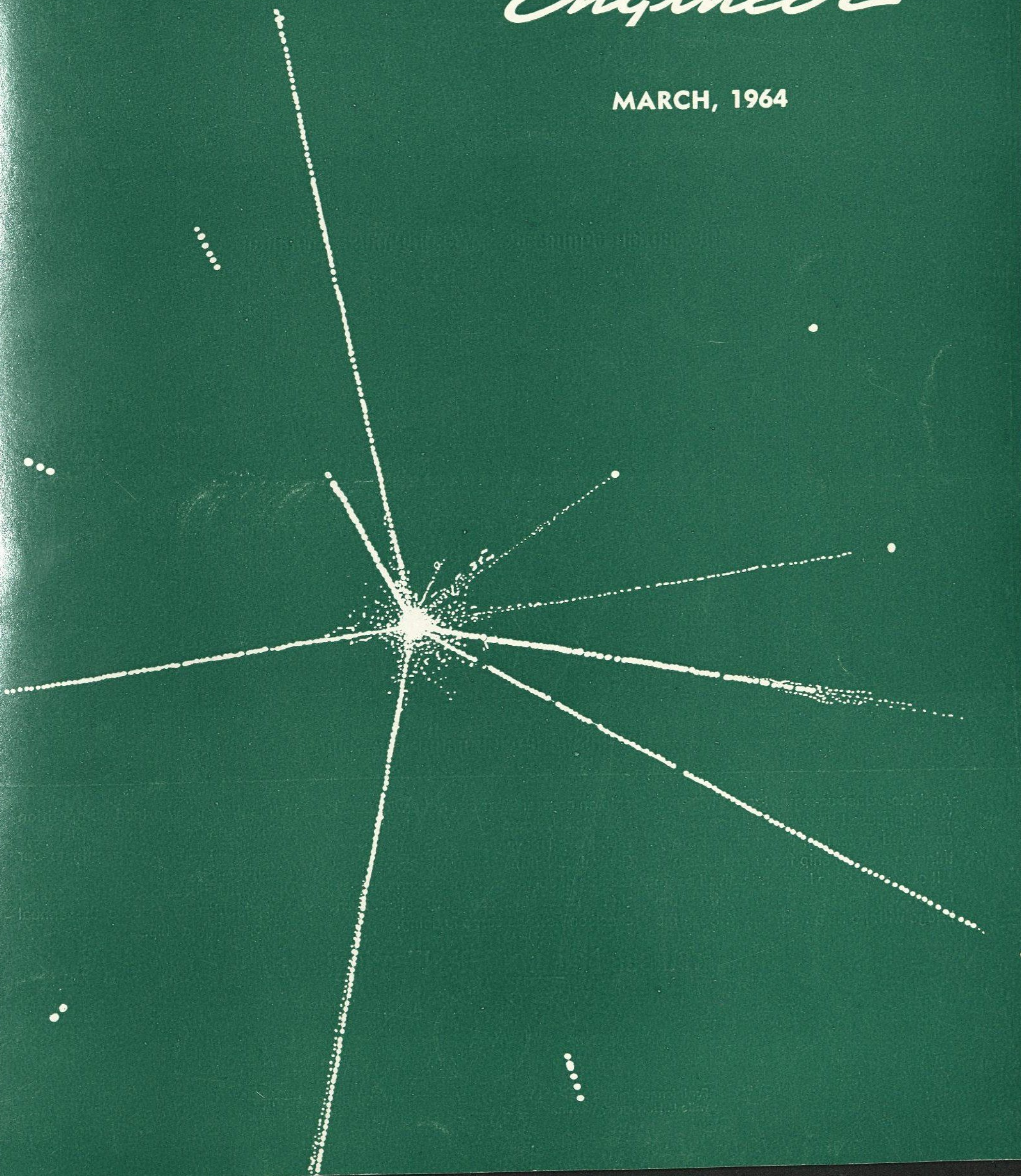
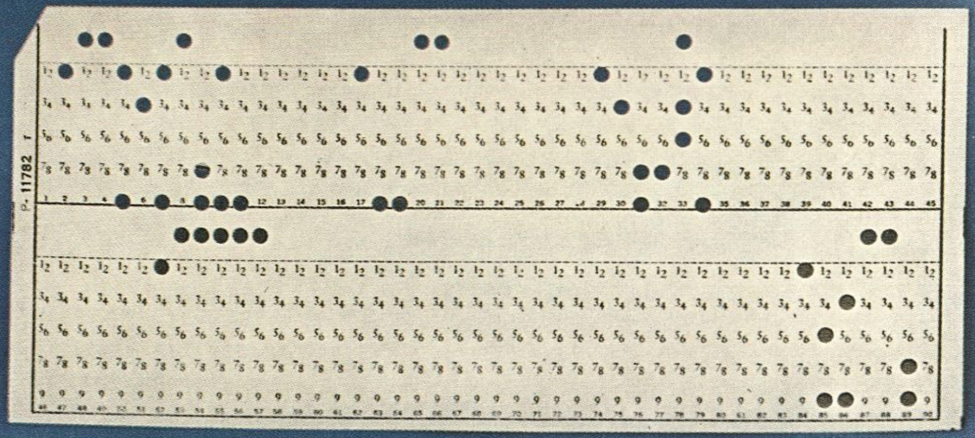
The COLORADO Engineer

MARCH, 1964



The captain commands a Westinghouse computer



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The COLORADO Engineer

UNIVERSITY OF COLORADO, BOULDER, COLORADO

VOLUME 60 **NUMBER 3**

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This month's cover is a representation of a Bromide or Silver Atom in a Nuclear Emulsion.

Member of Engineering College Magazines Associated, J. Chumley, Chairman, Louisiana Polytechnic Institute, Ruston, Louisiana.

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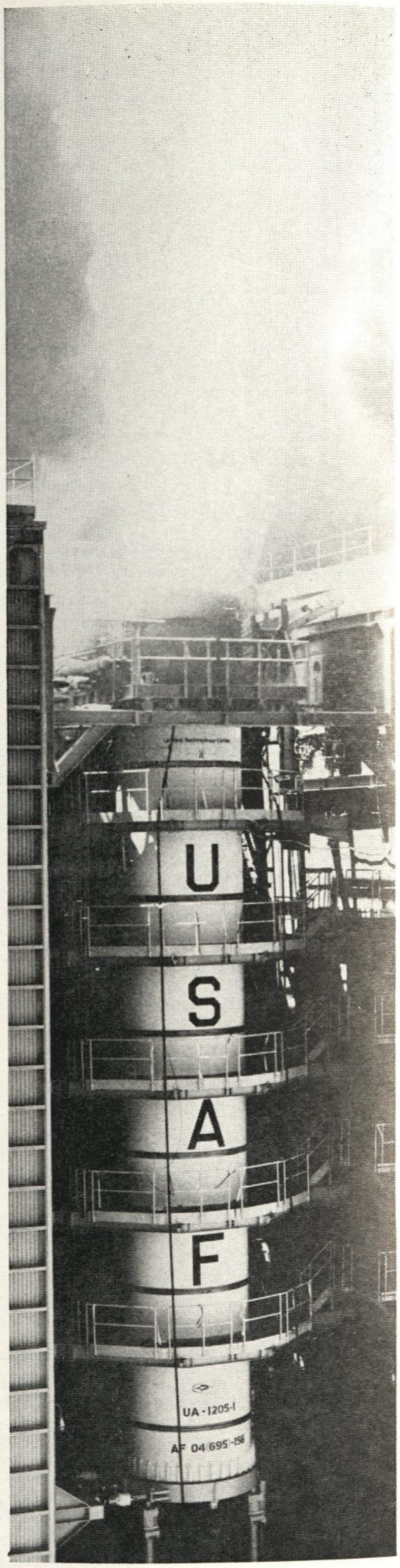

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THE DIPLOMA FACTORY

Two things will determine whether or not any given college will be a diploma factory. One of those items is the system of education that the college uses. The more mechanical the teaching and course approach, the greater the possibility that the mechanism will graduate pieces of paper and not educated men. The second item that leads toward a diploma factory is the student's attitude. If he takes the attitude that he will eventually graduate and will by definition of graduation know all he needs, he will find on graduation that he has been properly milled to the specifications implied in his attitude.

The difficulty with trying to remedy either of the above faults is that the people responsible cannot be reached. Those who manage the factory can easily claim that the busy-work the students do has *some* use. Alternately, the student can easily turn a legitimate method of education into a factory process. He can argue, "What good is all the 'education'? I only want to know how to do something, not why." No appeal to ideals and no moralistic approach can have any effect on this complete pragmatist, since he doesn't recognize the necessity for even a touch of idealism.

The solution, of course, appears to be a compromise in both administrative and student attitudes. The difficulty appears when the solution is attempted. Like all theoretical approaches, it must be modified in practice, and the practice lends to criticism. Ideally, "why" and "how" can be discovered simultaneously, but the history of knowledge contradicts that idealism, since one has almost always preceeded the other. So, the student is usually exposed to the "why" early and left with a hint of the "how." Or, if the "why" is too sophisticated, the "how" is taught and the "why" learned later. Both the student and the teacher are caught on the horns of this dilemma.

