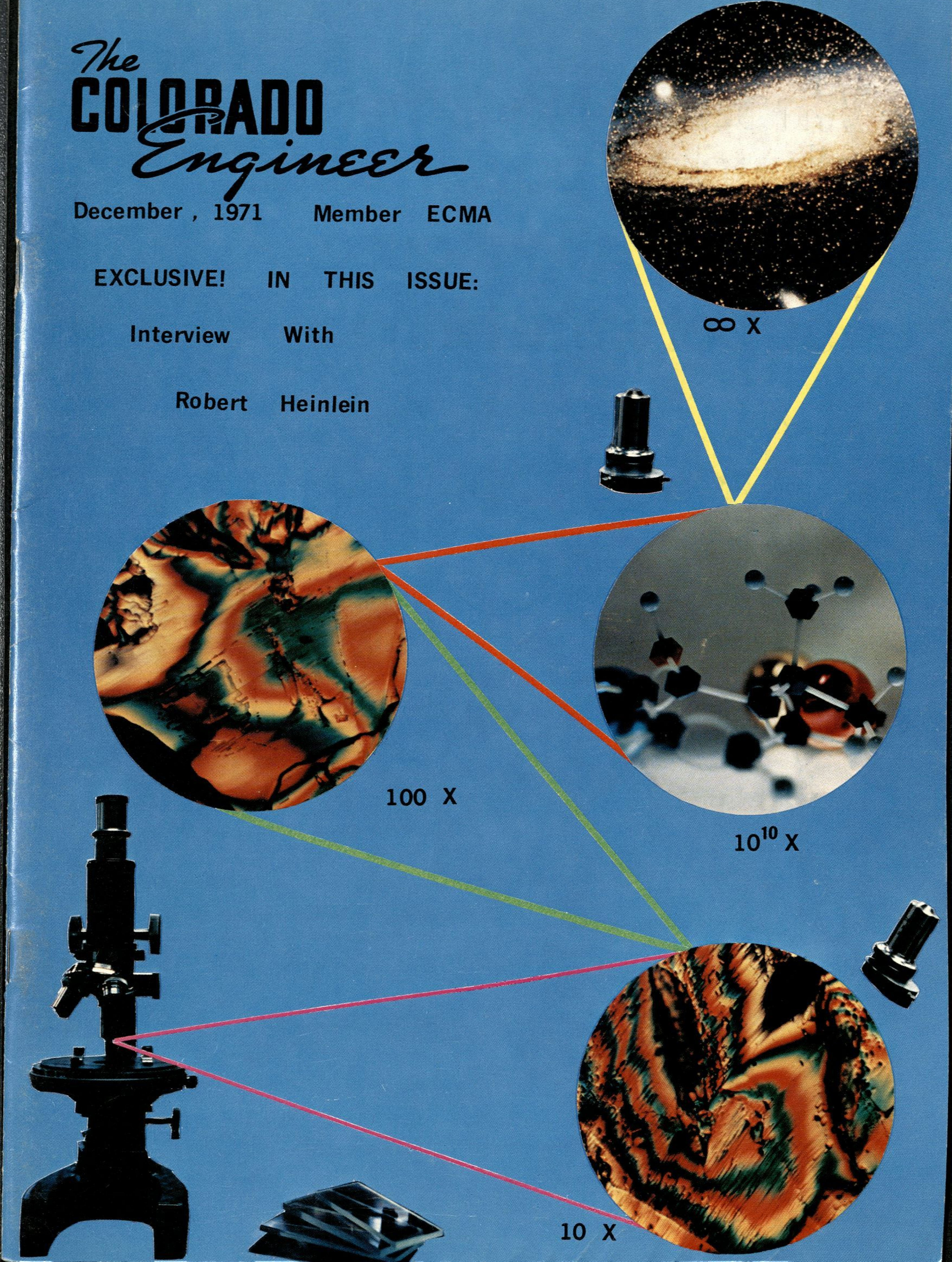
The COLORADO Engineer

December , 1971 Member ECMA

EXCLUSIVE! IN THIS ISSUE:

Interview With

Robert Heinlein



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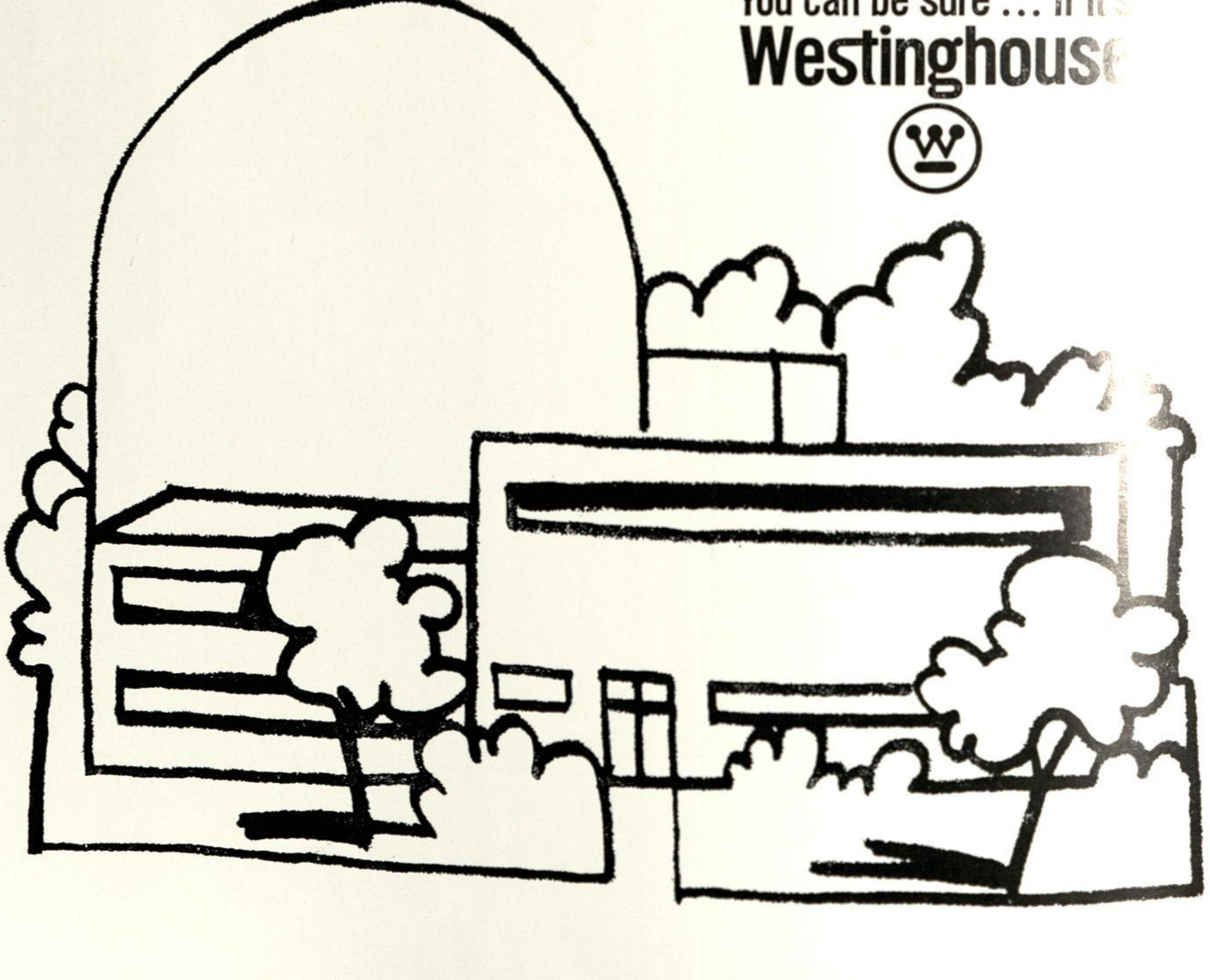

