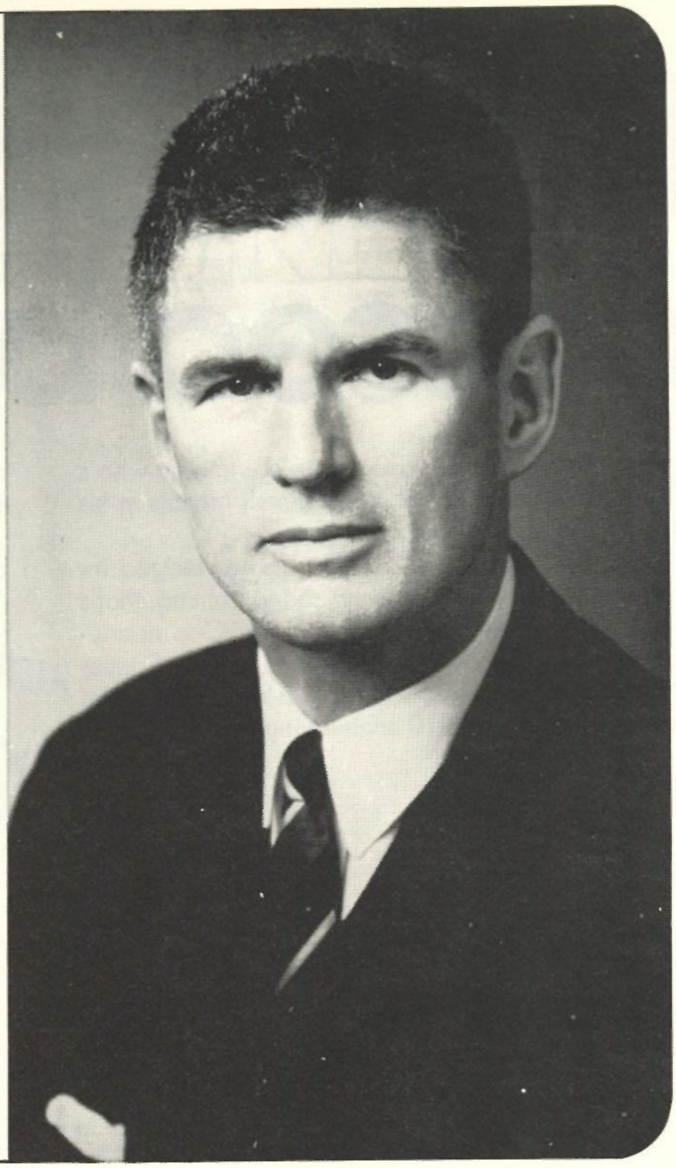
COLORADO ENGINEER

Engineering Days

MAY, 1969

"Mining has a challenging future for men with the desire to be challenged."

Lawrason Riggs III,
President



"The 'pick and mule' days of mining are gone. ☐ We in the minerals and metals industry are using many highly sophisticated production tools in our enterprises, and it is a fact that this great basic industry has introduced automation and computerization in every area from planning and production, to marketing and sales. ☐ At St. Joe we take special pride in having developed, with our own engineers, one of the most modern mines and mills in the world — our Fletcher facility in Missouri. We constantly seek, moreover, new and better ways to make older mines more productive and efficient in this era of increased competition. ☐ Added to this is St. Joe's continuing exploration program carried on both here and abroad, seeking new deposits of lead, zinc, and other minerals to meet the demands of an expanding international market. ☐ Wherever you look — in our mines and mills, our research and development laboratories—there are challenges for young engineers with imagination and enthusiasm. ☐ Whatever your field of interest, be it civil, electrical, mining, metallurgical or chemical engineering —at St. Joe there's an opportunity to use your talents and imagination, and to work with men with the knowledge and experience that have made St. Joe a leading member of the mining and metals industry."

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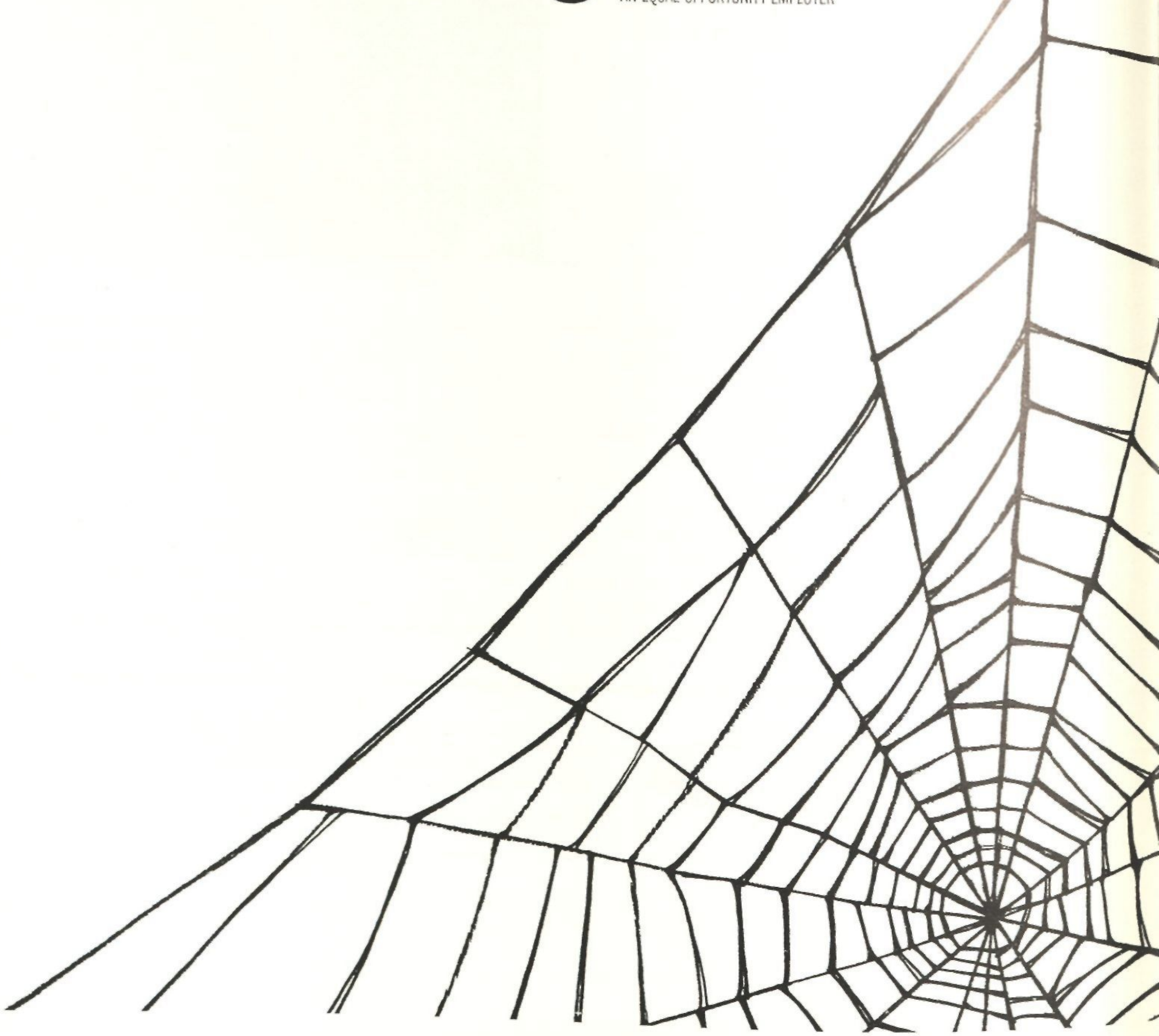

