’t feel sorry for yourself.
- Learn your abilities and limitations.
- Realize that it is nice to be important but it is more important to be nice.
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A quiet company? Maybe we should make a little more noise.
MODEL SIMULATION OF ISOMETRIC CONTRACTION

by ROBERT MARKSTEINER

The work which follows in this paper originated solely from an attempt to explain the tension-length relation during isometric contraction of skeletal muscle. Although experimental results show the tension reaching a maximum at a certain critical length in a manner resembling somewhat a bell curve, thus eliminating the possibility of modeling the system with a simple spring, the helical structure of the proteins involved and the experimental results on induced contraction of said proteins led the author to consider various combinations of springs in relative phase difference.

The structural picture of the active elements of muscle contraction, the sarcomere, is very useful in a discussion of this model and will be referred to often. The sarcomere, which is the small repeating unit of the muscle fibers, has been found to be divided into bonds of protein elements as shown in figure 1. Through measurements on the lengths of the filaments, it has been determined that contraction of muscle fiber is a result of the sliding of thin filaments through the thick filaments rather than an actual actual change in length of either filament. By extraction techniques, it has been shown that the thick filaments, three of which surround each thin filament, are composed of the protein, myosin, while the thin filaments are acting structures.

Further electron-microscopical studies showed cross-striations with a periodicity of 400Å which seemed to link the thin and thick filaments. Each thin filament is connected to the three thick filaments surrounding it once every 400Å along its length with the links evenly spaced of periodicity 133Å. Huxley maintains that this arrangement is consistent with a helical structure for both filaments with the bridges occurring at nodes on the helix. This would then, according to Huxley, account for 54 bridges of contact at the muscle resting length.

Consider now figure 3 in which a set of potentially parallel acting springs are set at phase differences of \( \Delta x \). An initial displacement of the bar (blue) complex by amounts less than \( \Delta x \) will result in no linear restoring force. With this displacement, however, each of the red bars will have ‘risen’ by an amount \( \Delta x \) (Continued on page 20)
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AN ERUPTION IN BIOENGINEERING

by ED GREEN

Editor’s Note:
In the fall of 1967 the bioengineering department at Rose achieved full departmental status, conferring both B.S. and M.S. degrees in bioengineering. Rose has thus achieved a first in engineering education, being the first college in the world to offer an undergraduate engineering program leading to a B.S. degree. The Technic is printing this article in recognition of this accomplishment of the bioengineering department.

Engineering, at first superficial look, might be thought of as the discipline farthest removed from biology; it is the application of generalized laws obtained by physics to the control of nature in the service of man. But note: in the service of man. It should not surprise us, therefore, if we notice that engineering is by and large nothing but an extension or magnification of biological function available to us in quantitatively smaller extent in our biological design. Transportation engineering extends our ability to change the location in space. Telephone and radio extend the range of our hearing. Telescopes and radar extend the range of our vision. Engines extend our available supply of force and energy.

How strongly biological thinking is entrenched in engineering one example may serve to show: in communication engineering, where information theory plays a major role, a basic concept is signal to noise relationship. Noise, of course, is a biological concept, extended here into a highly complex and generalized application.

Within recent years the life sciences have realized the significance of the contributions which can be made by the engineer, and the engineering sciences are beginning to realize the value of the contributions which can be made by the life sciences. It is this discovery that has brought about a new science which is bridging the gap between the engineer and the life science. This area has been called life science engineering, bio-medical engineering, biosciences engineering, bioengineering, and a variety of other names. It includes widely divergent areas embracing cybernetics, bionics, and medical electronics. It may be included as a portion of the area known as biophysics. Research interests can and do range through all forms of engineering (mechanical, electrical, chemical), all forms of life science (clinical medicine to pure biology), and many phases of physics and mathematics. This area is not composed of a homogeneous group of laboratories or individuals.

