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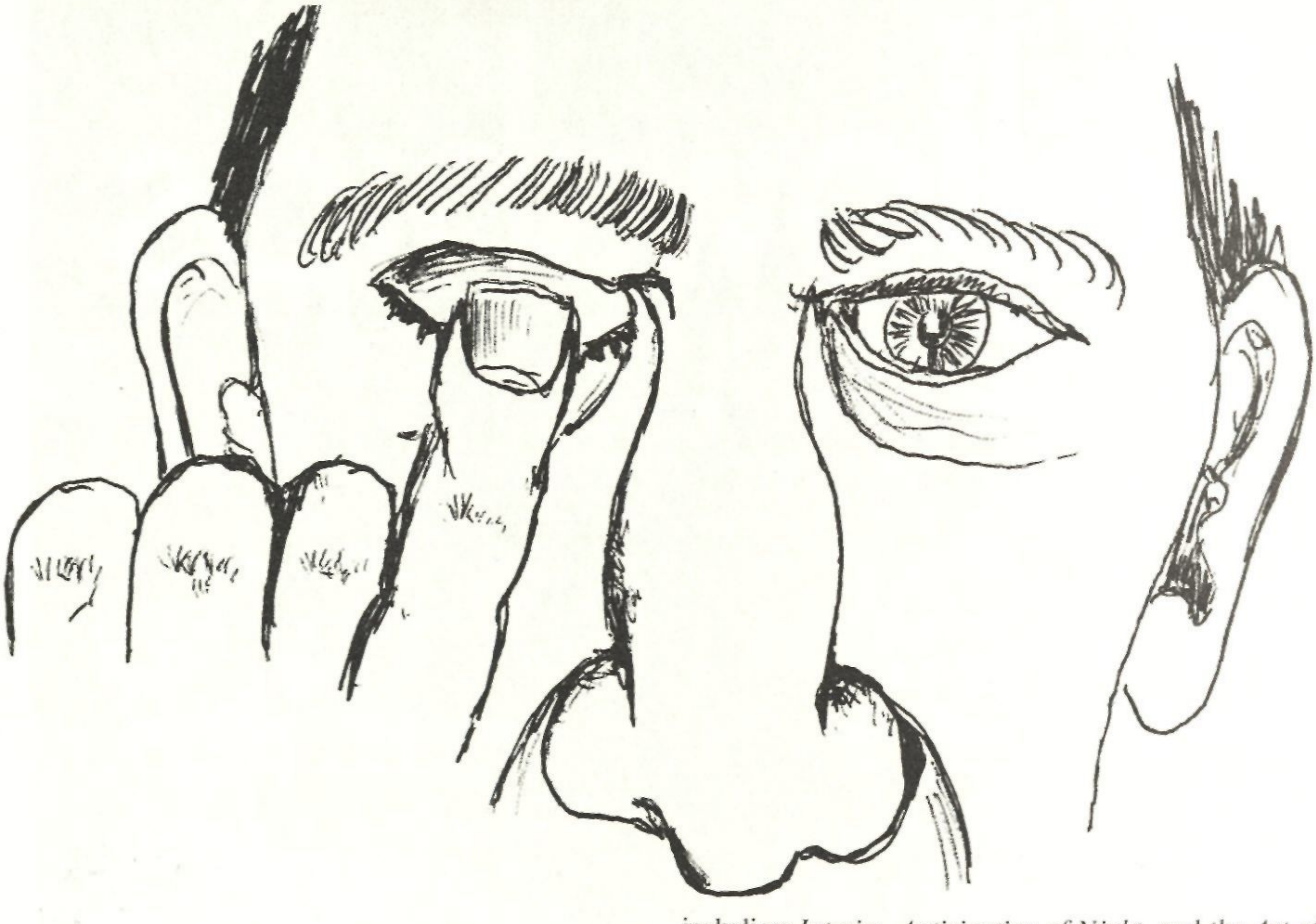
HYPNOGOGIC VISION — A SIGHT UNSEEN



by JAMES WOOD

"What one sees when one's eyes are closed" was the definition of hypnogogic vision proposed by filmmaker Stan Brakhage at a lecture presented at the University of Colorado, October 24, 1973. Brakhage's talk was one of a series of lectures called "New Horizons in Perception" sponsored by The Institute for Research on the Dissemination of Human Knowledge. His lecture entitled "Hypnogic Vision," included a variety of films illustrating various facets of this often overlooked mode of seeing. For Brakhage "closed eye vision," includes dreams, visualized memories and flashing colors and patterns called *phosphenes*. To exchange his thoughts on the subject he duplicated his personal visual experiences on film to allow the audience to re-discover the phenomenon of hypnogogic vision and to spawn new interest towards the study of this neglected visual experience.

Brakhage began making films at age 18 in Denver, Colorado. His first film entitled *Interlude*, was followed by numerous other films made across the country. Six years later, Brakhage and his wife, Jane settled in Rollinsville, Colorado. Since then, both have produced many films including: *Interim*, *Anticipation of Night*, and the *Art of Vision*. Though described by many as an experimental film maker working with fantasy, Brakhage prefers his films to be considered as works of art. Rather than experimenting, an artist strives to compose equivalents to actual sensual experiences. Every image is produced as a result of something perceived by Brakhage in the context of the hypnogogic vision. He considers his films documentaries because they are actual representations of real occurences.

Brakhage became interested in hypnogogic vision from his initial fascination with camera and film. In his philosophy, the camera is likened to the eye and the film is the counterpart of vision. Thus, the art of film making should attempt to include all elements of sight. Brakhage recalled his childhood experiences with phosphenes; the flashing stars and colored patterns one sees while rubbing the eyes or striking the head. Brakhage broadened the scope of his studies to include all the visual experiences occuring with the eyes closed. The term hypnogogic was first vaguely referred to in an essay by author Charles Olsen. It then came into prominence among poets, artists, and film producers during the mid-sixties. However, in spite of wide usage the expression had no concise definition. "So the word was wide open, which is to say to be abused if that's what one wants to do with words, or define it if that's what one wants . . .," commented Brakhage. "It was dear, to me — at least, that the word meant closed eye vision — is, what one can see when one's eyes are closed," he said concerning his reaction to the meaning of the word. So, he adopted the term for use in his film making claiming, in the words of poet Ezra Pound, "a word is a word if two people agree to mean the same thing by it."

Brakhage stated one of his goals early in the lecture when ingly, trained . . . that there is nothing to see." He explained that for small children, the world of hypnogogic vision is not separated from sight. It is not until the onslaught of symantic accuracy that a child learns that one can "see" nothing with the eyes closed. Most adults are no longer aware of "seeing" dreams or phosphene explosions, even though the capacity to see the images is still present. As a primary goal, Brakhage hopes to reintroduce this suppressed form of seeing through film.

The first major form of hypnogogic vision discussed by Brakhage was the dream, which includes both day and night dreams, and visual memories. Many of his colleagues claim that dreams are merely thought processes. Brakhage explained that after a dream, a person tends to believe that he actually saw the scenes occuring, making dreams a definite part of sight.

Brakhage went on to explain some of the problems he encounters in making documentaries on dreams. In the past, a dream signified fantasy, an untenable postulate for Brakhage. To counter this, he formulated his films out of the actual process of dreaming, to present an accurate picture of what one sees. The mixing of fantasy and real visions in dreaming inhibits any representation of an actual dream. Brakhage's problem was to extract the myth out of the dream and capture the necessary illustration of the dream on film.

The first film, a portion of *Dog Star Man*, consisted of a series of scenes of a baby crying, smiling, and talking, intertwined with shots of a bearded man climbing a rocky mountain side. At times the scenes were interrupted by flashes of bright colors. Based on a theme of birth, the purpose of the film was simply to express a dream. The various shots were connected to produce an array of picture and color jumping back and forth. Amid this imposed confusion, the film retained a strange sense of order and balance.

All of Brakhage's films are silent. He believes it is important to rid his movies from any literary effects, claiming that it is symantic accuracy that initially limited the expression of these sights. However, descriptive titles are given to "provide a key to understanding the inner meaning." Mr. Brakhage is opposed to having his films represented by single photographs, claiming that still pictures are static and cannot possibly depict the flowing nature of hypnogogic vision.

Next Brakhage spoke on a second mode of hypnogogic vision called *phospenes*. The word phosphenes comes from the Greek *phos*, meaning *light*, and *phainien* meaning to *to show*. Phosphenes are the flashing and swirling colors seen by rubbing the eyes. In sleep, these images also may appear as grainy sandlike pictures. Brakhage believes that the origin of the character "the sandman" can be attributed to these figures.

Phosphene images occur from the irritation of the optic nerve ends on the retina of the eye. Light pressure on the eyelids evokes a round orange disc, where as heavy pressure on the eyes produces the flashing patterns usually equated with this visual experience. Often these patterns are orderly dot arrangements resembling a checkerboard. An article written on the subject in *Scientific American*, by Gerald Oster, examines the inclination towards some basic patterns of phosphene images, and the fact that these same patterns appear on cave drawing and early pottery world wide. Oster concluded that the behavior of the images related to the geometry of the eye. Scientists believe these are the structure believe these are the structure of the visual pathways and visual cortex organization in the brain. It is believed that many blind people experience these images even though they lack normal vision.

Brakhage noted the inability of many adults to see these images. Apparently, if these images are continually ignored, all cognizance of the existence of such figures is lost even though the apparatus to produce them remains intact. Most children have little trouble producing these scenes and are fascinated by the ever changing array of colors. Brakhage himself admitted having to actively work at reviving these images for use in his films.

The film presented to illustrate this phenomenon was *Myth Making*. It was a six second film which took two years to produce. The movie was made by painting images on 16 mm. film. (One second requires 24 individual frames.) In addition to paint, Brakhage used such media as vibrated powder and light reflected off water. In *Myth Making*, five shapes were cast among the shifting grains of colored sand: a horse, a man, the sun, the moon and a moth. Taken together, the images combine to produce characters of mythology. The moth and the horse combine to produce the winged horse Pegasus, for example. "You get a thousand and one tales in six seconds by transposition of figures," said Brakhage.