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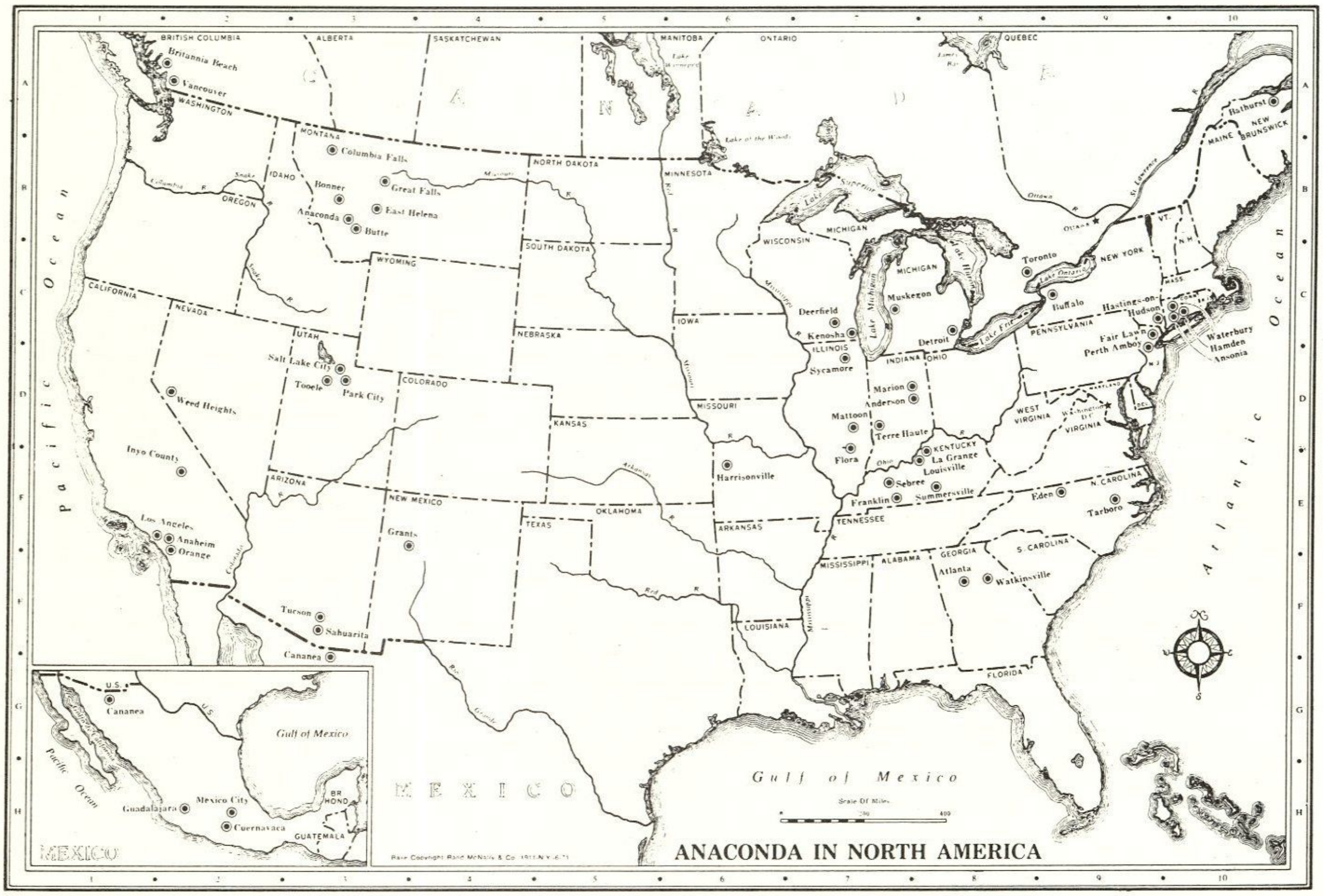

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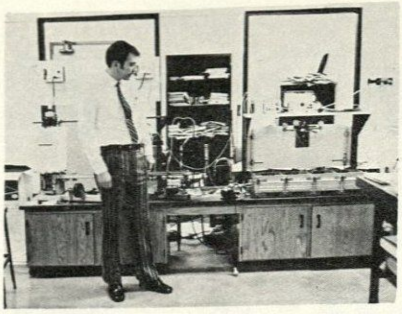

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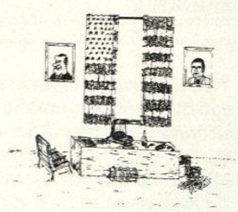

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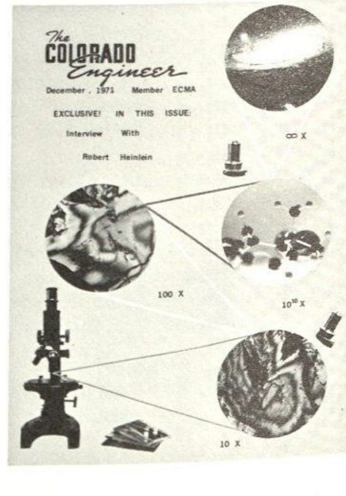
MEMBER ECMA

IN THIS ISSUE

STAFF

ABOUT THE COVER; "You can often find the greatest and most magnificent in the smallest and most humble." This month's cover by Ron Fattor, Joe Sencenbaugh, and Dave Slusher (using an exclusive technique to achieve infinite magnification) depicts this truth in these views of Thymol crystals under polarized light. Our thanks also to the T.A.'s of Chem 571 Lab for their assistance and cooperation in this endeavor.



From the Editor's Desk

GIVE A DAMN AND TRY!

Welcome, brave new baby, welcome to the Rat Race! Don't make waves, play it cool. It would seem that we have developed a strong hatred of encounter, to get involved, to personally act.

The result? Cynicism becomes an acceptable life-style. Nietzche becomes a popular philosopher. A diminishing trust in man's abilities to act in a sane, humanitarian fashion. And why not? We see Vietnam, the Middle East, Northern Ireland, West Pakistan, and the decaying urban hell of stinking ghettos and poverty regions in our own country. No one is going to argue that man has made a royal mess of things. But if life isn't what it *should be*, the least we can do is work to make it what it *can be*! To criticize–without doing anything constructive–is an empty show of cowardice, stupidity, and hypocrisy. There has never been a shortage of critics and Monday-morning quarterbacks (who would have been "too noble" to commit the acts they freely criticize). But men of personal action and commitment are rare. Honest dissent is fine, *but it isn't worth one damn UNLESS it gets a person mad enough to step up and be counted in the forces of change.* All the give-em-hell speeches and TV documentaries ever produced won't feed one hungry mouth or fight one injustice *unless* someone decides to take the reins of action and *do something*! It requires nothing to give lip-service, to oppose some great wrong or tragedy occurring 2,000 miles away, and sigh "what a pity", while you're holding a cocktail glass in a warm home. Copping-out is easy.

Personal action to change is a different matter. It takes something special. It takes *guts*. Whether in taking 20 minutes to write a letter to a congressman, or working 20 hours a day in the Peace Corps, it requires one to care enough to *do* something and *get personally, freely involved.*

But perhaps you claim it doesn't concern you, perhaps you're a charter member of the famous (infamous?) "Silent Majority." Pick up a Life magazine and look at emancipated refugees, 2-year-old skin-covered skeletons with bloated bellies and sunken eyes. Or go to a hospital and try sitting next to a person moaning in sedated agony from some uncured disease. Or watch a documentary on the Vietnam wounded and dying (or take a trip to the local airport and watch a flag-draped coffin being unloaded from a plane just back from Vietnam). *Then* try saying "it doesn't concern me."

The emphasis on personal action is not unique to any particular philosophy. Whether it is the concept of "Love your fellow man as yourself" (Christ), an "I-Thou" relation to humanity (Martin Buber), the Eight-Fold path of Buddha, the concept of "spiritual maturity" (Hinduism), or the principle of "dynamic selfishness" (Adam Smith, "The Wealth of Nations," an economic treatise) – it all boils down to the same basic idea: Man himself advances only through others, through mankind in general. For in furthering others, we ultimately further ourselves. Granted, this is not easy; being concerned and being able *to do something constructive* takes work, knowledge, ability, and - most important - self-discipline and honesty to the cause at hand. The last of these is often the hardest.

Ecology is "Hot Topic" on today's scene, yet it is ironic to see people campaigning for the environment while they light up a cigarette and blow smoke in your face as they emphatically emphasize the need for "Clean Air" and vehemently condemn those "damn polluters who get away with it." We see many so-called "aware" or "concerned" dissenters who bitch about Pakistan refugees and poverty and, then, go blow their paycheck on booze or pot and vow that if *they* were in control, things would be different - if *they* were in *control*? - more appropriately, if they had the *GUTS* and personal honesty to do something constructive about the situations they abhor, instead of dropping into a nice escapist dream world, only to emerge and yell some more about the mistakes of others. *There are too many people who need help, too many diseases to cure*, too many wars to end, before we can afford the luxury of empty escapism.

It's often tough to care, to get involved, to change; but, then, anything really worth a damn always is. It has always taken time, effort, blood, sweat, and tears, and the results have often been disappointing; but to do nothing is to already admit you've been defeated.

We have seen that the leaders of history never tried to "play it cool" and please everybody in order to avoid trouble. They did what was *just* and *right*, no matter how it shocked the "righteous" politicians or apathetic public. As men of applied and goal-oriented science, we have a unique opportunity to really *DO* something constructive, to make this world a little better - and not only in beneficial technical achievements, but - just as importantly - man-to-man. Even if only nominally so, it will still be far better to "light one candle than to remain in darkness."

We are all going to make mistakes and misjudgments sooner or later, since perfection does not exist for man. But, as has been pointed out by a famous medical scientist: *"What has distinguished the true leaders of humanity is an awareness of importance and a conscious effort to constantly improve oneself."* True, this is very idealistic. But then again, *idealism points to constructive reality. Without idealism we cannot even head in the right direction.* Those who scorn altruism and idealism, in effect, deny the potential of humanity and call man an irrational animal, not really capable of being a causal agent in his own destiny.

Not all of us can be Lincolns or powerful leaders, but we *can*, to our own capacity, do something to make life a little easier for *someone*, in some fashion. Look around you; you won't have to look far. There *is room for optimism* – not "passive optimism" (just sit back and let some unseen force straighten things out; all will naturally turn out well) but rather, *dynamic optimism*, which relies on man's own *action and ability to care*, to be effective. Its concepts are best summed up in the words of the late John F. Kennedy: "My fellow citizens of the world: Ask not what America will do for you, but what together we can do for the freedom of man. – Finally, whether you are citizens of America or citizens of the world, ask of us here the same high standards of strength and sacrifice which we ask of you. With a good conscience our only sure reward, with history the final judge of our deeds, let us go forth to lead the land we love, asking His blessing and His help, but knowing that here on earth God's work must truly be our own." (Excerpt from address given Jan. 20, 1961, Washington, D.C.)

Have YOU got what it takes?