Definition of Bioengineering
Bioengineering is a term that has substantially different meanings for different people as was just discussed. Therefore, before going on with this discussion, it is necessary that some attempt be made at making a definition of bioengineering that is broad enough in scope to encompass all areas of application. Also, some attempt must be made at categorizing the many varied disciplines involved in engineering as applied to biological sciences. Dr. Robert M. Arthur, the head of the bioengineering department at Rose, uses the following definition: “The application of the knowledge gained by a study of the physico-chemical phenomena of biological systems so that both biology and engineering may be more fully utilized for the benefit of man.” In order that I stay consistent, I will also use the system of categorizing employed by Dr. Arthur. This system consists of four main areas of application. (Fig. 1)

These areas are defined as follows:
1. Bionics—A study of biological systems to determine how the mechanism of the system can be used in engineering design to create hardware.
2. Applied Biology—The use of biological systems to create new products by synthesis.
3. Biomedical Engineering—The application of engineering to medicine to:
   a. Provide electrical-mechanical replacements or damaged structures.
   b. Provide instrumentation to study function.
4. Environmental Health Engineering—To use engineering principles to control an environment which is optimum for life.

History and Development
Although bioengineering as applied to fermentation processes has existed for centuries, the current interest in bioengineering as a dis-
The discipline has developed as a result of two rather recent phenomena: (1) Man-made systems have become staggeringly complex; and yet, in spite of high-speed computers, the presence of man as an integral part of the system is demanded. The space program is the most dramatic example; and the establishment of manned communities in the oceans is another increasingly important instance. Of perhaps greater importance are the attempts to prevent further depletion of man's environment by controlling the pollution of air and water. Problems in this field become increasingly challenging with the ever-greater volumes and staggering complexities of the waste products resulting from the activities of man. On a less colorful plane, but increasingly significant, is the incorporation of human factors in the planning of production lines and processing plants. The design of hardware systems can be achieved with known parameters, but we are now faced with the question, "What are the rules governing the integration of living components into the system?" Before this basic question can be adequately answered, a diverse spectrum of knowledge about biological response to stimuli must be placed on a quantitative basis. The quest for knowledge in this particular aspect of bioengineering has catalyzed the discussion between all branches of biology and engineering. (2) A second and more basic reason for the dialogue between the engineering and biological sciences is therefore the demand of all biological science for more quantitative descriptions and syntheses.

Possibly the first interest in bioengineering at Rose could be sighted at the first Bioengineering Symposium in 1953. The main topic at this symposium was fermentation. The present program at Rose was first initiated in 1963 when Dr. John A. Logan, President of Rose Polytechnic Institute, established a temporary Committee on Applied Biology and Bioengineering. This committee was to investigate the possibility of a program of biological sciences and of biological science applied to engineering. As a result of this committee's work, a survey was launched to find the interest in bioengineering. This survey presented sufficient evidence to warrant the creation of a bioengineering department and eventually an undesignated degree in bioengineering. In 1967 an M.S. and B.S. program were established at Rose making it the first college in the world offering an undergraduate degree in bioengineering.

Program At Rose
The undergraduate program at Rose is designed broadly enough to allow the student to prepare for the study of medicine, dentistry, or other medical sciences besides preparing him to go directly into any area of application of biological engineering. Specialization can be accomplished by the proper choice of electives. The program at Rose has several outstanding and unique points. The most interesting of these (Continued on page 28)
STATE OF THE CONGRESS

by KEN BURKHART

Although from an outside appearance one may not think that our Student Congress has accomplished much to date, the Congress has indeed been busy "behind the scenes." Student body president John Elzefron explains, "The first quarter was a quarter of planning. This quarter should see committee action, and research that will lead to positive results." I should like to take this opportunity to present a "State of the Congress" report.

The goals that the Congress is striving for are mainly of a short range nature, although many, if successful, will lead to long range results. Among these programs is the proposed Student Loan Service. Under the chairmanship of junior Jim Handeshell the committee has been investigating the possibilities of such a service and outlooks are very optimistic. Such a service could be in operation by February. New rules regarding girls in fraternity houses have at this time been approved by the Inter Fraternity Council and the Student Government. The Faculty Activities Committee, under Dean Ross, is now faced with the question. Student Body Vice President Pete Doenges is heading a committee concerned with changes in the Rose grading system. Presently action by this committee is behind schedule and any action taken will obviously subject to a final decision by the Rose faculty and administration.

On the immediate short range side of the picture is IMPACT. The topic for this year is "Society's Responsibility to the Underprivileged." The faculty advisor for the program is Doctor Maloney. The present concern of the IMPACT committee is securing a guest speaker. Among those who have been approached by the committee are Senator Robert Kennedy and Charles Percy. However, both of them have declined invitations to come to the campus. An invitation has now been extended to Vice President of the United States Humphrey and after several letters of correspondence, he has said a decision will be made early this month.