"[Hypnogogic vision] shall signify an activity that is always personal and thus all agreement as to its meaning shall be in reference to personal experiences," Brakhage said in conclusion. Brakhage suggested the best way to understand is to close your own eyes and observe the beauty of hypnogogic visions yourself.

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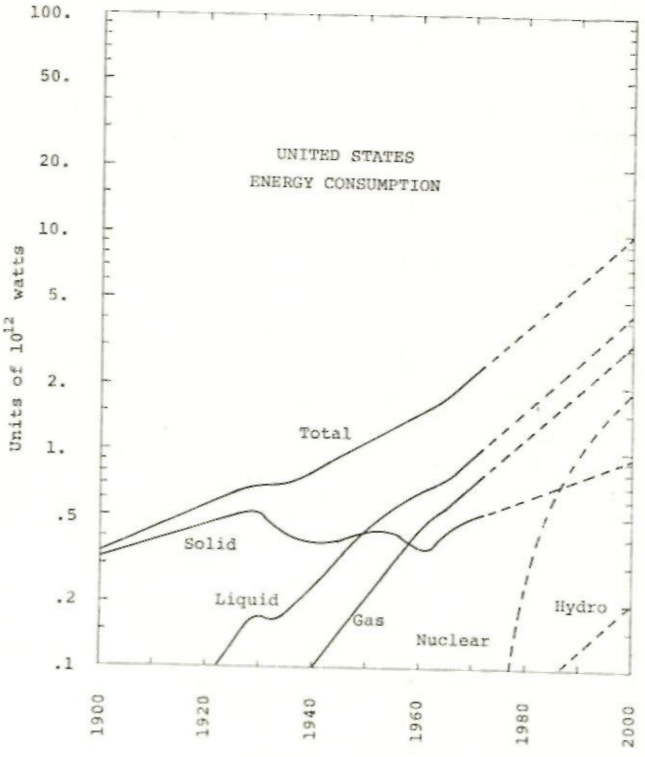
REFLECTIONS ON THE ENERGY CRISIS

by Jerrold H. Krenz

Dr. Krenz is an Assistant Professor of Electrical Engineering at the University of Colorado. He is a graduate of the University of Buffalo and Stanford University. Dr. Krenz will teach a spring semester course this year dealing with the subject of this article. The course is called "Energy Generation and Utilization".

In viewing energy consumption for the United States, one cannot but help be impressed with two salient facts. The consumption rate is large and increasing very rapidly. The steadily growing consumption rate is precipitating what is often referred to as an "energy crisis."

At present, the United States with less than 6% of the world's population, consumes one-third of the world's energy. On a per capita basis, this is six times the world's average and one hundred times that of an inhabitant of India. In terms of fuels, the average U.S. per capita energy consumption rate is equivalent to over one ton of coal or 240 gallons of gasoline each month. The growth rate for the past decade has been approximately 5% per annum, which implies that usage doubles every fourteen years. Therefore, if present trends continue, energy consumption will nearly double twice, or quadruple by the year 2000. For continued growth, a three-fold increase in energy supply will be necessary, that is, three additional refineries for every present refinery. Since electrical energy consumption has been increasing even more rapidly, namely at a 7% per annum rate, consumption will increase, if this trend continues, nearly eight-fold. That is, 6 to 7 new power plants will be needed for each present plant. Future siting problems will make present siting difficulties seem trivial.



Fossil fuels account for nearly all energy presently being consumed (liquid — 43%, gas — 33%, solid — 21%). Hydro power and nuclear energy account for only 2% of the total. A key question is the source of the additional energy if growth continues. The answer, with the exception of a small contribution of nuclear energy, is fossil fuels. While new energy sources will ultimately be developed, their contribution before the end of the century will be small and probably insignificant.

Nuclear Energy

In the late 1940's, nuclear energy was hailed as a near-infinite source of energy. Electricity so produced would be so cheap that metering would be unnecessary. It is now 30 years since the first controlled nuclear reaction was achieved, but nuclear generated energy is neither cheap nor plentiful. As of January 1973, the installed nuclear electric generating capacity was only 15 Gw, that is, four percent of the total electrical capacity. Half of this capacity became operational during only the past year. The capacity of plants presently being constructed, and that on order will bring the total to 100 Gw, or one quarter of the total present electrical capacity. If construction is not plagued with the delays of the past, this capacity will be operative in the early 1980's. Even accepting the most optimistic projections to the end of the century by the Atomic Energy Commission, nuclear reactors will supply no more than 20% of the total energy for the country if present growth trends continue.

While nuclear energy is still advertised as clean and safe by utilities and reactor manufacturers, many scientists dispute these claims. The A.E.C. claims that under normal operating conditions reactors are perfectly safe and that radiation is negligible. Implied is that non-normal conditions will never occur, an excessively optimistic view in light of the complexity of reactors. An unsolved and possibly unsoluble problem is that of waste products. Uranium and plutonium are used for fission reactions. Stimulated by a neutron, a fissionable atom breaks into two fragments that have a combined mass slightly less than the parent atom. The decrease in mass is accompanied by a large release of energy according to Einstein's famous formula, $E = mc^2$.

The parent atoms, uranium or plutonium, are, for their atomic number, excessively heavy or massive. The fission fragments are likewise excessively heavy (technically speaking, they have a greater number of neutrons than their conventional non-radioactive cousin atoms). The fission waste products are in themselves unstable and tend to radioactively decay, to more stable atoms. Some of the products decompose very rapidly while, unfortunately, others decay very slowly. Slow decay products include strontium-90, cesium-137, and carbon-14. A further complication is that these elements are chemically active and tend to concentrate in biological systems, man included. The only waste solution is to isolate it from the environment for perpetuity. Despite the large quantities of waste produced as a result of the past thirty years of weapons manufacture, and wastes to be generated as a result of anticipated power generation, no viable solution has yet been adopted. Last year the discussion centered on burying the waste products in abandoned Kansas salt mines. Kansas objected. This year it is burial in the internationally controlled ice caps of Antartica. Wastes are presently stored in large liquid vats containing a total of 70 to 80 million gallons of radioactively boiling solutions. Even breeder reactors for which it is usually emphasized that they "create more fuel than they consume" produce the same waste as their nonbreeder counterparts. It is no wonder that even the director of the A.E.C. Oak Ridge National Laboratory has referred to nuclear energy as a Faustian bargain. We can have energy, while posterity has the wastes.

Fusion

Another often discussed "ultimate" solution for energy is fusion, the process of the sun and the hydrogen bomb. Unlike fission reactors that split large atoms, fusion depends upon combining small atoms, particularly isotopes of hydrogen. Unfortunately, extremely high energies are necessary to initiate the reaction. For a hydrogen bomb an atomic (fission) bomb is used for a trigger. For a controlled energy generating system, a more docile approach is required.

Two schemes, neither of which have been successful, are being pursued. The first is a plasma fusion device in which it is attempted to hold the ionized reactants together by magnetic fields. To date, the calcitrant reactants have managed to escape before a fusion reaction has occurred. A more recent scheme relies on a laser to provide the energy to initiate a reaction. It is hoped that an energy releasing fusion reaction will occur before the reactants, owing to their high energy, fly apart. While this scheme looks promising on a limited experimental scale, large scale energy production will require major advances in laser technology. The most optimistic predictions of obtaining fusion power concede that it will not come about much before the year 2000. As put by one author, it can at best be considered as an "uncertain certainty."

In a fusion reactor, tritium, a heavy isotope of hydrogen will probably be the most important radioactive hazard. While the waste product will be helium, an inert and nonradioactive element, large intermediate quantities of tritium will be necessary. Its inadvertent release, as in the case of fission waste products, could be serious. The problem of "runaway" which has plagued fission reactor designers is not expected to be important in light of the extreme difficulty of initiating a reaction. Regardless of the ultimate potential of fusion power, its contribution to the energy supply of the 20th century can be considered zero.

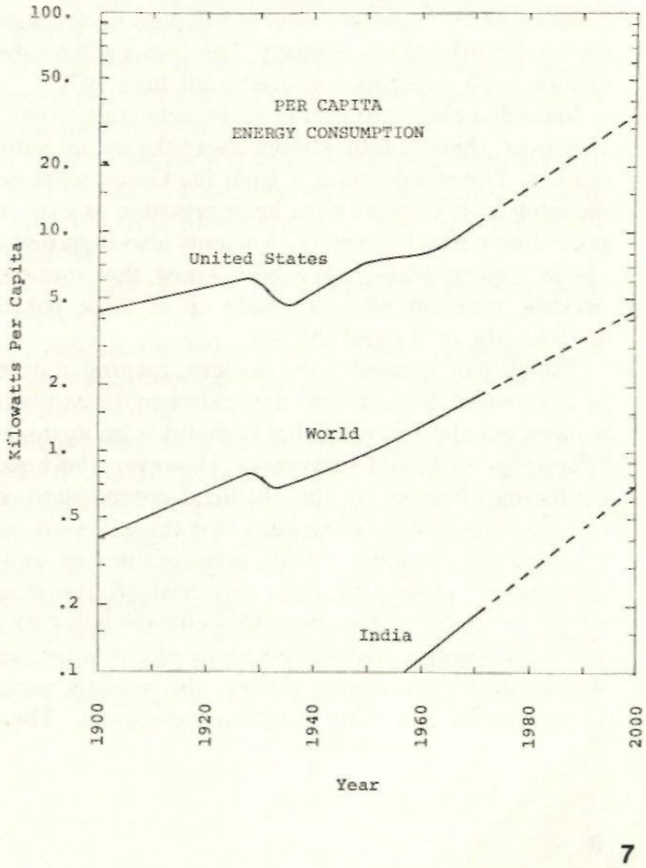
Geothermal, Wind and Water Power

Geothermal energy is produced by tapping the internal heat of the earth. Present power plants such as that of the Geysers in Northern California are in areas in which natural vents occur. Schemes to drill into thermal reservoirs and produce steam are actively being considered. However, the low thermodynamic efficiency associated with the low temperature of the steam produced, as compared to that of conventional steam plants, is a limitation. While the loss associated with the geothermal heat is tolerable, large amounts of cooling water will be required. Unfortunately, many potential geothermal sources are in water-scarce areas.