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COLORADO ENGINEER

COLLEGE OF ENGINEERING • UNIVERSITY OF COLORADO

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IN THIS ISSUE

FEATURES

SECTIONS

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ECMA Comments

"An engineer is not one who dreams up fascinating new gadgets with money as the sole object and reward. An engineer is acutely aware of the real, dirty, and uncompromising world and seeks to apply his knowledge to its problem. He must, therefore, be aware of the social sciences both to recognize his task and to accomplish it."

Denver ENGINEER, March 1969

"In short, the opportunities for personal growth as well as technical advancement are available for engineers. Don't miss the chance to work with people now, because your success in industry will depend largely on your ability to deal with people."

Iowa TRANSIT, February 1969

"Luck is the person who can sense his own "GPA" and its derivative, and use these in a personal feedback loop, even long after he has finished his formal education."

SOUTHERN ENGINEER, March 1969

"Dissension is the right to change. It is the power that can control this evolutionary force and form a world where we can truly exercise freedom without fear. Academic freedom, social justice and a democratic society can be had, if wisdom is granted us in our use of dissension."

Manhattan College ENGINEER, February 1969

"The schism that the students have placed between the Colleges of Science and Engineering may soon develop into an unbridgeable gap. This separation must be stopped, but it can be stopped only by the students. The students must see that understanding now will, in the future, lead to confidence, and that confidence will lead to a successful and, most important, an enjoyable career.

The SPECTRUM, November 1965

". . . were one able to claim the same amount of power as those who now control the direction and pace of social change in this country, one would have reached a position where prior social change to his betterment already had been achieved. The irony contained in the fact that a man with less power must resort to 'demanding' change of one who has power would seem to be obvious, but the bitter message implied by such irony is lost on those who would condemn an oppressed man for 'demanding' social change."

Wisconsin ENGINEER, March 1969

EDITORIAL

Defense of Total Education

David Asper

"The school should always have as its aim that the young man leave it as a harmonious personality, not as a specialist. This in my opinion is true in a certain sense even for the technical schools . . . The development of a general ability for independent thinking and judgment should always be placed foremost, not the acquisition of special knowledge"–Albert Einstein.

In a very real sense then, the "total" education is one that emphasizes the importance of how to think, not what to think–improve and develop the interpretive powers of the mind, not a mere accumulation in the memory of the thoughts of other men. Perhaps it is this very interpretive power, an understanding, an appreciation that provides the foundation for "independent thinking and judgment" and allows an empathetic condition to perpetuate itself between the engineer and businessman, student and professor, child and parent. To this extent then, it is a fusion of the "disciplines" that is sought rather than the dictitorial approaches that all too often result when the situation is insecure or the territory unknown.

What then is the training required for such a power, or better, what are the "prerequisites" for the above "degree? Perhaps it is the creation and/or cultivation of an inner sensitivity, a feeling, a certain inherent perceptiveness in relation to peers that comes only from working and dealing with one's fellows, not from the periphery, but rather from the inside out. It is the participation in the socio-humanistic activities, other interests "outside" the sphere of the more formal, structured academy that offers this opportunity to select "tools" for a value system to be utilized both now and in the future to evaluate one's circumstance and its inhabitants. Interests and activities and groups continually gather in and give out a proliferation of experiences and heteogeneities to entities where once before a relative dearth of expanding ideas developed and a state of stagnation existed. Such development and exposure is mandatory if communication is to be had.

Certainly the values of the more structured type of education can not be overlooked, especially if many areas and related fields are explored. "Independent thinking and judgment," to be sure, require a great deal of breadth and depth of assortment in several disciplines. In the past, such breadth and depth was acquired only after decades in the "business" and the neophyte was neither expected to have nor recognized for having such a premature collection of tools. Specialization is no longer the whole, but rather a part that should mesh well with other bodies of knowledge which then tend to liberalize and deepen general abilities and sensitivities.

Because of the rapid increases in technology and the expanding markets to be catered to, an engineer now must have the ability and understanding to both economically design and effectively determine consumer trends in commodity desirability, be it office and apartment buildings, transportation systems, or electrical component parts. It is to be his responsibility to understand the totality of a myriad of activities, whether it be business law, design, or consumer behavioral patterns. It is here that the understanding, the sensitivity, the total education feels the full weight of its success.

Perhaps the most significant contribution that can be made to any academic career is and has been being with and mixing with people, in all corners of the campus as well as community–

–they give the final exam.

What then of the College of Engineering?–Give a damn!

DEAN'S COLUMN;

Keep Cognizant of Changes

DEAN MAX S. PETERS

As we near the end of the 1968-69 school year, we can look back over the past year with pride at the added all-University involvement of our engineering students as well as the overall progress made in our College of Engineering. I give my thanks to Randy Lorance and Ellison Onizuka for the fine service they have given us as editor of the COLORADO ENGINEER and President of the Associated Engineering Students. I also congratulate and give my best wishes for success next year to Irving Susel as 1969-70 president of AES and Tena Poljanec as 1969-70 editor for the COLORADO ENGINEER.

As we look to the future, we must recognize the changing characteristics of university life and the overall engineering education pattern. One major influence we must consider in Engineering is the growing tendency on a national basis for more students to take graduate work to at least the Master's degree before starting on regular professional careers in Engineering. A number of schools throughout the United States are starting to initiate programs which eliminate the Bachelor's degree as a professional degree and lead directly to the Master's degree as the first professional degree in Engineering. Other schools are considering programs which start the student working toward a Doctor's degree after the sophomore year. Simlutaneously, various industrial concerns are calling for more part-time Master's degree programs to be available, so they can hire students with the Bachelor's degree and permit them to complete the work for the Master's degree on a part-time basis.