Ron A. Vattor

Dean's Column

THE ECPD AND ENGINEERING EDUCATION

As I read and listen to some of the comments of our students about engineering education, I become aware that we are probably not doing as much as we should in providing information relative to the conduct of the affairs of our great profession and the why behind many of the things our students experience in our College and in the engineering curricula. To begin with, let's be careful to remind ourselves that we are a profession and as such are charged with a great responsibility. Professor Allen Rosenstein stated this concept in a study report at UCLA and I quote, "Collectively the professions occupy a unique position in society. Their functions can be characterized by the one word, responsibility. Responsibility calls for training and judgment. Society often attempts to insure levels of professional competence by specifying educational minima, requiring examinations and issuing professional licenses. The special competence often demanded of the professional man is a measure of society's dependence upon professional decisions, for the world of the professional is a decision-making arena. Society expects action from the professional. No matter how imperfect his tools or understanding, the problems he faces cannot be avoided; they demand solutions. It is an overriding characteristic of the professions that decisions must be made in the face of incomplete knowledge and with the finite probability of failure. At the same time, the professional very often carries the attendant moral, legal or ethical responsibility for his decisions. It seems only reasonable then to assume that the prime responsibility of the professional school must be the preparation of men who will understand and discharge the obligations of the profession."[1]

To insure that the college curricula fulfills this responsibility represents no small task. It requires a great deal of thought, planning, organization, and the work of many dedicated people. I would like to tell you a little about one of the many important organizations that is charged to continually work toward this end. This is the Engineering Council for Professional Development (ECPD). The prime purpose of this organization is to promote and advance all phases of engineering education with a view to the promotion of the public welfare through the development of the better educated engineer, engineering technician, and engineering technologist, and to carry out a program of guidance of pre-college students, to formulate and maintain high educational standards for colleges of engineering and engineering technology, to assist such colleges in planning and carrying out their educational programs at all levels, to cooperate with state licensing agencies, and to promote the intellectual development of the young engineer. The Board of Directors of the ECPD accomplishes its purposes through nine standing committees, one of which is the Engineering Education and Accreditation Committee. The purpose of accrediting is to identify those institutions which offer professional curricula in engineering worthy of recognition as such. The ECPD is recognized by the National Commission in Accrediting as the sole agency responsible for the accreditation of curricula leading to first degrees in engineering. A detailed description of the criteria and procedures was set forth in the 1970 Annual Report, some of which are as follows:

CRITERIA

Engineering curricula considered for accreditation must be designed to prepare graduates for the practice of engineering at a professional level. The general objectives in accrediting would be the assurance of an adequate foundation in science, humanities and the social sciences, engineering science, introduction to engineering methods, and engineering while providing sufficient flexibility in science requirements to accommodate curricula requiring special backgrounds, such as life science or earth science. They are regarded as a statement of principles to be applied with judgment in each case rather than with arbitrary rigidity. Finally, they are intended to encourage and stimulate but never to restrain the creative and imaginative.

An engineering curriculum acceptable to ECPD normally will be characterized by:

a. The equivalent of approximately two and one-half years devoted to mathematics, the basic sciences, the engineering sciences and the integration of these into a meaningful educational experience directed toward the development of the ability to apply pertinent knowledge to the identification and the solution of practical engineering problems.

b. The equivalent of one-half year to one full year as the minimum content in the area of the humanities and social sciences. This program should be designed to reflect a rationale or fulfill an objective appropriate to the engineering profession and the institution's educational objective. Courses treating subjects such as accounting, industrial management, finance, personnel administration, introductory language, and ROTC normally do not fulfill this objective regardless of their general value in the total engineering curriculum. The remainder of the time in the curriculum to fill out the 4 academic years is then available for the full implementation of educational objectives of the areas listed in parts a and b above.

The pressures on four-year engineering curricula for strengthening the scientific approach to engineering and the social-humanistic content make it necessary that neither inadequate admission requirements nor additional academic objectives be allowed to compromise the standards inherent in these criteria. The engineering student taking an additional program in a field such as business, law, education, and advanced military science is in effect pursuing two curricula with separate and different professional requirements and objectives. A realistic view recognizes that such dual-purpose programs require more than the normal four academic years.

PROCEDURE

Consideration of curricula with a view toward accrediting is done at the invitation of the institution. The procedures usually call for written documentation from the requesting institution and a 1-3 day site inspection conducted by a team appointed by the committee. The written portion includes a comprehensive questionnaire and report on all aspects of the institution and the curriculum to be accredited. The site inspection includes for examination of student records and faculty vitae, personal interviews with faculty, students and the administration at all levels and the inspection of laboratory equipment and physical facilities, including the libraries. The committee is prepared to examine for approval any curriculum that appears likely to satisfy its criteria for an engineering curriculum leading to a first professional degree.

Accreditation of a curriculum is granted for a specified period, usually two, four, or six years, when conditions are considered as meeting or exceeding minimum overall requirements. Action is based on conditions as they exist at the time of the institution's report or the campus visit.

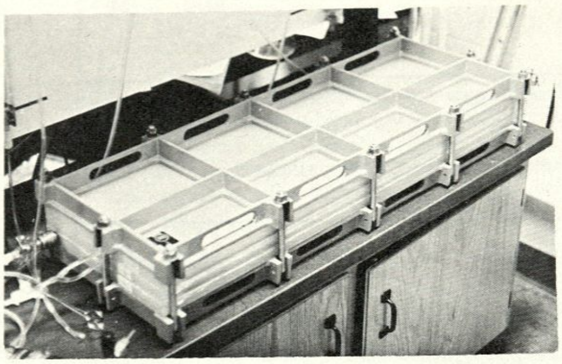
A comprehensive evaluation of the total program under ECPD purview at an institution, will be held at intervals not exceeding six years. Also, if for any reason the future appears precarious, or definite weaknesses exist which should be strengthened, the accreditation will be granted for a shorter period, usually two or four years.

As a taxpayer and a professional engineer myself, the value of accreditation for a state universities' programs is self-evident. If we then accept that accreditation is something we should have, it is apparent that a four year curricula, operating within its constraints, is going to be a crowded and a demanding one. Today's student should seek the best education he is capable of absorbing and should acknowledge his commitment to preparation for a professional status. While the curricula he pursues may seem at the moment to be less exciting and more confining than that of his liberal arts contemporary on the campus, I would suggest that in the end result the engineering student will be receiving the truly liberal education, one that includes the humanities and social studies as well as mathematics, science and the professions, and one that is safeguarded by established and recognized accreditation procedures to insure its quality and standards.

[1]A Study of a Profession and Professional Education, the final publication and recommendations of the UCLA Educational Development Program, Allen B. Rosenstein, 1969.

Associate Dean George J. Maler

ARTIFICIAL KIDNEY



It looks simple, but it can save 10,000 lives a year. This is a commercial version of a Kil Kidney, manufactured in Denver and used daily at the University of Colorado Medical Center. (The tubes on the left side carry the incoming blood.)

By John Malmstrom, Jr.

We are all aware of what happens when one of the better-known vital body organs quits functioning; if it is the heart, there is a loss of blood pressure which results in cessation of circulation and a corresponding loss of oxygen supply; if the respiratory system fails we "turn blue," and so on. In fact some people are given to the notion that the stomach stands right next to the heart and lungs in importance; that is, when they are hungry. In any case the results of failure are made known immediately, and actions are taken to remedy the situation. But, how much does the average person know about his kidneys? A little, a lot? Is his total knowledge in the area restricted to the general complaint of having to relieve himself too much, too ofter after a pot of coffee or a beer party. Has he realized that their proper functioning and well-being are as important to his health as any other organ, even though the results of failure may be delayed? Rarely, because their functions are not very dramatic. And when they do fail, what can be done? They can be replaced, usually with only one healthy kidney, by means of a transplant. However, the body needs to be maintained while a search is made for a suitable new kidney, and, more importantly, the new kidney will require aid while adjusting to its new environment. And so, the development of a mediary is necessary: an artificial kidney (hemodialyzer). This kidney also finds demand in short term situations and in cases where no acceptable kidney donor can be found. Its development requires a mimicry of the efficiency of the system it has replaced. And to make it readily available, it must be a low-cost instrument, while satisfying the additional demands of portability, size (remember it must replace something which can be held within the palm of the hand), and simplicity.

Healthy kidneys perform five life functions at their location at the lower back. Here they remove wastes from the blood, regulate the internal chemistry of the body, regulate the amount of water in the body, help to regulate blood pressure, and help to control red blood cell production. These processes are carried on around the clock, regardless of the activities being performed. And if they fail, their jobs must be supplemented or taken over by an artificial kidney, which in the present state of the art only performs the former three functions. The artificial kidney is used under conditions of acute or chronic kidney failure and poisoning. In the latter case an accidental or intentional overdose of a chemical or material normally removed by the kidney can cause permanent kidney damage. It can also lead to the irreversible damage of other vital organs (e.g. brain, liver) if the kidney cannot remove the poison quickly enough. Under these circumstances an artificial kidney can relieve overloads on the system and prevent permanent damage. When a person suffers from acute kidney failure his kidneys have suddenly ceased to function. This occurs when a person has suffered injury or shock, as in accidents and battlefield situations, has been sick or possesses body abnormalities (scarlet fever, edema, high blood pressure), or has had various passages in his kidneys blocked. When the above happens there exists a decrease in urination accompanied by chemical imbalances and waste build-ups in the body. In this case the use of the hemodialyzer allows the kidney to rest and recover in anticipation of resumption of its functions. The artificial kidney, though helpful in the above, is really intended for use by the person who suffers from chronic kidney failure, a condition brought about when the kidneys are slowly destroyed by disease. This type of failure is caused by, among other things, prolonged blockage within the kidney and progressive nephritis, and is suggested when high blood pressure or abnormal bleeding occurs. Even under treatment the deterioration of the kidneys is usually progressive with accompanying permanent damage. Eventually the patient will die unless presented with a transplant or placed on an artificial kidney. And so, for all of the above, this supplement to the bodily functions outside of the body takes the place of a vital organ: it eliminates waste products and regulates the fine balance of body composition with respect to water and necessary ionic components.