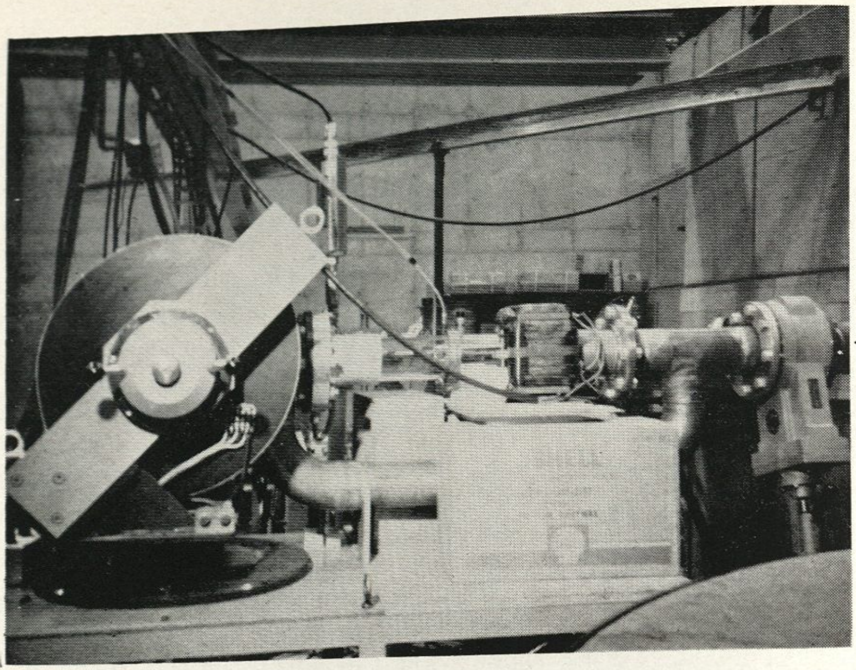
The current method of engineering education stresses accumulation of tools, the knowledge of "why," during the early part of the engineering training, and the use of those tools in the latter part with supplementary "whys" introduced as necessary. This may seem to be an adequate compromise; in comparison to previous systems, it is. One difficulty lies in the fact that the initial stages of the process may be too far removed from reality. Consequently, many students who have good potential as engineers drop out of engineering because there is either too much busy-work or too much theory. These students' interest must be maintained if this country is ever to produce a sufficient number of qualified engineers and if the engineer's image in society is to be improved.

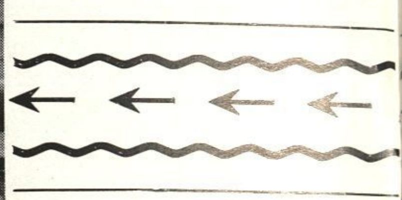
Some attempts have been made to stimulate this sort of interest in the early education here at CU. Some of the simpler sophomore courses are available to freshmen as well as an opportunity to take non-technical courses earlier. In addition, certain highly-qualified students are given an opportunity to participate in the Superior Student Program. Some work must still be done in certain areas, particularly in the laboratory courses, which in the past stimulated interest in little else besides where the "cookbook" could be obtained.

Major progress was made at CU with approval of funds for new engineering buildings which will have more needed laboratory space. If undergraduate research can be incorporated into the engineer's training early, much of the burden of millwork can be alleviated, for then the student can see what good his tools really are. In addition it might be possible to promote greater contact with the people who are applying their knowledge and skills, (graduate students, professors, and undergraduates doing research) and the students who are still learning the basic tools.

Perhaps this could be done by giving undergraduates one or two credit hours to assist a researcher in his project. This has the advantage of showing beginning students where their knowledge can be used, and also cutting some of the time researchers must spend. In many case, undergraduate research may be one of the keys to not only improving the quality of the engineers we graduate, but also decreasing the number of dropouts in engineering schools.

LARRY L. HUSTON





NEGATIVE IONS AND

One of the most interesting laboratories in the University's rapidly growing scientific complex is the Nuclear Physics Laboratory, whose main instrument is a new 30 million electron volt cyclotron. The laboratory's staff is headed by four faculty members, Professor David Lind, director, and Professors J. J. Kraushaar, W. R. Smythe and Martin Rickey. Sponsored by the Atomic Energy Commission, the cyclotron was dedicated by A.E.C. chairman Glenn T. Seaborg last June, and since then has proven to be among the most versatile and successful instruments of its type in the country. This article will briefly describe the principles of operation of the cyclotron, and discuss the application of the cyclotron to research in negative ions, an atomic physics problem.

In the study of physics, the cyclotron is a tool; the means to an end, not an end in itself. It is essentially nothing more than a source of a beam of high-energy charged particles, which can be aimed at various targets, such as a pellet of calcium, an aluminum strip, or a gas cell. In our cyclotron, the charged particles may be a proton or hydrogen nucleus, a deuterium nucleus, a tritium nucleus, or a helium nucleus (alpha particle). The charged particles are "created" in the ion source which works electrically much like a vacuum tube. Hydrogen gas, for instance, is fed into the system from a gas cylinder. The gas flows across an arc, which is simply a stream of electrons flowing from a heated filament (cathode) across a gap to a positively-charged plate. The electrons collide with the molecules of the gas, dissociating them into H atoms and then ionizing the H atoms into H^+ ions (protons) and H^- ions (proton and two electrons). The cyclotron can be tuned to accelerate either ion, but since it is easier for the H atom to lose an electron than to gain one, there are fewer negatives created in the ion source, resulting in weaker negative ion beam currents.

Acceleration

The ions drift out of the ion source and for positive ions, are accelerated during the half-cycle in which the radio-frequency voltage being applied to the dee is negative. Inside the dee, the particles travel in a semicircle due to the influence of the vertical field of the main magnet.

The frequency of the dee voltage is such that the dee will be positive by the time the particles again reach the dee gap, so that they are again accelerated. The relation expressing this motion is the cyclotron equation,

$$mv = qBr$$

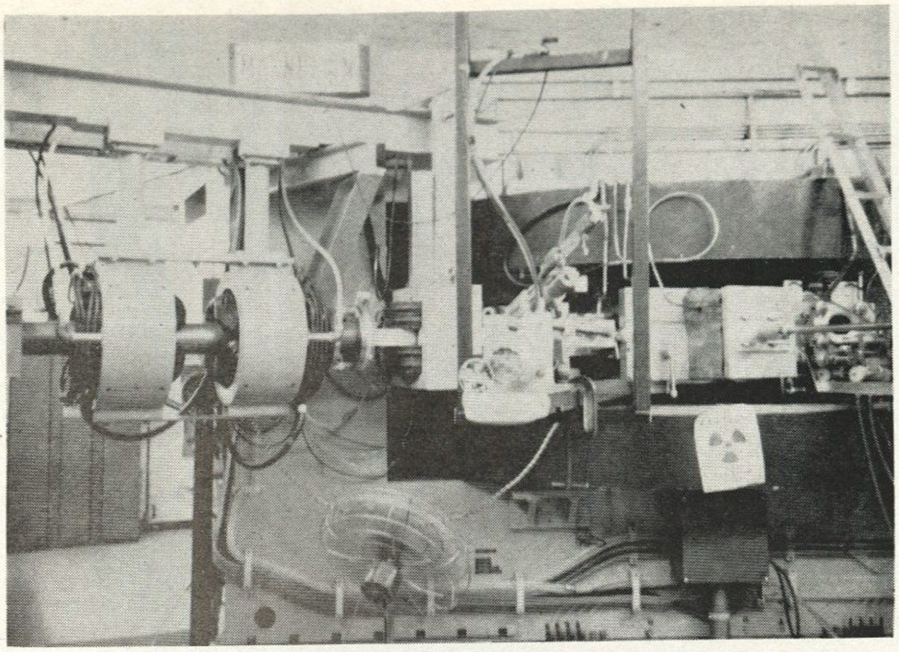
where m is the particle's mass, v its velocity, q its charge, r its radius at velocity v, and B the strength of the vertical magnetic field. The path length for one cycle is $2\pi r$, so at velocity v, the particle will make $\frac{v}{V/2\pi}$ revolutions (cycles) per second. Inspecting the cyclotron equation we see that

$$f = \frac{v}{2\pi r} = \frac{qB}{2\pi m}$$

which is a constant for a given particle and central field strength. To accelerate a given particle the RF coil is tuned with the capacitance between the dee and ground so that dee voltage oscillates at this frequency.

Each time the particles cross the dee gap, they gain an amount of energy equivalent to the peak voltage on the dee, which may range from zero up to seventy-five kilovolts. Thus, for a singly-ionized particle to reach an energy of 30 MEV with a dee voltage of 60 KV., it must cross the dee gap 500 times, or make 250 revolutions in the machine.

When the particles reach the desired energy and corresponding radius,



THE CYCLOTRON

JIM TOEVS

they encounter a strong, constant (in time) electric field, produced by the electrostatic deflector. This field counteracts the curving force due to the magnetic field, so that the particles stop curving and follow a straight line out of the cyclotron. From here on, the ions are focused and aimed at the target by magnetic lens, small "bending" magnets, and slit collimators.

If the experiment being performed does not require a large beam current, then the electrostatic deflector can be eliminated by using negative ions and a thin stripping foil such as carbon or aluminum oxide, inserted at the desired extraction radius. When a negative ion passes through this foil, the two electrons are torn off or "stripped", leaving the proton free to continue on its path with little loss of energy. Since the proton is positively charged, however, its path curves in the opposite direction of the negative ion's path, so that the proton curves out of the acceleration chamber and into the beam pipe.