All of these pressures relating to the importance of graduate work in Engineering are pointing towards changed standards for graduate degrees. With the extreme emphasis now on Master's degrees for everyone, it appears that the Master's degree may soon become merely the equivalent of our original Bachelor's degree, with standards related to the Master's degree changing completely from those which applied at our engineering schools in the United States several years ago. In any case, as we are examining our future at the University and as you students examine your own individual futures, it is very important to recognize the growing emphasis on the Master's degree as the first recognized degree in Engineering and make plans accordingly.

I extend my best wishes to all of you who are graduating, and I wish you the best of success and happiness for your future. We hope you will let us hear from you regularly as to what is happening to you as your careers develop, and we will always appreciate any remarks you may wish to pass on relative to your views on our engineering education program at the University of Colorado.

With such genius, who needs a genie?

Verily, these young people demonstrate remarkable intellectual acumen, for a successful career is indeed more precious than great riches. And the guidebook to a rewarding career is none other than that perennial favorite, "Careers with Bethlehem Steel and the Loop Course." Pick up a copy at your placement office. Or write: Manager of Personnel, Bethlehem Steel Corporation, Bethlehem, PA 18016.

BETHLEHEM STEEL

An Equal Opportunity Employer in the Plans for Progress Program

Municipal Water Re-Use

Steve Work

An adaptation of a paper presented at the student paper contest of the Rocky Mountain student chapters of the American Society of Civil Engineers, Fort Collins, Colorado; May, 1968.

Water is man's most abundant resource. And yet, like other life sustaining compounds, it must be used and discarded and used again. In each drop of sparkling tap water are molecules that have been consumed before–perhaps centuries ago, perhaps only hours. It is the latter case which has become a major engineering problem, but if properly handled, may produce major benefits. The problem is tied to water's role as a carrier for sewage. The hoped for benefits come from the field of water reuse.

Water reuse is not a new art; it has always been a byproduct of using rivers as water supplies. However, deliberate, planned reuse is quite new, and many applications have yet to be tried. Historically, anyone needing water has had only to divert it from the nearest stream and use it. Perhaps some form of treatment has been applied to it and perhaps some attempt has been made to clean up the resulting waste. In any case, the waste has ultimately been returned to the stream to flow on to the next diversion and use. All consumers along the river are injured by this time-honored process. The first consumer loses the water which may be only 0.1% water, and those downstream receive the pollution in their raw supplies. An example occurrs along the South Platte River below Denver. During the months of low river flow, Denver's sewage effluent accounts for 17% of the water in the river. (1) On a particular day this amount may reach 80%. And yet, thousands of people depend on the river and its seepage for their water supply.

Water may be man's most abundant resource, but it is not always abundant where man chooses to need it. In the United States, one fourth of all the available water is being used at least once. Considering the unequal distribution of this water it is obvious that shortages now exist. (2) These shortages will increase with time and cannot long be ignored.

The problems of scarce supply and unwitting reuse have become so accute that Congress has established a program to find new and better methods of water renovation. In a 1961 address to Congress, President Kennedy stated:

> Pollution of our countries rivers and streams has–as a result of our rapid population and industrial growth and change–reached alarming proportions. To meet all needs–domestic, agricultural, industrial, recreational–we shall have to use and reuse the same water, maintaining quality as well as quantity. (3)

Research carried out since 1961 has shown that direct reuse for a variety of purposes–including domestic–is feasible and can be made safe and economically competitive with raw water supplies (3).

RECENT APPLICATIONS

Actual applications of wastewater renovation can be divided into two groups primarily on the basis of the ultimate use of the product water. In one category are those projects designed to supply water for irrigation, recreation or industry. In a second group are those projects designed to produce a potable product.

In the first category are industrial waters. Many industries require water which need not be of high quality, and applications of direct recycle are numerous. In recent years, it has become economically attractive for some firms to treat their wastes and reuse them. The required quality may be only slightly above that of the waste, and the cost may be lower than that of acquiring new water.

Municipal reuse projects date back to 1932 when San Francisco initiated a park irrigation program using treated sewage effluent. (4) Several cities and government installations now use their wastewater in this manner. Several others sell the treated waste for the irrigation of non-edible crops. In most cases, the sewage receives conventional primary and secondary treatment along with detention in specially constructed ponds. This type of treatment is fairly inexpensive and often rivals fresh water in purity. In the Coachella Valley of California, secondary effluent is cheaper and of comparable quality with the alternate irrigation source–the Colorado River. (5)

POTABLE REUSE

While it is an accepted fact among researchers that potable reuse is possible today, the actual tests have yet to be performed except under emergency conditions. Naturally, the problems are quite complex.

The sociological effects of potable reuse have not been studied in great detail, although they promise to be of major importance. One promising indication of how people will react has occurred at Santee, California. Renovated water is used in a public swimming pool at Santee. As far as can be determined, the citizens have accepted this innovation and are quite confident of their safety.(6)

The physical problems of potable reuse are all solvable. At present, the expense is high; however, it is expected to decrease as the science progresses. In a classic reuse example, the town of Chanute, Kansas used the same water about eight times under emergency drought conditions. The episode caused no apparent harm to the citizens, although they soon rejected the water as its taste, odor and color rose. The presence of a detergent foam head on every glass probably swayed a few of them. The town applied only conventional treatment with storage. Damage to the facilities was extensive indicating the need for more advanced treatment methods.(7)

ADVANCED TREATMENT

The current trend in sewage treatment is to apply what is called primary and secondary treatment. Primary sewage treatment is a physical process in which heavy particulate matter is removed under the action of gravity. Conventional secondary treatment is a biological process in which bacteria remove organic material as food under controlled conditions. In combination, these two processes do much to purify sewage, but their are many pollutants which are unaffected by this treatment or by conventional water treatment. These pollutants are not too important in the normal cycle of river supply and sewage disposal, but they become very important in reuse cycles. It is the function of advanced–or tertiary–treatment to bridge the gap normally filled by the river and its dillution. Tertiary treatment must remove the pollutants which are added to water each time it is used and which would soon build up to alarming amounts.

Many substances exist in treated wastewater which are alien to the human body–many more which are unpleasant. Chief among the first group are micro-organisms (bacteria and viruses) and deleterious chemicals such as many heavy metals and insecticides. Among the second group are such items as suspended solids, dissolved solids (salts), color and odor. Figure 1. is a schematic listing of a few important pollutants. In column 1 are the amounts which are added to the water in one use cycle and remain after sewage treatment. In column 2 are the effects of standard water treatment. In column 3 are the amounts allowed in a potable water under the United States Public Health Service Drinking Water Standards. Listed in column 4 are those processes which are effective in removing each pollutant. The processes listed are:

a. Modification of the chemical coagulation–settling step of conventional water treatment to allow for heavy loads.
b. Ion exchange.
c. Electrodialysis. This process uses an electrical potential to draw charged ions from the water through a semi-permeable membrane.
d. Reverse osmosis. This process drives the water through a semi-permeable membrane leaving the pollutants behind.
e. Distillation.
f. Activated carbon absorption
g. Modification of conventional secondary sewage treatment.
h. Air stripping. This is a gas transfer process in which ammonia is dissolved in air bubbled through the water.
i. Modification of the chlorination step in conventional water treatment to allow for heavy loads.
j. Use of a separate disposal system for the industrial waste involved.

