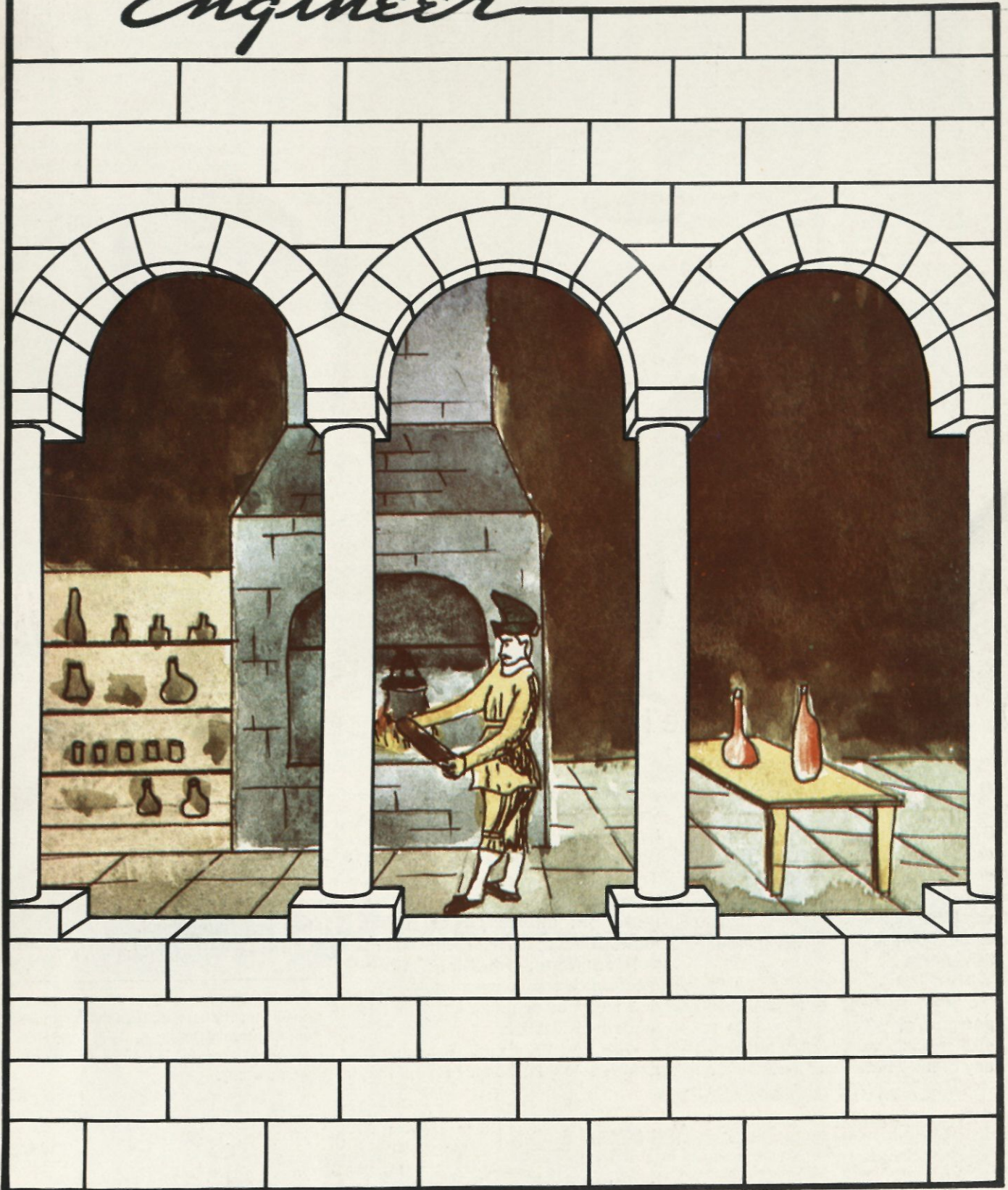


The
COLORADO
Engineer



MAY, 1967



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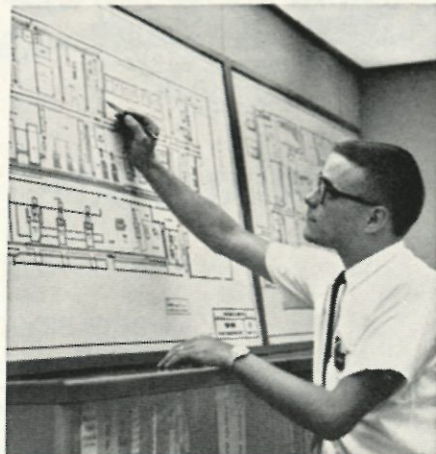
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Top: LUIS LOZANO (BS Met. E., Brooklyn Poly. '61) is research metallurgist at Anaconda American Brass Company's research and technical center.



Top: GEOFFREY IRELAND (BSME, U. of Louisville '63) is assistant plant engineer at Louisville works of Anaconda Aluminum Company.

Below: ROBERT SWIRBUL (BS Bus. Ad., U. of Tampa '58), center, district manager of Dallas sales office of Anaconda Wire and Cable Company, reviews cable specifications with power utility personnel.



Left: PETRUS DUTOIT (BS Mining Engrg., Montana Tech., '56), mining engineer, at the controls of a raise boring machine in the Mountain Con mine. This mine has the latest in underground mining equipment.

Below: LAWRENCE KENAUSS (BS Chem., Holy Cross '53; MS Chem., Boston College '55; PhD Chem., U. of Penn. '61) is senior research metallurgist at Anaconda research and technical center in Waterbury, Connecticut.

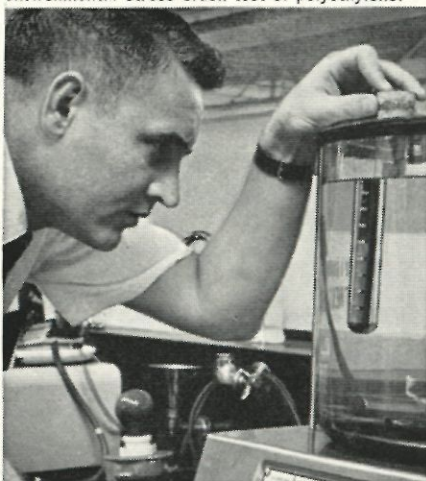


Top: JUDITH HIHNALA (BS Bact., Montana State '63) studies bacterial leaching of copper and zinc ore and concentrates in extractive metallurgical research laboratory.



Top: GLENN ZINN (BS Geol. E., Mich. Tech. '66), geophysicist with the geophysical department's southwest office in Tucson, Arizona, is studying toward a master's degree in geophysics at University of Arizona.

Below: FRANKLIN ANDREWS (BS Math., Northern Ill. U. '62), manager—quality assurance at Sycamore plant of Anaconda Wire and Cable Company, checks environmental stress crack test of polyethylene.



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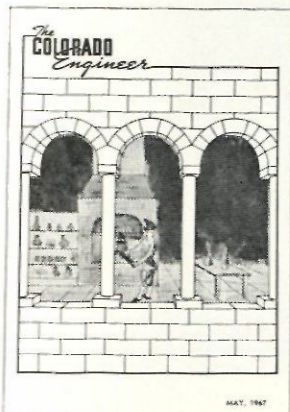
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This month, Steven Franek looks back into an alchemist's laboratory, one of the highlights of medieval science. See "The Skirmishes of Medieval Science" by Prof. Jerry Stannard, p. 9.

The Colorado Engineer is published by the students of the University of Colorado College of Engineering and does not necessarily reflect the opinions of the faculty and administration.



A Monetary Question

AES has been a little ASUC. It has been a social organization. Only this year has it achieved a balanced combination and begun to accomplish realistic goals.

Backing these goals has been money. There wasn't very much of it this year, due to the disorganization of past years, but there was enough, spent with extreme frugality, to come out ahead. What about next year? There is currently a referendum being voted on to provide AES with income enough to really get the programs it wants to initiate and expand, such as the tutor service, into good order.

If it passes, and hopefully it will, undergraduate engineering students will pay higher fees than other undergraduates—one dollar higher. This money will support the future plans of AES—and will benefit each engineering student at least that dollar's worth, undoubtedly more. It may not pass. If it doesn't, AES will not cease to exist. It will continue to oscillate at is has in past years.

Either way, the record AES has presented for 1966-1967 is an amazing tribute to the people who decided that the Associated Engineering Students has a worthy purpose and could accomplish.

—Kathy O'Donoghue

Photograph at left by David Lester.



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DEAN MAX S. PETERS

In this last Dean's Column of the academic year, I want to take the opportunity to extend my special congratulations and well-wishes to all of our graduating seniors in Engineering. You have attended the University of Colorado during a very exciting period. Somehow you have managed to weather the problems involved in moving into a new building and, as we now complete our first year in the new Engineering Center, I hope you are as well pleased with these facilities as all of us on the faculty are. No matter what one may think of the outside appearance of our building, at least everyone who comes to our campus is aware that there is an engineering college. Anyone who comes inside the building must get the additional feeling that there is

not only an engineering college, but a very good engineering college at the University of Colorado.

I have been extremely well impressed by our undergraduates, and particularly by our seniors, because of the increase I have noted in responsible student activities and student involvement in the over-all academic program. Kathy O'Donoghue and Fred Stoppelkamp deserve special recognition for the fine and responsible job they have done in their positions as Editor of the COLORADO ENGINEER and President of AES respectively. I congratulate all of the new officers in our various engineering organizations.

This has been a good year. I hope it has been a good four or five years for all of you who are seniors. I per-

sonally like the way things are moving in our College of Engineering. The credit for what I consider to be a bright future for the College must go to you students who have worked so hard and, simultaneously, given such fine service to our College, as well as to our faculty. I regard your efforts as representing true dedication to the principles of an academic environment.

For those of you who are graduating this year, I wish you the best of success, and I sincerely hope we have given you an educational and over-all background which will permit you to make a major contribution to our society. Good luck to you, and our best wishes from your *alma mater* for a bright, happy, and productive future.



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THE SKIRMISHES OF MEDIEVAL SCIENCE

PROF. JERRY STANNARD
DEPARTMENT OF HISTORY

If ever an idea was sanctified by the textbook, it was the belief that the period between 500 and 1300 A.D. was so benighted as to warrant the term "The Dark Ages." Today, after a century of scholarship in medieval studies, historians are aware of the bright spots and shadows and more willing to settle for gray in place of black and white. The belief still persists in some quarters, however, that whereas art and poetry, philosophy and jurisprudence flourished, science conspicuously was neglected. In some respects, namely the respect in which the word "science" is tacitly made to conform to *our* meaning of science, I agree. Were my agreement complete and unqualified, I should conclude now, becoming undoubtedly one of those rare persons who heeds the adage—*ars longa, vita brevis*—art is long but life short. But my agreement is far from complete.

Revolutions and Skirmishes

Looking back at the results and patterns of a century of historical scholarship, one term stands out in the historian's vocabulary. That word is "revolution." It is a commonplace

today for the historian of science to pit his "Copernican Revolution" against his colleagues' "French Revolution" or "Industrial Revolution." Now I have no intention of suggesting that in the middle ages there was any event with a significance comparable to the aforementioned revolutions. I do wish to suggest, however, that just as the "Dark Ages" is a misnomer, so too, one must re-examine the belief that there was no science in the middle ages. There was a great deal of activity, much talking and a fair amount of writing on issues which we see to be, in retrospect, scientific issues. As Friedrich Heer, one of Europe's foremost medievalists puts it, "Life inside the town walls was ebullient, raucous, and quarrelsome." These activities, dealing with a variety of topics, induced by diverse motives, and leading to a wide range of results, I call skirmishes. Precisely because no single world shaking scientific discovery came out of these skirmishes, this very activity provides a not atypical picture of the medieval mind at work. To try to summarize medieval science or, equally formidable, to explain it at one sitting, is an unthink-

able task. By locating, however, the grounds where the skirmishes took place and by commenting briefly on the scientific issues at stake, the nature of a sizeable part of medieval science thereby will be delineated.