As mentioned previously the kidney regulates internal chemistries and water levels in the body. Fluids comprise some 50-70% of the total body weight, blood plasma accounting for about 7% of this amount. It is this latter fluid that is being cleansed when an artificial kidney is doing its work. The plasma in turn is composed of various cations and anions, (Table 1), whose relative concentrations under conditions of kidney failure are distorted to higher or lower levels. For example, for the increased retention of various acids, suphate, organic acid, and phosphate will also be retained with an accompanying decrease in the bicarbonate and pH levels, this then leading to metabolic imbalances. Thus, when kidney failure happens the hemodialyzer becomes responsible for both the composition and amount of body fluid.

Perhaps the most familiar of all of the kidney functions is the removal of metabolic and other wastes from the body via the circulatory system, i.e., the dissolved wastes. In the past and in the current design considerations, three metabolites have been the object of selective elimination in blood plasma: urea, uric acid, and creatinine. These were chosen mostly because of the ease of identification and their presence in large, measurable amounts. However, continuing renal research has indicated that science has not even begun to understand the physiology and biochemistry of the kidney. In fact there are a multitude of other metabolic products that accumulate in the kidney. And their presence is difficult to detect since many occur in small, unisolable amounts that are difficult to quantitate by readily available chemical procedures. Besides recognizing these wastes, problems have developed in placing an accurate value on their toxicity. Among the metabolites that have been associated with kidney failure are various phenols, aromatic acids, phosphates, sulphates, and unidentified anions. Recently hypotheses have been made concerning the physical size of wastes on the kidney, not just the chemistry. One theory suggests that 500-1500 molecular weight particles contribute significantly to toxic wastes. And so the search continues for a fundamentally sound definition of function in the kidney. Until this is found, the old criterion of urea, uric acid, and creatine accumulation and disposal will continue to be the basis of design for artificial kidneys. However, it must always be remembered that other, possibly more toxic, substances are being retained, and, though they are being eliminated now quite by chance, their specific removal is of the greatest importance.

All of this is fine for the would-be doctor–function and structure of the kidney. But what can an engineer do in this area? Plenty. Supplementation of kidney functions *per se* has been practiced since the early 1900's. At this time a sterile cleansing solution was simply introduced into the patient's pertoneal cavity, and the removal of wastes was completed by capillary action. Then the solution was drained and discarded. This was inefficient, costly, and painful. Then, during the mid-1950's various engineering disciplines joined forces with medical researchers, primarily chemical and mechanical interests. And they approached the problem just as any typical problem is viewed–by analogies. In this instance they drew upon heat and mass transfer correlations for their models, specifically, conductive and convective forces in conjunction with diffusive and dispersive properties. As was then the case with most engineering problems, they were given large amounts of money and left alone. They worked hard and diligently, analyzing and expressing the functions to be duplicated in terms of elemental rate constants. And the engineers obtained results. Unfortunately the first product of their efforts was somewhat of a "white elephant". Like most committees they were given a "horse" and, after deliberation, their labors, produced a "camel". That is to say, when using heat and mass transfer analogies on a human organ and not having much prior experience in the biological and medical fields, what do you suppose the product looked like? That is correct–it looked just like a heat exchanger. But let us not be critical, they did get results; results which today are saving the lives of hundreds of thousands of people world-wide. In Table 2 are listed a few of the constraints and problems faced then and now in artificial kidney design.

As mentioned, analysis was conducted by the method of analogy; loosely, the study of a problem or system by means of interpreting its properties in terms of a known solvable problem. In the case of heat and mass transfer quite a bit of similarity is drawn from electrical engineering, primarily in fundamental descriptions of both phenomenon. At the time, and in virtually all machines in use today, dialysis (the transport of soluble materials across a porous membrane) is the basis of operation. To allow this to occur, the patient's blood is put into close contact with an "ideal" electrolyte solution, the two being separated only by a semi-permeable membrane. Dialysis then takes place across the structure due to a difference in ionic activity within the two fluids, the side of greater concentration decreasing, as such, until equilibrium is attained. In the case of the artificial kidney, resistances in series for mass transfer at the dialysate-membrane-blood interfaces become the model of choice (Figure 1). Of these three (simplified) resistances, one must remain a constant, another lies within a narrow range, and the third possesses a great variability of values, which depend on the constraints

Table One

Ionic Components of Normal Plasma
(in mEq./L)

Cation	Anion
Sodium - 142	Bicarbonate -27
Potassium - 4	Chloride -103
Calcium - 5	Organic Acid -5
Magnesium - 3	Phosphate -2
	Sulphate -1
	Protein -16

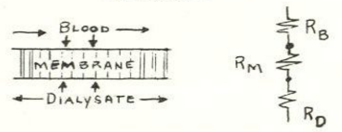
Table Two

Constraints and Problems of Design

1. Low operation pressures
2. Constant temperature system (ca. 98° F)
3. 75% (minimum) transfer of the "defined" body wastes: Urea, Uric Acid, Creatinine.
4. Cost
5. Non-toxic to the body

FIGURE ONE

RESISTANCES AT THE
BLOOD - MEMBRANE - DIALYSATE
INTERFACE



imposed on it. The blood flowing through the artificial kidney represents the former. Here is an excellent example of "do anything you want, but don't damage the merchandise." When considering the hemodialyzer, blood is both the raw material and the finished product. At the time it enters either the healthy or artificial kidney, it is filled with refuse within the blood plasma. In the body the blood is processed and passed on, no worse for wear. But, the real kidney is considerably more efficient than any crude market imitation. Besides, it knows what is good for the body and what is not; the "pretenders" do not even know where to start. And so the "pretender" opts to physically alter or adjust the blood, do its work, and then restore the blood. How can this be done? Well–pressure can be applied; the blood can be diluted or affected chemically; or turbulent flow can be induced (this is the classic answer to mass transfer situations, provided one does not care what happens to the system). Not so! Blood is one of the most sensitive components of the body: it is "torn up" when shearing is applied, loses its "will to live" when compressed, and is absolutely inhospitable to foreign substances. Hurt it, and there goes the whole "show"; the body will not get oxygen, antibodies or nutrition. The problem becomes one of inducing suitable laminer flow; i.e., non-turbulence, to produce an atraumatic pathway. And like it or not, laminer flow is not as critical so much as is the successful establishment of a laminer sublayer. It is across this relatively slow-moving layer that the diffusion to the dialysate takes place. To increase the diffusional gradient drive or differential results in an increase of hemodialyzer efficiency. To enhance this effect, the sublayer must be made thinner, which can be achieved by increased blood velocities (flow rates). However,

Continued on page 18

PROF'S CORNER

During a recent discussion with several students, the question of "who I am?" and "why am I here" came up. One student said he was in engineering school because a high school science teacher encouraged him, while another said he had a great interest in math and physics. The talk turned to what reasons students have for selecting a given course of study in college and even more important, selecting a profession to start a working career. There was general agreement in what reasons were not the most important – status, money and job location among them–but it was much tougher to find what *were* the important reasons. Some confessed a real feeling of being lost but see no other direction to go that seems any better. Others felt they have too much invested in one course of study to be able to change to another that looked more appealing. And then there are those who are excited and joyous in what they are studying and doing. Do these latter ones know something that the rest of us don't? Maybe so.

Out of our discussion, several interesting points came out. First, what kind of individual talents do we each have and how did we get them. It was quite obvious that the talents of the group were widespread with special abilities in writing, speaking, art, music, history and yet a common thread of abilities in math and sciences. Where we got them evoked quite a different response since none of the group would admit to "picking their parents". One member seriously challenged us that these talents were gifts, unearned but freely given as most gifts are. He asked what we normally did with gifts we got. Did we stack the gaily wrapped boxes in a closet, leaving them wrapped and unopened? Indeed we did not! We untied each box and lifted out the present, inspecting and exclaiming over it, and deciding what we could do to make the best of it. Some gifts were ready to use as received while others, like a do-it-yourself kit, needed additional labor. Sometimes, with too many gifts at once, we put some aside to be used later.