POLLUTANTS of CONCERN in WATER REUSE

Pollutant Group	*Increment per Use (After sewage treatment) (mg/l)*	*Effect of Water Treatment*	*Drinking Water Standards (mg/l)*	*Effective Advanced Treatment Processes*
Suspended Solids	20	good removal	5	a,j
Dissolved Solids	320	little	500	b,c,d,e
Organic Compounds (measured as Chloriform extract able compounds)	1.5	little	0.2	a,d,e,f,i
Ammonia-Nitrogen	20	little	0	g,h,i
Micro-organisms	10^4/ml widely variable	good removal	0	a,d,i
Heavy Metals (Pb, As, etc.)	Amounts in waste often in excess of drinking water standards, unaffected by water treatment.			b,c,d,e,j
Dangerous Chemicals (Pesticides, Drugs)	Amounts in waste often in excess of drinking water standards, unaffected by water treatment.			b,c,d,e,j

See text for explanation.

Figure 1

It should be noted that this is an abbreviated list and that average values are used for clarity. None of these processes could be used alone, and several systems are being evaluated in pilot plant installations. The cost of fresh water treatment is roughly 22 to 25c per 1000 gallons. Therefore, the cost of buying raw water must rise to the level to which advanced treatment costs will drop before reuse becomes economically attractive. This will happen.

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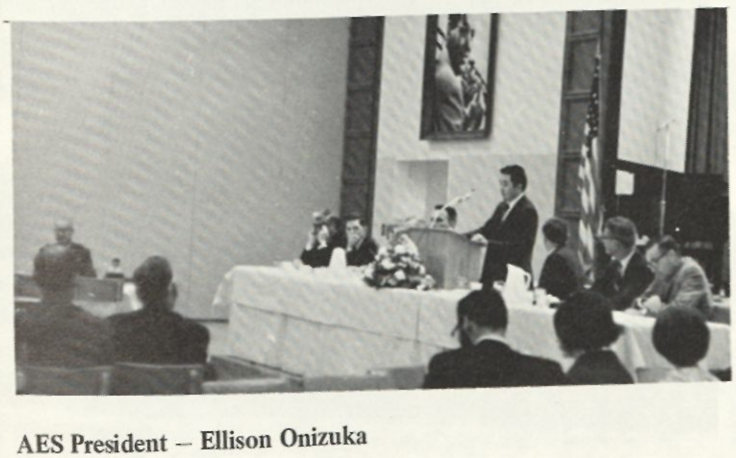
E-Days Luncheon and Convocation

Dr. Rieff of NASA in Washington, D.C. was guest speaker at the Convocation this year. He spoke on developments of engineering in today's society.

Outstanding Senior candidates Ellison Onizuka, Aerospace; Chip Parfet, Architectural; Dave Hattan, Civil.

Chip Parfet – Outstanding Senior



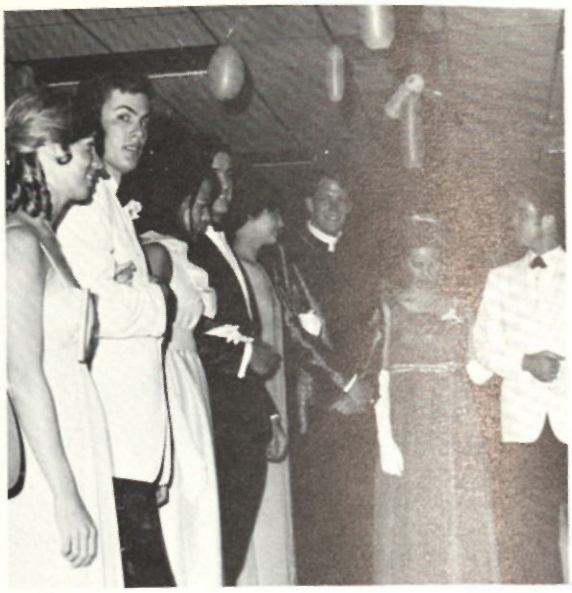
AES President – Ellison Onizuka

Entertainment was provided by the Flagstaff Singers and Rhythmaires (Not pictured).

Your money and your life.

PHOTO: ERNEST BRAUN

The annual Engineering Ball was held for the first time this year in the loggia of the Engineering Center with tremendous success. Music was provided by the Northwest Pedigree and was piped outside by the fountains as well. This event was highlighted by the crowning of the E–Days Queen, Miss Tena Poljanec, a sophomore majoring in electrical engineering. Attendants were Miss Bobbi Beran, Miss Judy Hickey, Miss Susan Gardner, Miss Debbie Hindlemann, and Miss Marianne Golan.

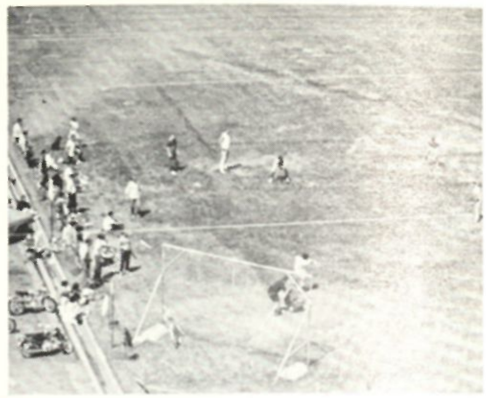


Engineering Ball

Held at the Boulder Resevoir, the E–Days picnic once again proved to be a time for good food, good beer, and lots of fun. Miss Laura Locke, a business major, was chosen Most Perfectly Engineered Coed, and Klass Kramer, a sophomore in electrical engineering, won the raffle for a date with her. Sludge Jorden, Civil Engineering, was voted meanest professor. As a reward, he won a free trip into the resevoir.

E-DAYS Picnic

The Softball tournament was another first for E–Days this year, and it was won by the Civil Engineers. Aerospace came in second. The booby prize goes to EDEE.



Looking Toward the Future

Alan Stage

"Looking for excitement, challenge and opportunity for creativity? Come make a future. . ."

"We select our engineers and scientists carefully. He tends to take care of his own kind."

"Motivate them. Creative freedom, personal satisfaction- and rewards."