Among the images associated with the medieval period, no term, perhaps, better suggests its vitality than scholasticism. It is not my purpose to explore the byways of scholastic argumentation. Yet, the structure of St. Thomas Aquinas' *Summa Theologiae* or Abélard's *Sic et Non* provides a useful reference point. Whatever be the merit of the conclusions drawn from such philosophic debates, it is obvious that they could, and indeed sometimes did, end in a skirmish. Let us eavesdrop on the *Quaestiones naturales* composed by Adelard of Bath (flourished circa 1120) for his somewhat dull nephew. "It is difficult to discuss with you," Adelard states at the outset,

for I have learned one thing from the Arabs under the guidance of reason; you follow another halter, caught by the appearance of authority, for what is authority if not a halter?

We do not know as fully as might be wished the nephew's reaction but

that it is a skirmish in the making seems probable. It is beyond doubt, however, that the dialogue symbolizes a wider exchange of views—of which scholasticism with its *quaestio*, *responsio*, and *demonstratio* represents but one side of medieval science.

The purpose of the scholastic debate was most certainly not what we call science today. However, underneath the dialectic and the casuistry was a method which, with modifications, looks ahead to another discipline with another method. I mention this because the skirmishes of medieval science were conducted over issues just as important to them as the carcinogenic viruses and U.F.O.s are to us. Moreover, by following a method—and that means using data wheresoever obtained—a conclusion was drawn which was as consistent with the assumptions and facts then known, as are the conclusions drawn by our laboratory-based contemporaries.

Astrology Governs Man's Destiny

For example, it was widely accepted, and not infrequently subjected to an apodeictic demonstration, that man's destiny was governed by the stars. We know, of course, this is not the case. But, before sophisticated complacency dims your historical sense, let it be said that one reason we know this, is that by distinguishing between the stars and planets, modern astronomers have not succeeded in finding any direct evidence—quasars or quasi-stellar objects notwithstanding. This very distinction, over which many a skirmisher found perdition rather than heaven, was a victory won in large measure by the work of astrologers. How the fixed stars came to be distinguished from the planets is a long and complicated story. For our present purpose, it is sufficient to call attention to what is involved in forecasting. It is essential, so my sources tell me, in casting a horoscope, to determine with the utmost of precision the position of the planets, the sun, and the moon, relative to the constellations of the fixed stars or the signs of the zodiac. Failure to observe precision renders the horoscope pointless—though even here there are records of rival astrologers competing for royal favor and one suspects a bit of fudging on the part of him whose horoscope is the more auspicious.

That the heavenly bodies were determining factors in human behavior can scarcely be doubted in the face of the correlation between the calendar and the position of the planets on the one hand, and seasonal cycles and weather, on the other hand. From this it is but a short step to ascribe the strange behavior of one too long exposed to the baneful effects of the moon as a lunatic. Fanciful, perhaps, but consistent with the data and assumptions governing medieval inquiry.

It was in an effort to formalize the rules which governed astronomy, that one of the greatest of all English speaking poets, Geoffrey Chaucer (circa 1343-1400) composed his *Treatise on the Astrolabe*, written in 1391 for his ten year old son "lilow Lewis." In 1951, Professor Derek Price, now at Yale University, discovered what is now believed to be its companion piece, "*The Equatorie of the Planetis*." The latter, whether written by Chaucer or not, is severely technical, being devoted to the construction of an instrument (the equatory) to determine the position of the planets just as the astrolabe is an instrument to determine the apparent position of the sun and stars. Astronomy is thus seen to be in the process of emerging from astrology though, as the presence of fortune-tellers and palmists testify, the break was incomplete.

Superstition Provides Framework

It is easy, though I think ahistorical, to dismiss astrology and its sister art, alchemy, on the grounds that they are shot through with magic and based upon superstition. To be certain magic is ubiquitous in medieval thinking, but so too is it characteristic of what is now commonly referred to as the "Counter Renaissance." But magic, that is the belief that nature can be manipulated by the performance of certain acts accompanied by specified utterances, provided a framework without which much of the skirmishing would have been completely aimless. There was, to put it as simply as possible, no better alternative and it is Goethe who reflects this impasse when he makes Faust exclaim: "Das Wunder ist des Glaubens liebstes Kind" ("The Dearest Child of Faith is Miracle"). As it was, the alchemist believed that by leading an exemplary life and by

certain manipulations, base metals could be transformed into their more precious counterparts, the noble metals. The sort of life the adept must live is of less consequence than the fact that his misguided search gave birth to the science of chemistry. Who but the alchemist would have spent his days and nights burning his fingers, inhaling noxious fumes, and endangering his eyes with the ever present possibility of an exploding glass vessel? In this process—not uncontested I might add, and therefore falling within the purview of a skirmish—chemical equipment began to assume its modern shape, chemical reactions were noted, later to be repeated with the newer methods of quantification, and innumerable reagents were prepared, purified, and analyzed. If the long sought *elixir vitae* turned out to be a mythical broth, at least the time spent on creating distilling apparatus has been redeemed by those treasured by-products whose very names—Aqua vite, Benedictine, or Chartreuse—bespeak the flavor of centuries.

Products such as those just mentioned, along with the still popular *aqua ardens*, were justified on the grounds of their medicinal virtues. As life and time went on, their concomitants—disease and infirmity—showed no sign of abating without external help. It was but natural, therefore, that efforts were made to remedy the body as well as the soul. Needless to say, many a skirmish took place over diagnoses, prognoses, and forms of therapy. The theory of critical days and the cycle of crises were but the admission that medicine was of little avail in the presence of malaria, whose causative agent lived in a blissful pre-quinine paradise. The search for drugs and a rationale for those that proved successful, *id est*, as a glossator might say, for those drugs whose takers survived—played an important role in the onward march of natural history to biology. Three distinct literary genres competed in this quest—lapidaries, bestiaries, and herbals.

Search for Magic Stones

The first-named type—the lapidary—is, as its name implies a book dealing with the properties of precious and semi-precious stones. Starting with two well-known passages from the scriptures—the description of

Aaron's breastplate and the opulence of New Jerusalem—generations of scholars devoted their energy in identifying the stones so depicted and investing them with occult powers. One of the earliest of such attempts, the *Liber lapidum*, of Marbod, Bishop of Rennes (1035-1123), was written sometime between the years 1061 and 1081. A poem, written in hexameters, it described some sixty different stones, minerals, and animal products such as coral and the testa of the sea urchin, known those days as *lapis judaicus* or jew's stone. Its purpose may be gathered from the opening lines:

Evax, king of the Arabs is said to
have written to Nero,
Who after Augustus ruled next in the
city,
How many species of stones, what
name and what colors,
From what regions they came and
how great the power of each one.

Given the state of geography at the time, it is no wonder that sharp disagreements arose concerning the origin of some of the stones. Even more disagreement ensued regarding the virtues and qualities ascribed, for example, to the sapphire. Of this precious stone, Marbod claimed that it nourished the body and preserved the limbs whole. It led those in bonds from prison. It served to placate God and to make him favorably disposed to our prayers. Judging from the disagreement on the next claim—it is good for peace-making and reconciliation—it may be supposed that controlled experiments had actually been conducted. While all the claims and counter-claims of innumerable lapidaries may seem sterile today, it should be remembered that it was in an effort to write a better text that Agricola's *De natura fossilium*—the first modern book on minerology—was written in 1546.

Allegories on Animals

Turning from the lapidary to the bestiary we enter into a realm at once more familiar and more strange. Familiar, because oxen, asses, swine, goats and their predators were part of the agrarian scene and continued to remain so for many centuries. Yet there is a strange, indeed an unreal quality about the bestiaries, for in addition to the farmyard animals, one meets the mantichora, yale, griffin and, of course, dear to all genealogists and students of heraldry, the unicorn. These latter animals, while they may

have rested on fact, belong rather to that class of animals whose modern representative is the pushmi-pullyou of Dr. Doolittle. That is, they were composites, put together in Western Europe from bits and scraps of information derived from classical sources and none too discerning travellers without recourse to a comparison with the separate parts. The monoceros, for instance, is described as possessing the head of a stag, elephant's feet, the tail of a boar, and a horse's body. It is remotely possible that beneath this camouflage there lurks the rhinoceros, an animal still very strange to Europeans of the sixteenth century; witness Dürer's famous woodcut which was actually used by the great Swiss zoologist, Conrad Gesner (1516-1565) in his *Historia animalium* in lieu of better evidence.

In a subject where allegory often took the place of description—the sons of Israel, states the writer of an eighth century bestiary in a Bern manuscript, are like the hyena because first they served God and then they adored idols—difficulties beset the compiler at every turn. In the process of emending, compiling, and criticizing,—all parts of what I term the skirmishes of medieval zoology—progress was slowly made. Not all compilers agreed that gold was mined by ants in far-away Ethiopia or that sticks of cinnamon were obtained by raiding the nest of that fabled bird, the phoenix. But by gathering information under such headings a *corpus animalium* was taking shape such that the next step—a critical review of the data based on comparison with living specimens—was inevitable.

As one passes slowly from the medieval bestiary, to the illustrated Renaissance books of animals such as Gesner's, there is observed a steady elimination of the fabulous and, equally slowly, a better understanding of the life habits of real animals. Some of the latter, alas, are no longer with us and were it not for some of the charming fables, we would be forced to conclude that the *urus* was, like the griffin and dragon, the product of the over-active imagination of an under-traveled compiler. Thanks to some clever zoological detective work, we know today that the *urus* is the extinct aurochs, the wild relative of the European ox, last recorded alive in the forest of Lithuania in the seventeenth century.

Another Approach to Biology

Not all zoological investigations of the middle ages were confined to bestiaries. Just so, no statement regarding medieval zoology would be complete without reference to Albertus Magnus (1193-1280), the Bishop of Ratisbon. As a Doctor of the Church and Provincial of the Dominican Order in Germany, his orthodoxy may be taken for granted. Surprising enough though, Albert the Great was an eloquent preacher of the unorthodox.

In his two major scientific writings—*De Animalibus* and *De Vegetabilibus*, some phraseology occurs that portends more than an idiosyncrasy of medieval Latin grammar. One expects to find, in both the theologically and grammatically orthodox writers such impersonal constructions as these: that a certain fish *videtur in fluminibus nostris* (is seen in our rivers) or that a particular plant *latiora folia habet* (it has rather broad leaves.) Phrases like these may, or may not, indicate a personal knowledge of the organism in question. But when a verb in the first person occurs—that is rare, so rare, in fact, that I have not hesitated to credit Albert with heterodoxy. Consider the following passage:

The formicaleon, called the lion of ants, is also known by the name murmycaleon. But this animal was not first an ant as some claim. I have often observed and demonstrated to my friends (*expertus enim sum multotiens et ostendi sociis*) that this animal has a structure similar to that of a tick. It hides in the sand and digs there a half-globular pit. Its mouth is situated at the bottom of that pit. If an ant passes, looking perchance for food, the formicaleon catches and devours it. This I have often seen. (*Et hoc saepius aspeximus.*)

Entomologists will testify that there is but one way of observing this characteristic behavior of the larva of the ant-lion. Not dignified, perhaps, but unless one be lynx-eyed, the best position is to lie flat on the ground, eyes just inches away from a life and death struggle enacted literally *en la arena*. The picture of the *doctor universalis*, as Albertus is known in the ecclesiastical hierarchy, in such an unbishopric pose no doubt is amusing. But as the stance which would be adopted by future biologists, it is typical only because it is essential.