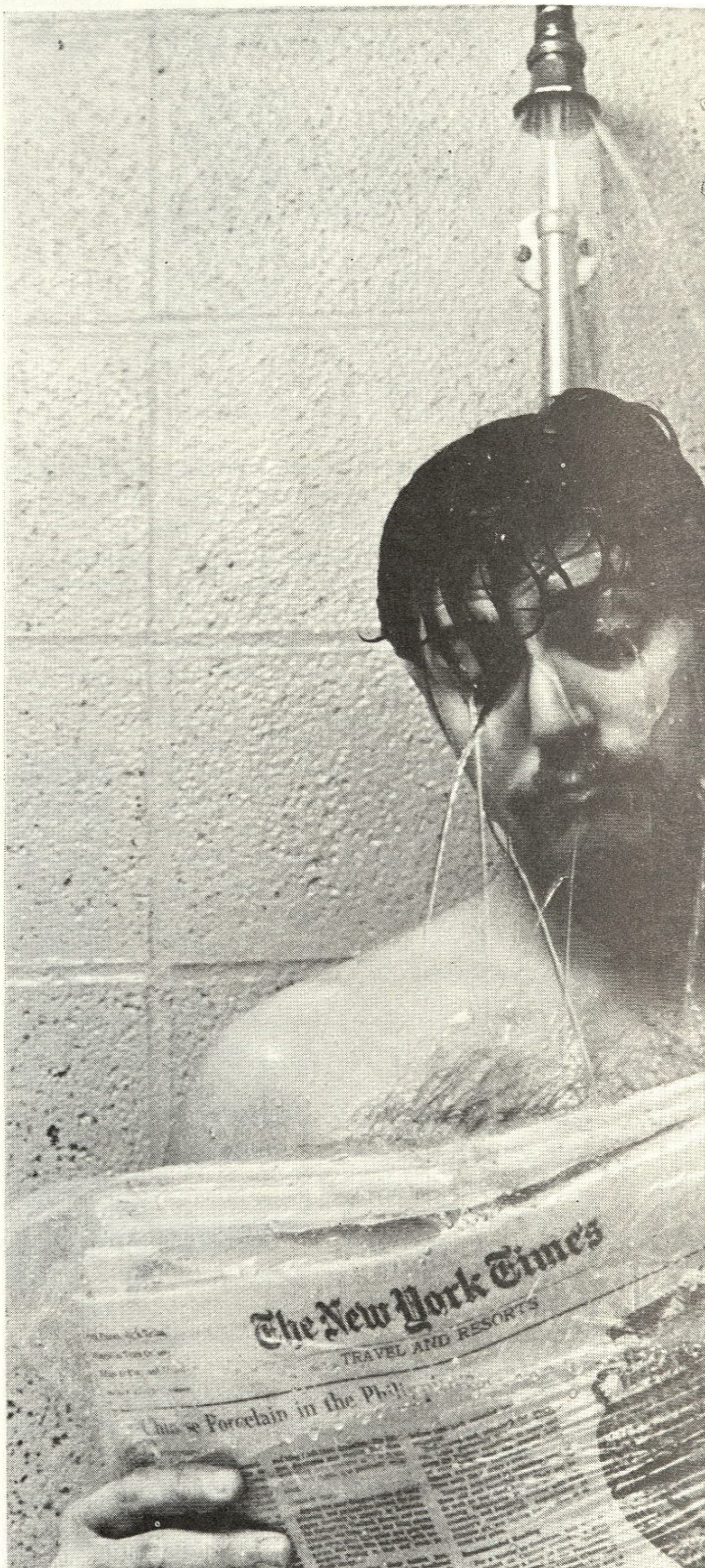
Our friend asked us if we had really looked at ourselves to see what our unique gifts or talents were and, especially, were we making decisions that required the best use of them? He was bold enough to suggest that this kind of a look might provide some fresh sign-posts for the direction our lives might take. He implied that maybe those who seemed excited and joyous were the ones who unwrapped all their gifts, large or small, and after looking them over, decided on the proper importance of each and whether or not they needed additional work and then made the best use of them.

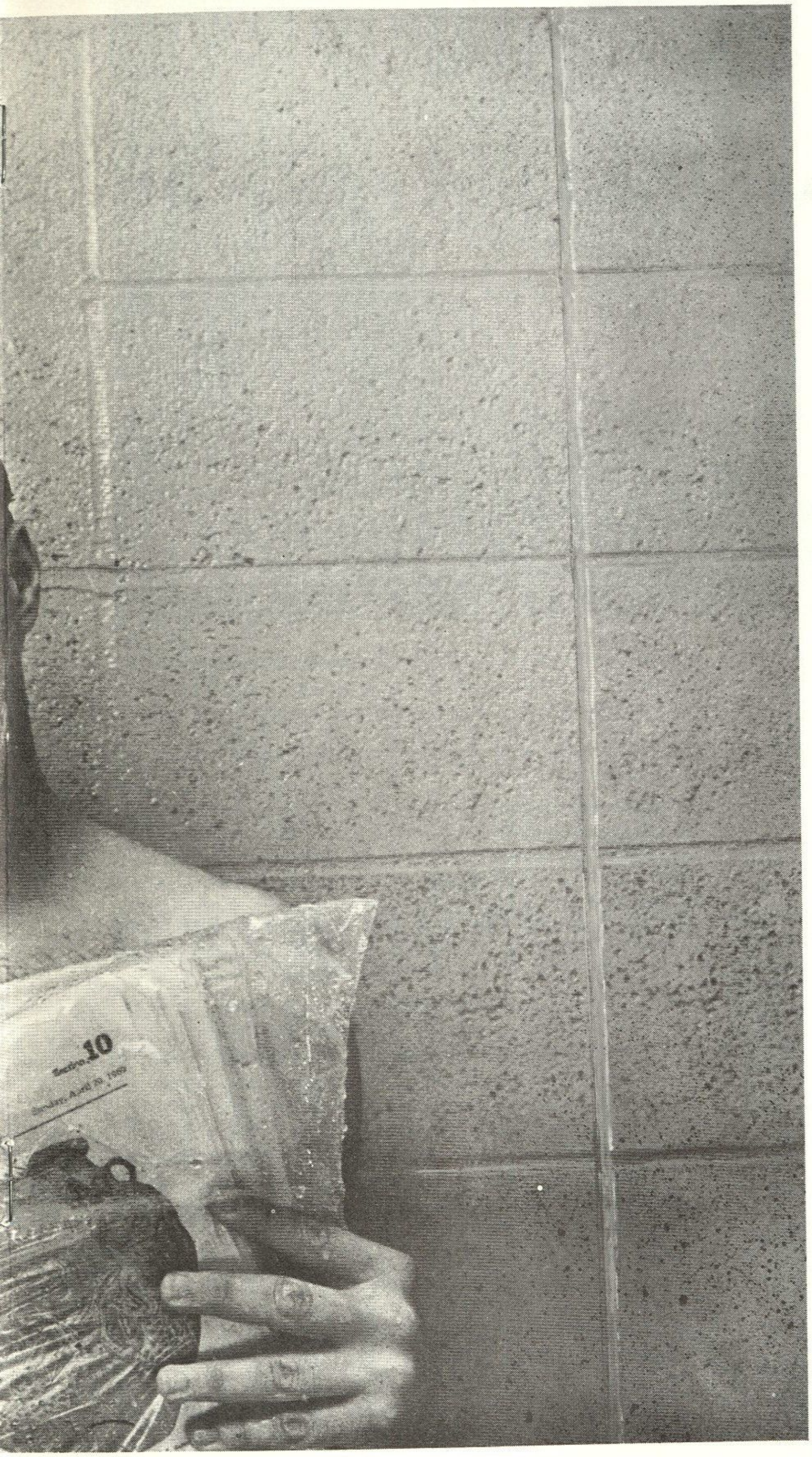
And I guess each of us headed home wondering if there was an unopened box in the back closet that we had never untied and peeked at.

Professor Jackson Fuller

(Editor's Note: Rated as one of the "Top Two" E.E. professors at C.U. (by students), Professor Fuller establishes an excellent rapport with students and shows an honest love of teaching. In the words of one of his most apt critics–a student: "When he teaches, you feel like a colleague in science; he really comes across." Mr. Fuller holds a full professorship (this is his third year of teaching) and has spent 27 years in industry, working with General Electric. He received his B.S. (E.E.) from C.U. and holds a patent in power systems networks as applied to areas of commerce (shopping centers, etc.). He is a prof that C.U. can be especially proud of.)

We keep the news fit to read.





Colorado Engineer Interviews:

ROBERT A. HEINLEIN

To most of us, Robert Heinlein needs no introduction. Acclaimed the "Dean of Science Fiction," and author of over 35 books, he is perhaps the most popular science fiction writer of today. But Robert Heinlein is more than an author. He is a philosopher, a man seeking wisdom in a world of people. His background includes a B.S. in Naval Science from the United States Naval Academy (1929). It is with pride that we present his ideas.

1. How does a science fiction writer (like yourself) get his ideas and his insight into the future? What is the criteria that makes a creator?

Ideas come from everywhere. "Insight" (so far as I know) is another name for "using your head"–an activity most people resist. I can't define the criteria for a "creator."

2. What is the role of a science fiction writer with respect to engineers and to other so-called practical men of science?

Entertainment, for the most part. Long experience leads me to think that many scientists and engineers attribute their interest in S & E to SF (Science and Engineering to Science Fiction.)

3. What do you think will be obsolete in medicine-of-the-future? What are the new innovations that will come about because of scientific achievement?

I am not expert in these fields. I recommend George Rattray Taylor's THE BIOLOGICAL TIME BOMB, N.A.L. & World Pub.

4. Do you think that a computer will ever have a consciousness of its own and be truly creative (shades of THE MOON IS A HARSH MISTRESS)?

I don't know and have no data on which to guess.

5. Will it ever be possible for man to exceed the speed of light?

I don't know and the data are as yet far too incomplete. My guess is "yes."

6. Will teleportation ever replace the present means of transportation?

It might supplement it if we ever really learn anything about geometry.

7. Will it be possible for future engineers to have direct interaction with a computer, and to use it to extend their memory (man-machine mental hookups)?

I think so. The data are incomplete.

8. In your opinion, will man ever establish cities in orbit around the globe?

Yes.

9. Will "Artificial Man" –i.e., a man with replaceable organs (heart, lungs, liver, etc.) –ever become a reality, or will aging just be eliminated by pure medical science with drugs?

Probably both.

10. What kind of futuristic leisure activities can man look forward to?

All that we have now, plus an unlimited variety possible in free fall (including sex) –plus tourism to places off this planet.

11. **Will it be possible for man to redesign himself, to adapt to hostile environments; such as, the arctic, or to different planets, to permit cheaper space exploration?**

Yes. I'm not sure I like the idea.

Your questions have not mentioned *any* of the real mysteries—the relation of the human spirit to its physical body, the purpose of life, survival after physical death, the possibility of changing morals from guesswork to verifiable science. Most of us follow religions 1,000 to 5,000 years old—what will be the religions 10,000 years from now? (Don't tell me there won't be any—*there will be*! But are we stuck in a rut at the moment? Take a look at the world around you.)