"A heck of a good place for an engineer to work." "Not for people."

"Keeps you technologically hot." "Cyrogenics- the science of extreme cold"

"Come with us and be fulfilled." "Be frustrated,"

"there's no end in sight." "Come with us" "An equal opportunity employer"

I would like to express my thanks at this time to the company advertisements of the November, 1968 and the January, 1969, issues of "The Colorado Engineer" from which the above series of quotations were taken. I also recognize that the quotations given have been taken out of context, but space being what it is and in light of the length of the rest of this article, I felt compelled to take certain liberties with material. I also seem to have unwittingly taken the advice of some educators. I have listened for four years and now I am taking a turn at speaking out.

In reading this article I hope that the reader will keep a few basic ideas in mind. I believe that the points put forward in this article are true "in general." Of course there are exceptions but I hazard to guess that the ideas put forward apply to the vast majority. At any rate, the ideas about engineering students presented here apply to at least one student–myself. I have not used statistics to back up my points because in most cases they don't exist and they would only confuse the issue.

The apparent lack of engineering students in student demonstrations or in any controversial student movements has often been attributed to the greater responsibility of engineering students. It appears that engineering students were too busy with studies and found no time to respond to the vocal minority. But upon further investigation we find that the engineering students are also remarkably absent from the service organizations on campus that neither demonstrate nor are particularly controversial.

It appears that the fact of the matter is that there is a general apathy among engineering students concerning involvement in matters outside of engineering. I doubt whether engineering students in general would be able to respond to the vocal minority intelligently because they are by no means well versed in the current issues. The engineer seems to be working on a rationale of being uninvolved in activities not directly related to his engineering career.

The uninvolved engineering student is produced by a path of least resistance towards his engineering courses. There is a feeling among many engineering students that if a course is nonengineering, it is nonessential.

The engineering student expects to be trained by his engineering courses and "socialized" by his nonengineering courses. This "socialization" is far too unadequate; however, I have heard many engineering students complain about it. If the engineering student decides to take on more nonengineering courses he faces more years in school, and the pressure of his draft board.

By virtue of this heavier course load he is induced to keep his nonengineering courses at a minimum. If indeed the study attempts to carry the extremely heavy load for four years he suffers the inevitable drop in that all important grade point average. Few engineering students will risk this since good grades are basically the only thing the University officially recognizes and in fact the only thing the University uses to reinforce the student's sense of accomplishment. A dichotomy between engineering and nonengineering is prevalent.

This dichotomy between the "engineering school" and "the other side" has fostered "intramural education." Paul Goodman notes in, Growing Up Absurd, that:

"Whole areas and provinces of science and scholarship have become merely intramural, they no longer importantly exist as the property of adult academies and learned societies, which in turn have tended to become merely honorary membership that give prizes and sponsor social gatherings. Extramural science is bound to industry, extramural scholarship does not exist at all;"

The "intramural education" of the student in the College of Engineering is most significantly marked by a preponderance of honoraries and societies giving prizes and sponsoring social gatherings. The concern expressed by the honoraries for the man who has more attributes than just a good grade point average is not applicable in practice. Honoraries looking for men with qualities such as "practicality," "sociability," or "exemplary character" are concerned with only a very limited amount of time in which to screen prospective members for attributes which are vaguely defined and hard to observe.

Scholarship however is concretely indicated in grade lists which in practice determine the eligibility of prospective members. It is unfortunate that grades play such a significant role in the rocognition given by honor societies because it does little to stimulate involvement in "the other side."

It is tragic that this rationale of being uninvolved should be perpetuated. It is the Engineers' Creed of the National Society of Professional Engineers that "As a Professional Engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare." But the uninvolved engineer is isolated from the poeple whose welfare he is supposed to better.

How can such an engineer better human welfare? He is isolated from many of his fellow human beings. First he is isolated from the issues discussed by his collegiate counterparts in the humanities. But this group of collegiate counterparts in the humanities is only the highly educated fraction of the less educated masses who have assorted desires and needs. The engineer is also isolated from interaction with the millions of blue collar workers of the country who have their own set of problems. He is isolated from interaction with the minorities who each have a distinct set of their own problems.

He is also very much isolated from interaction with the poor peoples of America whether they are Blacks, Hispanos, Indians, Orientals, or Whites. How many engineers have recently visited a slum? How many engineers have asked a Black in Harlem what he feels about his slum or engineering gadgetry and technological advancements? It seems that the engineer has designated someone else to direct him in pursuit of the betterment of human welfare. This source of direction seems to come from his client and his industrial or governmental employer.

The pre-empting of the means and the brains by the organization, and the shutting out of those who do not conform his trained the engineer to be a bastion of conservatism and conservative types. The engineer is geared and committed to the values of organizational conservatism.

His profession is one of the most highly paid and he will naturally oppose any real threat to upset this condition of economic abundance. He does not wish to personally challenge the industrial complex :since he is payed well and since he is neither encouraged nor trained to be courageous and confortable with people, only with his slide rule. Shielded from adverse effects by the complex he works for, the engineer enjoys his isolated cult.

He is free to dream of a world of utopian technological advancement without having to involve himself immediately with the issues of how his own work is being used. Acknowledging the possibility of future problems with the products of his original design, he feels perfectly confident that he can go to the drawing board again and produce a new design that will rectify the damaging aspects of his original design.

He procrastinates indefinitely and he hands the political questions of the use of technology to another unwitting group while taking a stand of benevolent neutrality.

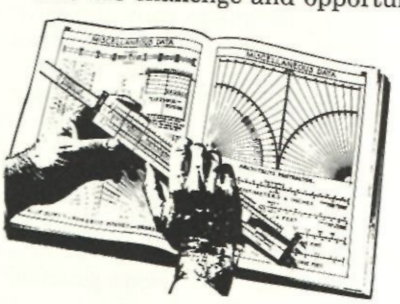
The engineer has relegated a vast field of political and moral questions to his employer or client. The engineer rarely speaks out on political and moral questions concerning his work and even more rarely acts contrary to his employer's or client's desires for political or moral reasons.

The position of benevolent neutrality of the engineer is neither benevolent nor neutral. As Stuart Umbleby notes in the November, 1968 issue of "The Colorado Engineer," "Existing policies in any organization are at least a little out of date. Existing policies are rarely if ever solely the product of the minds of enlightened men." Not only does the public face the existing policies but modern business has brought us a new policy maker. More and more the engineer is appearing in policy making positions. Whether our unenlightened engineer feels responsible or not he is often the one making policy decisions.

In the January 24, 1969 issue of "Time" magazine we note that, "According to Economist John Kenneth Galbraith, the efficiency of these corporate cornucopias reflects the fact that decisive power within them is exercised not so much by headstrong top leaders as by an unemotional "technostructure" composed of specialized middle-level experts."