Now to the last of the three kingdoms of nature—that of plants and trees. What was known about them,

or believed or perhaps more accurately, what was believed to be known about them, was incorporated into the herbal. Their therapeutic properties, real or imaginary, provided the nucleus around which other material was organized. As a consequence of an old belief that for every illness there was a corresponding remedy, plants and plant-products were studied with care. That is, they were eaten. Pharmaceutical practices today do not always bear out the findings of the herbalists, but that mint leaves when chewed are of avail for stomach distress is a matter easily confirmed. On another score, however, there is no doubt that we are the beneficiaries of those who loved flowers for aesthetic purposes and who, as a consequence, propagated the more showy ornamentals. Walafrid Strabo (809-849) was such an *amateur des fleurs*. Abbot of the Benedictine monastery at Reichenau on Lake Constance, he was the author of many, quite good Latin lyrical poems, among which his *Hortulus* or "Little Garden" is given a place of pride in the annals of horticulture. Twenty-three of the plants growing on the monastery grounds are described in this small poem composed about the year 827. Botanists may deplore the lack of precision in his descriptions and physicians may decry the ineffectiveness of his remedies, but the common man, the garden lover, surely will rejoice at this description of the rose—the *Rosa gallica* L. of science:

Since Germany yields no tint of
Tyrian purple
And the wide realm of France cannot
boast the glow of murex
For us the rose from year to year
renews in abundance
The yellow stamens (*comas*) of its
crimson flower.
Far and away the best of all in power
and fragrance,
It well deserves its name, "the flower
of flowers"
It colors the oil which bears its name.
No man can say, No man remember,
how
Many uses there are for ail of roses as
a cure for mankind's ailments.

Perhaps because Walafrid loved the rose so much that he did what few before him did—he peered at the blossom and discovered the stamens which he calls *comas*, that is, hairs. It would be sometime before Linnaeus and the systematists of the eighteenth century counted the stamens and found them

to be constant for a given species. Yet the start was made and with it, the end was in sight of botany continuing to serve as hand-maid to medicine.

Let us turn from this "Romance of the Rose" to more earthy things, to the very realistic and sober Carolus Magnus, better known as Charlemagne (742-814), whose grandson was tutored by the aforementioned Walafrid. In one of his Capitularies, written around the year 800, the Emperor, foreseeing the need of an economic survey, ordered the following:

Each steward shall make an annual statement of all our income: an account of our lands cultivated by the oxen which our ploughmen drive and of our lands which the tenants of farms ought to plough; an account of the mills, the forest, the fields, bridges and ships; of the firewood, torches, planks, and other kinds of lumber; of the wool, flax, and hemp, of the grafted trees of all kinds, of the gardens, the fish ponds, of the hides, skin, and horns. . . .

Under the watchful eye of a bailiff, the Emperor could momentarily relax in the belief that the realm was well attended to. That it sometimes was, is a bit of optimism in which the medieval historian occasionally must indulge himself. More often than not, the records reveal an appalling regularity of epidemics, famines and floods, of invasion and treachery—the sort of skirmishes in which human life was in the balance. Despite these unsettled conditions, skirmishes of another kind were making history.

Empiricism and Innovation

We shall never know the names of the farmers who alternately cursed and beseeched the stumbling oxen to move a little faster or the gasping plow horses not to pause so frequently. Nor shall we learn much of the nameless artisans who transformed agriculture by innovating and breaking with a tradition more than a millennium long, that is, oxen were shod with iron shoes and the old Roman horse collar was replaced by a modern harness which prevented the horse's wind pipe from being throttled with each lurching step forward. Born of an equal mixture of empiricism and need, innovations such as these and the more spectacular stirrup, were destined to change the face of Europe. These technological advances, and others such as the successive modifications of the plow and windmill made large scale agriculture possible. An-

other innovation may be mentioned at this point which though not of medieval origin, its very existence might still be suspect but for the curiosity of a few historians. Ten years ago, a Belgian archeologist was able to restore to the historical record, the existence of a remarkable agricultural vehicle. Best described as a harvester, this two-wheeled cart, equipped with a toothed frame in front and pushed by oxen, is mentioned only once in all of classical antiquity. This one reference occurs in Pliny the Elder (23-79 A.D.) whose credibility on other matters naturally made scholars suspicious. But the fortunate find of a stone block, dating back to Roman times, but apparently used later as part of a foundation, with Pliny's harvester clearly carved, has removed all doubt about the existence of labor saving devices in antiquity.

Some Skirmishes Delivered Nothing

Thus far I have concentrated mainly on those issues whose lineal descendants are still parts of the scientist's concern. To claim that all the skirmishes of the middle ages so neatly anticipated modern science would be as ahistorical as to say that otherworldliness was a characteristic trait of medieval man.

Continued belief in the otherworldliness of our medieval ancestors and their supposed detachment from the world about them is difficult to maintain in the presence of some very un-medieval documents. I refer to a class of writings known as the Anglo-Saxon Riddles. Not only the choice of style and genre, but an obvious knowledge of the subject matter is contained in these short poems. The following, dating probably from the late tenth century concerns the oyster:

The sea fed me; the water-helm was
over me and waves covered me, close
to the ground. I was footless. Often
toward the water I opened my mouth.
Now people will eat my meat. They
want not my skin. When they rip my
hide with the point of a knife . . .
Then they eat me uncooked.

It cannot be denied that obscurantism and anti-intellectualism did occur. At the hands of their advocates, not only did science suffer, but any of the *artes liberales* which showed signs of innovation. As the late Professor Lynn Thorndike demonstrated, novelty was not the high priority item that it is today.

In order, then, to provide a balanced picture of the skirmishes of medieval science, it is well to look to the other side. No single term quite captures the range of meanings intended by what is to follow. Call it arm-chair science, if you will, or bookish and literary, or again, rationalistic or supernatural—all found expression in those skirmishes which characterize the side of medieval science flavored more of the scriptorium than of the orchard or stable.

The commentary is a case in point. Designed originally to aid the reader by supplying interpretations of vexing points or emendations of corrupt passages, the commentary succeeded so well that in time it, rather than the text commented upon, came to be the principal reading material. In this process, where the reading and writing of commentaries became ends in themselves, the initiative to create was almost stifled. There are instances, indeed, of original texts appearing under their author's name but many of them are little more than a series of extracts gathered from older texts, almost, but for the anachronism involved, a scissors-and-paste job. No text was completely exempt from being commented upon, though by and large, sacred texts by Christian authors received more attention from the commentators than did secular texts written by pagans.

Biblical Commentaries Flourished

A good example is provided by the commentaries on those chapters of *Genesis* in which the first six days of creation are described. The successive commentaries are known collectively as the hexameral literature, from the Greek *hexaemeros*, meaning, "in six days." Now if you have looked over the first three chapters of *Genesis* recently, you must admit that a good many scientific puzzles are raised. The medieval commentator was struck by this fact too, though, taking a different route, he proceeded to explain those same events by a mixture of Greek philosophy, supernatural intervention, and ad hoc hypotheses. If time permitted, it would be instructive to follow the various interpretations given for a single verse from *Genesis*. As it is, I must limit myself to a single example, derived from the Commentary on the Hexaemeron by St. Ambrose (337-397 A.D.), Bishop of Milan. Commenting on the third day's activity and the verse

Then God said: Let the earth produce vegetation, seed-bearing plants and the various kinds of fruit-trees that bear fruit containing their seed

Ambrose immediately runs into trouble. Some persons, he states, but does not name them, are of the opinion that the earth could not give birth to plants without the fructifying heat of the sun. This makes sense to us and is readily translated in biochemical terms. But it was anathema to Ambrose for the simple but sufficient reason that the sun had not yet been created. No less repugnant to this defender of the faith was the view that birds, by eating the fruit, scattered the seeds in a very normal manner. Repugnant because it conflicted with the one authority recognized by Ambrose and according to it, the book of *Genesis*, birds and the other animals were still two days off, standing in the wings, as it were, awaiting their cues. From this point on, Ambrose put all his energy and ingenuity to the task of trying to reconcile, wherever possible, the Biblical account with the demands of dogma. And if, in the process, science and common sense were forced to retreat, the justification, in Tertullian's words, is always available—*Credo quia absurdum est*—I believe because it is absurd.

A dozen pages later, but still, presumably in the morning of the same day, Ambrose again raises an issue pregnant with the future. "But why do I linger," he asks,

in describing only the grapevine when all species of trees have their own utility? Some are created to provide fruit while others are granted for our use.

For nearly two millenia, in one form or another, the egocentricity of this and similar passages was to haunt biology. The issue here is a basic one: Can the diversity of organic forms be accounted for by assuming a divine plan made manifest in the separate and special creation of each species? The final answer, as you all know, was not turned in until a little over a century ago when the English biologist, Charles Darwin, eliminated, once and for all, teleology as a legitimate category of biological explanation.

In commentary upon commentary, the same procedure repeats itself, broken only by an occasional personal observation that makes commentaries

almost worth reading. Such an example occurs in a ninth century manuscript from St. Gall. At first glance it is nothing more than one of the numerous manuscript copies of the so-called Pseudo-Apuleius, the anonymous fifth century author of an immensely popular herbal. Pseudo-Apuleius was not an original writer himself, for his herbal is based almost entirely upon Dioscorides (first century A.D.). And he, that is Dioscorides, described among other things the plants, animals, and minerals of the Near East and North Africa. Thus, it comes as a bit of a surprise to find that the anonymous ninth century scribe, when copying out the Pseudo-Apuleius, omitted the plants which he did not know. Even more surprising, however, is the fact that he substituted for them an equal number of plants growing in his own native Switzerland.

Lexicons and Encyclopedias

Coupled with the commentary as a source of pre-digested information were the lexicon or glossary and the encyclopedia. Before the advent of printing in the middle of the fifteenth century, there existed no more ready means of communication than the lexicon. Its modern counterpart—the dictionary—plays an undisputed role today but, be it noted, not in the absence of the other information on which it is based. A glossary of scientific terms in the absence of specimens, equipment, laboratory procedures, and measuring devices is, admittedly, difficult to imagine today. But such was the state of affairs up to the sixteenth century when the written word was not subjected to confirmation or disconfirmation. Naturally, as the horizons widened, older or erroneous information tended to be supplemented by newer, and hopefully, more accurate information. The sources used by lexicographers and dictionary-makers have always varied. In the late medieval period, travellers reports were avidly searched in the hope that some new and exciting morsel might emerge. One of the travelers whose reports, unfortunately for science, were ransacked was John Mandeville (died 1372). Although he has left us a most readable, in fact, a rather bawdy account of his travels in the Orient, it is possible that he never got further East than Flanders. But John, or Sir John as his name occurs

in some manuscripts, was a scholar, and whether he physically travelled is a mere academic issue compared to the lands he visited vicariously. Describing some of the mythical and half-mythical creatures of India, he at last comes to a creature we recognize. "In this land," he states in the quaint language of a fifteenth century English translation,

there be a great plenty of cockodrills, that is a manner of a long serpent. In the night they dwell in the water and on the day upon the land, in rocks and in caves. They eat no meat in all the winter, but they lie as in a dream, as do the serpents. These serpents slay men, and they eat them weeping; and when they eat they move the overjaw and not the nether jaw and they have no tongue.

I cannot personally vouch for the statement regarding the crocodile's tongue or the articulation of his jaw. But as a specimen of travellers' reports, portions of which were incorporated into glossaries, the fatal weakness of the system is as evident as is its potential for giving rise to endless debates.