12. **Will work, as we generally think of it today, be eliminated in the future; and if so, would man ever adapt to some other activity, to replace the satisfaction of work; or, is work a necessary part of man?**

There is more work to be done *now*, both with hands and brain, than ever before in history. Creative work is *never* done by "labor-saving" machines. A typewriter is merely an adjunct to my work—and requires a skilled repairman to keep it working, with his hands and his brain. The more machines we have, the more skilled hands and trained brains we need to use them and keep them running.

My dermatologist has the busiest waiting room in this city . . . which is odd, as he is completely paralyzed and has been in an "iron lung" for 22 years. It takes a minimum of six people, skilled and semi-skilled, to enable him to care for his hundreds of patients, allow his brilliant brain to alleviate their sufferings. When a patient is unable to come to him, they put him into a portable lung and take him to the patient, at hospital or at home. Obviously it takes much machinery to keep him going . . . but could he do this without those twelve or more hands (guided by human brains) to do the dirty work, and the donkey work, and also the skilled work that machinery cannot do? Can you design machinery to replace those six and more people?

I do not think that work can be eliminated—and I certainly hope not. Work is the greatest benison we have invented in all history. The stupid man does simple work; if he is stupid enough, he is content with it. The superior man finds much harder work that interests him and a forty-hour week is rarely enough to content him.

13. **What might a university or college be like in the future—or, will education even be necessary if man can have direct mental access to a computer? Also, will the length of education be longer or shorter (will a person 10 years old be able to have the equivalent education of a PhD today?), to permit man to spend more time doing useful work?**

This calls for thousands of words. In the first place, education never stops; and the best of it continues right up to encroaching senility. A 10-year-old today can know many, many things that a wise man of a century ago could not possibly know. Does that make the youngster "wise"? Education is not a bag of facts. It takes innate capacity, long experience and much hard thought to achieve wisdom—the best a normal 10-year-old can be is "bright"—wisdom is years beyond him. I mean no offense; I was once a "bright" 10-year-old myself . . . and I am still striving to achieve wisdom.

A computer can be an enormous timesaver in retrieving facts and in solving problems—but it is an adjunct only. Remember the GIGO law—"Garbage In, Garbage Out." Present-day computers are only as good as their programmers. They are wonderful timesavers—but they turn out wrong answers as easily as right answers; they are utterly dependent on the intelligence of the human brains who design them, service them, program them. A true "Turing machine" is not yet with us.

Much "education" today is baby-sitting for overgrown babies, misinformation for the misinformed given by the incompetent—advance flycasting, folk dancing, undisciplined "art," "social adjustment" taught by the maladjusted. Education is *not* easy and it *cannot* be spoonfed. We need to clean the Augean Stables; our curricula are loaded with nonsense; our faculties are loaded with degree-bearing incompetents who could not make a living as machinists and are too lazy to be stevedores. They should be stripped of their cushy jobs, and either go to work—real work—or, at best, given a minimum of relief without franchise.

(Is it any wonder that many youngsters are dropping out of such schools?)

The above does not apply to all professors; it simply applies to too many of them. If the shoe fits, wear it. If not, be happy that you have something real to teach, and that some kids want to learn. Some departments are relatively free of this nonsense: A boy who majors in mining engineering simply must learn something of stopes and stresses and drainage and geology and metallurgy and machinery; he can't get by with a snow-job. But in some other departments a lad can spend four comfortable years, acquire a degree, and still learn nothing important enough to get him a job as an assistant manager in a Safeway, or driving a gasoline truck—certainly not enough to get him hired to operate a bulldozer. But he may wind up with some notions for "saving the world" —notions that were tawdry nonsense in the Renaissance. He may even (God help us) think that it matters under what Sign of the Zodiac he was born—a lot of professors think so today and don't hesitate to say so in classroom.

There are subjects other than slide-rule subjects which need not be useless and too easy. To be useful and spiritually illuminating, history *does* require the memorizing of dates and of battles and of kings. Such trivia are not history in any broad sense; on the contrary they resemble the narrow lines and tiny figures on a map which give latitude and longitude and distances—without them you are lost. In history, only by tediously memorizing such apparently "useless" facts are you then in a position to study and appreciate and *enjoy* the broad picture—and with application you may begin to understand how the human race got where it is and why. Until you do, you will not appreciate the true cliche (most cliches are true; that is why they are cliches) that people who will not study history are doomed to repeat it.

If you find yourself under a professor who does *not* require you to memorize key dates—hundreds of them—*quit his course*! He is not a teacher of history. History is a *hard* subject; accept no substitutes (and a computer can't do it for you).

Analogy: A scientist or engineer might not happen to remember offhand that the sp.g. of mercury is 13.55—but the chances are he would, even though a dozen-odd reference

Continued on next page

Continued from previous page

books at his desk have that figure. He will know thousands of obscure figures, hundreds of logarithms, dozens of useful integrals, etc.—all things which he can pick out of reference books usually at hand. But he *knows* them. These figures or formulas are not science, not engineering—they are the sharp tools of his profession; he handles them as easily as he finds the light switch in his bedroom in the dark. Without them he is as sloppy as a carpenter with dull and rusty tools. The same is true of history. Dates are not history—but an historian or a teacher of history who does not know thousands of dates is a fake . . .and a history major who accepts such fakery from his soi-disant teacher has been cheated.

I am not criticizing the teaching of history qua history. Let's take another non-sliderule subject, e.g., Christianity. If you truly want to know something about it, you will certainly tackle Higher Criticism. Easy? It's even harder than engineering. (Are computers useful in it? You betcha! A good computer, properly programmed, can date an otherwise undated ancient manuscript or codex from the internal evidence.) But the subject is *hard*. You will start out by learning the following languages as a minimum: French, early Latin, early Greek, Aramaic, and classical Hebrew—and still you will not have learned anything about Higher Criticism; you will simple have sharpened your tools. If you want to become an expert, you then add on Sanskrit, classic Chinese, Arabic, and probably several other languages, dead and difficult—and, then, and only then, will you be able to get down to real study.

How many preachers of the Word do you know who have this much scholarly background? What percentage could read the "Dead Sea Scrolls" if they had them in front of them? How many Gospels were in existence at the time of James I, and why were less than ten percent of them included in the King James version of the Bible? What is the Aquarian Gospel and why was it left out? Why do so many people call this the "Aquarian Age"? What one verse in that Gospel is so extremely important to the people who do (if they have ever heard of it, which many have not) —and how does that verse fail to fit our present dismal situation?

(By the way, I am still looking for a practicing astrologer who is truly skilled in spherical trigonometry and in astronomy—I have yet to find him. I will say nothing about the "true believers" —many millions—in astrology who do not claim skill but accept on faith.)

In discussing education I picked mining engineering, history, Higher Criticism arbitrarily; I have nothing for or against any of them. I simply wanted to show that there is enough in any subject to work a student silly if he really wants to work. If you *don't* want to work, drop out of higher education and quit crowding the real students—because a computer will never do the *hard* work for you; the most a computer can do is to free your time for the grindingly hard work a computer cannot do for you.

ROBERT A. HEINLEIN

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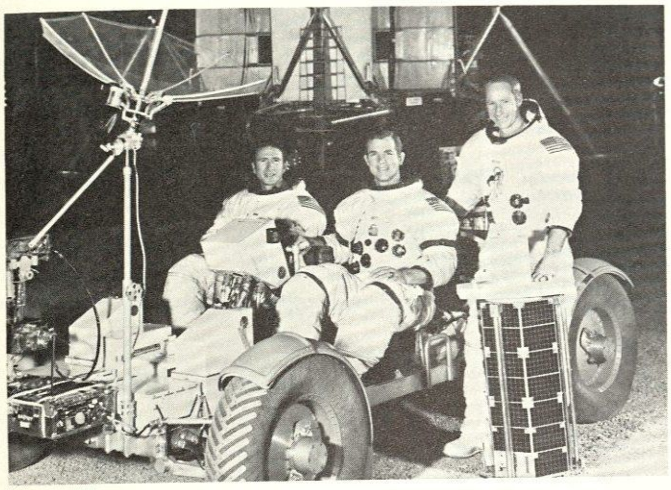
(signed) Robert A. Heinlein

PROPULSION ENGINEERING



The "ultimate" electric car. It's transportable via rocket, is a "foldable" compact, carries 2 over rough terrain, has electric power steering, its own TV station, blowout proof tires, and has a "CB" radio with a range that you wouldn't believe. It can even travel on the Moon! What else could you ask?!

By Sheila Wall

Air pollution is a scary topic. There is something very unsettling about the vast amounts of articles that appear yearly attesting to the fact that our air is slowly being poisoned. The very idea of death en masse is so unbelievable that most people fail to see the seriousness of the problem. What, then is causing our air pollution? It can be traced to several sources, some of these being, power generation, industrial operations, refuse combustion and agricultural burning. The most prominent, however, is transportation which contributes 67.2% of the pollutants. Clearly, this indicates that a reform is needed. But where? How drastic a measure must be taken in order to insure the stoppage of the fouling of our air?

One must first take a close look at the propulsion system in American cars. This is the internal combusiton engine (ICE). The problem with ICE is that it emits large amounts of unburned and partly burned hydrocarbons and gaseous vapors in start-and-stop traffic. This puts two strikes against it from the beginning. First, it is not fully utilizing its fuel source and secondly, it is becoming increasingly impractical for short distance driving. This last fact is obvious to anyone who has waited on street corners in downtown Denver during rush hour. Emergency precautions might include plastering oneself against the nearest building, holding one's nose and waiting for the air to clear. What is needed is alternative–or perhaps an improvement in the present system. Let's look at some alternatives presently being worked on.