Wind is one of the oldest sources of energy. Both the large windmills of Holland and the wind driven pumps of the midwest farms come immediately to mind. In Denmark, a windmill is being used for electric power generation. Research was conducted, in this country in the 1940's in an attempt to construct commercially viable windmills to generate electricity. Proposals which even include the construction of a modern transport ship with mechanized and computer controlled sails, are being considered. That a significant component of our present energy needs can be derived by this means is doubtful.

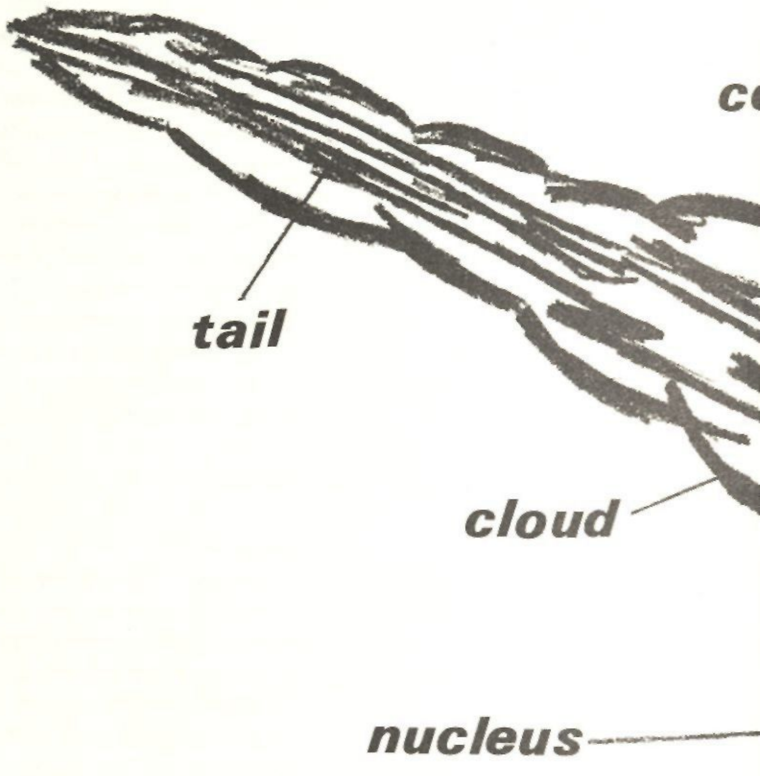
Approximately 50 Gw (one eighth of total electrical capacity) is hydropower. While a water potential of over twice this quantity could be realized, the development at present would be economically marginal. Tidal energy is another potential energy source. In France, commercial electric power (240 Mw) is being generated by a plant on the la Rance River in Brittany. Proposals to utilize the tides of the Bay of Fundy and the Passamaquoddy Bay have been presented almost perenially. Even if constructed, its proposed capacity of 500 Mw would be ex-

continued on page 10



COMET KOHOUTEK -

by Walter Cranor



Spectacular and gleaming lights in the sky, comets have intrigued men for centuries. In the past, comets have represented the fiery hand of destiny sweeping omens of good and bad into the lives of ancient Greeks and Romans, Reformation and Renaissance humanists, Medieval magicians and cleric. The interest in comets has not abaited in our day of science. It is not surprising then that the coming of our latest visitor will generate an unequaled inquiry into what the Comet Kohoutek has to tell us.

The Comet Kohoutek 1973f was discovered on March 7, 1973. The comet was named after the man who first observed it, Lubos Kohoutek, an astronomer at the Hamburg Observatory in Germany. At the time it was first sighted the comet was 3.7 X 10^8 miles from earth. Kohoutek is traveling at a speed of slightly over 18 miles per second. In the next few months, it will pass within the earth's orbit, go around the sun and recede back out of sight.

Kohoutek was invisible from mid-May until late September because it passed the opposite side of the sun from earth. By the first of November, Kohoutek was plainly observable in larger telescopes, and was rising 1½ hours before sunrise. By the end of November, the comet was within earth's orbit and had the intensity of a dim star when viewed through a telescope. During this time several good photographs were taken. The comet should become visible for six to eight weeks depending on atmospheric conditions. Kohoutek will pass closest to the sun on December 28 at roughly 4 a.m. Mountain Standard Time at a distance of 13.2 million miles. It will pass back outside of the earth's orbit in late January. The comet will be observable through telescopes at least until June 1974.

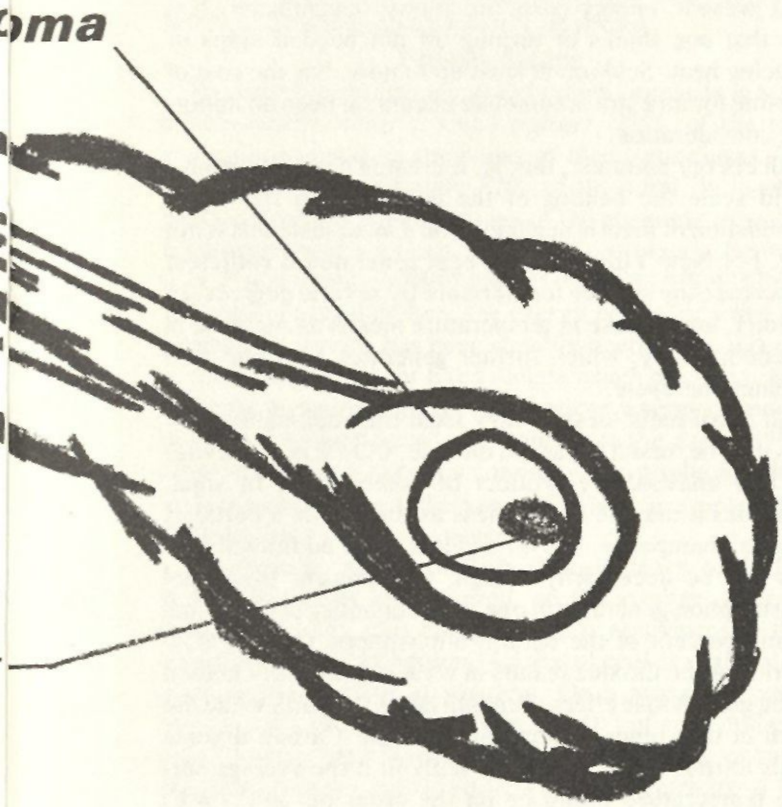
Recorded observations of comets date back to 467 B.C. However, there is little known about the actual nature of comets. The word *comet* is from the Greek work *koma*, meaning hair. Comets have been regarded as evil omens preceding natural disasters. Ancients also regarded comets as "guest stars." We now know that comets are periodic celestial visitors, made up of three parts: the *nucleus*, the *coma* and the *tail*.

The core of a comet is the nucleus, ranging in diameter up to six miles. No concrete data exists on the nature of the nucleus but the current belief is that it is an aggregate of interstellar dust and frozen gases. However, there are two conflicting theories on the chemical composition of the nucleus. One theory postulates that the gases are water, methane and ammonia. The presence of these gases would indicate that comets form from material left over from the birth solar systems. For this reason, the nucleus may yield much information about the history of our solar system. According to the second theory, the nucleus gases are formaldahyde and other simple organic gases. The presence of these gases would indicate origin of comets in interstellar space. This is credible for two reasons. First, the lack of strong solar radiation would allow the formation of such molecules. Second, radio astronomers have detected similar gases in galactic clouds. In both theories, the nucleus is surrounded by a spherical envelope of gases. When the nucleus is exposed to solar radiation the frozen gases sublime and liberate gases to form the coma. The coma of a comet ranges from 50,000 to 100,000 miles in diameter.

Operation Kohoutek will be utilizing the Skylab 4, Mariner Venus-Mercury, Pioneer 8 and 9, and a number of orbiting satellites. In addition, airplane based experiments, sounding rockets and ground based operations will be employed. Several other government organizations and most observatories and universities worldwide will be studying Kohoutek.

In Boulder, the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the Laboratory Atmospheric and Space Physics (LASP), and the University of Colorado Department of Astro-Geophysics are conducting experiments concerning the comet.

— CELESTIAL VISITOR



Dust particles liberated in the coma and gases ionized in the coma form the tail of the comet. The dust particles are forced away from the sun by solar radiation. This part of the tail is slightly curved due to the curvature of the comet's orbit and is yellowish in color due to reflected sunlight. The *ionized* gases are also forced away from the sun by the charged particles of the solar wind. This portion of the tail, the plasma tail, is bluish in color and is straight. The blue color results from a change in energy levels in the $CO+$ molecule. The tail of a comet may reach a length of well over ten million miles.

There are two classes of comets — long and short period comets. These classifications are based on the orbital size of the comet and thus its revolution period. To further describe the two classifications, it is necessary to define two points in the orbit of a comet. *Perihelion* is the point in the orbit where the comet passes closest to the sun, and *aphelion* is the point farthest from the sun. If a comet's aphelion distance is less than the radius of the orbit of the planet Pluto, it is a short period comet. Short period comets typically have a period of 80 to 100 years. Halley's Comet, a famous short period comet, has a period of 76 years. If the aphelion distance is greater than the radius of the orbit of Pluto, the comet is a long period comet. Kohoutek is a long period comet, with estimates of its period ranging from seventy-five thousand to one million years — if it returns at all.