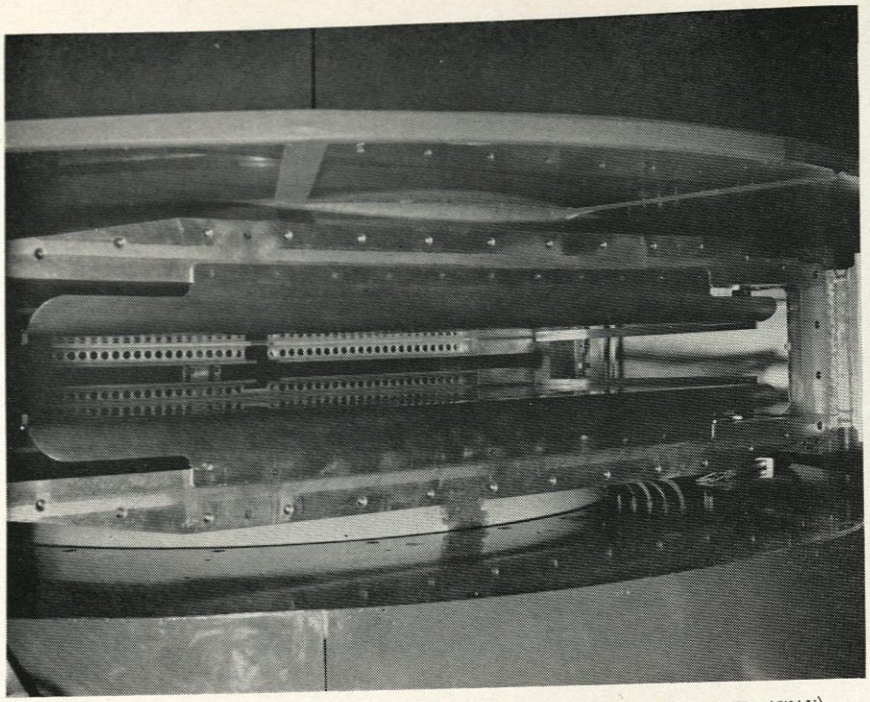
Perhaps the most interesting single feature of the C.U. cyclotron is the special shape of the pole faces of the main magnet. The faces are not smooth, but are shimmed in alternate sectors with extra metal, making "hills" and "valleys." The gap between pole faces in a hill region is about 4 inches less than the gap in a valley region, resulting in a stronger magnetic field in the hill region. This configuration solves two problems of particle acceleration. First, at high energies, the particle's mass is not constant, as assumed in the cyclotron equation, but increases relativistically with velocity according to the equation,

$$m = m_0 (1\text{-}v^2/c^2)^{-1/2}$$

where m_0 is the rest mass, v is the velocity, and c is the speed of light. Since energy and therefore mass increase with radius, it is necessary to increase the field strength B if the frequency is to be kept constant. If the tuned cyclotron frequency differs from the frequency required by the cyclotron equation (using relativistic mass), then when the particles cross the dee gap, the dee voltage will be in the wrong part of its cycle, and the particles will not be further accelerated. The width of the hill sectors increases with radius in such a way that the average magnetic field also increases with radius, so that the B/m ratio remains constant. Secondary coils wound in the shims allow "fine tuning" of the magnetic field.

The second problem is one of focusing. For maximum beam power into the target, it is necessary to keep each pulse, or accelerating group of particles, focused, that is, the cross-sectional area of the group perpendicular to the group's path should be as small as possible. Such focusing takes place when the pulse encounters a decreasing magnetic field. In the C.U. cyclotron, this occurs when the pulse passes into a valley region. A cyclotron using this principle is called a "sector-focusing" or "alternating-gradient" cyclotron.

Prof. Smythe and the author are presently using a low-current negative hydrogen ion beam to study the stripping cross-sections of the negative ions with various gases at various pressures. The cross-section for a particular reaction is the probability that the reaction will occur under given conditions. The beam is aimed with the aid of a small "tweeker" magnet and passed through a small brass collimator into a pyrex cell containing the test gas at a measured pressure. The collimator is simply a 1/32 inch thick piece of brass with a 1/32 inch hole in the middle of it. Its purpose is to cut down the beam so that all beam particles passing through it are traveling



INTERIOR OF ACCELERATION CHAMBER (DEE AND R-F EQUIPMENT BACKED AWAY)

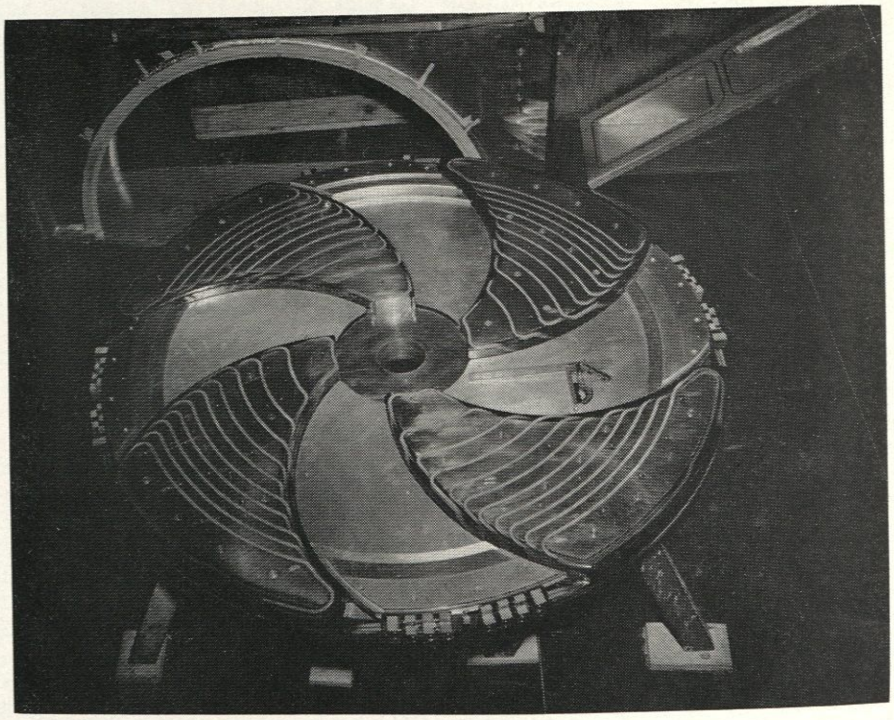
parallel to one another. When the beam passes through the cell, the gas molecules may knock off or "strip" both, one, or neither electron from the beam ion, leaving respectively a positive, neutral, or negative particle. After passing through a second collimator, the beam, which now contains three types of particles, is passed through a strong magnetic field which separate the three elements by curving the positive particles (protons) upward, the negatives downward, and not affecting the neutrals (hydrogen atoms). Each one of the three beams now passes through a "window" of brass shim stock 0.001 inches thick. Counters are placed just outside the windows to count the number of particles passing through each window per unit time. The first stage of the counters is scintillation plastic, which, when struck by a moving particle such as a proton, emits a light pulse whose intensity is proportional to the particle's energy. The second stage is a photomultiplier tube, which, using a photoelectric cell and dynodes for current amplification, emits an electrical pulse whose current is proportional to the intensity of the light pulse from the scintillation plastic. The current pulse is passed through a cathode follower to match impedance with the impedance of the coaxial cable used to transmit the pulse to a double-differentiating amplifier. The amplified pulse is sent into a single channel pulse-height analyzer which sends out a uniform signal if the incoming pulse is of the proper shape and size. The outputs of the three analyzers are fed into a multiscalar, which simply counts the number of pulses coming from each analyzer. Thus, if a particle passes through one of the three brass windows, a count is registered in the corresponding channel of the multiscalar.

A cesium-137 source is used to calibrate the counter-amplifier units. The cesium decay spectrum as seen by the counters is monitored with a multichannel pulse height analyzer.

The number of counts in the three channels is added to find the total number of particles in the beam. This total is then divided into each channel total to give the fractional percentage of each element (positive, negative, and neutral) in the beam. By taking measurements at various pressures, it is possible to construct a curve from which values may be obtained for the stripping cross-sections for a particular gas.