Electric propulsion systems are well known on golf courses and factory lots. It appears to the cleanest and quietest of propulsion systems. However, it needs a lot of work before it can be adapted to day-to-day driving conditions.

Professor Jackson Fuller, in an interview, told me about a class in the department of Electrical Engineering, which is looking into the development of this system and experimenting with some of the possibilities. E.E. 400 is a class of thirteen students which is guided in the endeavor by Professors Gless, Hanna, Carlin and Twombly. The thirteen students are divided into four squads, each of which is working on a different aspect of the problem. Squad 1, for example, is investigating engine and generator operation, while Squads 2 and 3 are looking into the use of the silicon controlled rectifier. Squad 4 concerns itself with the electric drive motors that are responsible for rear wheel propulsion.

In addition to the Nash, the class is using an electric drive cart to test out different phases of development. Hopefully by the end of the semester, a vehicle running under a control scheme will have been produced.

E.E. 400 is working on a new concept in electric propulsion. The electric drive cart uses a variable resistor which in a start and stop situation, like in-town driving, uses a lot of energy which it gives off in heat. The car E.E. 400 is proposing would use a silicon controlled rectifier and in so doing incorporate that energy which is being wasted in heat into the system. This would increase the range of this car some 2 to 3 times over that of the typical electric-drive car.

The electric car, as proposed, would be largely an in-town car whose main purpose would be short trips. This points the way toward a new perception of the car in transportation. No longer could transportation be so much of an individual matter. With the short-trip auto designed to take 4 people to the shopping center or to school, some new concept in longer distance commuting would have to be realized. Perhaps a non-polluting mass-transit system would be used in addition to the electric car. Such a service would provide transportation to the mountains and to nearby cities. Airlines would complete the transportation network. Whether this means a decrease in individual freedoms is up for debate. All possibilities would have to be considered.

One major disadvantage of the electric car is its batteries. The electric drive cart carries 500 lbs. of batteries, for its storage power. These batteries must be recharged every 3 to 4 hours of operation. Needless to say, this could pose a tremendous problem. Some solutions might include a recharging system in shopping center parking lots and in the private garage. Obviously, the whole idea needs time to be worked on.

Another solution to pollution might lie in steam driven vehicles. Unlike the vintage Stanley Steamer, the modern steam car would not carry a large boiler. A monotube boiler is used and is made of 3/8 in. diameter high strength steel tubing which would only have a small amount of steam in it at one time. In the event of collision there would be no boiler to explode. Only a small amount of steam would be dissipated.[1]

An example of the new steam car is the Rankine or vapor cycle propulsion system. In this, fuel explosion takes place outside the engine in the burner. The heat from fuel combustion is used to vaporize a working fluid which, by way of the monotube steam generator, becomes the power source for the engine. The Rankine is also less noisy. It would cut the noise level by 4 at peak loads. It gives off 1/45 of the amount of hydrocarbons ICE gives off. Further, there is no lead emissions. It will operate on varied fuels: gas, and white kerosene are two of the many.[2]

As far as alternatives go, General Motors prefers the Stirling Engine. This is more efficient than the steam engine, but it uses helium or hydrogen as its working fluid, and operates at a

Continued on next page

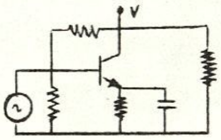
high temperature. This means that economically speaking, a car with a Stirling Engine is no bargain.[3]

Finally, what about ICE itself? Can it be converted to a less polluting system? The National Air Pollution Control Administration, which has been looking into the situation since 1967 apparently thinks not. Fuel additives aren't terribly effective and the catalytic muffler, as well as other techniques, may hike the price of the car so much as to make ICE worth scrapping.[4]

While pollution seems to be a totally grim and grisly thing, it is opening up new fields for engineers. Some of the unlimited possibilities for jobs, and independent invention are:

1. Technological Exploration
   This would include research and development on actual propulsion systems. A new idea which hasn't been thought of yet, might be the foundation for the revolutionizing of the entire transportation system.
2. Environmental Engineering
   We waste too much of our precious land and resources on transportation. Look at the miles of meadow land and mountain areas which have been smothered with asphalt. With some new type of propulsion, perhaps more efficient use of what we have could be thought of, instead of constantly adding to our network of roads. This would at least save some of the money which is spent on road projects.
3. "People" Engineering
   People are strange organisms, in that they will adapt themselves slowly to conditions which are unpleasant, until they cannot realize that there are other and better forms of living. Surely our smog-choked cities are hardly pleasant, and the rush to and from unstimulating jobs is straining. With what is available we need not settle for mediocre lives nor allow our fellow men to do so either. Perhaps new propulsion systems are a key to making life a little more pleasant—a little more worth living. And isn't that what we are working for?

[1] Irwin Hersey, "What Future for Auto Emissions?" *Engineering Opportunities* p. 12.
[2] ibid., pp. 11-12.
[3] ibid., p. 10.
[4] ibid., p. 10.



FEEDBACK

CR0-0-3: Ode to

White walls
Embellished by no windows
Entomb twenty-three beings
Perching on pedestals
With eyes afixed and ears atuned.
Thoughts transmitt,
Through a lingering haze of smoke,
Filtering out an abstract,
An impugning aura,
Forcing identity
With sterile thought.
While only a quiescent coat rack
Remains unblemished,
Assuming no identity
Except its own.

the author, Craig Rueckert

Artificial Kidney

Continued from page 7

when the latter occurs, the designer is risking damage to the blood. Sound familiar? Probably. This is another popular phenomenon referred to as "going in circles". And so, while being the most important facet under consideration, blood is also the most apathetic. Literally and figuratively, blood truly represents a constant resistance.

Fortunately, the dalysate (cleansing solution) presents fewer problems when viewed as an analogous resistance. Though its composition is restricted (Table 3), there is not much that cannot be done with it mechanically. Its purpose is to "scrub" the blood of wastes and replace certain known bodily essentials, and this is done by a process known as dialysis.

This removal and replacement is proportional to the concentration gradient across the membrane–in a sense, the reverse of what is occuring on the blood side. To make this exchange expedient and efficient, a maximum gradient must exist. And since the blood represents an "untouchable" and constant medium, the dialysate side becomes a variable whose concentration of waste products should be maintained at zero. This presents another common engineering problem–converting (impossible) ideal situations into physical realities. Once again heat exchanger design is called upon to produce the answer, and this time the result is a little more practical. Two familiar conditions of operation are employed, those of recirculation and single pass flow of the dialysate. Both of these patterns utilize a provision which was unfeasible with blood, that of low pressure turbulent flow (which increases ionic transport, accordingly). Recirculation places emphasis on the popular topic of recycling but is an extremely poor alternative when the over-all result is considered–eventually the dialysate possesses as much waste as the blood does. Single pass systems are further divided into con-current or counter-current flow configurations. In each, the fluid is passed at a relatively high velocity to induce turbulence. This effect is enhanced by the design of a supporting structure for the membrane which incorporates small, regular obstructions to flow–a cone field (Figure 2). Concurrent flow, though better than recirculation, is a self-defeating concept (Figure 3). Here the operating gradient is initially large, but diminishes in the direction of flow. Counter-current flow through the kidney (Figure 4) becomes the obvious answer; a system whereby the dialysate enters the kidney at the blood exit and where blood concentrations of waste products are at their lowest level, insuring a fairly large, constant diffusional gradient.

Thus far, alteration of the blood resistance has been considered infeasible, and the reduction of dialysate resistance possesses practical limitations. Therefore the last (and most obvious) site for any advances in mass transfer, as related to artificial kidneys lies in the lowering of the permeable membrane resistance, P_M. Since the membrane represents a restricting solid in what may be loosely termed a liquid phase reaction, it exists as the highest deterrent to dialysis within the system. A general set of requirements for the ideal membrane are presented in Table 4. Present dialysis membranes work on the basis of micro-holes or pores, which allow the passage of waste solutes. For this reason permeability in the blood is based upon the size, shape, and density of the solute. Thus a trade-off must be established; pore size must be enlarged to cleanse the blood of the larger metabolites, but without including the valuable blood proteins; and to improve efficiency, the surface area can be increased but at the cost of equipment size and also blood priming volumes. Efforts have also been made to increase the permeable proficiency of present cellophane or cuprophane membranes by a variety of physical and chemical processes, none of which have proven successful. Yet, while contemporary membranes are seriously lacking in view of scientific performance specifications, they are certainly vastly improved over the German sausage casings used by Kolff in the early 1940's. To significantly improve the current art in terms of capability and equipment size reduction, new membranes and concepts pertaining to them must be developed. Thus, it is in membrane design that engineering and medicine must make their next big advance: to more accurately isolate and duplicate the functions of the kidney, and to develop materials which will allow for the successful use of these discoveries outside of the body.

Bio-engineering is a relatively new and exciting field that is opening up new areas of relevance and cross-disciplining for the scientist-humanitarian. This article is an endeavor to acquaint the reader with the artificial kidney, by outlining a few of the associated problems as viewed from medicine and engineering. A future article will deal more precisely with the functioning of the hemodialyzer, discuss current machines, and explore some future considerations in kidney design.