According to Dr. Ernest Hildner of the National Center for Atmospheric Research High Altitude Observatory, Boulder, Colorado, it is probable that Kohoutek has never passed the sun before. This was deduced from the comet's apparently parabolic path. Since the comet probably hasn't passed the sun before, a much thicker layer of the nucleus should sublime than ordinarily would. This will greatly increase the size of the coma and tail, a fact important to both research and spectacular viewing. Since the volume and thus the area of the coma and tail will be increased, the intensity of the reflected light will be increased making more detailed and more accurate observations and measurements possible. In addition, Kohoutek will be exceptionally brighter than most comets because of its large nucleus (between four and five miles) and because it will pass relatively close to the sun.

Comet Kohoutek is creating great excitement among researchers worldwide for several reasons. Unlike most comets, spotted only four to five months before perihelion, Kohoutek was spotted more than ten months before perihelion. This allowed scientists an extra six months to prepare equipment and experiments.

The National Aeronautics and Space Administration organized Operation Kohoutek to organize and coordinate research activites, including the use of spacecraft. The operation is attempting to scientifically analyze all aspects of the comet. Stephen Maran, director of Operation Kohoutek at NASA's Goddard Space Flight Center, outlined several specific goals:

1. Identify the parent molecules of the gases observed in comets.

1. Identify the parent molecules of the gases observed in comets.
2. Determine the processes that break down the parent molecules and that form products and excite their radiation spectra.
3. Determine the physical nature and causes of transient events in the comet and their relation to solar activity and phenomena of the interplanetary plasma.
4. Measure the solar wind velocity in the inner solar systems.
5. Search for helium, deuterium, molecular hydrogen and other substances which have not yet been found in comets.

The primary NCAR experiment, a white light coronograph, is aboard Skylab. NOAA has been instrumental throughout the project for giving advance warning of solar flares. Their primary emphasis is on studying the solar winds. LASP scientists are in charge of two of the five sounding rockets to be sent up when Kohoutek is closest to the earth. The University of Colorado Department of Astro-Geophysics is engaged with establishing as complete a photographic record of the comet as possible.

continued on page 17

ceedingly small compared to the total electrical generating capacity.

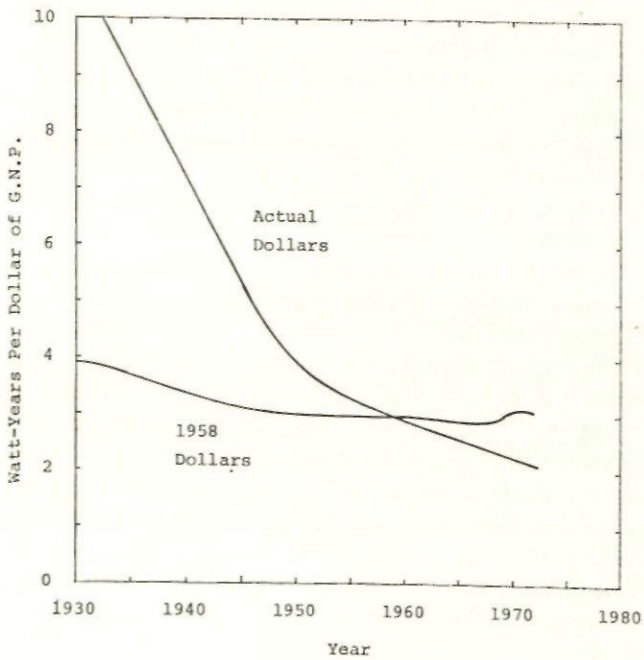
Solar Energy

Solar energy being both "free" and abundant will undoubtedly be one if not the ultimate source of energy. Fossil fuels are a form of stored solar energy, energy that resulted from past biological activity. While "free," solar energy is diffuse, that is, it is of a low quality. Nevertheless, it can be successfully used. Comfort heating in particular is an ideal application of solar energy. Even though long term storage is still a problem, one half to two thirds of the total heat for residences in most parts of the U.S. could be obtained from the sun. While modifying existing structures for solar collectors is difficult, there is no reason why solar heating could not be incorporated in new structures. The developmental work is minimal, especially compared to fission and fusion reactors.

In addition to heating, cooling by means of a solar absorptive refrigeration unit is feasible. For cooling, the peak in need coincides with the peak in supply. Again, the developmental costs necessary to produce manufacturable units are minimal. Such units could do much to alleviate summer electrical demands of the Southwest and hence provide a more attractive solution to the electric shortage than the Four Corners power plants.

In the past low fuel costs and relatively high interest rates have made solar energy economically nonviable. With rising energy costs and shortages, the market system itself may bring about changes. Even if, however, a substantial portion of new construction incorporates solar heating and cooling, the impact on total energy consumption for this century will, unfortunately, be minimal.

Large-scale direct conversion of solar energy to electrical energy is still remote. Solar cells such as used for satelites are available but their present cost prohibits their use except for specialized applications. With present technology, more energy is required to produce solar cells than that which they can produce. Improvements will obviously occur. In nature, solar energy is converted by photosynthesis. Utilizing nature's process may some day be feasible. Despite or because of its potential simplicity, solar energy research, at present, is poorly funded by both the government and industry.



Ultimate Limits

At present, energy costs are almost insignificant. It is rare that one thinks of turning off not needed lights or reducing heat. Seldom, at least up to now, has the cost of gasoline for an extra automobile excursion been an important consideration.

All energy pollutes , that is, it creates heat. While on a world scale the heating of the earth due to the direct combustion of fuels is negligible, on a local scale this is not true. For New York City, the heat generated is sufficient to increase the surface temperature by several degrees. In summer, an increase in temperature means an increase in air conditioning, which further generates heat and perpetuates the cycle.

All fossil fuels, despite how ideal the combustion process may be, result in carbon dioxide, CO_2. It is an inevitable and unavoidable product of combustion. In small quantities it may be as harmless as the CO_2 in a bottle of soda or champagne, but on a global scale additional CO_2 may not be necessarily benign. Our present fossil fuel consumption generates in one year a quantity of CO_2 equal to one percent of the natural atmospheric CO_2. Atmospheric carbon dioxide results in what is commonly known as the greenhouse effect. Sunlight heats the earth while the earth in turn tends to reradiate its heat. Carbon dixoide tends to reduce the radiation. Without it the average surface temperature would be on the order of -20°C (-4°F) instead of the present more comfortable 13°C (55°F). Increasing the CO_2 content through combustion tends, if no other changes occur, to increase the average temperature of the earth. It has been estimated that an increase of only a couple degrees would be sufficient to melt the polar ice caps which in turn would inundate coastal cities.

The combustion of fossil fuels also adds other pollutants to the atmosphere that are not only a health hazard, but that can also disturb the solar energy balance. Opaque pollutants can decrease the solar energy reaching the surface of the earth and hence decrease the average temperature. Both these effects are occurring, the one tending to conteract the other. Unfortunately our knowledge of the earth's atmosphere is too limited to know either the exact effect or the degree of change possible before catastrophic effects might occur. Even precise data on average temperature is lacking. Satelite measurements will hopefully do much to increase our knowledge of the earth's energy balance.

Despite future developments, our society will be dependent on the types of fossil fuels that are presently being used for the rest of this century. At best, only a small portion of the energy will be due to other sources. Much needs to be done to clean up combustion processes for both coal and petroleum. This is particularly important for coal, owing to its high abundance. At present consumption rates, the ultimate U.S. reserves of coal would last 1000 years, oil and gas 70 to 80 years. These are, it should be emphasized, ultimate reserves. Reserves based upon present extraction costs are considerably less. As less accessible reserves are tapped, extraction costs and hence fuel costs, will increase. Even without growth, fuel costs will significantly increase before the end of the century. If present growth trends continue, our reserves of oil and gas will be completely depleted before the end of the century, unless substantial quantities are imported.

Energy Usage

To conserve energy, we usually think primarily in terms of consumers. Only a small portion, 28%, of the total energy consumed, is the result of direct purchases. The remainder, approximately 72% of the total, is used to produce the goods and services of the economy as well as for government services. The high correlation between G.N.P. and energy consumption is therefore not surprising. In terms of actual dollars, the energy per dollar value of a product or service has been steadily decreasing, whereas in terms of constant or fixed dollars which provide a more accurate measure of goods and services, energy consumption has remained nearly constant since the early 1950's. Since energy is a necessary input of the productive process, the energy per dollar value of G.N.P. is a measure of the efficiency of energy usage.

At present, approximately 2 watt-years of 60,000 B.T.U. of energy are required, on the average, for each dollar of G.N.P. This energy value is equivalent to that obtainable from 2 kilograms (4.4 lbs) of coal or slightly less than one-half gallon of gasoline. On a monetary basis, energy costs represent between 2 to 10 ¢ of each dollar of the economy, the range depending upon the type or types of energy sources used (Petroleum — 8¢, electricity — 10¢, gas — 6¢ coal — 2¢).

Every purchase represents an energy requirement. Each productive process could be considered in terms of an energy value added. If an energy accounting existed, the energy value of goods could be compared and energy-efficient processes could thus be readily identified.

Normally, only the very energy intensive industries such as aluminum or iron and steel manufacturing come to mind. While these sectors are extremely energy intensive (high energy input per dollar of sale) their contribution to final consumer demand is negligible. Each step of a manufacturing process also requires energy. Energy is needed to operate machinery, for heat, light, and transportation. Even retail and service sectors rely upon inputs of energy for comfort, lighting and transportation. For most sectors with significant consumer final demand the energy consumed by energy intensive suppliers, such as steel, is a relatively small portion of the total energy value of a finished product such as an automobile.

By means of the input-output structure of the economy, energy usage based upon indirect dollar requirements can be obtained. While one might expect large variations in energy values, particularly in comparing service and industrial sectors, this is not the case.