The resulting influence on American taste and values has been the installation of the mediocre and sometimes the baneful (such as polution). The engineer is by no means entirely to blame but he can not remain neutral when he can be benign. The engineer must seriously take up his commitment to human welfare by first obtaining a better background in human understanding.

In my mind the whole concept of engineering education should be re-examined. The position of the engineer in society has been obtained without legitimate proof of the engineers' interest in human welfare. At present, the engineer demonstrates little desire to be a part of the human community. In the future, I hope there will be more engineering responsibility towards human welfare.



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Cathodic Protection Saves Money for Pipeline Companies

Chas Andreson

Pipeline companies, with their extensive and complex pipe systems expanding throughout the United States, are the common carriers of product fuels and crude oil. Because these pipes are of iron composition, and are buried beneath the ground, they are exposed, at sometime or another, to corrosion. It is this corrosion which costs the U. S. ten billion dollars each year.[1] What can be done to combat these conditions and spare our country of this great expense? The answer to this question is up to the newly formed group of people called the corrosive engineers. Let us now turn to what causes corrosion and then to one of the solutions of the corrosive engineer in combating corriosio–that of cathodic protection.

Electricity is the prime mover of metal. In corrosion, there are two types of electric cells; the galvanic cell and the electrolytic cell. In galvanic cells, current flows from the pipe to the soil due to the chemistry of the metal and the surrounding soil. The corrosive portion where the current leaves the pipe is called the anode and the area is said to be anodic. The galvanic cell circuit is completed by current flowing through the soil and being picked up at another place on the pipeline. The place where this current is picked up on the pipe is the positive cathode and the area is called cathodic. Galvanic corrosion can be exemplified by explaining how a flashlight battery works. (See figure 1.)

The zinc case is one electrode and the cargon rod is the other. The two are suspended in an electrolyte and allowed to react chemically. The current flows from the anode, which is the zinc case, to the carbon-rod cathode. This principle of corrosion to the galvanic cell can also be exemplified by the reaction of two dissimilar metals or pipelines. (See figure 2.) When an existing pipeline is attached to a new, shiny pipe as a part of the system, corrosion will occur. The new pipe will corrode and become the anode; the old pipe will be the cathode, and the earth will be the electrolyte.

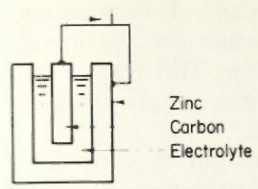
Oxygen deficiencies may be another corrosion factor in the galvanic cell. (See figure 3.) This condition arises where wet soil produces a more concentrated electrolyte than that found in adjacent sections of drier earth. Compact clays or mucky soil contain less oxygen than soils such as sandy loam. Also relative to the principle of soil corrosion in the galvanic cell are the differences of aeration and moisture conditions. This can be exemplified by an antpile, or by a pipeline which runs parallel to an irrigation canal. (See figure 4).

The electrolyte cell operates in a different manner than the galvanic cell. Current is induced into the system by an external source. Examples of external sources would be stray ground currents from extra high-voltage direct current transmission, electric railroads, and external corrosion rectifiers. The movement of this type of current flow can be compared to the movement of a river; that is, current will travel through the electrolyte in the path of least resistance. In electrolytic corrosion, the pipeline picks up stray current at a place called the cathode and dissipates it at another point called the anode. The anodic area is the place where the current leaves the pipeline with the resulting displacement of metal. (See figure 5.)

Now that we understand what causes corrosion, let us turn to a solution to combat it–that of cathodic protection. Since the field of cathodic protection is new, there is an unanswered question as to which procedure and system to use. In order to avoid any chance of electrolytic corrosion, the corrosion engineer must be totally aware of all possible sources of stray currents near his pipeline. For example, a stray current might come from a rectifier cathodically protecting a paralleling pipeline and the result is electrolytic corrosion of this pipeline. The corrosion engineer must make arrangements to either shut down the neighbouring rectifier current source of connect his own pipeline system to the rectifier.

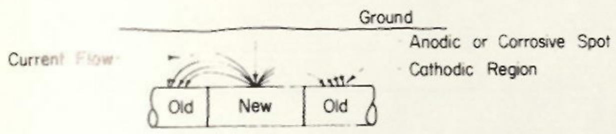
In my brief experience with cathodic protection, I have become familiar with two methods for determining the impressed current requirement for overcoming galvanic corrosion. The first of these methods is called "pipe-to-soil".

Figure 1



Battery Cell – An Example of Galvanic Corrosion

Figure 2.



Galvanic Corrosion Cell – New and Old Pipe Joined

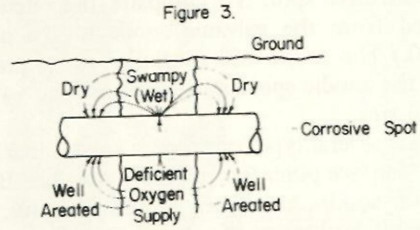
(See figure 6.) This is an effective means for determining corrosive areas along bare, buried pipeline. The basic equipment for this type of corrosion survey consists of one copper sulfate electrode, one voltage meter, and one spool of wire, approximately one-half mile in length. The circuit consists of the current travelling from the copper-sulfate electrode through a wire to the positive terminal of the voltage meter and returning from the negative terminal to the pipe. This circuit is closed whenever the copper-sulfate electrode is placed on the ground. Readings are taken every twenty-five feet "on" and "off" the pipeline. The "on" reading is taken directly above the pipeline and the "off" reading is taken ten feet perpendicular to the pipe at the point where the "on" reading was taken. The "off" reading is the base potential, the normal or static potential at a given point on the ground. The "on" reading is the potential due to pipeline corrosion, if any exists. (See figure 7.) If the "on" voltage reading is greater than the "off" voltage reading, the area is said to be anodic or corrosive. This procedure is repeated until the spool of wire is depleted. After the survey has been completed, the data is interpreted for the number of corrosive areas grouped closely together (one to two mile range).

When the survey has been made, one of two possible methods must be chosen for impressing current into the pipeline. Impressed current can be made available by either a rectifier system or by galvanic anodes. Since the pipe-to-soil survey determines only corrosive areas and not exact points of corrosion, and whereas the galvanic anode has limited coverage (ten to twenty-five feet), the rectifier system should be selected economically for its ability to extend coverage (one to two miles). The rectifier-system will be a sure way to avoid missing any possible corrosion points which would be likely should galvanic anodes be installed in the predetermined corrosion area.