Valuable Descriptions of Medieval Life

Unlike Mandeville, there were some bonafide travellers whose reports have been corroborated by archeological and other forms of external evidence. Jews and Christians alike felt an obligation to visit the Holy Land and to men like Benjamin of Tudela (1100-1177), who visited Bagdad and Damascus in the twelfth century, we are indebted for material often nowhere else preserved. Benjamin, for example, is our earliest and best source for the dyeing and glassmaking industries of medieval Palestine. The travels of Marco Polo (1254-1324) to China and the Near East are not without value to historians of science. The earliest reference to that funny animal the yak, for example, is contained in Marco's account. For sheer drama, however, few accounts can match his story of the bravery of the whale fishers from the Island of Sacotra in the Gulf of Aden. After having thrown out over the stern of their craft some fish refuse and rags soaked in garum or fish paste and attached to the transom with a line, the sailors were ready. When the whale came within sight, attracted by the odor,

they throw him two or three morsels. When he has eaten them, he becomes intoxicated, as a man is with wine.

Then some of them climb upon his back, carrying an iron harpoon, so barbed that once driven in, it cannot be pulled out. One of them will stand this harpoon on the whale's head, while another hits it with a wooden mallet and immediately drives it home full length. For the whale in his drunken stupor scarcely feels the men on his back, so that they can do what they like.

Many portions of this *tableau vivant* remain obscure. But that spermaceti whales were, until recent times, taken in Arabian waters for the large reservoir of oil in their heads rests on fact. Other portions, such as the men astride the whale's back seems more akin to Pinocchio or its ultimate source, the legend of Jonah. At any rate, and this is the point, there was no better written account of the whale until 1555 when Olaus Magnus, Archbishop of Upsala, published his *Historia de gentibus septentrionalibus* in which the practices of Scandinavian whalers are no less picturesquely recounted.

Surprisingly, even the New World played a part in the skirmishing of the navigators and cartographers but also the medieval historians who have failed to reach agreement on the location of Vinland. At any rate, the Vikings setting out from Iceland and Greenland in the eleventh century made a landfall on the coast of what may have been present day Labrador. But Labrador, Nova Scotia or even Cape Cod, historians have had a field day in attempting to identify the fish, birds, mammals, and plants mentioned in the Norse Sagas. Whatever be the correct identification of the flora and fauna reported by Columbus' predecessors, their reports regarding a berry—the *Vinber*—(whence the name Vinland or Wineland) must have touched off shirmishes and prompted others to make plans for future voyages.

Range of Literary Fancies

As we have noted, the reports of travellers sometimes tend to draw more heavily on fancy than fact. Literary fancies cover a wide territory and while I do not propose this as an exhaustive classification, it may be convenient to distinguish between the philosophic or normative sense, the mystical and, finally, the magical sense.

Earnestness, not sobriety, characterizes many of the philosophic schemata designed to make this a better

world in which to live. As in the case of some of their modern counterparts, this has led philosophers of the middle ages (as well as some middle-aged philosophers) to positions that scarcely seem reasonable. Nicolaus of Autrecourt (died after 1350) maintained that

the existence of the external world cannot be demonstrated, and the only substance which a man can know with certainty is that of his own soul.

This does not provide the most congenial environment for the prosecution of science or, more exactly, for one kind of science. Descriptions of the world and an inventory of its contents cannot easily be carried on by one who entertains such doubts. But in order to analyze and to state in mathematical terms certain idealized, spatial and temporal relationships, tables and chairs, whales and yaks can be dispensed with. If the worldly furniture does not happen to obey the laws of impressed force or to confirm the principle of virtual velocity, this does not mean that the scholars at Merton College, Oxford, in the thirteenth century were misdirected in their attempts to understand and explain gravitational forces. True, they seem not to have gotten around to Galileo's inclined plane experiment—but then again, Galileo never seems really to have dropped leaden balls from the balcony at Pisa. The Bishop of Lincoln, Robert Grosseteste (1175-1253) attempted to apply mathematics in his analysis of such optical phenomena as the rainbow. That he failed, being ignorant of the laws governing the propagation of light, is of less moment than that he bequeathed to his followers, including Roger Bacon, the alleged inventor of gunpowder, a programmatic conception of science. The role of science, thought they, was to elucidate the laws promulgated by the Creator but in a language that was expressible in mathematical terms. The language of God, said Nicolaus Cardinal Cusa (1401-1464) is the language of number and proceeded to document his beliefs by one of the most modern books of the pre-modern period—his *De staticis experimentis* (Concerning Static Experiments). Take away the theology from Cusa's conception of science and it would be a statement not unacceptable to some modern theoretical physicists.

Science in Medieval Times

A definition of science that has found a favorable reception with some practitioners is that science is the search for the invariant and the laws governing the observed regularities. But to a mind nurtured on the scriptures—from the bold *fiat lux* to the logos that was in the beginning, probabilities and possibilities harmoniously coalesced. St. Francis of Assisi (1181-1226) may have preached to the birds but from that it does not follow that he was privy to their plans for a coming migration. The growth of the legend of Noah is a vivid reminder of the successive attempts to create a reasonable explanation of what is unreasonable. The very attempt to explain in secular terms, that is, in the scientific terminology of the pre-scientific era, the miraculous flood and the equally miraculous solution to some problems of logistics, proved to be the undoing of the legend as history. Retreat was possible, however, before this onslaught of reason and it was in mystical interpretation that an impregnable fortress was found. I know of no mystical interpretation of the ark, though its transm miraculous ventilation system fairly begs for one. But the mystic often found himself, or herself, pushed to the forefronts of knowledge in attempting to explain the unexplainable. One such mystic was St. Hildegard of Bingen (1098-1179). Abbess of a convent at that old Rhineland city, she was a remarkable woman in every respect. Filled with a piety that did not prevent her from supervising an infirmary for her ailing sisters, enthusiastic about her vocation but nightly writing, in painful detail, the events of the day, she presents a window through which one may obtain a glimpse of how her simple life was threatened.

Exactly fifty years ago, manuscript copies of her little tract *Scivias*, usually translated "Visions" and written, perhaps, within a year of her death, were examined by an eminent historian of medicine. Noting the peculiar, indeed bizarre ornamentation in the illuminations—typical biblical scenes

placed on a background of nightmarish colors and interlaced with what can only be described as bolts of lightning, so painfully bright as to be blinding—Charles Singer poured over the text ever so carefully. A recurring theme in Hildegard's writing were the torments she endured. These torments, which she believed to be Satan's work, which a less generous man than Singer might interpret as psychosomatic, are now accepted as the description of migraine. Our Abbess, lacking medical relief, retreated to a mystical interpretation of her pains and it is now accepted by some scholars that the brilliant drawings, once thought so gaudy, are but her way of recording what was happening to her. Mystical and miraculous but withal a medical document which lay too long uninterpreted.

Medieval Approach

To seek for a rational explanation of every event contained in a medieval tale is not, perhaps, the wisest approach. Certainly it was not the approach of the medieval believer. To him, demons were accepted on par with angels, and what mattered most to him was the practical effect of what we call magic. In a subject so large and well-explored as medieval magic, there is little need to rehearse the evidence. On the other hand, there is a need for caution against a too-quick identification of the pre-scientific method with magic. A case in point concerns the interpretation of meteorological disturbances of unusual astronomical phenomena. It was commonly believed that they were the result of incantations and that they portended disaster. Yet, the careful examination of a series of daily weather reports, covering the period 1 September 1399—25 June 1401, permitted a series of scholars to pinpoint the location of this "weather station." That magical elements were a part of medieval weather-forecasting cannot be denied. It is only charity which leads me to believe that they have since been discarded.

The Beginning

Far surpassing the lexica and travelers' reports for popularity, and certainly in size, were the encyclopedias which gathered much of the foregoing in palatable and accessible form. Unlike commentaries and lexica, the encyclopedia had no direct classical analogue. Starting with Isidore of Seville's (circa 560-636) *Etymologiae*—itself an interesting example of another way of doing science—by the analysis of the origin of words—there appeared a series of encyclopedias, each one larger and more pretentious than its predecessor. This procession virtually came to a halt with the appearance of the *Speculum Naturale* compiled by Vincent of Beauvais (died 1264) shortly after 1244. About 450 authors are represented in this "Mirror of Nature," sometimes by rather long extracts. Unfortunately for Vincent, but fortunately for those of us who do not have access to the latest edition—two volumes in folio, 1624—there is really little need to consult him today. Thirty-two books, divided into 3718 chapters are filled with an uncritical sampling of all that was known in the thirteenth century. I have not read all of Vincent nor do I have any immediate plans to do so; but I have read Books X-XV in which trees, plants, and herbs are discussed. And when I reviewed my notes, I came away ever more convinced of better ways to spend my time than reading a rewarmed Aristotle or a boiled down Galen. The truth of the matter is that the authorities Vincent excerpted are available today in critical editions and good translations. Unwittingly, then, he contributed to a skirmish as poignant as it was decisive. No man today can claim for himself that he knows all that is to be known. That he *can* claim that there is much he does not know, is not only a confession of humility; it is where science and history, and, I submit, history of science begin.

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1893

1967

A TALE OF TRADITION

KATHY O'DONOGHUE

Student activities in the University of Colorado College of Engineering have definitely had their ups and their downs. Ever since the first student enrolled in the School of Applied Science in September 1893 (the name was changed to the College of Engineering in 1906), there have been many types of activities—some became annual events, others were forgotten; some were very small scale, some grandiose.

The first graduating classes were small and the pranks were numerous. The classes of '01, '02, '03, '04, and '05 announced themselves to Boulder by painting their respective numerals on the powerhouse smokestack which, until May 1955, towered 140 feet above the campus. Along with the pranks, the most enduring traditional activity was begun in 1902. The Engineers' Ball, then a strictly informal event, was held in conjunction with the Quarto-Centennial celebration of Colorado's statehood. The smallness of the School of Applied Science was typical of the rest of the University and rivalry between schools and colleges was very evident—especially between the Engineers and the Laws

and the Engineers and the Medics. Both the Laws and Medics looked down on the Engineers from their pedestals of professionalism but the Engineers worked hard and were soon accepted on equal ground. The rivalries took physical shape in events like the 1903 tug-of-war between the Engineers and the Laws. (The winner is a mystery.)

On the more serious side, the Colorado Beta Chapter of Tau Beta Pi, a national engineering honorary, was founded at CU in 1904. This was marked by the first annual Smoker, held in the old Armory at 9th and Pearl, which became a traditional send-off for the senior class.

By 1905, the separate departments of Civil Engineering, Electrical Engineering, Mechanical Engineering, and Chemical Engineering had formed individual societies and combined to make up the Associated Engineering Societies. This organization, with the encouragement and guidance of Dean Milo Ketchum, published the first annual issue of the *Journal of Engineering*, a technical publication aimed at the alumni and faculty.

In 1907, the Smoker was held in

the fall as a mixer for old and new students rather than as the senior send-off. The fall was apple season and the affair, held in the old Field House, was soon renamed the Applefest. The program began with informal talks by the Dean and faculty followed by apple cider and donuts. As would be expected, knowing the spirit of the engineers, a free-for-all ensued with apple cores for ammunition.

1907 was also the year that Vulcan, a local engineering honorary was established. In 1908 the American Society of Civil Engineers established a Chapter at CU, the first of many professional societies which now have chapters on campus.

The First Issue of the ENGINEER

To complement the *Journal of Engineering*, the *Colorado Engineers' Magazine* began quarterly publication in 1912. It was non-technical and aimed at the student body and at high school seniors to encourage careers in engineering. Two years later, the *Journal of Engineering* also began quarterly publication, giving the College of Engineering both a technical

and non-technical journal four times each year.