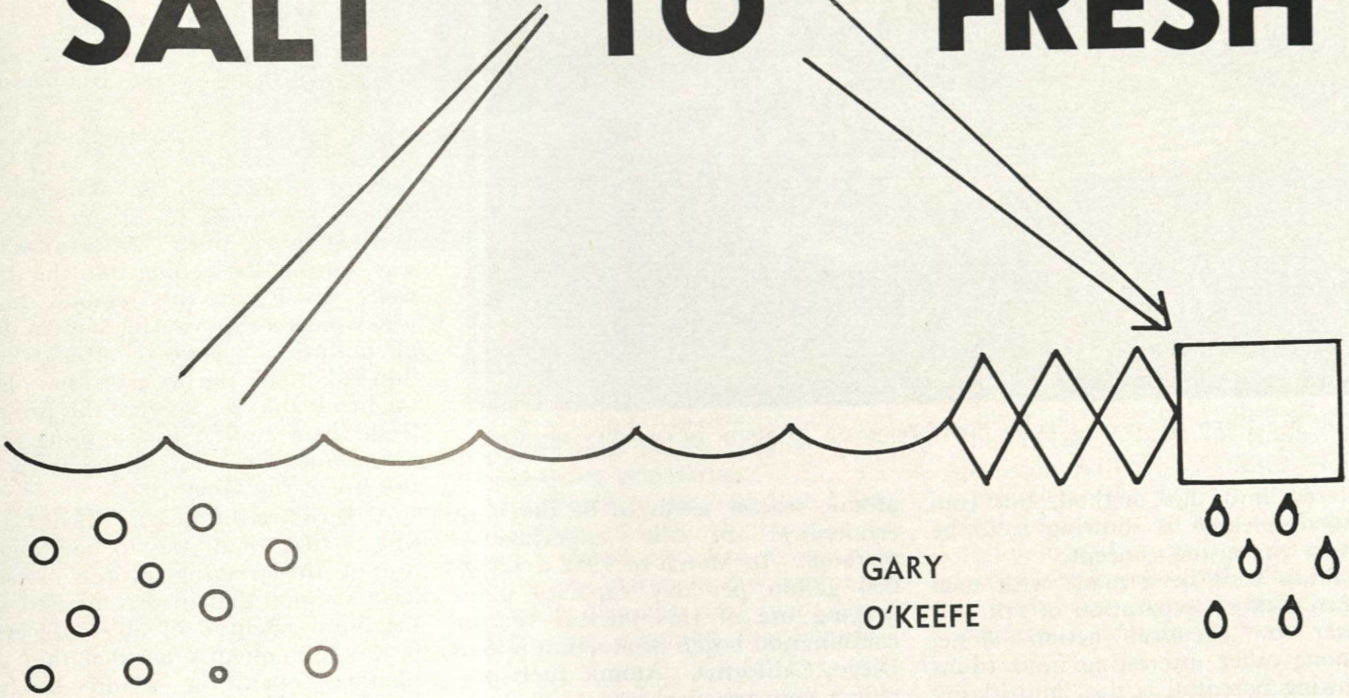
So far we have worked only with hydrogen gas, at pressures varying from less than 0.1 micron (10^{-3} m.m. of Hg.) to around 100 microns. Because of loss of gas through the brass collimators to the vacuum system, it is necessary to supply gas to the stripping cell to maintain constant pressure for the experiment. This is accomplished by leaking gas into the cell from a 45 liter reservoir through a special low conductance continuously-variable value. The reservoir is maintained at a pressure slightly higher than atmospheric. The cell pressure is measured with an alpha particle emission gauge, which is calibrated with a McLeod gauge. The beam energies used so far have been between 4 and 5 MEV.

We have not yet calculated values for the cross-sections, but the experimental results are primarily as expected—namely that at low pressures, where few gas molecules are present, very little stripping takes place, and the beam consists almost entirely of negative ions. As the pressure is increased, the percentage of negatives drops, and the neutral and positive percentages rise. At high pressures, almost every ion is stripped completely, so that the beam consists almost entirely of positive ions.



MAGNET POLE FACE, SHOWING SHIMS AND SHIM COILS.

SALT TO FRESH



GARY
O'KEEFE

By far the cheapest commodity available in the United States today is fresh water. It is also, by far, the greatest article in demand. On many occasions in the history of civilization, it has been water, as a sole entity, that has been held responsible for the losing of kingdoms and the making of fortunes. Today the United States alone uses up 300 billion gallons per day. About 45% of this amount is used for crop irrigation, 45% is used by industry, and about 10% is reserved for the personal use of man. For his individual water rights man pays about twenty cents per 1,000 gallons. Farms and industries pay a fraction of this amount for their privileges.

Rainfall in the United States provides a yearly average of 5,000 billion gallons per day. The bulk of this, of course, is drained by such means as surface runoff into the sea or other regions where water is overly abundant. The distribution of water to the areas where it is needed is very much equal to the problem of supply itself. With the tremendous rise of population, and consequently of industry, in this country, it is not difficult to predict that within the next few decades a wealth of problems might well exist involving the supply and distribution of water. Of course, the average citizen will not be aware of the importance of the matter until he is told when he may or may not water his lawn, and the soft fizz from his spigot expresses air, not water.

Office of Saline Water

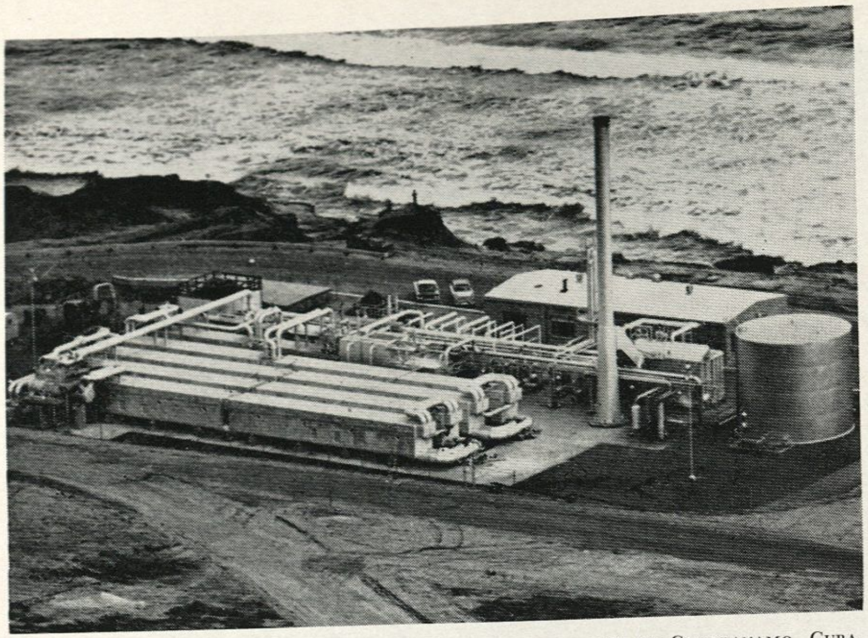
In 1952, the United States Department of the Interior organized a special branch, the Office of Saline Water, to deal with what was at the time a foreseeable possibility — a lack of usable fresh water. The Office was specifically designated to research the idea of finding a low-cost method of converting saline water to fresh water. Today, twelve years later, the problem is becoming much more evident to all concerned.

Changing salt water to fresh is nothing new by any means. It has been done on a small scale by distillation for years. Modern ships constantly make good use of this old method. However, the Federal government is interested in large scale, low-cost techniques which differ vastly from the old tried and true processes. Thus the government is sparing little expense in authorizing multi-million dollar expenditures in this field. Numerous methods are being investigated and experimented with.

In the process known as distillation, impure water is boiled, and then the steam, free of foul particles, is condensed and drained off as fresh water. A pronounced problem in this method is the high rate of fuel consumption in running the apparatus, which is complicated more by scaly deposits of residue which form on the inner walls of the containers, interferring with heat conduction.

The "membrane method" makes use of electrical power. A series of thin membranes is set up and saline water is forced through them by electrical charge. This results in fresh water being trapped between membranes. However, due to the great amount of polluted deposits in sea water, this technique would only be practical for inland brackish water conversions. The electrical energy needed to free sea water of salt would be far too costly.

The freezing of water is, like distillation, a purification procedure seasoned by years of use. Northeast Asian fishermen have been employing it for decades. It is obvious that the cost would be less in simply freezing water to purify it rather than going through a more involved process, such as distillation. In the past few years many complications have



The San Diego Multi-stage Flash Plant Presently en route to Guantanamo, Cuba.

entered into this method, but continued research is showing it to be a very promising concept.

Trials have been made with such ideas as direct separation of salt and water by chemical action alone. Among other interesting innovations showing potential is the "multiflash" method, which combines nuclear energy with a conventional distillation method.

Situated in various locales around the world today are saline conversion plants producing fresh water on a limited basis for local inhabitants out of sheer economic necessity. On the Caribbean island of Aruba such a plant exists with a capacity of 2,700,000 gallons of water per day, at a cost to the residents of two dollars per 1,000 gallons. Without this plant fresh water would have to be shipped in at a cost of probably three times as much.

Experimental Plants

At present the Office of Saline Research has built, or is in the process of building, five authorized experimental conversion plants around the United States. Each plant will use different basic method, and three of them are to be used in seawater conversion. The other two will concentrate on inland water conversion. Each is designed for a capacity of at least 250,000 gallons per day.

In Freeport, Texas, 1,000,000 gallons of fresh water per day is the end result of this distillation-type plant utilizing a process known as the long-tube twelve effect distillation method. The plant opened in May of 1961.

Thus far the multistage flash process involving distillation with an atomic reactor seems to be the most economical of the experimental methods. In March of 1962 a 1,000,000 gallon per day capacity plant making use of this nuclear reactor combination began production in San Diego, California. Atomic fuels provide a very practical way of deriving the vast quantities of heat required for the distillation procedure.