Of interest is that both automobiles and food have nearly the same energy dependence, a result that would hardly be anticipated. Per dollar value, both automobiles and food require, on the average, 1.5 watt-years (45,000 B.T.U.) of energy to produce. Both farm mechanization and food processing are energy intensive. For a car, the energy equivalent of the gasoline consumed in two years of driving (20,000 miles) is required to produce an average priced ($3,000 vehicle).

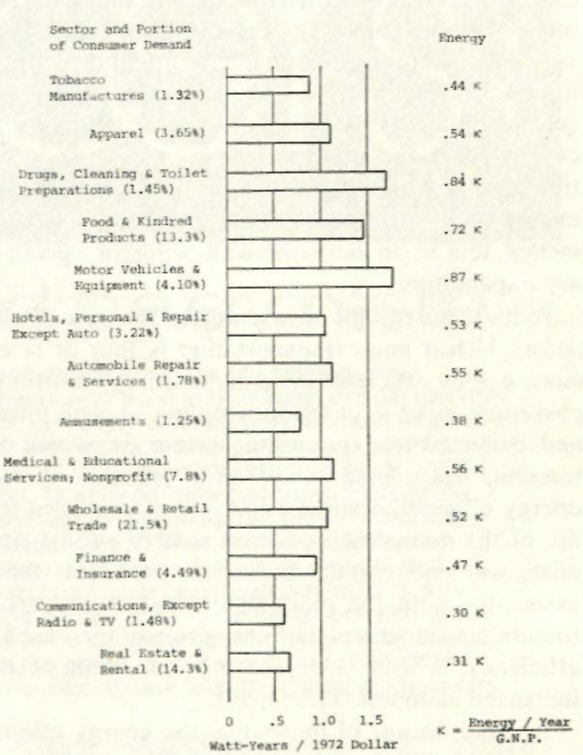
Since variations in energy requirements per dollar value of goods and services are not very large, total energy consumption is not critically dependent upon the mix of goods and services of the economy. This implies that a growing economy (G.N.P.) necessitates a growing energy consumption rate. Even though the efficiency of energy dependent processes (for example electricity generation) has been steadily increasing, increased efficiencies have had negligible effect in the past two decades in the relation between energy and G.N.P. Future improvements will very likely have no greater effect.

Conclusion

In light of the strong correlation between energy consumption and economic activity as measured by G.N.P. over the past two decades, further economic growth implies a concurrent growth in energy consumption. Even considering nuclear energy (fission), and accepting the most optimistic estimates of the A.E.C., fossil fuels will remain the prime source of energy for this century. As a result, however, of the present delays in construction of nuclear plants and the unsolved and possible unsolvable waste disposal problem, the A.E.C. predictions are being increasingly questioned.

It now seems unlikely that an unforseen "technical fix" will provide a viable short-term energy solution. The magnitude of the energy problem is simply too great. For example the replacement cost of U.S. electrical generating facilities is on the order of $100 billion. Keeping in mind

Energy Required Per Dollar Value of Goods or Services



that electricity generation accounts for only one-quarter of our total energy consumption, the economic scale of introducing a new technology is immense.

Unfortunately, even new sources of conventional fuels will have but a limited 20th century impact. The Alaska pipeline is case in point. At the present U.S. petroleum rate, the ultimate Alaska reserves probably represent no more than a six year supply. If growth continues, the oil will be sufficient for only four or five years. While the oil may be significant in reducing trade deficits, only a minimal impact on the total energy picture can be expected. Coal reserves are plentiful and could be significant, if the problems associated with large scale strip mining and the pollution resulting from its combustion could be ignored or resolved. While efforts are being made to produce a cleaner combustion process, the only solution to reduce sulfur oxides has been the use of coals with a low sulfur content. Limiting coals to a one per cent sulfur content, as is typical on the East Coast, is fine, as long as the number of plants do not increase. Six or seven new plants are equivalent to using six or seven per cent sulfur bearing coal in a presently operating plant. Reserves of low sulfur coals are limited. Continued world-wide growth in energy consumption will result in further fuel scarcities. Development of the less developed areas will create significant energy demands. As a consequence, increased energy costs owing to increased scarcity will probably be extremely significant before the end of the century.

Growth in energy consumption, at its present U.S. annual rate of four to five percent for the remainder of the century, may, from both technological and economic considerations, be nearly impossible. Predictions of energy consumption have been and are being continually revised downward from that which would be expected on the basis of present growth rates. Increasingly, discussions are concerned with reducing waste and improving the efficiency of energy usage. The economic impact of reducing the growth rate of energy consumption has not received very wide attention, at least not the attention warranted by its past correlation with economic activity. Energy conserving policies may either directly or indirectly imply a concurrent reduction in economic activity. Stated in positive terms, however, an increase in the efficiency of energy usage may result in an increased economic efficiency, that is, an increased well-being for a given monetary expenditure.

To illustrate this premise, consider the case of transportation. Urban mass transportation is four or five times more energy efficient (in terms of energy consumed per passenger mile) than the automobile. A well intergrated and balanced transportation system, in which the automobile has a lesser role than at present, will be more energy efficient. Capital costs when amortized over the life of the mass transportation system and its operating costs will undoubtedly be substantially less than costs associated with the individually owned and driven automobile. Concurrent with the resultant increased energy efficiency, will be a decrease in economic activity (or increased economic efficiency).

Another means of increasing the energy efficiency of goods is to increase durability. While the energy cost per dollar value will probably be little affected, the longer life of the product, could more than balance the additional energy and dollar cost. This also results in a decrease in economic activity.

While it is usually argued that economic growth can be maintained by expanding economic activities that are less energy intensive, the data of the previous section implies that the impact on overall energy consumption will probably be minimal. Variations between sectors are not sufficient especially when considering a potential doubling or quadrupling of economic activity.

Viewed from an energy perspective, the economic implications may be more far-reaching than simply the issue of continued growth. The present U.S. per capita energy consumption rate of 12 kilowatts may in itself be excessive. As for metabolism (also an energy consumption rate), a form of energy obesity may be occurring. The marginal utility for well-being associated with our present energy consumption rate may very well be either zero or even negative. Again, consider transportation. Present increases in gasoline consumption may be partially reflecting an increase in commuting which in turn may be the result of a decline in urban environments and an exodus by the more affluent to the suburbs. Rather than simply improving the transportation system which may further increase commuting, a more rational approach would be to deal directly with the deep-seated urban problems. Improved urban conditions would not only reduce energy expenditures for transportation but would concurrently enhance the well-being of both those presently commuting and those living in the urban blight. Associating increased pleasure or an increase in well-being with an increase in gasoline consumption, as implied by petroleum commercials, is, for our highly developed society, a dubious assumption.

Further reflection can reveal many other negative social changes that have resulted in a concurrent increase in energy consumption. Increased lighting to reduce crime, higher airconditioning loads associated with crowded working conditions and poor building design, and increased use of recreational vehicles (while minimizing the pleasure of walking). Furthermore, excessive consumption of material goods (all of which require energy to produce) may reflect efforts to compensate for deteriorating social conditions.

Energy, per se, is not a directly useful commodity. Of importance is how it is used to enhance well-being. Areas of obesity associated with energy usage are not particularly difficult to identify and will gain even more importance as discussions of minimizing energy consumption become more widespread. Perhaps, since energy and economic activity are so very closely related, energy discussions will further stimulate similar discussions of economic activity. We may find out, as for the case of energy, that an understanding of the U.S. economy can no longer be validly based on a theory of scarcity but should, assuming that our goal is to improve human well-being, take into account economic efficiency.

Is The Metric System The Best We Can Do?

By D. F. Bartlett

Editor's Note: A graduate of Harvard University, David Bartlett received his doctorate from Columbia University in 1965. He taught at Princeton before coming to the University of Colorado to be an associate professor of the Physics department. His interest in measurement units stems from extensive work in experimental high-energy physics and from teaching undergraduate laboratory courses. Dr. Bartlett will give a more detailed discussion of this topic in an upcoming issue of the American Journal of Physics.

"But were the authority of Congress unquestionable to set aside the whole existing system of metrology and introduce a new one, it is believed that the French system has not yet attained that perfection which would justify so extraordinary an effort of legislative power at this time."
—John Quincy Adams (1821)

The French system has matured. Spreading at first by its inherent superiority and lately by its expected universal application, the metric system promises soon to become in fact what it already is in name: *The International System of Units (SI)*. Yet being superior to the customary English system is not the same as being the most perfect system man can devise. Many who frankly acknowledge the problems of the SI system feel these defects to be overbalanced by the benefits of having one world-wide system.

Experience shows, however, that any scheme, once universal, is almost impossible to change. Thus the very feature of the metric system that is now most attractive — namely, the prospect of a world-wide measuring system — is potentially most dangerous. By adopting the metric system will we be committing countless future generations to the use of a system which is not the best man can devise?

The development of an ideal system of measurement will require the contributions of many men. In this paper, I shall only try to:

1) Indicate the demands made of an ideal system.
2) Show where the SI system fails to meet the ideal.
3) Illustrate one current attempt to devise an ideal system.

First, we demand *convenience*. We should like a system where any quantity may be expressed by a small number. Our customary system is rightly praised by the U.S. Metric Study for its convenience: "The householder buys a few tons of coal for the winter. The farmer delivers a few hundredweight of produce to the market. The grocer sells a few pounds of potatoes to a customer. A pipe smoker buys a few ounces of tobacco." Notice that none of these men need know how many ounces there are in a pound. In fact, many of our present units are restricted by practice to certain commodities. Only one half of all Americans know the number of inches in a yard, but nearly all women can visualize a yard of material, all men, a yard gained on the football field.

So overriding is the importance of convenience, that by 1789 the entire civilized world had become accustomed to using the inch for carpentry, the foot, acre, and mile for land, and the ton for shipping. Yet there were problems. The most pressing was that the Austrian foot, the English foot, the Spanish foot, and the *pied de roi* were all slightly different. The French revolutionary government could have chosen one of these feet as a standard and based all existing customary units on it.