The years 1914 and 1915 brought two more national organizations to campus—Sigma Tau engineering honorary and the American Society of Mechanical Engineers. In 1918, the American Institute of Chemical Engineers became the third professional society on campus and one year later, the CU chapter of the Society of Women Engineers began—a small but quite noticeable group.

In 1920, the Association of Collegiate Engineers Colorado Chapter was chartered "to establish national unity through exchange of ideas and customs." The next year, the *Journal of Engineering* absorbed the *Colorado Engineers' Magazine* into Volume XVIII and became the *Colorado Engineer*. The *Engineer* affiliated with the Engineering Colleges Magazines Association, a national organization of about sixty student engineering publications. One of the regular features of the *Engineer* until World War II

was the Oil Can Society, a collection of the more stupendous student and faculty blunders.

E-Days Begins

1921 was also the year of the first E-Days celebration. The Mechanical Engineering steam whistle announced the beginning of the events with a blast on a Friday morning, dismissing all engineering classes for the rest of the day. The Honors Convocation, recognizing the scholars and leaders, was held in Macky Friday morning. In the afternoon, the students and faculty gathered for the picnic and field events. Friday evening and Saturday morning, all the labs were open with special displays. The Electrical Engineers piped in wireless music from Denver; the Mechanical Engineers poured molten metal; there was an electric "E" on the power plant smokestack; and all over campus there were special lighting effects. Saturday evening, there was a banquet and the already established Engineers' Ball bringing E-Days to a close

until the next spring. The second E-Days celebration added a keynote speaker to the Honors Convocation, a senior-faculty baseball game (planned but snowed out the year before), and a Mothers' and Fathers' Banquet.

During the next decade, three more honoraries were established on campus. Eta Kappa Nu, the Electrical Engineering honorary, organized a CU chapter in 1922. In 1926, the Civil Engineers established their own honorary, Sigma Epsilon, which, in 1929 affiliated with Chi Epsilon, the national Civil Engineering honorary. And in 1932, Pi Tau Sigma, the Mechanical Engineering honorary fraternity became the fifth national honorary to have a chapter in the College of Engineering.

The Applefest in 1937 was quite a jubilant affair—the first load of stone arrived for the new Engineering Administration Building, which was sorely needed to relieve the overcrowded condition of the College. During E-Days—1939, the Chemical

(Continued on page 22)



THE LUNCHEON AND HONORS CONVOCATION

Left: Deans Peters, Timmerhaus and Maler present Fred Stoppelkamp with the Dean's Recognition Award.

Right: Some of the hungrier people at the luncheon.

Photos by
Mark Phillips





Mr. Frank Kapple, of Wheaton College, spoke as a businessman to the young engineers.



David G. Messerschmitt was presented the Outstanding Senior Engineer Award by Dr. A. L. Benham, President of the Colorado Engineering Council.



Fred Stoppelkamp presents Dianne Kaufmanis with an AES Appreciation Award.

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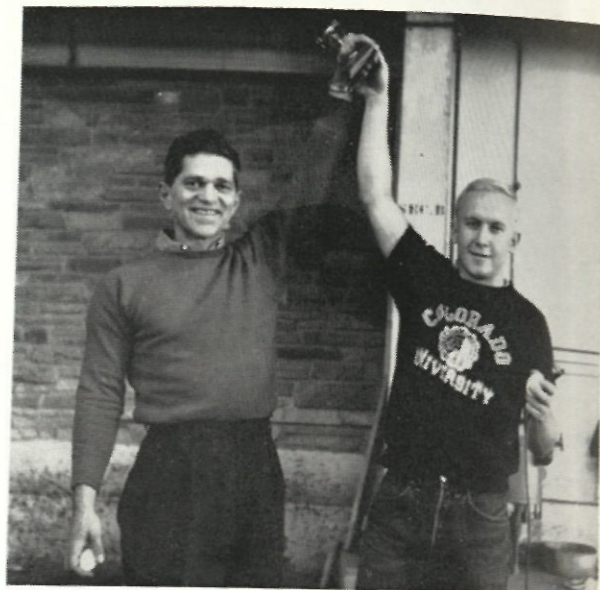
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Meredith Pate, Miss Perfect Bod, and friend.

THE E-DAYS PICNIC



Winners of the Dean's Challenge Race—the Dean and Steve Klimoski.



The victorious Civil tug-o-war team meets a challenger in the fieldhouse. (There was snow outside.)

The Perfect Bod Candidates: Mary Shicora, Sheri Cravens, Joan Burley, Wendy Miner, Cindy Hustead, Brenda Wright, and the winner, Meredith Pate.



The Queen Candidates: Diana Kifer, Nancy Simpson, Louise Carville, Pricilla Holland, Laura Watt and Winnie Wellein.



Queen Diana Kifer
E-Days -- 1967

THE ENGINEER'S BALL



Bob Pratt of Larry Dee and the Blue J's wails.



Dean Hutchinson chats with Astronaut Scott Carpenter, one of CU's more famous alums, at the Ball.

(Continued from page 18)

Engineers proudly showed their new lab and demonstrated the equipment—most of it student constructed. The Civil Engineers exhibited their new hydraulics lab at the E-Day festivities that year. Among the model homes, bridges and other projects on display was Professor R. L. Downing's proposed model of the Boulder-Denver turnpike, constructed more than ten years later.

World War II hit CU and E-Days was abandoned in 1941, not to be revived for eight years. The Applefest lasted a while longer, continuing until 1943 when the Navy Radio School took over the Field House as a barracks. By the end of the war, Aeronautical Engineering was a major department and the Institute of Aeronautical Sciences established a local chapter. In 1960, the Society for Industrial and Applied Mathematics was begun at CU. This soon became one of the largest professional societies in the technical realm.

In 1947, the Slide Rule Follies, an evening of skits presented by the de-

partments in a competitive but very hilarious manner, succeeded the now forgotten Applefest. In 1963 the Follies were cancelled because of the assassination of President John F. Kennedy and have never been revived. E-Days was celebrated again in 1949 with the same zest and has been an annual event ever since.

Associated Engineering Students

In 1956, the Colorado Engineers renamed their organization Associated Engineering Students, and so it is called today. AES, governed by a president, four councilmen and the Control Board made up of the presidents of all professional societies and honoraries and the editors of the "Vector," the bi-weekly newspaper of AES and the *Colorado Engineer*, has saved itself from imminent death because of waning student interest several times.

For E-Days, AES organized the Open House in 1956, which was replaced in 1959 by seminars for students and visitors. Another event which met an early death was the student-faculty pie-eating contest. Others,

however, have endured and continue to provide a release of tension before finals in the spring. A typical E-Days celebration now is little different from the one held in 1921 for the first time. The Honors Convocation has been combined with a luncheon on Friday followed by seminars in the afternoon. The semi-formal Engineers' Ball is held on Friday evening and the picnic on Saturday. The crowning of the E-Days Queen and the presentation of the Purple Screw to the "Meanest Professor" highlight the ball, made formal in 1927, to "soften the roughneck image of the engineer."

The picnic, with competition between the departments in field events like the bat race, egg toss and the tug-of-war, is climaxed by the choosing of "Miss Perfect Body" by the "Meanest Professor" candidates. The Beard Growing Contest has replaced the "Most Kissable Engineer" competition but the judges have remained the "Miss Perfect Body" candidates.

There will be student activities as long as there is a College of Engineering. They change and will continue to do so—but so will the students.

FUTURES

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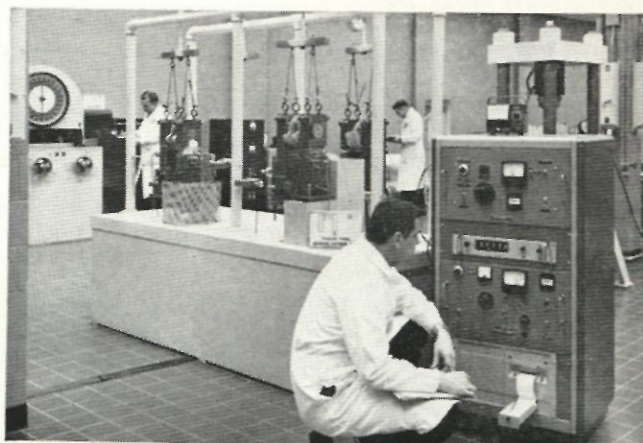
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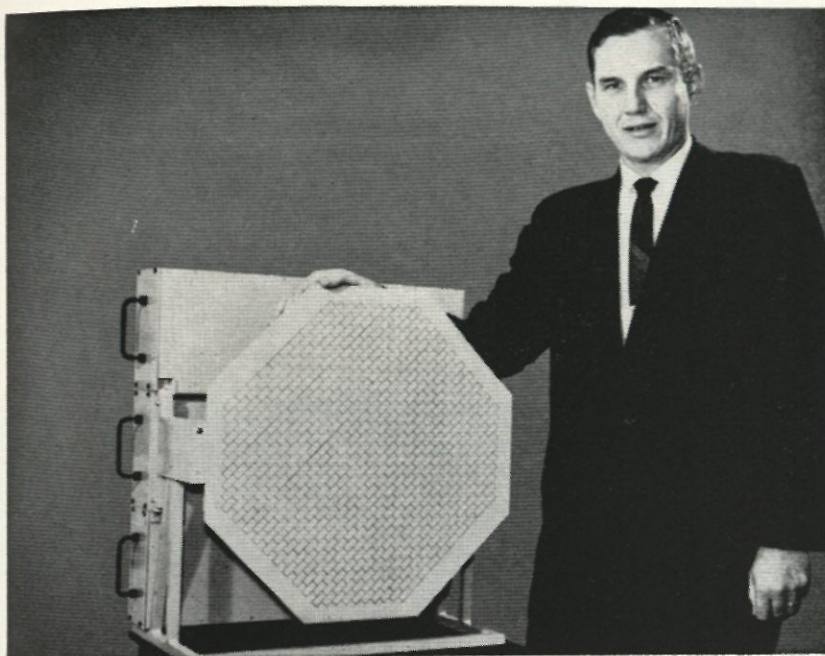
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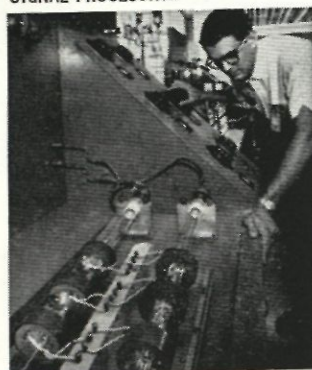
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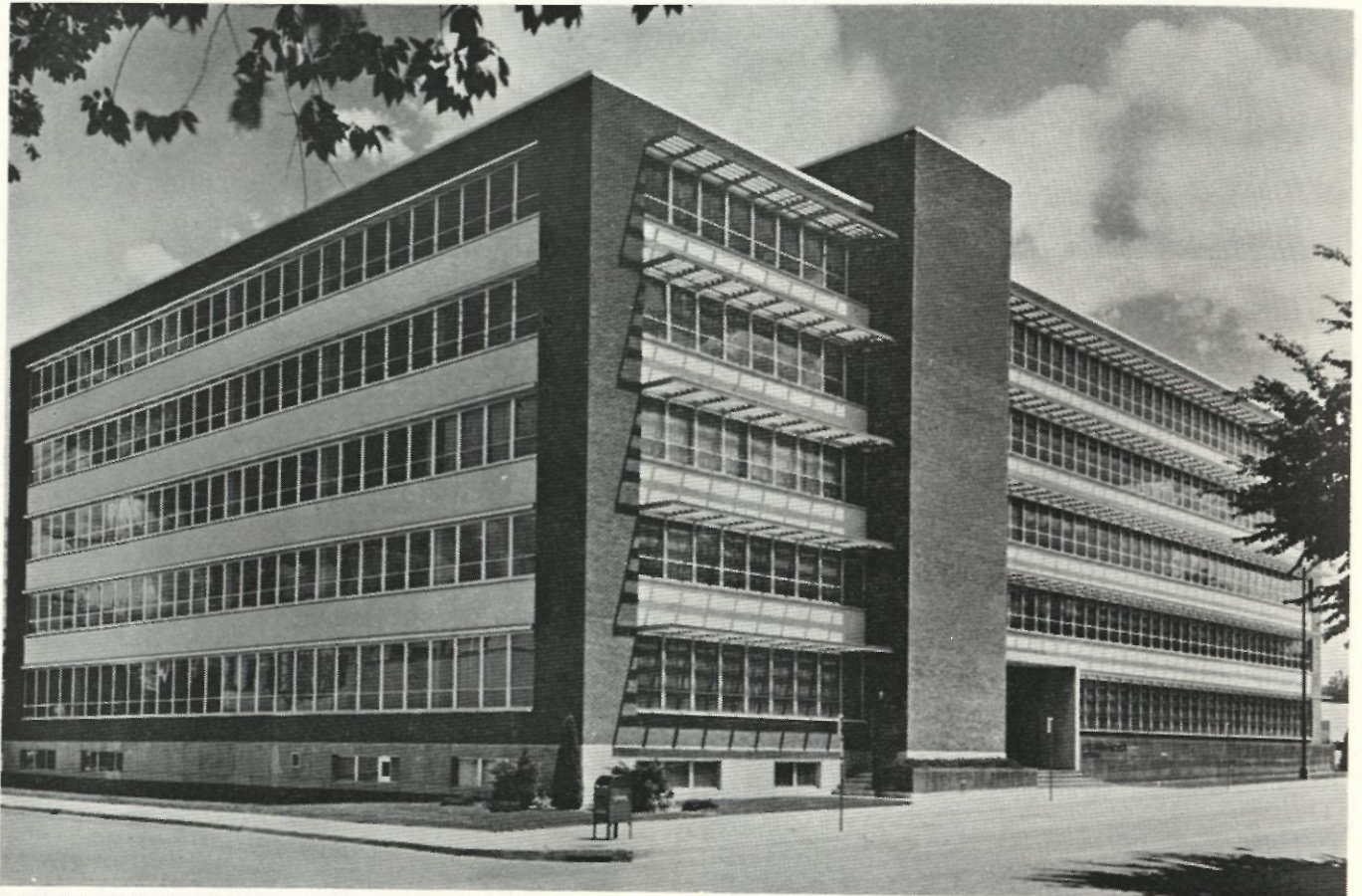