Also along the immediate goal line is the possibility of a schedule change during the spring vacation break. This is of interest to all the student body and again the Congress hopes to be successful. The Inter-Dormitory Council and its president, Tom Folty, is working with Congress to organize a trade dinner with St. Mary-of-the-Woods to be held late in January.

As a result of the Associated Student Government Convention held in San Francisco over Thanksgiving vacation, John Elzefron and Pete Doenges have brought back to Rose new ideas such as the formation of a Student Cabinet compose of "campus leaders." I hearing the problems of other schools, John and Pete feel assured that the programs this year's Congress are engaged in are good and sound. Presently John is very much interested in the formation of ACE, Associate Collegiate Effort, a united effort of St. Mary's, Indian State, and Rose.

Indeed the Student Congress has been active to date and concrete results should be evident in the very near future.

Ken Burkhart
Publicity Director of the Student Body
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An Equal Opportunity Employer.
Miss Technic for this month is Susan Koesterer. Susan is a sophomore at Saint Mary-of-the-Woods College majoring in special education. She is from Mascoutag, Illinois and enjoys canoeing and swimming. Susan spent her summer instructing mentally handicapped children. She has brown hair, hazel eyes, and is 5' 4" tall.
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The Pied Piper of America

by John Burke

Long ago in a little village called Hamelin, the people lost their children because they refused to pay the price of a service done their community. They refused to pay the piper and, consequently, that which they held dearest was lost to them forever.

Today we are confronted with a similar situation. Shall we pay the piper or shall we too lose our dearest possession... our children? But who is this piper and what do we owe him? The piper is freedom and the service he has provided is life itself... a life that is full, rich, happy, and secure... the American way of life. His due is preeminence... being kept first in our hearts and in our thoughts. He has exacted his due before and we have paid with our lives from Nathan Hale to an unknown soldier on a sandy beach in Guam or in a desolate field in Korea.

Freedom can never and must never be relegated to less than first place or there is a great possibility that it will be altogether lost. Personal safety, material gain, individual security must occupy second place, for, after all, without freedom these others cannot exist. The patriotic founders of this country led a revolt to establish freedom as a permanent base for a way of life. Only after this was an established fact did they begin to seek methods of fulfilling their material needs. Contrast this with the Russian revolution in which the mistaken leaders enjoined, “Workingmen of all countries, unite!” The object of the revolution was to obtain “land and bread for all” with the promise that freedom was to be added later. They said, “Of course, in the beginning, this cannot be effected except by means of despotic inroads on the rights of property...” The people let their stomachs rule. Freedom took a back seat to material well being and as a result neither was ever attained. This same pattern is seen in many of the new African nations and in other places, and unhappily the result will probably be the same.

Americans have never been afraid of hard work as it is the price they paid for freedom and, for all but a few, it was well worth the price. Without this love of freedom on the part of the settlers, America might never have been settled. Certainly the early settlers had a rough time here with rough seas, bleak winters, Indians, no comforts of home, no established trades or manufacturing and few familiar friends. Materially they probably would have been better off in England, Holland, or wherever they had come from, but freedom was more important to them than material comforts. Later settlers, such as the Germans, Chinese, Poles, and Czechs, willingly left beautiful beloved homelands to work in dirty, crowded industrial cities, or on railroad gangs, or in coal mines, or to live in unsettled and inhospitable areas just to live with freedom from tyranny. Thus America was settled by idealists, not by people seeking material wealth.

Today with fighting in Viet Nam, with bombings and terrorist activities in Hong Kong, with strife in Kashmir, in Cyprus, in the Congo, and in the Middle East, with riots in Detroit, Cleveland, Newark, and Watts, the strains of the piper’s melody again become audible. The piper must again be given his due or the awful consequences of that time long ago will be upon us again. Our children and our grandchildren are too precious to be taken away by an unpaid piper... he must be paid. Freedom must come first or it will not come at all. When it is relegated to second place, liberty dies.
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ease in computation let \( x = 0 \) be the point of \( A, A \) bonding and \( \Delta x \) be the region of force \( kx \). When the second spring is added, however, it has not been stretched as greatly as the first and restores with a force \( k(x - \Delta x) \) since it began \( \Delta \) 'later.' The total force between \( \Delta x \) and \( 2\Delta x \) is then \( kx + k_1(x - \Delta x) \). It is not only reasonable but beneficial to the theory to assume that the \( (A, A) \), \( (B, B) \) \ldots \( (I, I) \) bonds can only take so much force. This critical force will be reached by spring \( \# 1 \) first, of course, and at intervals of \( \Delta x \) in consecutive springs thereafter.