Instead, they followed a more ambitious course. The standard of length was derived from a *natural, immutable standard*, the distance from the earth's pole to the equator. One ten-millionth of this distance was called the metre. A tenth of a metre cubed had the volume of a litre, which when filled with water weighed a kilogram. Finally, for the sake of convenience, secondary units, differing from the standard ones by *factors of ten* were given special prefixes (e.g. a hundredth of a metre = a centimetre, a thousandth of a litre = a millilitre, etc.) Seven prefixes, ranging from "milli" (a thousandth) to "myria" (ten thousand) were sufficient for the needs of everyone — the consumer, the doctor, the engineer, the scientist, and the lawyer alike.

The system was simple and elegant. By eliminating the various products of 2 and 3 which relate units in the customary system, the metric system made it easy for the ordinary citizen to relate small and large measures.

Yet from the onset, the metric system had troubles. It spread slowly, even in France. John Quincy Adams blamed this slowness in part on the unfamiliarity of the new system which demanded that every citizen memorize seven Latin or Greek prefixes. But he felt that the inconvenience of the system was its basic problem: "The French metrology, in the ardent and exclusive search for an universal standard from nature, seems to have viewed the subject too much with reference to the nature of things and not enough to the nature of man . . . The standard taken from the admeasurement of the earth had no reference to the admeasurement and powers of the human body. The metre is a rod of forty inches; and by applying to it exclusively the principle of decimal divisions, no measure corresponding to the ancient *foot* was provided."

Scientists, whose professional inquiry is into "the nature of things" were among the first to use the metric system. Paradoxically the very success of the last five generations of scientists and engineers has severely compromised the basic simplicity of the original metric system.

First, man has greatly extended the range of his observations. He now measures routinely lengths as small as the billionth part of a millionth of a metre or as large as a quintillion million metres. In order to cover even a portion of this extended range, the old system of prefixes has had to be extended by the addition of eight more prefixes separated by factors of a thousand rather than ten. Then to reduce the total number of prefixes, the present metric system deprecates or eliminates those which represent factors of 1/100, 1/10, 10 100 or 10,000. But such action has been taken only at the expense of convenience. In particular, the deprecation of the centimetre and decimetre leaves the SI system without any completely acceptable unit remotely related "to the admeasurement and powers of the human body".

Second, man has greatly extended the variety of phenomena he can measure. When the metric sytem was introduced, man generally measured only six quantities: length, area, volume, mass, temperature, and time. The relationship between the first three of these was clear from geometry and reinforced by the metric system. Separate standards were established for the last three.

But since 1800, whole new specialties have been developed. These specialties include molecular biology and chemistry, heat, electricity, illumination, aeronautics, acoustics, and radiation. It would have been a miracle if the units for these developing sciences had crystallized in the best way possible.

The present crystallization is, I believe, far from perfect. The units of optics are in such disarray that the editor of a prominent journal has established a separate section for the discussion of the problems. The 100-year old debate between physicists and practical engineers over the proper units for electricity and magnetism is still flourishing. The units of radiation are so complicated that seven factors are required for a simple dose calculation that in principle could be made with only three.

The framers of the SI system have made a strong effort to organize the potpourrie of units which have developed within the metric system and to eliminate those which are unnecessary. Their philosophy has been to choose arbitrarily certain quantities within the metric system as basic and to express all others in terms of the chosen ones. The difficulty is that scientists and engineers have not achieved a consensus about what the basic units should be.

Scientists have favored a system based on the centimetre, gram, and second, whereas engineers have favored the metre, kilogram, second, ampere, and lumen. Since 1930, the international standards organizations have favored the engineering system, but this action has done little to ease the stalemate. A potpourrie of units continues in all branches of science and engineering. The tables in the 1970 edition of the Handbook of Tables for Applied Engineering Science were specifically written to reflect current engineering practice. About 70% of the tables are in customary U.S. units, about 25% are in metric, but only a handful are in the official SI units.

The mistake which I believe the framers of the SI system have made is to promote a system of seven arbitrarily chosen base units in the hopes that they will be accepted by all. It is a little as though the revolutionary French chose, say, the Austrian foot and attempted to make it an international standard.

But if the developing sciences have complicated the basic simplicity of the metric system, they have also shown the way towards a more ideal system. Since the beginning of history, man has attempted to let nature set the scale for physical measurements. (One of the earliest of these natural standards, the grain of Egyptian wheat, survives in today's 5 gr. aspirin tablet.) But generally — like the metre which is now divorced from the measurement of the earth — these attempts have failed because man could reproduce an artifact more accurately than he could measure a natural standard.

Now, however, some natural phenomena have been observed which are so well measured that they can serve as a practical basis of measuring system, but which are at the same time so important that conceptual simplifications can be achieved by setting their values to a simple number like 1. Preeminent among these phenomena is the velocity of light. This velocity can now be measured so precisely that the standard length will soon be determined by how far light travels in a given time. Yet the speed of light is so basic to the entire subject of electricity and magnetism as well as to Einstein's famous equivalence between mass and energy that dramatic conceptual simplifications could be made if we adopted a measuring system in which the speed of light were set equal to 1.

Systems where the velocity of light and a few other fundamental atomic constants are set equal to one are called "natural systems". Max Planck, the founder of 20th Century physics, gave an excellent explanation for the attraction of these units: "they are independent of special bodies or substances and necessarily retain their significance for all times and for all environments, terrestrial and human or otherwise". In short, they form an ideal basis for a measurement system.

Yet, although these units have been popular among theoretical physicists for 50 years, there has not been a general movement to replace the existing metric system with a natural one. There have been two reasons for the reluctance to give up the familiar system. The first problem, that of accurately relating metric measures to natural units is just now being eliminated by new measuring techniques. The second problem is one of nomenclature. The velocity of light is so large that the velocity of ordinary objects seems very small by comparison. What motorist would exchange 60 mph for 90 billionths (of the velocity of light)?

The problem of nomenclature can be solved by the development of an automatic way of representing repetitive multiplications or divisions by 10. For instance 10 000 is the product of 1 x 10 x 10 x 10 x 10. The product of 10 multiplied by itself four times may be written in the scientific notation (now being taught in our junior high schools) as "ten-to-the-fourth" (10^4). Similarly a billionth, which is the quotient of 1 divided by 10 nine times may be written as 10^{-9}. But "ten-to-the-minus-nine" is even more awkard than "a billionth." Ironically, computers are slowly humanizing scientific notation. The "exponential notation" of computers is so widely used that it is the notation os choice in the list of conversion factors for the Standard Metric Practice Guide of the American National Standards Institute. In this notation, ten thousand is written as E+4 and a billionth as E−9. It takes but little imagination to visualize the simplest exponential notation where 10 000 becomes Positive 4 or P4 for short, and 1/1 000 000 000 becomes Negative 9 or N9.

For the motorist, N9 would effectively become the "bench-mark" to which his car's speed is referred. He would no more need to visualize N9 as a billionth of the speed of light than today's motorist needs to visualize a mile as *milia passuum* or a thousand paces. In time, "N9" could be omitted from highway signs entirely, just as "mph" is generally omitted now.

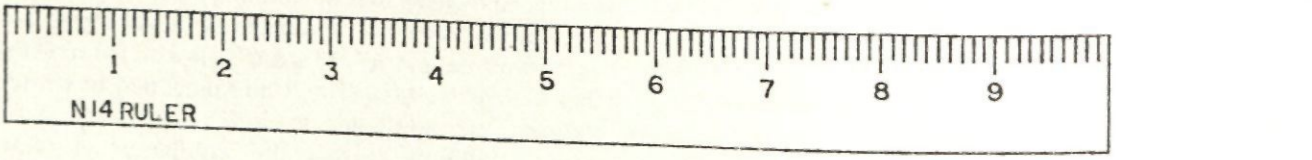
Although the day is not a natural unit in the sense defined by Planck, it is inescapably the fundamental period of our lives and hence is a "natural" unit for earthbound men. If the day is taken as the unit of time, the natural unit of length is the distance light travels in a day. Accidentally, the light-day is very close to 10^{15} thumbbreadths or 10^{14} times the length of the naked human foot. Said another way, in this natural system, the practical units of length, the N15 or N14, are very close to our present inch and foot respectively. The natural system thus yields measures for length which fulfill Adams' ideal of being related to "the admeasurement and powers of the human body"

But if the conduct of one's daily life need not be dramatically perturbed by natural units, his understanding of our technological society can be significantly improved. For instance, one problem of the pollution crisis or the energy crisis is one of communication. The ordinary citizen is increasingly being asked to relate his activities to the nation's and world's need for energy or tolerance of pollutants. This communication is impeded if the units used for one's daily life are entirely different than those used for the nation's activities. This is the case for energy different than those used for the nation's activities. This is the case for energy consumption which the individual measures variously in Calories per day, kilowatts, or gallons of fuel per week, but the nation may quantify in Btu per year. In the natural system, an individual's consumption of food, electricity, and fuel are each expressible by a single number (like 0.13 P46, 1.3 P46, and 6 P46 respectively). The sum of these numbers multiplied by the nation's population gives approximately the nation's power need.

The engineer as well as the layman would benefit from the all-numerical scheme of natural units. The engineer frequently makes long calculations involving successive multiplications and divisions. Inadvertently omitting a factor is the most common error in these calculations. Since customary measurement systems strive to have a unit close to the practical measured quantities, this omission is often unnoticed. However, as measured in natural units nearly all practical quantities are different and are very large or very small. For instance, an engineer who forgets to put a velocity of 30 metres per second into a calculation may still get an answer that looks right; whereas one who forgot an equivalent velocity of 1.0 N7 would get an answer that was wrong by a factor of ten million!