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The Quest for Excellence

BOB HOPF

The College of Engineering is gone a-grailing and the object of its quest is Excellence. Like the Holy Grail, nobody who's looking knows exactly what it looks like, but each of the searchers has his own ideas. There are some serious questions to be asked: Who is to say what greatness is? Who will tell us when we have it? What's in it for me?

What Makes a Great College of Engineering?

To the student of engineering, greatness might mean that the school has fully prepared him to tackle real problems. A graduate of a truly great engineering school should feel much more than mere relief when he graduates. He should be confident of his ability to work in his profession. I do not mean that he should be overconfident; physicians are probably the most intensely trained professionals, and even they have much to learn by experience. The graduate engineer of a great school should be aware of his limitations, but certainly should

not be apprehensive about performing in his job. It is a sad fact of life in the factories that engineers go through a rather long breaking-in period before they begin to produce for their employers. Some companies plan on a year or more of job training before they turn a new engineer loose to do any work. That this situation does exist, and is so widespread, makes me wonder what takes four (or n) years in engineering school to learn?

I think that from the standpoint of the faculty and administration, an excellent engineering school is one which is regarded by others as excellent. In this light it becomes important to know who we ask about our own standing. The standards by which this school presently measures itself are the opinions of various graduate schools, and the opinions of people in industry concerning the performance of CU's engineers as contrasted with engineers from other schools of a similar kind. The annual pile-up of industrial recruiters suggests that CU

can't be all that bad a school, but the push for improvement indicates that it could be better. In order to answer the question "How can we improve?" a consultant was retained to search for a way of making this a better school. In view of the kinds of comparisons made, the question might just as well be "How can this school become more popular with graduate schools and industries?"

A Lesson in Popularity

If the question the administration really asks is how this school can be popular with the people who count, the answers which come back begin to make more sense. The consultant was a renowned professor, noted for his research efforts. He suggested that more funds and facilities be made available for expanded research programs. This answer surprised nobody. If you have securely in mind the real questions you intend to ask, then you can select the people whom you consult, according to the answers you'd like to get.

The really important point is this: the school asks various graduate schools, asks the businessmen, sends off for an opinion from the University of Whatsit. The school asks everybody except its own students. The heart of the whole matter is that students are just not important enough to worry about. Students are a commodity, to be bought as freshmen, processed and sold as graduates. The interest of the administration is the interest of a manufacturer in how his product performs. Students are not people. The colleges of engineering across the country are subject to the identical weakness. The way to greatness is to break this pattern.

Unconcern for Undergraduates

Freshmen are tested in the same impersonal way that General Motors tests cotter pins. Those passing an incoming inspection are assigned a part number; those failing are rejected. The student's part number is his matriculation number; it is all-powerful. Just as parts and processes are designed by engineers and turned over to machinists and technicians, courses are designed by good teachers and left to graduate assistants for the actual contact with the students.

Students sense the unconcern on the part of the faculty and staff and resent being regarded as an onerous burden. Students swallow whatever pride they had when they came and accept this shabby treatment until they graduate and are out of it. I think that a commonly held feeling among undergraduate students is a sense of being *in* the college of engineering, but not *of* it. There is a real feeling of impermanence among the students, as contrasted with the feeling that the faculty and administration would continue to draw their checks, even though all the students were to disappear overnight. Students *need* the college, the college gives small indication that it even notices the students.

Out of Sight—Out of Mind

In the March 1967 *COLORADO ENGINEER*, Dean Peters relates that he sent some 1300 letters to former students, asking what they thought about the College of Engineering. He got back only about 100 replies. The overwhelming silence of the 93% who didn't answer is ascribed to acceptance

on their part of the way things were done. No doubt some of the letters were sent to no longer current addresses, or otherwise lost, but I expect that the small response was due mostly to unconcern on the part of the graduates. If the prevailing opinion is one of waiting it out, then once away, most of the former students couldn't care less about what happens back at the old mill. Contrary to popular opinion, students *do* know good teaching from bad, *do* know when their time is being wasted, and *do* resent being regarded as vegetables. The opinions which truly ought to matter to the deans are not the opinions of those long gone, but the undertone of grumbling among the present students.

Protest is exceedingly feeble among the students, not because there is nothing wrong, but for two entirely different reasons. The first is that students live in fear of the police powers of the University. To complain about poorly prepared instructors is to gamble on antagonizing the very people who make out their grades. On those grades hinge jobs and graduate schools. The police powers of the University are held in high esteem by others in the community. A Boulder merchant told me, in accepting my check for his merchandise, that a CU identification card is the best there is for cashing a check. If I wrote him a bad check, he'd just give my matriculation number to the University, and they would hound me 'til the day I died. Whether true or not is of little real importance. What *is* important is that he believed it, and so do the students.

Not Acceptance But Resignation

The second reason for the notable lack of loud protest by the students is that, contrary to faculty legend, we are a pretty reasonable bunch. Adherence to the precept "If you don't have anything constructive to say, keep quiet" keeps most of us quiet most of the time. There is no real point to petty griping about the major problems. Cavil is of no use to anyone. As small problems can be isolated, and reasonable solutions suggested, they are usually taken care of. It is the obligation of the students, as well as of the administration and faculty, to recognize situations

which need improvement, and suggest reasonable approaches toward solutions.

If former students don't care about the excellence of the College of Engineering, and the research people and the graduate school people and the business people each have their own pet notions about how to be great, where is the guidance to come from? The College of Engineering has fallen prey to the naïve hope that there is somewhere a complete set of easy answers. Students will recognize the feeling. In order to achieve greatness, the first people who must be convinced are the students. If they are convinced, and their convictions are valid, the word will rapidly spread to all the requisite quarters. The college will not be in the position of trying to live up to an inflated image.

New Attitude Needed

Nobody doubts the technical qualifications of the faculty in their respective fields, or the administrative abilities of the deans. What will set the CU Engineering College apart from the others and will strongly influence the opinions of the students is a rebuilt attitude toward undergraduate students. There are two programs which I believe would do more toward making this a great school than anything else.

The first is to actively promote excellence in instruction. Classroom instructors have more function than as collectors of homework and takers of attendance. Every person can be reached by some set of words. Textbooks are very rarely written for students. Textbooks are written by people already competent in their fields. A good instructor must be able to point out, in terms which have immediate meaning to his students, just what it is the text is saying. It should be the major business of the administration—the deans and the department chairmen—to actively promote good translative instruction. Department chairmen should frequently visit classes to assure themselves that their instructors are adequately prepared, and are conducting their classes in a manner which reflects the instructor's concern with both the technical qualification and the human dignity of the student. The Dean's office should employ a man who knows good teaching from poor,

and who will visit classes to commend good instructors and suggest improvements to the poor. The concept of Academic Freedom extends to cover unusual or dissident opinions; it should not be used as a screen for hiding sloth, sloppiness, and unconcern.

Cooperative Program

The second suggestion can be of direct benefit to only a few, but will serve as an example of concern and cooperation between the college and its students. Although this is nominally a four-year curriculum, many students require five and some six years. A seven-year cooperative program would be of direct and immediate benefit to students who are self-supporting, and to those who want a taste of engineering before making a commitment to a specific major field. It would require no small amount of arm-twisting by the deans and the faculty to secure appropriate jobs for the participating students. A summer

job before entering as a freshman could be crucial in helping a student to decide for or against an engineering career. Sad but true, many students never see an engineer at work until they graduate and take jobs. An early look at what engineering is about would provide incentive for the freshmen and help to cut down the large attrition rate. After the first year, the student should progress to a more responsible job than the one he held the previous summer. He would work in this job for fifteen months, and then begin his second-year studies. By this time, he should have seen enough to have a good idea of his major field. An additional advantage is that during the year-plus of work, he has time to think over and to put to use some of the knowledge he acquired as a freshman. Alternating years rather than semesters gives the student an opportunity to become deeply involved in his work; and further, gives the employer more useful time from each student. If it

takes six weeks to get a man going on a job, an employer will be less hesitant to hire a student who will remain with him for a year or more of useful work than one who must leave after six months.

It Will Work

The knowledge, spread among the students, that the college (which is to say the deans and the faculty) is actively interested in undergraduate education, would increase morale immensely. Quality control in instruction, and the active assistance of individual undergraduates can be decisive in lifting the College of Engineering from the level of many other schools to a position of prominence. This elevation will not come cheaply; it must be bought at the expense of prodding some of the laggard faculty. The administration must not be content to operate the College; it must lead. The students will follow.