If the strength of the bond is of such a nature that it corresponds to the \# of springs \( N \) in the system and ruptures as the last spring is added, and from the structural comparison to be made later, from symmetry, and esthetic value, if such an assumption is far from rash, the force calculations below can be made (with larger \# systems the exact place of this rupture will be less important and only a breakage at the magnitude of the \( F_3 \) will be needed) using natural unit \( \Delta = 1 \).

In this example \( F_3 \) is critical; spring \( \# 1 \), which had the force \( k5\Delta x \) on it, has broken its bond and ceases to contribute while no additional springs have been added. Notice that the maximum tension has occurred in this area in which the maximum number of blue bars were in contact with black bars. Note also that during the stretching of the system the length of the blue bars has remained constant and that the blue bars have 'risen' relative to the black bar carrying its last element 'higher' and 'higher' through the black bar system.

The geometry shown in figure \#3 is not unique to the action derived from it. One may imagine a curling or bending of the line marked \( Z \) to which the blue bar system is rightly attached. If the \( Z \) line is curled so as to bring the \( I \) position back around to the \( F \) position and so on down the \( Z \) bar, and will have their \((i, i)\) bond oriented similarly in space for \((1, 4, 7, \ldots)\) or \((2, 5, 8, \ldots)\) or \((3, 6, 9, \ldots)\), the original problem can then be solved by the addition of two additional black bar complexes positioned appropriately and requiring the horizontal bond sites only \( 1/3 \) as often along the length.

The blue bars have of course been included as representatives of the thin filaments and the overall structure curled to indicate the helix. The black vertical bars analogue the thick filaments, three of which have been found to surround each thin filament, while the \( Z \) bar represents its sarcomere counterpart. The horizontal block bars are, of course, the "ratchets" seen by Huxley. The sliding action and bonding referred to in the model should now be seen in this light.

Since it is known that maximum tension occurs when there is maximum contact between the ratchets and thin filaments and since Huxley has given 54 as the \# of bridges of contact, work similar to that was conducted for \( N \) such that max tension occurred about \( N = 54 \). Since writing out the force for such large numbers becomes unmanageable, I found a general formula for \( F_\nu \) by inspection of the first few terms:

\[
F_\nu = F_\nu - K_\nu \sum_{\nu=0}^{55} \frac{\Delta x}{\nu} - K_\nu \sum_{\nu=0}^{\nu-55} \frac{\Delta x}{\nu}
\]

It then became necessary to find a generating function for \( F_\nu \) for \( N > 54 \):

\[
F_\nu = N\nu K_\nu - \Delta x K_\nu N(N-1)\Delta x
\]

Since, as Ruch and Patton state, the length tension curve for a single muscle fiber, if all sarcomers in the muscle were equal in length for all total muscle lengths during contraction, would be the same as that for a whole muscle, and since such a first order approximation is in order here; there exists a means by which the model posed can be compared with experimental results.

Graph \#2 shows the tension length relation attained through the most probable result of a great number of measurements of isometric tension production. I have taken
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forms through linear aggregation of some mechanism in the model at is fibrous. It has in fact been determined that under suitable conditions conversion can occur between these forms through linear aggregation of globular molecules forming filaments. Although this aggregation proved promising in an explanation of the contractile process, it has since been demonstrated that the conditions prevalent are such that the action would constantly be in its F form.

Evidence now suggests that A.T.P. is responsible for both the contraction process and the relaxation process. Both myosin alone and combined in actomyosin act as ATP-ases catalyzing the hydrolysis of ATP to ADP. The ATP-ase of myosin is activated by Ca++ and inhibited by Mg++. Through this enzymatic action, part of the free energy of the ATP phosphate bond can be available to actomyosin for contractile activity.