A natural system of units is most convenient for use with today's computers or with the miniature calculators that are rapidly displacing the slide rule. By recording the exponent (e.g. N9 or P46), these devices could effectively keep track of the physical quantity being measured as

continued on page 20



From December 14, 1973 until perihelion occurs December 28, Comet Kohoutek will be visible in the southeast sky before sunrise. On the 14th, Kohoutek will rise at 5:45 a.m. Mountain Standard Time. As perihelion approaches, the comet will rise later every day until December 28 when Kohoutek will rise approximately 1½ minutes after the sun and will be northwest of the sun at an angle of 2½°. Following perihelion, the tail of the comet will appear to grow as it swings around the sun. On January 15, 1974 the tail will be visible at full length. In the post perihelion stage, Kohoutek will be rising later than the sun and will be viewed most successfully in the southwest evening sky. See Figure 1 for more detailed information on when and where to view the comet.

Care should be taken when observing Kohoutek near perihelion to avoid eye damage. Blocking out the sun or standing in the shade of a building should make it possible to see the comet in the daytime. Photographs should be attempted during this period only with the help of an experienced observer.

The Max Plank Institute, Germany, has undertaken the task of assembling a complete chronological record of the comet from photographs and drawings from around the world. For this reason, if you have a photograph or drawing which shows some unusual detail or a particularly clear photo you may wish to bring it to the attention of one of the groups observing the comet. It may be that you were the only person observing at the time and captured previously unrecorded phenomena.

It is unquestionable that science will yield a great wealth of information on the nature of comets. The sorting, reading and interpretation of data from Comet Kohoutek will continue for months and even years, lending a more complete understanding of our universe.

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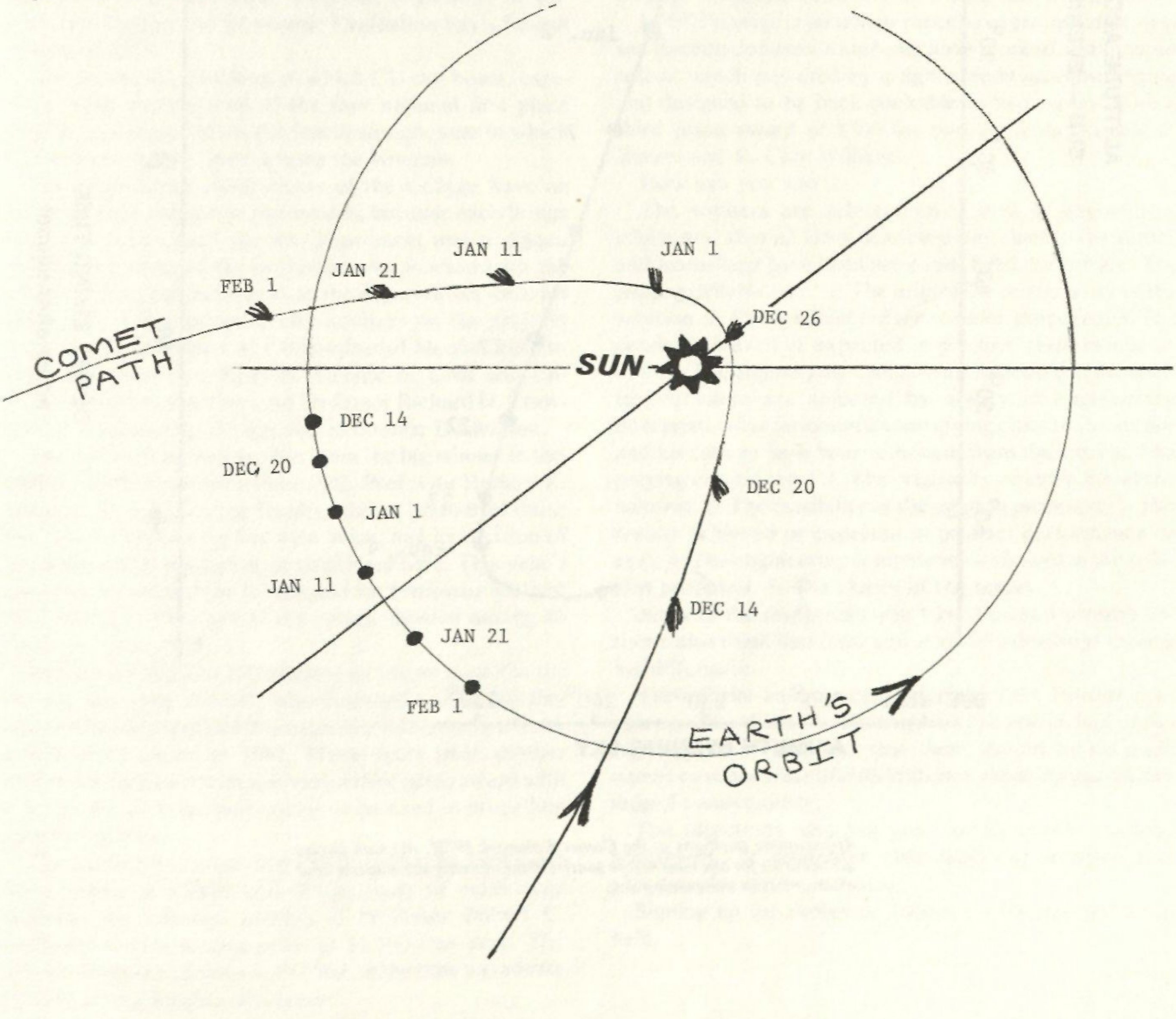
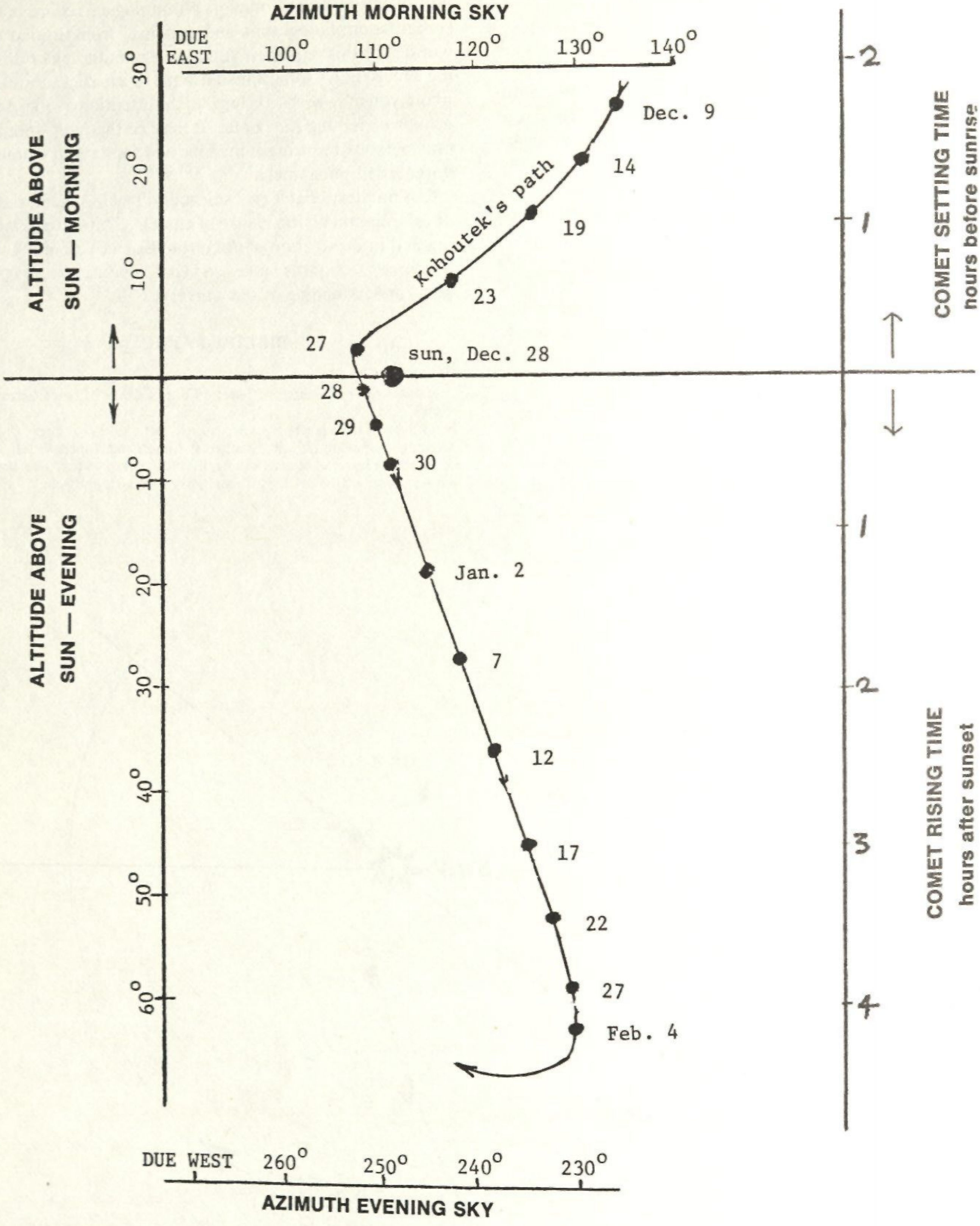




Approximate positions of the Comet Kohoutek 1973f. Azimuth angles are accurate for one hour before sunrise in the morning sky, and one hour after sunset in the evening sky.

Rewards for Lab Work

by Martin Barber

The senior project laboratory is a performance course in which you demonstrate to your own satisfaction (and for the record) that you can carry out a job of engineering. It pays off in confidence and experience, but for fourteen CU seniors since 1970 it has also paid off in professional recognition and cash, in the form of prize awards from the Student Design Competition of the Lincoln Arc Welding Foundation.