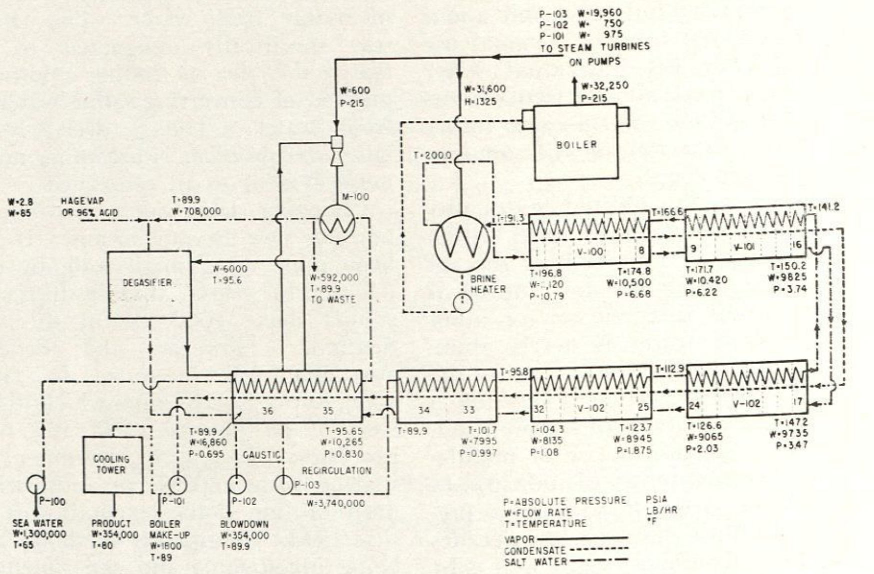
November, 1961, was the target date of a Webster, South Dakota, complex constructed to test electrodialysis methods. Designed for investigation of transformations involving inland brackish water sources, the plant provides 250,000 fresh gallons a day. It removes over 1000 parts of salt per million parts of water, furnishing potable water to the public of the area. The United States Public Health Service defines potable water as having less than 500 parts of salt per million parts of water. In this electrodialysis method the water is cleared of contamination to a point well below this level. More than a ton of salt daily is removed from the brackish water.

Vapor Compression

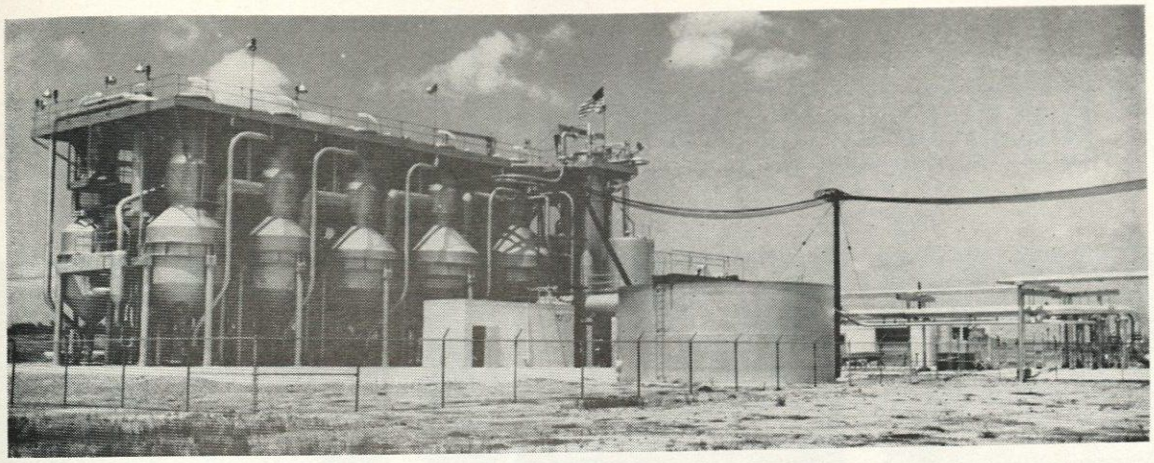
Another type of distillation plan is known as the vapor compression method. Another 1,000,000 gallons per day capacity operation was completed very recently at Roswell, New Mexico. The plant was designed because there was a severe water crisis existing in the area. Brackish water was continually seeping into the deep wells which are the region's main water source, thus causing a great deal of pollution. Federal officials are hopeful that the conversion plant might be able to conserve the present fresh water aquifer by pumping pure water into the wells and directly to the city at the same time.

At Wrightsville Beach, North Carolina, a fifth plant was to have made use of the freezing process. Some have claimed that in this method lies the most potential of all. However, it was subsequently decided that the planned operation would be too small to be of genuine value, and it will be delayed until more decisive research in this area can be attained at smaller pilot plants.

Currently small "pilot plants" are being set up around the country to investigate other methods. Apparatus such as stills using solar energy are being looked into, along with other types of electrodialysis and membrane systems. Large contracts are being let out to universities and industrial corporations alike in hopes of finding newer and better techniques.



Flow Sheet for Flash Distillation Plant in San Diego.



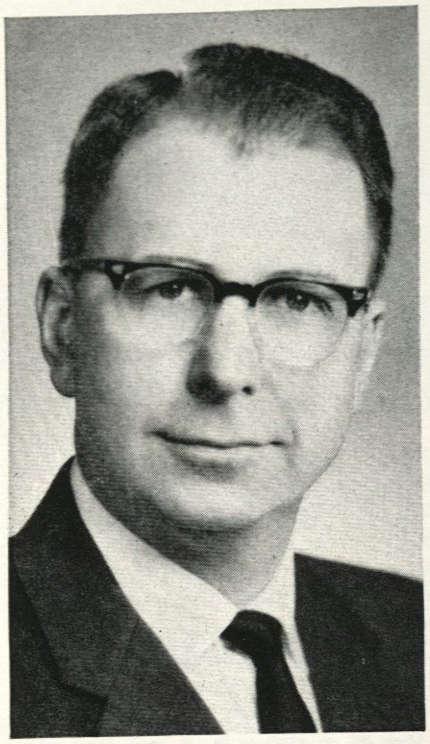
THE LONG TUBE VERTICAL DISTILLATION PROCESS PLANT AT FREEPORT, TEXAS.

Already, through the government's program, the cost of fresh water purified by saline conversion has dropped to less than one-fifth of its 1952 price. The large 1,000,000 gallon per day plants can deliver potable water at a cost of about $1 per 1000 gallons. When the program reaches its expected efficiency, it is thought that this price will be cut in half or lower. By the end of this century many experts in the field think it reasonable to assume that a myriad of saline conversion plants will dot our coastlines and interior lake shores, supplying by pipeline vast quantities of fresh water to even the most remote desert region, giving cities new life and aiding farmlands in the feeding of the ever-growing population.

In a speech to the American Chemical Society in 1960, the chief of the Federal Office of Saline Water summed up the matter in this fashion:

"The demonstration plant program has captured the interest and imagination of the nation and the world, but plant construction is not the key to low-cost conversion. While these plants are being constructed, the research and development program will be continued—for research is the key to progress. One must turn to scientific and technological research to develop a new source of supply that can provide an ever-growing percentage of tomorrow's water."

THESE GRADUATES THRIVE ON CREATIVE CHALLENGES...THEY'RE



PROJECT MANAGEMENT
V. H. Simson
Iowa State University—BSEE—1948

MANUFACTURING ENGINEERING
R. A. Busby
University of Michigan—BSME—1952

DEVELOPMENT ENGINEERING
R. P. Potter
University of Illinois—BSME—1959

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K. M. Nelson, Manager—Industrial Control Sales, discusses the functioning of Cutler-Hammer's automation teams, and how creative graduates contribute to pioneering developments.

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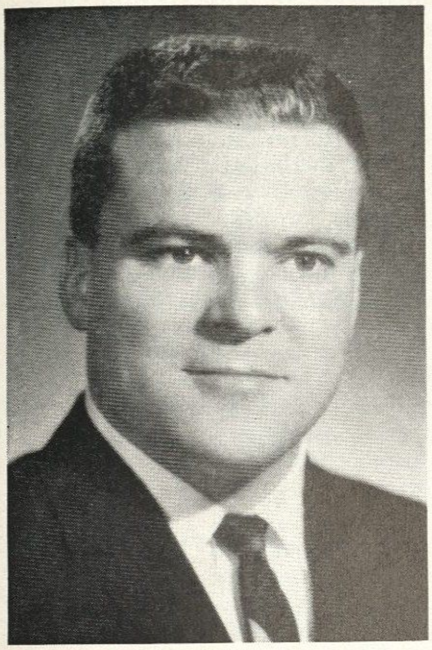
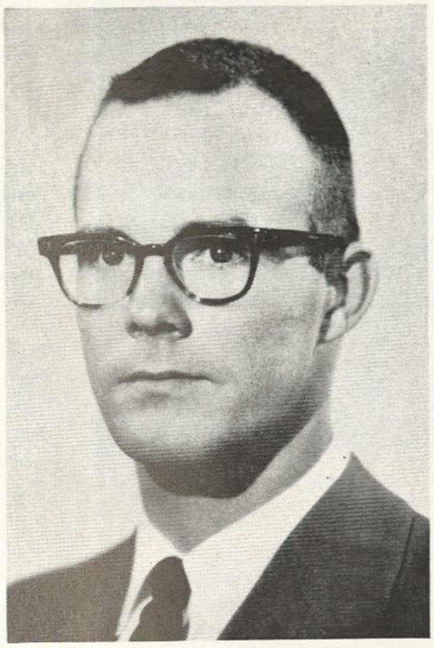
AUTOMATION PROBLEM SOLVERS



CONTROL ENGINEERING
B. O. Rae
University of Wisconsin—BSEE—1957



SALES ENGINEERING
J. B. Hewitt
University of Colorado—BSME—1957

ANALYTICAL ACCOUNTING
D. R. King
University of Wisconsin—BBA—1957

too, on a Cutler-Hammer automation team

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CH CONTROL

With today's strong fundamental knowledge of the physical characteristics of fluids, scientists are finding that even more understanding is required. It might be termed a snowball effect; the more they understand, the more they need to know.