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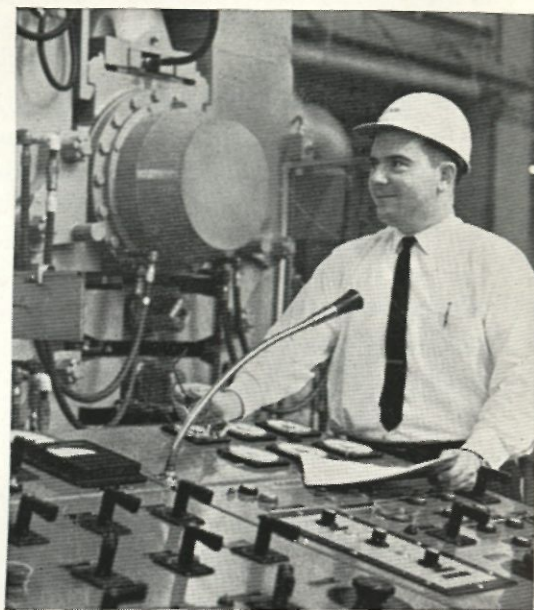
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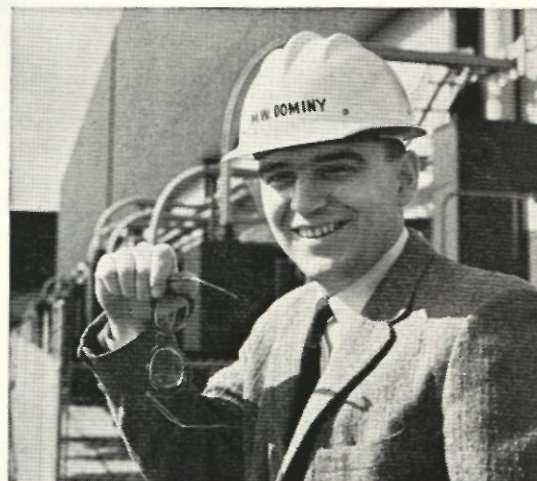


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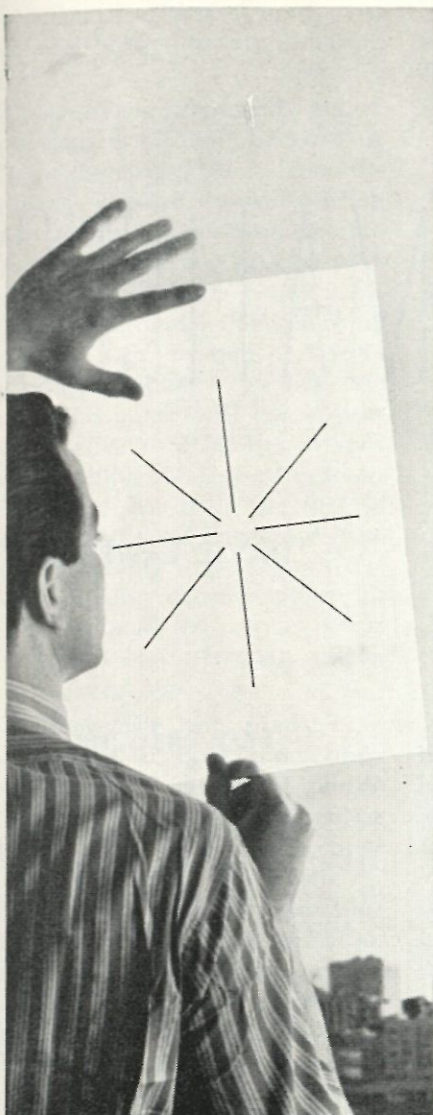


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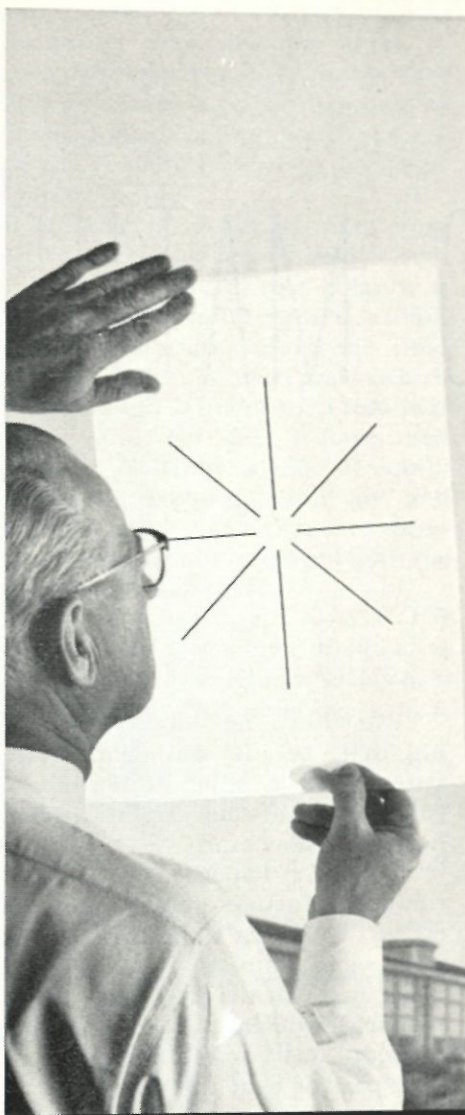
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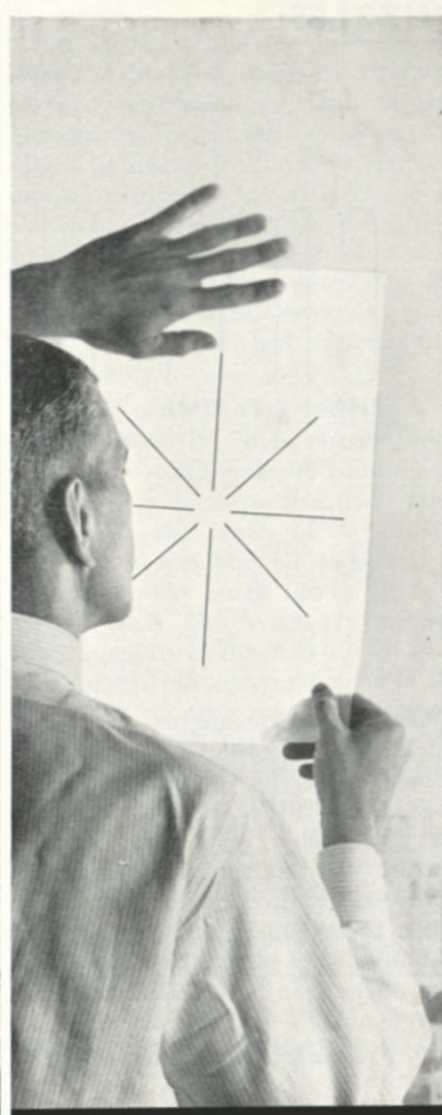
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CRYPTIC MATHEMATICUS

DAVID LAWRENCE

On those rare nights when our uncles' full schedules allow them to come together for dinner, they spend the evening filling the air with puzzles, anecdotes, and tales of their travels. My brother and I sit enraptured, especially during those times when the evening is wearing on and our minds are pleasantly tired. Then our uncles lean back reflectively and, accompanied by billows of pipe smoke, carry on a dialogue something like this:

"We've amused ourselves with minor puzzles well enough, but there comes a time when you can't help wondering about the ultimate mathematical puzzle, the question of what mathematics is and why it works. We can calculate probabilities, count things, make predictions, work modern miracles—all with the aid of a tool nobody understands. What in the world *is* math. . . ?"

"Russell says *he* knows. Math is the composite of systems developed from axioms, with certain rules of proof. The axioms are *true*, they can't be questioned meaningfully, and the things you derive from them are true, too. Of course, you can't say anything about the *world* with those systems, because they are merely hypothetical constructs. But once mathematicians realize the beauty of the pure endeavors they carry on, the world becomes unimportant. It isn't the job of the mathematician to worry about *applying* his systems. Math is *creating* them."

"I've always felt uneasy about saying that, because our mathematical systems *can* be reduced to axioms and rules, that's *all* they are. Math *works*, no matter how much you try to make it a purely hypothetical field. Insurance companies make money, rockets go where we want them to, and we're seeing into the atom. We began doing math in the first place to solve practical problems, and it seems quite arbitrary to try to eliminate the practical part of it at this late date."

"Yes, and the way you've approached math makes it impossible for it to be anything *but* a logical construct. You, and Russell, look at math logically. No wonder it turns out to have a logical essence. You have defined the application of mathematical systems as non-mathematics, but that seems as arbitrary as your claim that being able to reduce systems to axioms proves that that's *all* the systems are."

"I always end up thinking about the old mystical systems. Whenever a new unifying principle is found, whenever the order we see in the world becomes *more* manifest, whenever things are found to be even *simpler* than we had suspected, you feel an overpowering sense of 'mathematicalness' in the world. You feel laws lurking behind everything you turn your mind to, and at last you lapse into a sort of mystic wonder at it all, just as the mathematicians of thousands of years ago felt that same wonder."

"Perhaps the Pythagoreans were right, and God *is* a geometrician. When I feel the mood you just described, I can't avoid feeling the presence of a mathematical hand behind it all. The awareness of all the smoothly-running machinery gives me an intimation of some logical presence somewhere, smiling and letting his laws work. Perhaps that's the answer to this puzzle, that's why mathematics works: the ordering principle of the universe is mathematical. Perhaps someday all the arbitrary systems of Russell's analysis will be united in a sweeping meta-system which describes and illuminates all the things we see as separate phenomena today. The whole thing fills your mind."

"Einstein's statement, 'God is sophisticated, but not malicious,' seems to be answer to the puzzle, then. But there's no way to support that answer, you know. Perhaps the Russell school has taken something *out* of math to make its analysis—although you may have trouble proving that. But the Einstein answer puts something there you'll never be able to justify. Don't throw out Russell because he doesn't have a poetic soul when he talks of math. There are worse crimes."

Quiet thinking goes on for a while. If you accept Russell's answer to the puzzle, you deny the cosmic feelings you get every time you see another manifestation of the beautiful order *outside* your mind. If you take the cosmic view, you're left being unable

to *prove* your point, while the essence of the notion of math you hold is its unemotional perfection, its objective validity.

So the puzzle our uncles talk about, what is math, is difficult to solve. If you know the answer to it, then its companion, what are we doing when we do math, is simple. But, due to the methods which are necessary to an understanding of the puzzle's answer, and the difficulty of explaining them (since they probably haven't been developed, if they can be), the answer to this puzzle will not appear here. If it exists at all, it lies in your mind, your glimpses into the structure of things. For it is the sort of answer a person must create for himself, and my giving it here, even if I knew it, wouldn't make it right for you. If you should happen to puzzle about it, good luck. And my uncles wish you success, too.

ANSWERS TO

CRYPTIC ARABIC

The pearl puzzle is best explained with a table. The crux of the puzzle lay in knowing how many pearls to

weigh in the first weighing. Strangely enough, weighing all twelve gives less information than weighing eight. A clue to the number eight is the fact that *four* pearls may be handled in two weighings, leading one to suspect that the remainder *have* to be determinable in three.

The table is set up by numbering each of the twelve pearls. Which ones go on which side of the balance is shown by their numbers and a dash for the separation. If, on the final weighing, there is one pearl which was left out, it is understood that that pearl is the odd one. I have used "Balance" to denote a state of equilibrium in a weighing. "Same tilt" and "different tilt" mean that the direction of the scales has changed with the changing of the pearls.

First Weighing: 1, 2, 3, 4-5, 6, 7, 8

Balance: 2nd weighing 9, 10-11, 5

3rd weighing 9, 11-5, 6

No Balance: 2nd weighing 1, 5, 6, 9-2, 7, 10, 11

Balance: 3rd weighing 3, 8-9, 10

No Balance: Same tilt, 3rd weighing 1, 7-9, 10

Different tilt, 3rd weighing 5, 2-9, 10

With this scheme, the odd pearl

and its lightness or heaviness may be determined.

The puzzle of the odd gold coins is solved with a trick—since the king was allowed one weighing, and he was allowed to place the coins on the scales, he did so in this way: He took one coin from the first sack, two from the second, three from the third, and so on. Then the number of ounces the *total* weight was short was the number of the seditious noble's sack. This, because each bad coin was one ounce short.