Glycerol-extraction is a process whereby most of the soluble proteins and crystalloids are removed from the muscle while leaving the contractile machinery intact. In such a condition chemical but not electrical stimulus will produce contraction-relaxation. Soaking such a muscle in a medium similar to its intracellular constitution produces rigor. Tension can be produced by increased ATP concentration. As the ATP is hydrolyzed by the actomyosin and ‘used up’ the stiffness returns. Addition of ATP-ase inhibitors during such a contraction induces relaxation, leaving the plasticized state for duration of ATP. ATP can then bring about tension or plasticity.

In isotonic KC1 action and myosin are strongly bound together in actomyosin. The addition of both Ca++ and ATP brings about a “super-precipitation” of actomyosin which is believed analogous to contraction in muscle. Injection of Ca++ then brings about contraction by stimulating ATP-ase of actomyosin and myosin and reducing Ca++ in actomyosin brings about relaxation-like effects of ATP. The theory poses that excitation brings about a release of Ca++ probably from sarcoplasmic recticulum and induces contraction while the recollection of Ca++ brings about relaxation, the recollection also requiring the energy of ATP.

This mechanism will then provide a means whereby the sarcomere could be stretched without exerting a restoring force due to the plasticizing effects and yet be capable of exerting a restoring force upon excitation, with the tension eventually decaying again in time after stimulation. It will also be noted that this mechanism occurs only at positions where the possibility of actin-myosin interaction is possible (the places of interfilament bridging) and corresponds well to the spring force elements the model sets up which too exist only at the horizontal black bars. In the plasticized state then the springs can be extended with no tension being developed until after stimulation. The springs in the model are then taken as analogs of the actin-myosin interaction and the symbolism of the model is complete.

(Continued from page 20)
Doesn’t it seem like yesterday when you took everything in the house apart. First the toy cars and trucks . . . then your electric train . . . finally mom’s toaster. You caught it for that, but you found out how everything worked, and later why.

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Sports

Rose's Most Winning Team

by DON RILEY

During Thanksgiving vacation, the Rose basketball team traveled to Greenville, Illinois where an eight team tournament was hosted by Greenville College. While most of us were still enjoying leftover turkey, the Fighting Engineers were enjoying a beautiful trophy, representing three victories and a tournament championship.

Rose drew Lincoln Christian for their first challenge. And what a challenge it was. For the first thirty minutes, it appeared as though our men had left their tennis shoes at home. They were “flat”, lacked hustle, couldn’t spring the fast break, and committed many mistakes. With ten minutes to go, Lincoln Christian, led by two 6-6 men, had built up an impressive fifteen point lead. But, at this point, the tide began to roll in, and with it came “hustle”. Rose began to play a strong defensive game and finally chopped away at that big lead. With just two seconds to go, sophomore guard, Dong Ings was fouled while attempting to tie the game. His two free throws dropped neatly through the hoop and the regulation game ended with the score deadlocked at 88-88. In the overtime period, Rose “blew them off the floor”. Final score read Rose 105, Lincoln Christian 92.

In their second match, Rose played host Greenville. Greenville couldn’t match the Engineers for forty minutes and Rose moved into the championship game against favored Illinois College.

The first half, both teams played well but Illinois College, a particularly strong team, held a two point advantage as the second half began. During the next ten minutes, Rose sprang the fast break seven times in a row and pulled into the lead. Late in the game, foul trouble hampered the victors, but they held on for a four point victory.

George Shaver, a 6-4 Junior was chosen as the Most Valuable Player of the tournament.

These three wins gave Rose a four game winning streak against no losses. Since that time, Rose has defeated Blackburn College 102-82 with Jerry Wones canning thirty-three points and Don Ings hitting for twenty-one.

December 8 and 9, Rose hosted the Rose Bowl Invitational, a four team tournament including Principia, Northwood Institute, and rival college, Wabash, with Wabash coming out on top.

Following final exams at Rose, the Engineers hopped aboard a Jet Airliner for a trip to New York where they met Queens College and Brooklyn Poly. The Jet Transportation is being provided by a 1929 Rose graduate, Mr. George Hadley of Louisville, Kentucky.

Queens was a strong team. However, they weren’t accustomed to a fast style of ball. Rose literally outdistanced them on fast breaks with Rose winning by a narrow margin. Ings and Shaver tied for high point honors with twenty-five each.

Brooklyn Poly was a fairly weak team. The over-confident Engineers played mediocre ball the first half and lead by narrow margin at halftime. During the second half we played real ball and at one time we outscored them 21-1. We built up a lead and the reserves played the last ten minutes of the game.