Professor Arnberg of the Department of Mechanical Engineering at the University of Colorado is directing research to determine accurate primary measurements of compressible fluid flow rates. A primary measurement of a derived quantity (i.e. a quantity other than mass, length, or time) must be completely independent of any other measurement of this same quantity. The primary measurement can then be used to calibrate secondary measuring devices.

In this case the primary method of measuring mass flow rates of air, which will be described in detail later, will be used to calibrate critical flowmeters. A critical flowmeter is a nozzle with a gas velocity equal to the speed of sound at the throat. The inlet pressure and temperature to the nozzle can be measured and correlated against the mass rate of flow if the properties of the gas are known. Advantages of the critical flowmeter as a secondary, or transfer standard are 1) its freedom from moving parts which gives it reliability and stability, 2) its dependence upon only two operating variables—the inlet stagnation pressure and temperature – for regulation of the flow rate 3) its believed lack of sensitivity to disturbances in the inlet stream, such as swirl, pulsations, and changes in the inlet velocity profile, 4) the wide flow range that can be covered, and 5) the nearly linear relationship between the mass flow rate and the inlet pressure when the temperature is constant. A former disadvantage, the inadequacy of theoretical solutions for the critical flow of gases, has been greatly reduced by recent studies which provide a variety of solutions for real gases and vapors.

The advantages of critical flowmeters make them desirable for working transducers as well as for transfer standards, but the pressure loss across the nozzle over a range of flow rates is often too large to be tolerated, so that, in this case, the critical flowmeters will be used to calibrate orifice plates, which are the most commonly used type of variable-head flowmeter. The orifice plates will then be used by the Lawrence Radiation Lab on heat transfer research for the Atomic Energy Commission, the sponsors of the project.

COMPRESSIBLE FLUID FLOW

ELLEN HARRIS

Formerly gas meters were calibrated using liquid flow primary methods in conjunction with expansion factors. For example, it is quite easy to measure the mass flow rate of water simply by running it into a weight tank and noting the change in weight during a specified time. The success of this method depends on the nearly constant density (i.e. the incompressibility) of water. However, extending this method to compressible fluids by correction with expansion factors does not give the accuracy required for jet and missile operations, and by ordnance and other industries.

Although little has been done to develop a primary standard for gases, some of the methods conceptually possible include direct weighing methods such as described above for liquids, methods measuring stagnation and static pressures across the fluid stream, and methods involving equation of state data in conjunction with initial and final pressure, volume and temperature measurements.

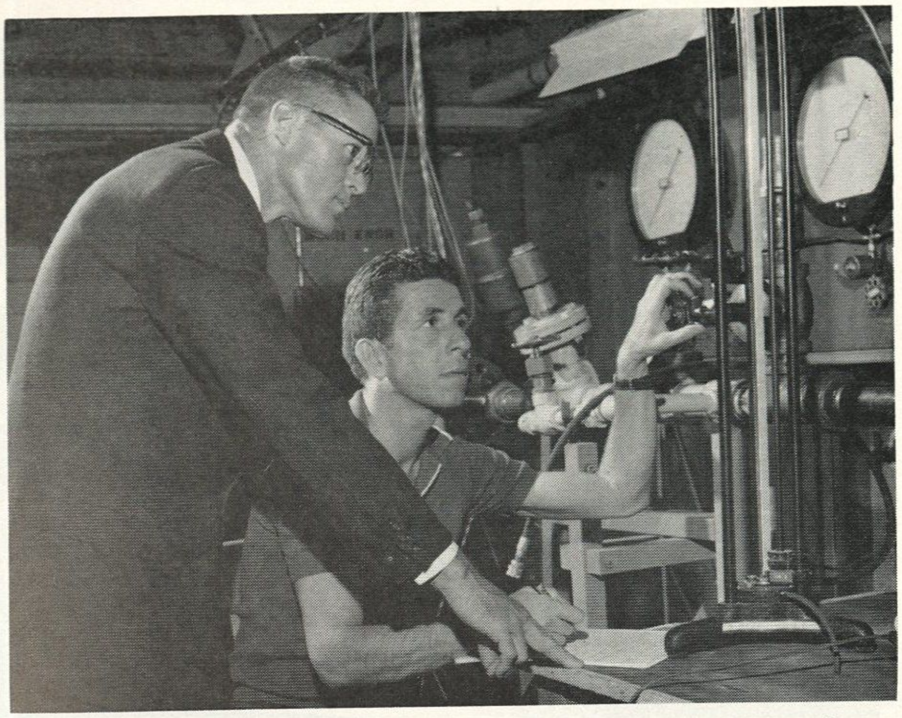
Difficulties arise in direct weighing methods due to the large weight of a tank required to maintain gases at high pressures as compared to the small mass of gas that is discharged. Static and stagnation pressure methods are not good for small nozzles due to the ten to twenty per cent uncertainties in boundary layer calculations. For these reasons an equation of state method was chosen as the primary method to be thoroughly investigated in this project (preliminary investigations of other primary methods have been made, but so far show little promise.)

In the particular technique chosen —the P-V-T-t method—the volume of a receiver is carefully calibrated, and changes in temperature and pressure are measured to determine the mass of gas discharged over a timed interval. The method is quite flexible since flow may be either to or from the primary standard and a wide range of flow rates may be covered by varying the size of the receiver and the length of the test.

The most accurate equation of state data available uses

$$pV = mZRT,$$

where $Z = f(p, T)$ is a compressibility factor that has been tabulated by the National Bureau of Standards. Initial temperature and pressure measurements establish the mass of gas in the calibrated receiver. Air is first pumped through the system from the start-up receiver. Its temperature is maintained equal to that of the air in the calibrated receiver using the No. 1 heat exchanger. This prevents a temperature transient from occurring when the flow is switched from the start-up receiver to the calibrated receiver.



Professor Arnberg Watches as Halis Odabasi, now a Ph.D. Candidate in Physics, Controls Fluid Density During a Performance Evaluation Test of a Flowmeter.

When the pressure in the start-up receiver has reached the pressure in the calibrated receiver, or a slightly different pressure as required to compensate for differences in the line losses and inertial effects, the flow is switched from the start-up to the calibrated receiver using the two-way switching valve. The switching operation also starts the automatic timer.

The throttle value and the No. 2 heat exchanger are adjusted during the test to maintain a constant desired pressure and temperature of the air going to the flowmeter. The test run is terminated after the pressure in the calibrated receiver has been reduced to approximately one-half the initial pressure. Closing the two-way value stops the timer, marking the end of the test run. After a thermal stabilization period of about thirty minutes the final pressure and temperature measurements are obtained from the calibrated receiver.

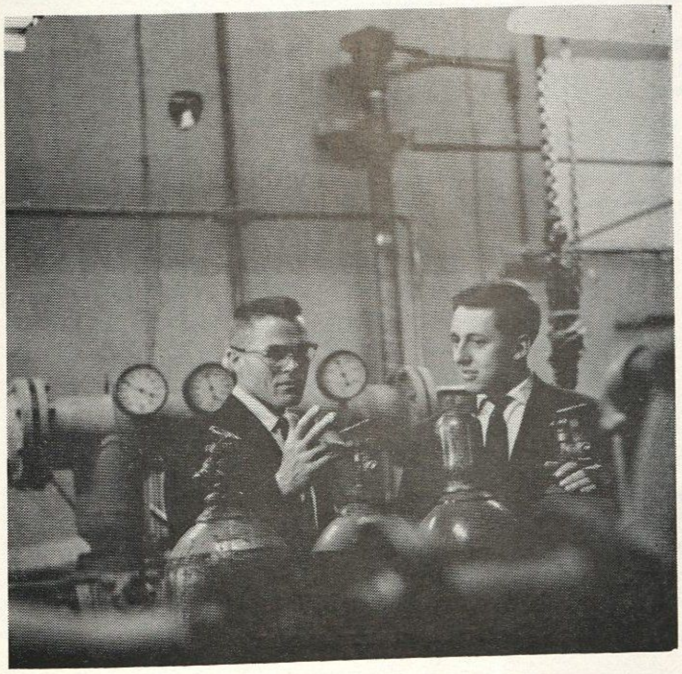
These measurements are repeated after several time intervals to establish the rate of leakage from the system. The leakage rate must be determined and taken into account even though it has been reduced to an almost insignificant magnitude. This is necessary not only because of the slight effect on the absolute accuracy, but also to establish confidence in the results.

Finally the average rate of mass transfer is determined from the following equation:

$$V = \text{constant} = mZRT/p$$

$$\dot{m}_{avg.} = (m_i - m_f)/t = (V/RT)(p_i/T_iZ_i - p_f/T_fZ_f).$$

The p-V-T-t method has been used before; the most important objective of this project is increased absolute accuracy by refinements in instrumentation and techniques in order to provide accurate data for the calibration of transfer standards.



Professor Arnberg Explains Air Compressor, Purifier, and Drier Used to Supply Air at 3,000 psi to the Compressible Flow Test Facilities.

So far most of the work done has been in refinement of technique. It is imperative that extreme care be taken at each step of the process. Two of the most troublesome difficulties so far have been leakage and the change in volume of the tanks with pressure. A detailed error analysis was made of all instrumentation which showed the flowrate error to be about twice the systematic error in the receiver pressure measurement. Much attention was therefore given to this measurement.

In all cases effort has been made to secure the most reliable instruments available, and with the painstaking care which has gone and will go into eliminating every source of unnecessary error, this investigation should yield some extremely valuable results.