The rectifier supplies direct current to special iron-alloy anodes buried at intervals perpendicular to the pipe for maximum coverage. (See figure 8.) A typical set-up might have the first anode one hundred-fifty feet from the pipeline with each successive anode at ten to twenty feet from the previous anode. When the circuit is closed, current is impressed on the pipeline, and all corrosive, anodic areas transform into cathodic areas. Total cathodic protection will occur only when the impressed current exceeds the current flowing from the anodic area. On bare pipe, some corrosive areas may require more impressed current than can be supplied by the rectifier. This renders the pipe-to-soil survey-rectifier combination somewhat inadequate for bare pipe, compared to the surface potential survey-galvanic anode combination, which will be discussed later. On the other hand, new pipeline systems which are coated and wrapped with protective materials require little current and the rectifier system is almost one-hundred per cent efficient in maintaining ample impressed current. It is important to note that if any other pipelines or buried metal surfaces are not tied into the rectifier, they will pick up the impressed current flow as stray ground currents and corrode due to electrolytic action.

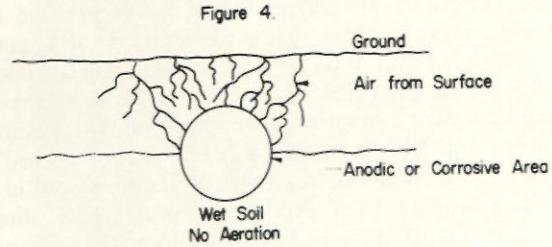
The other method used for determining corrosion in bare pipelines is called the "surface potential" method. Unlike the "pipe-to-soil" procedure, this method can pinpoint exactly corrosive spots on pipeline. The basic equipment required for this method is two copper sulfate electrodes, one voltage meter, and ten feet of low-resistance wire. Each copper sulfate electrode is connected to a terminal of the voltage meter and the circuit is closed when the two copper sulfate electrodes are placed on the ground. The entire system is portable and can be taken through any terrain. The two electrodes are repeatedly moved simultaneously at ten-foot intervals directly in line with the pipe until a corrosive area is found. The best procedure for finding an anodic area is to take potential readings every ten feet until a lange positive-to-negative area or negative-to-positive reversal occurs. This constitutes a corrosive area. (See figure 9.) To

Figure 3.



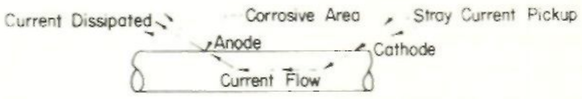
Galvanic Corrosion Due to Deficient Oxygen Supply

Figure 4.



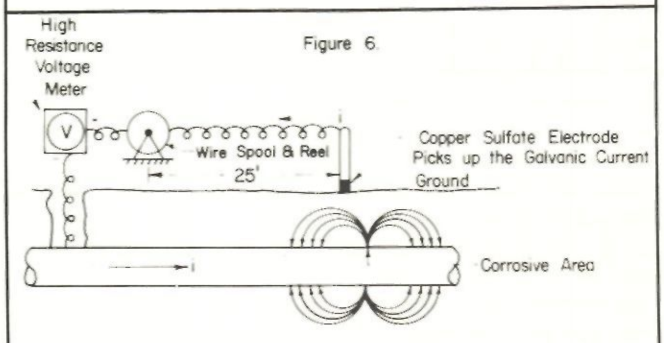
Galvanic Corrosion Due to Differences in Wet and Areated Soil

Figure 5



Electrolytic Corrosion – Stray Current on Pipeline

Figure 6



Pipe – to – Soil Survey

exactly pinpoint the spot of corrosion the electrodes should be moved toward each other by trial-and-error until the reading is null (zero). The exact point of corrosion then exists half-way between the two electrodes. After the first several corrosive spots have been determined, the pipe should be dug up and inspected. A relative correlation is then made between the severity in corrosion and the magnitude of current reversals. This correlation can be used for the rest of the pipeline survey in determining the magnitude of a reversal sufficient to require cathodic protection.

By pinpointing the corrosive spot, external current can be accurately supplied to a small area by a galvanic anode. To activate the anode, it is first buried in a prewatered hole next to the corrosive spot. To complete the circuit, a wire is connected from the galvanic anode to the pipeline. (See figure 10.) The anode will centralize the impressed current flow on the anodic spot and transform it into a cathodically protected area.

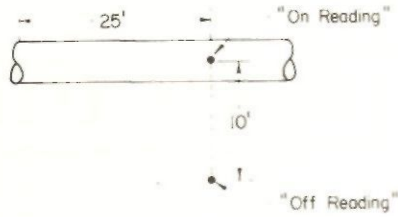
There are several types of galvanic anodes that may be used with the "surface potential" method of surber. Both zinc and magnesium anodes have been proven effective. The output efficiency of both type of galvanic anodes is relative to the soil conditions. Soil with low resistance is essential in maintaining 1.7-volt output for zinc and 1.55-volt output for magnesium. With ideal soil conditions, these anodes may protect up to thirty feet of pipeline.

Pipeline companies are also in the economic position to cathodically protect their pumping stations and tank bottoms. Since the cost of repair work for replacing corroded pipe in this intricate network is so high, an effective means of supplying impressed current must be employed. The method with which I am familiar is called a "deep-well ground bed". A rectifier supplies current to a series of anodes placed in a well hole extending to a depth of approximately three hundred feet. (See figures 11 and 12.) This gives maximum protection for a circumferential geometry such as a pumping station. The number of anodes used will be proportional to the amount of current needed to protect the system.

It must be remembered that any type of anode output is maintained by the law, E=IR. If the anodes are to be at all effective, the soil between the anode(s) and the pipeline should be low in resistance. If high-resistance soil is present, the anode will not function and current will not flow properly to the pipeline. Therefore, it is this case of highly resistant soil that inhibits galvanic anodes and rectifier forms of cathodic protection.

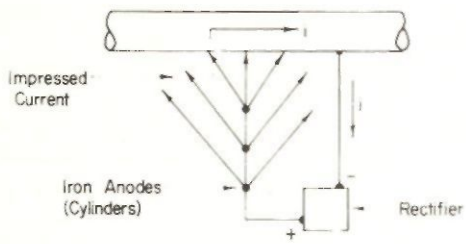
Both electrolytic and galvanic corrosion are serious, and if any element of a process is missing, corrosion cannot occur. It is, therefore, up to the corrosive engineer to take a step out of the cycle. This is what has been employed in previously mentioned cathodic (anode-to-cathode

Figure 7



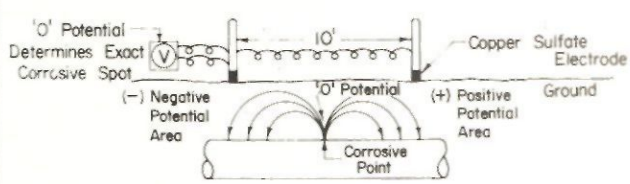
Top View of "Pipe-to-Soil" Survey

Figure 8



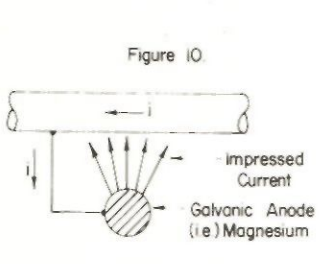
Cathodic Protection (Top View)
Impressed Current by Rectifier System

Figure 9



Surface Potential Method for Determining Corrosive Spots

Figure 10



Galvanic Anode Impressing Current to a Corrosive Point (Top View)

Figure 11. (above) These are iron anodes being layed out for easy access just before lowering into the deep-well ground bed.