Rose played the best defense against Kenyon that Coach Mutchner said he has ever seen a Rose team play. Yeager, Horton, and Tucker did a superb job containing their All-American guard. Down 15 points at one time, Rose came back and was down only seven points at halftime. Our rebounding was much stronger in the second half due largely to Pettee’s increased efforts. We lead by one point with five seconds left. Their All-American guard missed a one-and-one free-throw. Rose won with the final score 87-86. Ings was high man with 29 points.

Team and Coach Mutchner with Turkey Tournament Trophy.
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Robert Lindsay (BSME, U. of Kansas '64) is quality control supervisor of Anaconda Aluminum Company's plant in Louisville, Ky.

Joel Kocen (BS Commerce, Wash. & Lee '59; LLB, Wash. & Lee '61) left, is senior tax analyst at New York headquarters of Anaconda.

David Madalozzo (BSEE, Bradley '61) is plant engineer of the new Anaconda Wire and Cable Company mill in Tarboro, N.C.

Alvin Cassidy (BA Econ., Bellarmine '54; MBA, U. of Louisville '59) is director of financial planning of Anaconda Aluminum Company, Louisville, Ky.

Robert Zwolinski (BSME, Rutgers '57) is chief mechanical engineer with Anaconda Wire and Cable Company, New York.

Willard Chamberlain (BE Metal. Eng., Yale '53) is manager of Anaconda American Brass Company's Valley Mills, Waterbury and Ansonia, Conn.

Robert Ingersoll (BS Geol., Montana Tech. '51 MS Geol., Montana Tech. '64) right, is senior geologist, Anaconda's mining operations, Butte, Mont.

Thomas Tone (BS Mining, U. of Arizona '62) is foreman of the furnace dept. of the electrolytic copper refinery in Perth Amboy, N.J.

Richard Symonds (BS Met., U. of Nevada '57) is superintendent of the lead plant at Anaconda's smelter in Tooele, Utah.

Jay Bonnar (BS Met., M.I.T. '57; MS Ind. Mgmt., M.I.T. '62) left, is research administrator of Anaconda American Brass Company's research and technical center, Waterbury, Conn.

Wilson McCurry (BSc, Arizona State '64) is an assistant geologist in Anaconda's new mines dept., currently working on development of the Twin Buttes mine near Tucson, Ariz.

Terrence McNulty (BS Chem., Stanford '61; MS Met., Montana Tech. '63; DSc Met., Col. School of Mines '66) is senior research engineer, extractive metallurgical research, Tucson, Ariz.


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Before one can discuss anti-corrosion techniques, a general knowledge of what corrosion is and how it develops must be present. Corrosion is defined as destruction by chemical or electrochemical agencies, in contrast to erosion, which means destruction by mechanical agencies. Essentially corrosion is the reverse process to that involved in reducing metals from their ores. Iron occurs in the ground as oxide or hydroxide; it returns to the state of oxide when it produces scale at high temperatures, or to hydroxide at low temperatures.

Most metallic corrosion occurs through electrolytic action, the single exception being corrosion by "direct" action. Direct-action corrosion occurs on metals exposed to certain dry gases, or as a result of applying acids uniformly over a surface. Electrolytic action is essentially the same in the corrosion of all types of metals and for all corrosive solutions, the principal differences being of degree.

Electrolytic action starts with the dissolving of a metal in water or other dissolving medium. When dissolved, the metal is ionized and therefore possesses a positive electrical charge. It then either gives up its charge and is deposited in some other place or combines with another ion to form a new compound. The place from which the metal was dissolved is called the anode, and the place at which it is deposited is the cathode; these two form the electrodes of an electrical circuit. The water or solution is the electrolyte and the driving force is the solution pressure of the metal. Solution pressure may be roughly defined as the electromotive force which exists between a metal and its ions in a solution. Solution pressure differs in all metals.

There are two basic types of cells formed by electrochemical attack. One is the galvanic cell, which results when two dissimilar metals are electrically connected and immersed in an electrolyte solution. The other type is formed when two pieces of the same metal are immersed in two different concentrations of an oxygen solution or of an electrolyte, and it is termed a concentration cell. Galvanic corrosion often occurs on the unprotected steel of ships' hulls. The steel is anodic to the brass of the screws, and therefore the hull is selectively attacked.