. . . AND THE LIONS

Remember the lion puzzle? Four lions in a square begin running at the one in a clockwise direction? They spiral into the center of the square. The puzzle was, how far do they run? The key to the puzzle lies in the realization that the symmetry of the square results in the direction of each lion's path being perpendicular to the lion he is running towards. In effect, this perpendicularity bends the straight-line path the lion follows into a spiral, but he still runs as far as he would have had his target remained still. That distance is the length of the side of the square.

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Chips

"Winter draws on," said the Mech. E. as he tucked Sandy into an old fashioned sleigh.

"It's really none of your business," she replied coldly.

Mother-in-law: "That's a cute little tree you've planted in the front yard. It's only a foot high."

Son-in-law: "Yes. The next time you come, I hope you can sit in its shade."

"Tommy," asked the teacher, "if I lay one egg on the table and two on the chair, how many will I have all together?"

"Personally," answered Tommy, "I don't think you can do it."

A sad case is two dozen empties.

A harassed father was trying to tell his son that there was to be an addition to the family.

"Son, someday soon, the stork is going to swoop down over our house."

"Golly," replied his son, "I hope it doesn't scare Mom. She's pregnant, you know."

Two businessmen were conferring on the merits and drawbacks of advertising. "Is your advertising getting results?" inquired one.

"Why, yes," replied the second. "Last week we advertised for a night watchman and last night, we were robbed."

"I'd like to buy a corset."

"What bust?"

"Nothing bust. The old one just wore out."

Wife: "Dear, do you know where all those empty bottles in the basement came from?"

Husband: "Gee, I sure don't. I only buy full ones."

Did you hear about the oilman who decided to reform? The first week he cut out tobacco. The second week he cut out liquor. The third week he cut out women. The fourth week he cut out paper dolls.

Then there was the forlorn engineer who, on seeing a pigeon flying overhead, exclaimed, "Go ahead. Everyone else does."

Sadist: A person who locks the bathroom door on the night of a beer party.

What do they call those guys who frequent topless joints? Chestnuts.

Thermometers aren't the only things that are graduated and have many degrees without having any brains.

Porter: "Did you miss the train, sir?"

Out-of-breath passenger: "Oh, no. I didn't like the looks of it, so I chased it out of the station."

Ole and Olga had just been married, and at the reception one of the guests laughingly said to Olga, "Olga, I think you have a little Swede in you."

"Ya," replied Olga. "Ole, he yust couldn't wait."

Then there was the guy who was so good at karate that he killed himself while saluting.

A man wandered into the Sink and while drinking his seventh beer, he noticed a girl in a booth in the rear with a large white duck. He sauntered over and spoke: "Pardon me, but I just can't help wondering. What are you doing with that pig?"

The girl coldly replied, "This isn't a pig. It's a duck."

Our hero returned her icy look tenfold and replied in his most lofty manner: "I was speaking to the duck."

Steve: "I thought you were going to visit that blonde in her apartment."

Fred: "I did."

Steve: "Well, how come you're home so early?"

Fred: "Well, we sat and chatted for a while. Then she suddenly turned off the lights. I can take a hint."

It's an old Indian legend—and, as all old Indian legends, this one is about a handsome young brave and a beautiful Indian maiden. They lived across a wide and treacherous lake from each other, and each day, they would stand on their respective shores and look at each other. Soon, the young brave decided it was time to declare his love to the Indian maiden and he dove into the water. He swam with all his might, but the water was rough and he drowned. To this day, the name of the lake commemorates the brave Indian and his love for the beautiful Indian maid. It is called "Lake Stupid."

A sailor, taking his first ride on a San Diego bus, lit up a cigarette, as he sat reading the advertisements overhead. Soon, the driver came back and asked him if he could read the sign that said "No Smoking."

"Yeah, but the one next to it says 'Wear Playex Girdles' so I ain't paying attention to either of them."

Drunk: "Hey, lady! You got two very beautiful legs."

Lady (quite indignantly): "How would you know?"

Drunk: "I counted them."

Two duck hunters were sitting behind the blind, one drinking from a thermos of coffee, the other from a jug of whiskey. After some hours of waiting, they spotted a lone duck winging through the sky. Taking aim, the whiskey drinker rose, fired, and got the duck. His quite amazed and sober companion complimented him and he replied, "Aw, that's nothing. I usually get three or four out of a flock like that."

A drunk staggered into the police station and confessed that he had just pushed his wife out of a tenth story window.

"Kill her?" asked the Desk Sergeant.

"I don't think so," replied the drunk. "That's why I want to be locked up."

—John Brooks

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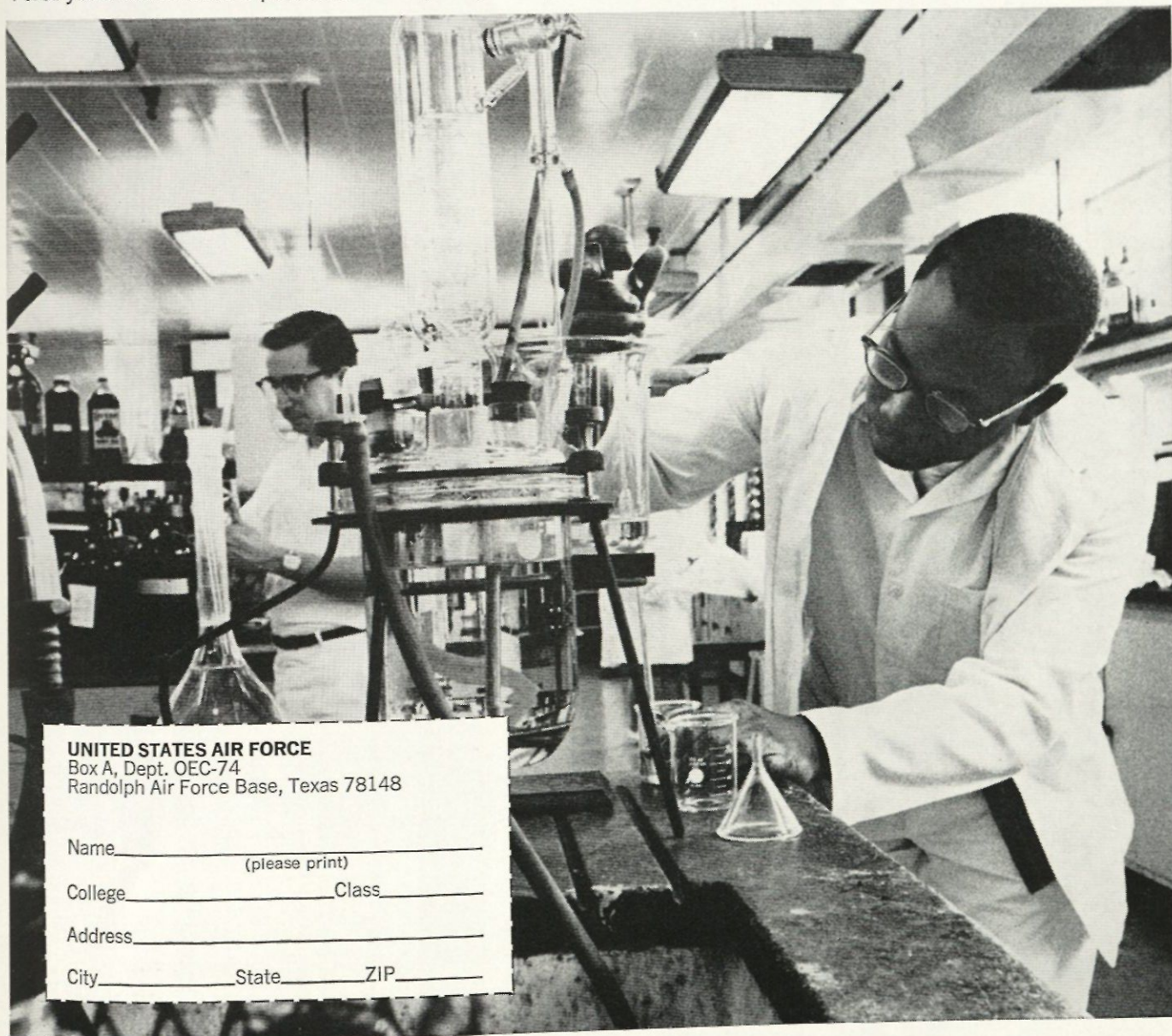
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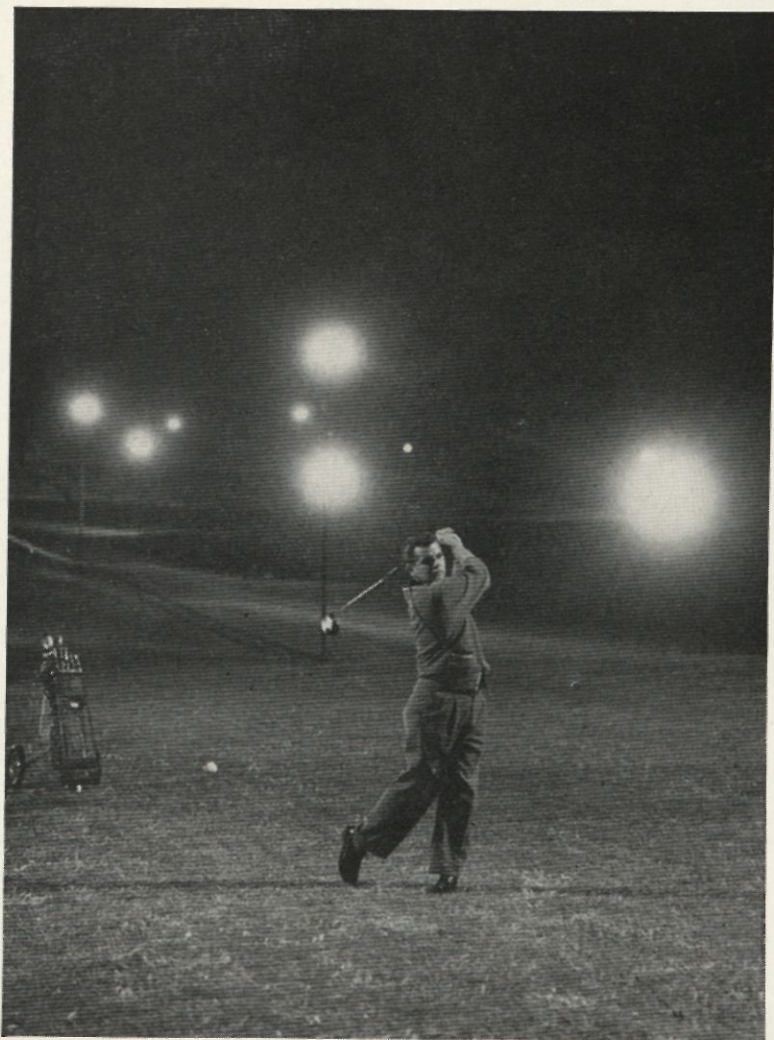
College _____ Class _____

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City _____ State _____ ZIP _____

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engineers and scientists
are satisfying the
needs of society . . .**

like longer days



Turning night into day with outdoor lighting is one of the many challenges you may face in your technical career at General Electric.

For example, inquisitive minds in research and advanced design at General Electric are evolving many concepts to make our recreation areas available day and night. Design engineers are developing concepts into specifications, while manufacturing engineers are developing the techniques and processes that translate designs into outdoor lighting systems.

In addition, technical marketing specialists are working with electric utilities and city planners, applying night-lighting to athletic stadiums, city parks, or outdoor pavilions.

You can help develop new products and concepts, new facilities, processes and manufacturing systems, or new applications and markets in your technical career with General Electric. For more information write: D. E. Irwin, Section 699-21, Schenectady, New York 12305.

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