This year Roger A. Cozens and David V. Hampton of Mechanical Engineering are splitting a First Award of $1,500 and Garland Wilson III of Civil Engineering has a first prize of $1,000, while Ralph O. Muncaster of Engineering Design and Economic Evaluation has a Fourth Award of $250.

The record is something of which CU can boast, especially after winning two of the four national first place awards this year. This is the fourth straight year in which CU engineers have been among the winners.

The engineering departments of the College have an extra reason to welcome the awards, because each brings with it a cash award for the department and a plaque bearing the name of the professor who worked with the winner. This year the checks to the departments were for $300 each. Honored as faculty advisers on the projects were Professor Robert A. Christopher of Mechanical Engineering; Professor Kurt H. Gerstle of Civil and Environmental Engineering; and Professor Richard H. Crawford of Engineering Design and Economic Evaluation.

Mechanical Engineering has been the big winner in this college, with five awards since 1962. Professor Herbert E. Johnson III has been the faculty adviser on four of those five. Civil Engineering has won twice, and its division of Architectural Engineering an additional time. This year's award is the second for EDEE and for Professor Richard H. Crawford. The total is ten prizes, divided among 16 students, since 1962.

Apparently the first CU student to win an award in the contest was Dale Amend, who designed a truck loading hoist in the laboratory of Professor Herb Johnson and took a fifth place award in 1962. Three years later another student of Professor Johnson took a third place award with a design for an induction nozzle to be used in propelling ground vehicles.

The current four-year win streak started in 1970, with three prizes. A survey and design study of multi-story buildings by a former student of Professor Robert E. Rathburn won a second prize of $1,500 that year. The winner, Robert F. Johnson, Jr., was at the time a graduate student at Washington University.

A design for an office building of cuniform, or concave wedge, shape took a $500 second prize that year for Joseph F. Stucka, a student of Professor Larry J. Feeser.

A wheelchair lift, a project on which a number of mechanical engineering seniors have worked, also won in 1970, for a five-member team of Professor Johnson's students. The device makes it possible for a paraplegic youth to enter a station wagon van.

The next year John A. Tuthill, whose hobby was restoring old cars, won a fourth place with a demountable loading frame he built to help him hoist heavy parts into his pickup. Professor Crawford of EDEE was his adviser.

In 1972 a project on which successive groups of Professor Herbert Johnson's students have worked, a mountain rescue winch powered by a light-weight gasoline engine and designed to be back-packable in two pieces, won a third place award of $500 for two students, Ronald J. Berger and R. Clay Williams.

How can you win?

The winners are selected by a jury of engineering educators, after all identification giving clues to the author and his college have been removed, from the entries. The judging criteria are: "1. The originality or ingenuity of the solution. 2. The feasibility of the solution proposed. 3. The results achieved or expected in product performance or cost. 4. The engineering competence indicated in the solution qcvners are selected by a jury of engineering educators, after all identification giving clues to the author and his college have been removed, from the entries. The judging criteria are: "1. The originality or ingenuity of the solution. 2. The feasibility of thesolution proposed. 3. The results achieved or expected in product performance or cost. 4. The engineering competence indicated in the solution proposed. 5. The clarity of the report."

Some of the professors who have coached winning entrants also think that clear and attractive drawings make a big differnece.

The official announcement for the 1974 contest asks among other things that entries be typewritten and drawings legible. It tells you that there should be no trade names or school identification shown, since the papers are judged anonymously.

The directions also tell you not to submit models, specimens, or computer printouts, but mention that photographs can be included.

Signing up for Professor Johnson's lab also seems to help.

well.

The scientist, citizen, and engineer alike are hopeful that after the upheaval wrought by the abandonment of our present measuring system, our units may emerge so perfected that future generations will have no wish to change them. Often, however, these hopes run counter with the reality of *standardization* — namely, that the new system must be identical with the International System of Units. Unless this system is the best we can do, the goals of perfection and standardization will continue to be in conflict.

This conflict is present even for manufacturers, whose quest for international standardization is probably the driving force behind the metrication of America. Consider the well-publicized example of screw threads. As I understand it, The Industrial Fastener Institute and the American National Standards Institute have developed a design which is superior to both the existing metric and U.S. designs. The difficulty is that the present metric countries may well elect to keep their existing threads indefinitely even if U.S. manufacturers adopt the new design. If European manufacturers do not switch, then the benefit of standardization is lost; if we adopt existing metric threads, then we lose the benefit of a superior design. However, if a "third" measuring system were adopted universally, both U.S. and metric countries could cooperate in developing optimal screw thread standards without offense to national pride and practices.

The question is whether other industries might benefit from the thorough reexamination which a world-wide change-of-units would provide. I doubt that this question can be answered without detailed study. There is no reason, however, why this study cannot proceed in parallel with the early planning activities of the proposed Metric Conversion Board.

AN ANALOGY

Around the turn of the century, one could telephone a person by simply ringing the central operator and saying "I would like to speak to Mr. Smith". This system was very convenient for the user. But as towns grew and people died or moved, the system became increasingly complicated for the operator. Soon every phone in the town was given a number, and one would ask to speak to "Jamesberg 124". But the capacity of even this less personal system was rapidly exceeded by the growing number of users, and phones had to be identified by a combination of an artifical name and a number like MOnument 3-2747 or MO 3-2747 for short. But some people complained that "monument" sounded too funereal; others had trouble spelling the two-letter abbreviations. So the telephone company had an idea. Why not replace the named exchanges with purely numerical ones. At the time this substitution was made, many felt uneasy. Some warmth was lost with the departure of ACademy and BOwling Green. But after 10 years, most have become happy with a system that does not tax one's spelling and allows one to use a long number to dial across the nation or a short number to dial across town.

The University of Colorado chapter of Tau Beta Pi, national engineering honorary society, has won the 1973 award for the "Most Improved Chapter in the United States." The chapter also has won an honorable mention in the judging for the Outstanding Chapter in the United States. Felix Fisher is student president.

Dr. Ronald M. Helms of the Department of Civil and Environmental Engineering returned recently from a meeting of the United States Committee of the International Commission on Illumination at Pennsylvania State University. At the meeting he made a presentation urging that the next international meeting be held in Boulder. The international commission has representatives of countries on both sides of the Iron Curtain. One of its primary functions is establishing recommended standards for illumination.

Professor John C. Twombly of the Department of Electrical Engineering is the recipient of an Arthur J. Schmidt Foundation scholarship. The award enabled him to participate in an intensive 3-day course on new analog surface-wave filter techniques and applications in St. Charles, Illinois November 14-16.

Development and Design.
Is this the kind of engineering for you?

Trying to figure out the exact kind of engineering work you should go into can be pretty tough.

One minute you're studying a general area like mechanical or electrical engineering. The next you're faced with a maze of job functions you don't fully understand. And that often are called different names by different companies.

General Electric employs quite a few engineers. So we thought a series of ads explaining the work they do might come in handy. After all, it's better to understand the various job functions before a job interview than waste your interview time trying to learn about them.

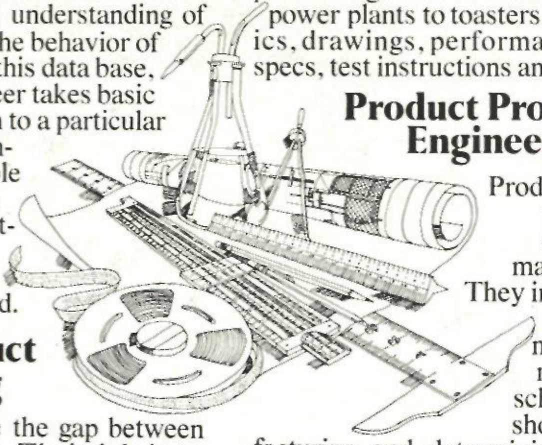
Basically, engineering at GE (and many other companies) can be divided into three areas. Developing and designing products and systems. Manufacturing products. Selling and servicing products.

This ad outlines the types of work found in the Development and Design area at GE. Other ads in this series will cover the two remaining areas.

We also have a handy guide that explains all three areas. For a free copy, just write: General Electric, Dept. AK-1, 570 Lexington Avenue, New York, New York 10022.

Basic/Applied Research Engineering

Motivated by a curiosity about nature, the basic research engineer works toward uncovering new knowledge and understanding of physical phenomena (like the behavior of magnetic materials). From this data base, the applied research engineer takes basic principles and applies them to a particular need or problem (such as increasing the energy available from a permanent magnet). Output is aimed at a marketable item. Both work in laboratories and advanced degrees are usually required.



Advance Product Engineering

Advance engineers bridge the gap between science and application. Their job is to understand the latest advances in materials, processes, etc., in a product area, then use this knowledge to think up ideas for new or improved products or to solve technical problems. They must also prove the technical feasibility of their ideas through laboratory testing and models. Requires a highly creative, analytical mind. A pioneering spirit. And a high level of technical expertise. Output is often a functional model.

Product Design Engineering

Design engineers at GE pick up where the advance engineer leaves off. They take the product idea and transform it into a product design that meets given specs and can be manufactured. Usually, they are responsible for taking their designs through initial production to prove they can be manufactured within cost. Requires a generalist who can work with many experts, then put all the pieces together to make a product. From power plants to toasters. Output is schematics, drawings, performance and materials specs, test instructions and results, etc.

Product Production Engineering

Production engineers interface between the design engineer and manufacturing people. They interpret the product design intent to manufacturing. They maintain production scheduling by troubleshooting during manufacturing and determining deviations from specs. When necessary, they help design adaptations of the product design to improve quality or lower cost without changing the essential product features. Requires intimate familiarity with production facilities.

Engineering Management

For people interested in both engineering work and management. Engineering managers plan and coordinate the work of other engineers. They might oversee product development, design, production, testing or other functions in marketing and manufacturing. Requires a strong technical base gained through successful engineering work. Sensitivity to business factors such as cost and efficiency. Plus the ability to work with people.

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