Anti-Corrosive Method

Corrosion of iron and steel by water probably accounts for the greatest losses from corrosion. The controlling factor is usually the oxygen normally dissolved in natural waters. This type of corrosion can therefore be considerably reduced by removing the free oxygen or deaeration. Removal of free oxygen is particularly useful in water that is recirculated, such as boiler feed water. The water is usually deaerated by spraying in a low pressure or vacuum chamber.

One of the most obvious ways of improving corrosion resistance is to use a more corrosion resistant metal. Although costs may be increased by such a procedure, the savings resulting from lower maintenance and replacement charges should not be underestimated.

Another anti-corrosive method is termed organic coatings. These coatings include organic films such as paints, resins, and varnishes. In the case previously mentioned about the ship, an organic coating of paint would greatly reduce the corrosion of the hull. Here protection is supplied through exclusion of moisture, air, and other corrosive media. Since the coatings are organic, they are subject to deterioration at high temperatures, and are recommended only for use at or below the boiling point of water.

Inorganic coatings include such materials as ceramics, where the coatings resist high temperatures and are usually wear resistant and brittle.

Metallic coating is another anti-corrosive method. These coatings are either to protect against structural damage or to preserve appearance. Metallic coatings are applied by electroplating, dipping, and spraying with atomized molten metal. I shall discuss these three methods of application shortly. Protection is afforded in some cases because the metal coating is resistant to attack, whereas the basic metal is not. In other applications the coating is anodic to the basic metal, which I have previously described in my discussion of electrochemical attack. The coating is sacrificed, thus preventing attack until appreciable portions of the metal coating are removed. Galvanized sheet steel and fence wire are examples of cathodic protection.

Inhibitors are chemicals which, when added to the corrosive media,
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(Continued from page 11)

is the bioprojects. The bioproject is a research project that is conducted by the student with the supervision of the faculty and the aid of some interested industry. A student can learn at the same time, as students working on these projects usually are paid. Besides this, the project usually leads to summer work on the same experiment within the industry itself. It is also worthy to note that departmental seminars are held weekly in which invited guests are allowed to lecture on the latest developments in bioengineering. The bioengineering staff has a nucleus of three men, each holding a Ph.D. Besides them, there is a supporting staff made up of professors from other departments.

**Opportunities As A Bioengineer**

At this point one might ask himself what the opportunities are for a bioengineer. Looking first at just one refinement of bioengineering, J. H. U. Brown makes the following statement: "At the present time (1962) and for the last 10-15 years, the size of the bio-medical engineering area has been doubling over 2½ years. On this basis, about three generations of doubling will occur by 1970. At the moment, about $20,000,000 per year is spent on research in this area which suggests a budget of $150,000,000 per year by 1970." 2

Brown goes on to say: "In addition to the nucleus of trained individuals in the departments interested in engineering, there is a steady demand for such people in many other departments of the medical and physical sciences. . . Demands exist today in departments of surgery, medicine physiology, bio-physics, and radiology, with current estimates indicating that 100 Ph.D. engineers could be placed immediately. Various industrial groups are also on a constant lookout for the trained bioengineer. Most of the companies making biological instruments desire such individuals. Demand also exists for such engineers in aviation, computer facilities, and telephone laboratories. The current estimate is for about 200 men this year. Present estimates of NASA indicate that the space program in the government will absorb 100 engineers and that these demands will increase. Contractors of NASA will need many more as the space program expands. The NASA programs are 5 percent "in house" and 95 percent by grant and contract. Conservative estimates indicate that 500 bio-medical engineers could be utilized in 1962. With current plans for expansion the number may be 1500 or many more by 1970. By the most conservative estimates training programs accomodate approximately 20 times as many graduates as at present in order to meet the current demand. This does not take into account the sudden spurt which may occur (as happened in biophysics) when trained individuals begin to enter the field and influence the future development of the science." 2

In the Fall of 1964 Dr. Arthur conducted a survey among 51 employers concerning the employment and the education of bioengineers. Specifically it was concerned with the extent to which bioengineers are employed today and what their future opportunities are. Also the survey asked what level of education would make a man most desirable for hiring.