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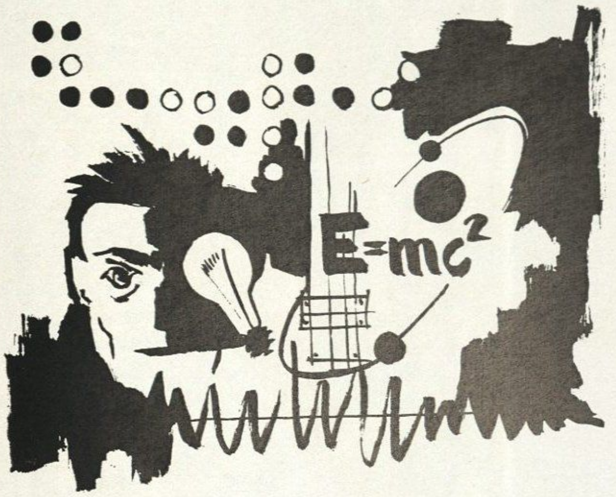
APPLIED MATHEMATICS Today and TOMORROW



CHARLES A. NELSON

You have probably heard and read about the computer revolution which is now going on. No doubt, you also know that applied mathematics is playing newer and greater roles at the frontiers of research. But are you clear as to the twentieth century trends in engineering and science which are causing this? Do you know why to some people this appears more an "explosion" than a revolution? Have you thought of the intellectual and educational revolutions which these trends are also causing?

Many of the advances on the frontiers of mathematics are coming from the intense trend to research in many areas. Some basic research has been motivated by unfamiliar demands on classical engineering knowledge, as man longs to try to apply what he has but recently learned of ocean, earth, and sky. Both engineering and basic research are asking questions with regard to components large and small. Is it possible to prove this, to design that, to do these, to build those, and to apply this? Mathematics is being called on to answer these questions of possibility, and practical interest is arising in the more abstract concepts of mathematics, such as modern algebra. Often advances in theory result from the development of these applications.

An example illustrating new needs for mathematics can be found in some new trends in biomathematics—the mathematics of biology. For some time bacteria growth has been expressed as an exponential function. Now attempts are being made to describe the area of the living cell with topology. A new type of algebra to represent the thinking process is being sought by neurophysiologists. Success in these attempts will bring many practical rewards, and perhaps new mathematics as well, even though the neurophysiologist would probably not be called an engineer.

A New Tool

Many of the advances on the frontiers of mathematics are increasingly related to the "applied" interests of the social scientists, economists, statisticians, operation researchers, and industrial and design engineers. Subjects like linear programming, game theory, network theory, Boolean algebra, Markov processes, and information theory are frequently used in industrial and military applications. These appear increasingly often as topics for research and as tools of investigation in other areas besides electrical, mechanical, and civil engineering. Much of this mathematics is called finite mathematics: being concerned with problems of arrangement, operation, and selection within a finite or discrete system. Instead of the continuous curve of freshman calculus, there is the curve of separated points resembling a plot of laboratory data. Thus today the fields of application and the kinds of mathematics needed and used are vastly broader and are expanding at a faster rate. Mathematics, like the engineering sciences, develops through this myriad of branchings in the mid-twentieth century. Growth appears to be a repeating cycle of branching and regrafting—the new discoveries and developments which are found lead to new and vivid insights into classical phenomena. Mathematics today by means of new applications finds itself largely in the branching phase of the cycle.

Now, what is the direction in which the applied mathematician's own research is going to go? Dr. H. O. Pollak of the Bell Telephone Laboratories has answered, "One of the most significant directions which I see is that of setting absolute standards, absolute bounds beyond which the user, no matter how clever he is, cannot go . . . . If you can find the best that you can do in a particular situation and give a specific instruction for it, then you have an optimization problem." In particular, there is optimization of large systems in engineering.

This trend towards the engineering of large systems is a modern trend in comparison to the engineering problem of possibility with regard to individual components mentioned above. It is often fairly clear that a system performing in the desired way can be built, but what is the best, most economical way? These systems, both military and nonmilitary, are of increasing complexity and must be optimized with regard to such factors as cost, reliability, and maintenance. Thus there is interest in probability, statistics, and linear algebra. Here the engineer and applied mathematician are the middle men between the scientists and the businessmen. Here, too, the engineering solution is not an answer, for optimization is guidance, not the answer. One can optimize surface to volume relations all one likes, but no one complains when milk bottles turn out to be neither spherical nor cylindrical.

Model Building

Another trend today in engineering is to represent situations by means of models, and this requires the services of the applied mathematician. Of course, the representation by means of models is understandable when one recalls that any definition of science and engineering recognizes that "exact" physical laws are only idealizations and approximations of reality. There are the common approximations which we meet in our courses: the ideal gas law, the ideal mass points that Newton's laws are applied to, the continuous media of elasticity and acoustics, and the "circuit fiction" simplifications of the electrical engineering courses. Almost any given physical situation is capable of being idealized mathematically, often in many different ways. Sometimes this idealization will only have an approximate solution and finding the best approximation will require ingenuity on the part of the engineer.

There are four criteria which ought to be satisfied by any well-formulated mathematical model which hopes to represent reality: 1) the model should possess a solution, 2) the solution should be unique, 3) the solution should be stable (that is, a small change in any of the data of the problem should produce only a correspondingly small change in the solution), and 4) the solution and its implications should agree with reality and the solutions to related problems. The first two criteria for approximation express a belief in causality or determinism without which experiments could not be repeated with the expectation of consistent results. The third criterion requiring a stable solution is important because the data upon which the problem is based may be only marginally correct. The fourth criterion requiring agreement with reality is extremely important, for the model or approximation may have some stray properties no one bargained for (spherical milk bottles would roll all over the breakfast table and would waste icebox space.)

Consequently, to avoid misuse of applied mathematics, there must be professional understanding of both the situation and the available mathematical tools. It is important here for the complete situation to be understood by at least one person or in the case of a team, that the team must have joint and individual responsibility for the whole enterprise. It is not practical to delegate professional responsibilty. Often it is the applied mathematician who is best able to have this complete understanding, for he should have been prepared to do the key task of abstraction of the problem from the physical world into the mathematical world.

Two Scientists from Bell Telephone Laboratories Listen to a Tape Recording of Synthesized Speech Produced by a Computer.

New Trend

It has often been said that mathematics is the greatest tool of engineers. In many cases it is the working engineer who has to solve the optimization problem of an engineering system or abstract a mathematical problem from reality. These are sample illustrations of how engineers are finding that they, too, need to use new and unfamiliar mathematical tools, and as a result they are showing interest in more variety and depth in mathematics. Much specific problem solving is being done by mathematically talented and mathematically trained people in fields other than mathematics. The engineer also has to realize that unless a differential equation, or similar problem, is an exercise in the textbook, he can't possibly hope to find a closed form solution for it. Therefore, he either uses much more powerful analytic methods to get some information about it or he puts it on a computing machine. He must also realize that in application, especially in research areas, the engineer or anyone else can't predict beforehand what kind of mathematics he will need. If you choose to be an expert in the analytic theory of continued fractions, you will not be happy in applications.

But the major trends in engineering—today, and in our lifetime—are due to the computer revolution. Through the industrial revolution people were relieved of acting like beasts of burden, and through the computer revolution they are being relieved of dull, repetitive routine. Perhaps it is better to compare the computer revolution with the Copernican revolution or the Darwinian revolution — both of which greatly changed man's idea of himself and of the world in which he lives.

While the significance of something presently occurring is always difficult to judge, what is expressed by the above comparisons with the past can be grasped by the concept of order of magnitude. For example, we can speak of an automobile being 10 times faster than a horse and wagon—one order of magnitude faster. It is customary to recognize that a change of a single order of magnitude in technology often produces fundamentally new effects. For instance, given enough horses and time you can do almost everything that you can with a car, but it is not the same. Indeed, the automobile is said to have caused even a change in our morals!

Computers have improved in speed by six orders of magnitude over hand calculators—a million fold. It is like first having only one dollar and then having a million dollars. You can readily see that in two different situations there are fundamental differences in the view you adopt of yourself and of the possibilities which are open to you.

Second, computers are much more reliable.

A third factor is that they offer a decrease in cost per operation—three orders of magnitude cheaper. It is as if suddenly automobiles cost two to four dollars.

So these orders of magnitude indicate that this revolution will require a gradual reorganization of man's concept of himself, of the man-machine combination, and of the rest of the universe. But even while realizing the truth of these figures and predictions, many of us tend to look at the computer as a super slide rule —faster, more accurate, and a possessor of a faultless memory. When computers came in fifteen to twenty years ago, this was an accurate conception—but it is a poor one for tomorrow.

They are not merely super slide rules: computers have made it possible to apply more abstract techniques; problems previously too big and too difficult have been tackled. It had been known theoretically for a long time that a process could be followed to eliminate variables between polynomial equations, but only the coming of the computer made application feasible.

The distinct trend to use mathematical models, which was mentioned before, has been enhanced by the availability of a computer. Looking at an engineering or scientific index, one is quickly impressed with this fact. In engineering research the special purpose device for trying an experiment is being replaced by simulation in a computer. One does not build an encoder or a transmission line to test an effect, but rather simulates it on a computer and converts the output to an audio tape to see how it sounds. R. W. Hamming of Bell Telephone Laboratories has said, "At present I would guess that perhaps 10% of the experiments in the Bell Telephone Laboratories are done on the computer rather than in the laboratory; I expect that in time the reverse will be true, only about 10% will be done in the laboratory."