Figure 12. (right) This is the sixth anode being attached to the lowering pipe.

transformation) protection. It might be of interest here to note, without any discussion, two methods other than cathodic protection used by the corrosive engineer: those of a chemical attack on reactions at metallic surfaces, and of coatings of electrical insulation used with cathodic protection.

In summary, cathodic protection supplies current via circuit to the pipeline by either galvanic anodes or power rectifiers. This applied current impresses the current coming from the anodic area in a reverse direction, thus halting the corrosion of the pipe.

The subject of corrosion is very open-ended, due to the many variables. This essay covers only my brief experience and is by no means conclusive. I do, however, feel that a good cathodic protection program will pat for itself in a short time, and return the investment many times over. It takes economic evaluation, planning, and organization on the part of the corrosion engineer to make a return on these investments.

Marry not an Engineer

Verily I say unto you, marry not an engineer; for the engineer is a strange being possessed by many devices; yea, he speaketh in parables which he calleth formulae, and he wieldeth a big stick which he calleth a slide rule; he hath but one bible—a handbook.

He talketh away of stresses and strains and of no end of thermodynamics; he showeth always a serious aspect and seemeth not to know how to smile; and he picketh his seat on the car by the number of springs therein and not by the damsel thereon. Neither does he know a waterfall except for its power, not a sunset but for its specific heat.

Always he carrieth books with him, and he entertaineth his maiden with steam tables. Verily, though the damsel expecteth chocolates, when he calleth, he opens the package to reveal samples of a new alloy.

Yea, he holdeth a damsel's hand, but only to measure the friction, and he kisseth only to test viscosity. For in his eye shineth a faraway look which is neither love nor longing, but a vain attempt to remember an equation.

Even as a little boy, he pulleth a girl's hair but to test its elasticity, and as a man he discovereth different devices, for he would hold a maiden to his bosom only to count the palpitations of her heart, and to reckon the strength of her material.

Alas! his marriage is a simultaneous equation, involving two unknowns and yielding a periodic function.

Anonymous

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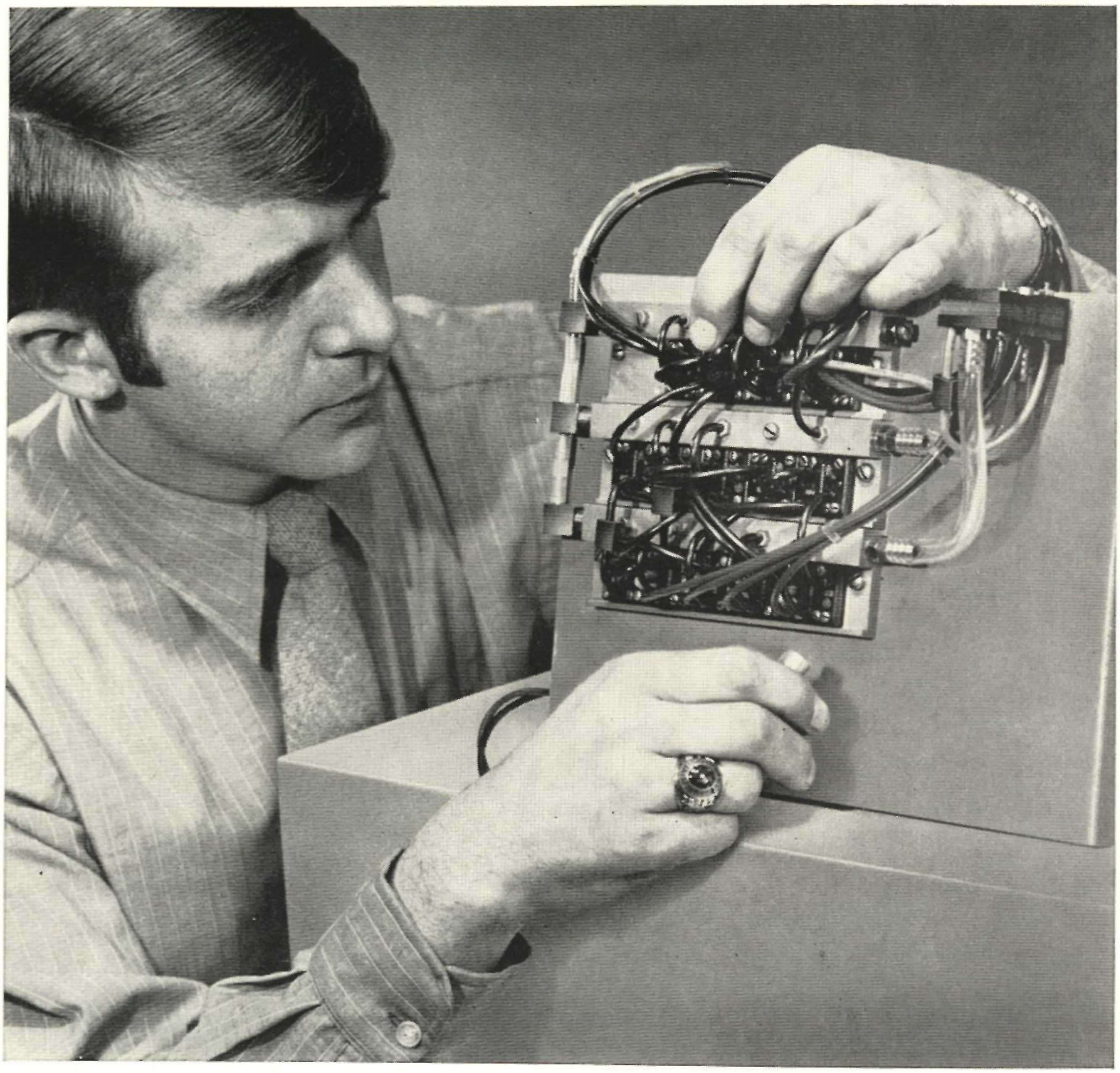

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