It was found that at that time 71 percent of the industrial employers surveyed employed bioengineers while 100 percent of the governmental agencies questioned employed them. The total number of bioengineers employed in these industries at that time was 1544. The survey showed that the biggest percentage of bioengineers were employed in fields related to environmental health engineering. However, these were mostly employed in the governmental industries. In private industry applied biology had the most employed with medical engineering also employing a substantial number. When asked about future employment, 89 percent of the answering industries said they intended to increase the number of bioengineers employed. It is worthy to note that 90 percent of the private industry questioned said they were intending to increase the number, while the governmental agencies had only 75 percent. 89 percent of the employers questioned said that they would employ a bioengineer with a B.S. The survey seems to indicate that all refinements of bioengineering appear to have a nearly equal future opportunity of employment. Dr. Arthur feels that this survey indicates that the development of bioengineering at the present might be compared to that of chemical engineering 40 or 50 years ago.

Summarizing, the engineering and basic life sciences can carry out a mutually advantageous cooperative program in at least three major areas of science:

1. Design of experiments, their instrumentation, and the processing of data.
2. Development of new experimental methods combining the best features of both fields.
3. Design of physical models of many complex biological systems which will aid in understanding and analysis.

Colleges are beginning to recognize this fact. In the words of Dr. Arthur, "Engineering schools are now recognizing . . . that biology is a necessary adjunct to present engineering education. In fact, there are indications that bioscience may become as important to the engineer as physical science. One thing is sure, the prospects for the future of bioengineering are as exciting and as fascinating as life itself." Bioengineering is here; and from all indications, it is here to stay.

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**DELCO RADIO**

Division of General Motors, Kokomo, Indiana
Q. What do you get if you throw a canary in an electric fan?
A. Shredded tweet.

Recent tests made by several bio-engineering majors prove that grasshoppers hear through their legs. When a vibrating tuning fork was placed near a grasshopper, it was found that in all cases the insect would hop. There was no reaction to this stimulus, however, when the insect’s legs were removed.

Real estate man: “Now here’s a house without a flaw.”
Southern belle: “Reallly? What do you-all walk on?”
Nell: “Oh, he’s so romantic. When he addresses me he always calls me ‘Fair Lady.’”
Belle: “Force of habit, my dear. He’s a streetcar conductor.”

Engineer on the telephone: “Doctor, come quick! My little boy just swallowed my slide rule.”
Doctor: “Good heavens, man, I’ll be right over! What are you doing in the meantime?”
Engineer: “Using log tables.”

The human tongue seems to run faster when the brain is in neutral.

The percentage of alcoholics in the United States is staggering.

And then there was the frosh named Six and Five-Eights Smith. He claims his parents pulled his name out of a hat.

They laughed at Watt, too, until he invented the Watt Schmacallit.

One lecturer on this campus is so boring that during one of his lectures last month two empty seats got up and walked out.

M.E. Student to Prof.: “Sir, are you performing some important calculations with that slide rule?”
Prof.: “No, I’m killing flies with it.”
M.E.: “But doesn’t that effect its accuracy?”
Prof.: “No, I’ve already killed 20 flies with it; and it kills just as well as when I started.”

We’d have less trouble in this country if the Indians had had stricter immigration laws.

An EE once spent $200 on a cure for halitosis and then found out that nobody liked him.

A beatnik ran a red light; the cop pulled him over and said, “Didn’t you see that red light?”
The beatnik replied, “Like man, I didn’t even see the house.”

DEFINITIONS

Kiss: What the child gets free, the young man steals, and the old man buys.
Pessimist: A person who looks both ways before crossing a one-way street.
Optimist: A person who tells you to cheer up when things are going his way.
Politician: One who shakes your hand before election and your confidence after.
Small business: A business that has never been investigated by a congressional committee.
Stork: The bird that gets all the blame and none of the fun.
Voluptuous woman: One who has curves in places where some girls don’t even have places.

Chief Engineer: “Your reports should be written in such a manner that even the most ignorant may understand them.”
Assistant Chief: “Well, sir, what part is it you don’t understand?”

A liquor salesman, a food salesman and a mattress salesman were sitting around and chatting.

“Y’know I hate to see a woman drink alone,” the liquor salesman said.
The food salesman countered with, “I hate to see a woman eat alone,” the liquor salesman said.
The food salesman countered with, “I hate to see a woman drink alone,” the liquor salesman said.
Then the mattress salesman said, “Say, what do you think of the weather we’ve been having lately?”
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