Table Three

Typical Dialysate Formula

Component	Amount in mEq./L
Sodium	132.0
Chloride	105.0
Magnesium	1.5
Potassium	2.0
Calcium	2.5
Acetate	33.0
Dextrose	200.0 (mg%)

Table Four

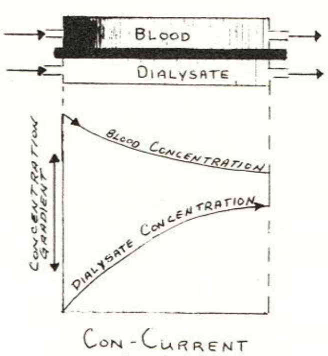
Requirements for the Ideal Dialysing Membrane

1. High permeability to water, organic metabolites, and ions
2. Capability of retaining plasma proteins.
3. Sufficient wet strength to resist tearing or bursting
4. non-toxic to blood and to all body cells
5. Inexpensive to produce

FIGURE TWO

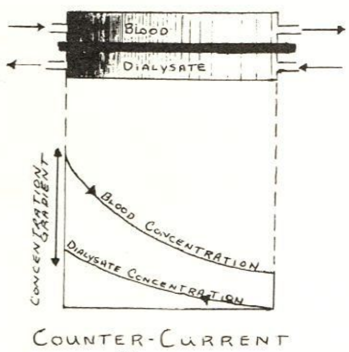
CONE FIELD FOR TURBULENT FLOW – DIALYSATE SIDE

FIGURE THREE

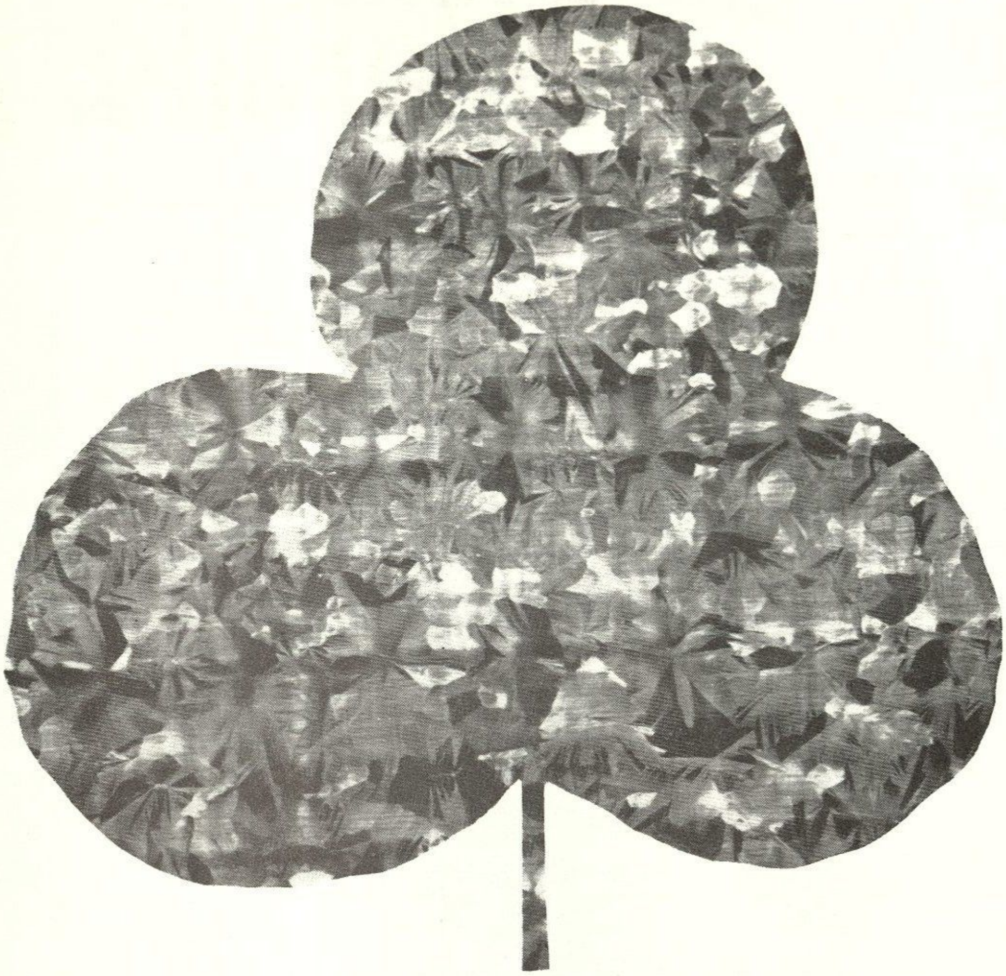


CON-CURRENT DIALYSIS

FIGURE FOUR



COUNTER-CURRENT DIALYSIS



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Merry Christmas

and Peace on Earth

DESIDERATA

Go placidly amid the noise & haste, & remember what peace there may be in silence. As far as possible without surrender be on good terms with all persons. Speak your truth quietly & clearly; and listen to others, even the dull & ignorant; they too have their story.

Avoid loud & aggressive persons, they are vexations to the spirit. If you compare yourself with others, you may become vain & bitter; for always there will be greater & lesser persons than yourself. Enjoy your achievements as well as your plans.

Keep interested in your own career, however humble; it is a real possession in the changing fortunes of time. Exercise caution in your business affairs; for the world is full of trickery. But let this not blind you to what virtue there is; many persons strive for high ideals; and everywhere life is full of heroism.

Be yourself. Especially, do not feign affection. Neither be cynical about love; for in the face of all aridity & disenchantment it is perennial as the grass.

Take kindly the counsel of the years, gracefully surrendering the things of youth. Nurture strength of spirit to shield you in sudden misfortune. But do not distress yourself with imaginings. Many fears are born of fatigue & loneliness. Beyond a wholesome discipline, be gentle with yourself.

You are a child of the universe, no less than the trees & the stars; you have a right to be here. And whether or not it is clear to you, no doubt the universe is unfolding as it should.

Therefore be at peace with God, whatever you conceive Him to be, and whatever your labors & aspirations, in the noisy confusion of life keep peace with your soul.

With all its sham, drudgery & broken dreams, it is still a beautiful world. Be careful. Strive to be happy.

Found in old Saint Paul's Church, Baltimore; dated 1692

Ron A. Fattor	*Fred Sprague*	*Arsci Unoco*	*Mac Jolly*	*Dr. Leo C. Novak*
Dave Slusher	*Bob Conner*	*Sheila Wall*	*Joe Sencenbaugh*	*Roger Wortz*
Bill McNair	*Bill Trout*	*Jim Johnson*	*Jim Ottmer*	*Larry Rainey*

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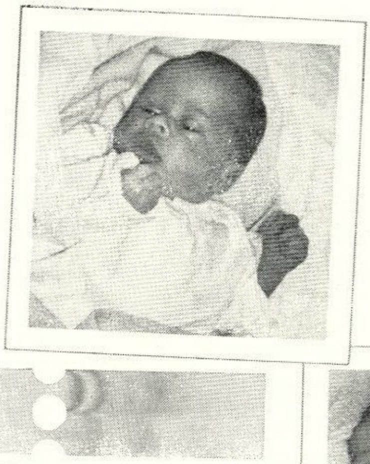
A young Kodak technical guy convinced us we ought to market that product.

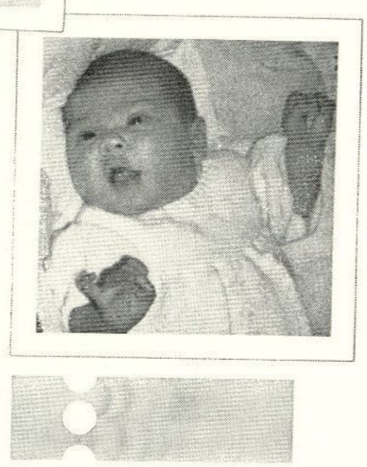
Convincing us was not easy.

Nobody who wants to do a little good in the world *ever* has an easy time of it, *any place*.

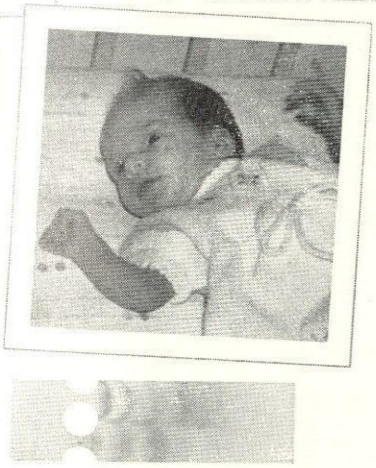
EASTMAN KODAK COMPANY

Kodak





The upper row of crescents in each case is for comparison.
The lower row is from the baby.



Baby pictures

Seen here as strips beneath the familiar kind of baby snapshots is a new kind, made from urine samples donated by these healthy new citizens. (A test of blood plasma is also desirable.) The strips tell about body chemistry. One out of many thousands of such patterns may turn up with a prominent crescent in the lower row at this particular point

Such is the hint that the infant's body is mishandling phenylalanine, a required substance that results from digestion of any natural protein food, like milk. If this continues, the child will probably suffer mental retardation.

Most states already require a test for this condition. If after the first weeks at home babies had an additional blood test with one of these snapshots, chances would increase of detecting other such metabolic defects. Unrecognized and untreated, many of these also lead to retardation and other severe impairments.

Treatment consists of precise regulation of diet.

Kodak, long known for simple snapshots, also makes the material on which these simple non-photographic ones are taken. (Thin-layer chromatograms, they're called.) No camera, only a few plastic accessories.

The physician's time and insight are required only for the infant whose test falls outside the common range of variation—to decide on more detailed confirmation of abnormality and, if confirmed, on remedial measures.

Cute baby pictures are both priceless and remarkably inexpensive. So is this less cute, biochemical kind. Who ought to pay for it is an interesting question in ethics, politics, and economics. Here is one place where industry's ambitions for efficient production may encounter little opposition.