Of course, there is the bull session topic of a machine with artificial intelligence—a thinking machine. So far, however, computers cannot even play good chess. It will be noteworthy when a machine can translate as well as a human, when a machine proves a new theorem or is capable of investigating all the conjectures one has in proving a theorem, and when a machine can beat all comers in chess most of the time. This last stage has been reached in checkers.

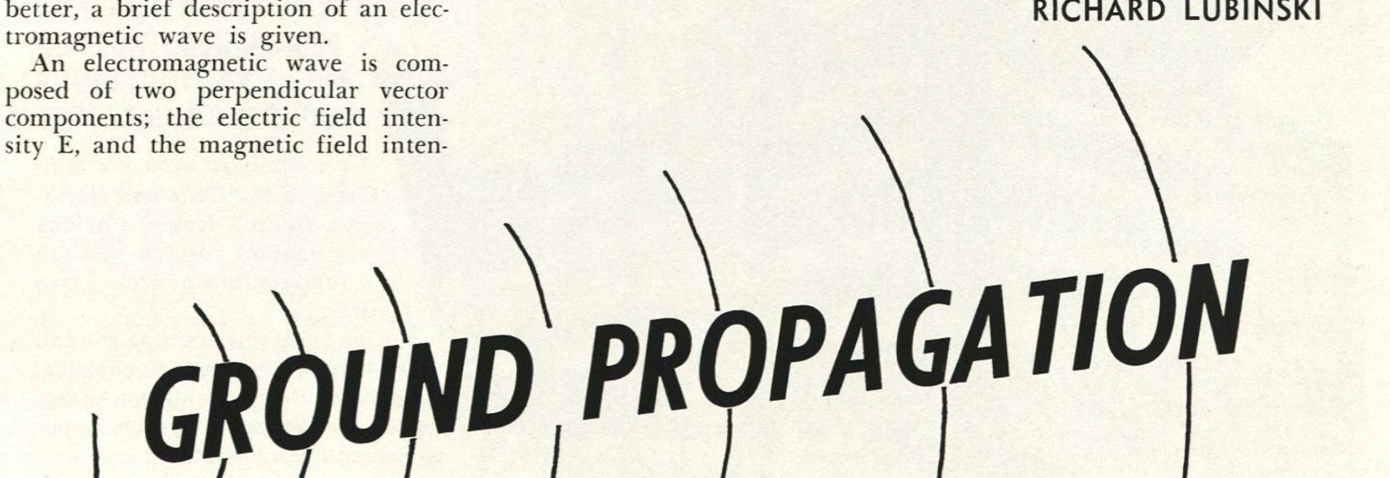
It appears that computers in the future will work out the details and do many of the experiments in engineering. The engineer, at the moment, is better able to suggest broad lines of attack and uniform methods for approaching problems, and is better at speculating and conceiving new ideas. It is of importance for both the engineer and the appiled mathematician to understand the uses, methods, and limitations of the computer. Knowing only how to program a problem on a computer, an engineer can easily overlook a significant item.

As with engineering in the past, the results of significant mathematical research now being initiated in the many fields of application and the new methods with the computer will flow from industry back to the graduate schools and into the undergraduate curricula. In response to the trends which have been mentioned, there are demands on the curricula for more varied and broader mathematical training for engineers so that they can better optimize, idealize, approximate, and program. Companies and others are asking, "Students now in college can still be expected to be working in the year 2000, yet how is their present education preparing them to live in a world full of machines?"

For your own excitement and benefit, you might ask questions, similar to those being asked by engineers and applied mathematicians in the field, of mathematical concepts you are now learning. Some of the questions for a calculus course might be: By an approximation to the root of the equation $f(x) = 0$, do you mean that the approximation "x_a" is close to the real "x_0", or do you mean $f(x_a) \cong 0$? How would you find maxima or minima without differentiation? How would you handle an improper integral numerically if you could not handle it analytically, and how would you combine the two methods?

GROUND PROPAGATION

RICHARD LUBINSKI



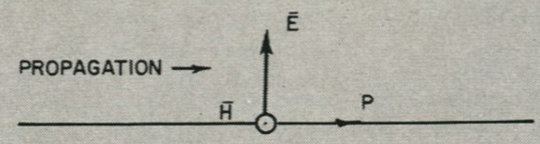


FIGURE 1

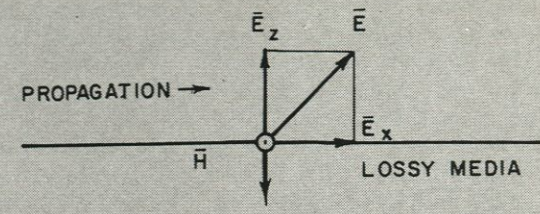


FIGURE 2

The conveyance of information via electromagnetic radiation has become very important at this time in history because of radar, radio, television and communication by telephone. There are many methods by which this information can be transmitted; for example, telephone messages are transmitted across country by means of a series of communication towers, each within sight of the other. This is known as the line-of-sight method. Radio waves are often broadcast to distant receiving stations by reflecting the waves off the earth's ionosphere. Information from radio waves or radar can also be directed along the contour of the surface of the earth by means of ground propagation.

One of the problems confronted when working with electromagnetic waves is the loss of power associated with the transmission of these waves with distance.

Experimentation has shown that a ground wave transmitted over a surface such as the earth with high resistive power loss (lossy medium) dies out very rapidly. To understand this better, a brief description of an electromagnetic wave is given.

An electromagnetic wave is composed of two perpendicular vector components; the electric field intensity E, and the magnetic field intensity H. If a plane wave is transmitted in a perfectly conducting medium such as free space, these components are perpendicular to the direction of propagation. If the plane wave is transmitted in a lossy medium, certain phase changes of the E and H vectors occur along with other complications.*

When a ground wave travels over a lossy medium, the electric field intensity vector has two components, one normal and one tangential to the boundry surface (see figure 1). By considering the energy per unit area contained in the wave or the Poynting vector ($P = ExH$), a component of the energy P will be directed perpendicular to the plane formed by the E and H vectors. Therefore, one component of the energy is directed into the lossy medium and another is in the direction of propagation. The component of energy directed into the lossy medium is absorbed, causing the total energy of the wave to decrease. The other component of P causes the wave to travel over the surface of the boundary. This loss of energy into the lossy medium causes the wave to diminish rapidly.

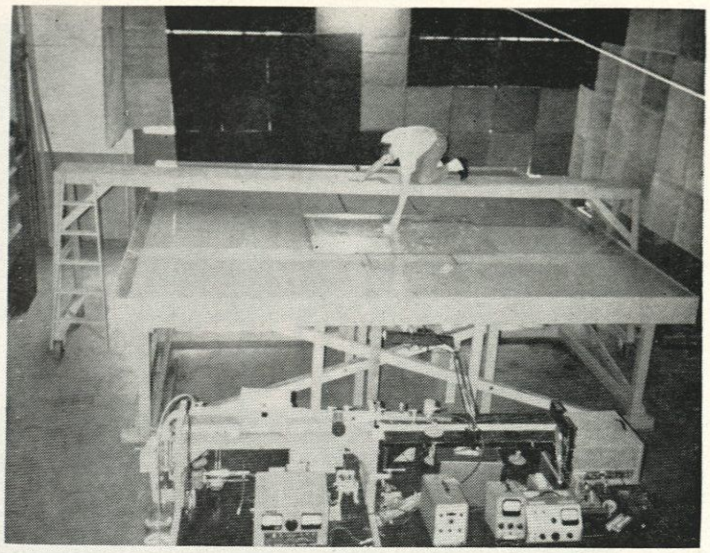
If the wave is transmitted over a conducting surface that has little resistive power loss, the E vector can be considered as being vertical, and the energy vector will be primarily in the direction of propagation (see figure 2). However, all materials, even those considered "perfect" conductors, have resistance. Therefore, power will be absorbed by the boundary surface. In this instance, there is assumed to be no power loss and the E vector is considered as being vertical. This ground wave will therefore diminish slowly since there is essentially no power absorbed by the boundary surface.

When the ground wave is transmitted over a mixed path consisting of both lossy and conducting media (see figure 3), the energy vector is still composed of two components when the wave traverses the lossy medium, and the wave will diminish as expected until the wave nears the boundary. During the interval it is in the vicinity of the boundary, teh wave dies out more rapidly until it reaches the boundary. The wave is then enhanced, and more energy is contained by the wave behind the boundary than was contained by the wave before it crossed the boundary. This gain of energy (recovery effect), as yet, is not completely understood. Electromagnetic theory is being applied to understand this phenomenon. As the wave continues over the conducting medium, this new energy level diminishes very slowly as explained above. If the wave is transmitted over a mixed path in the opposite direction, from a conducting medium to a lossy medium, this recovery effect is not observed because the intensity of the wave makes a normal transition as the wave crosses the boundary (see figure 4). The energy loss is very small as the wave traverses the conducting medium. When the wave crosses the boundary, its intensity simply begins to diminish rapidly as if the wave had been transmitted only over a lossy medium.

A research project currently being conducted at the University of Colorado is verifying the validity of the theory established concerning the recovery effect. This experiment utilizes a model of the lossy and conducting media rather than using the actual environment. By using this model, the experimenters eliminate the need of extensive equipment such as mobile antennas to detect the wave intensities at various locations, and the need of numerous positions from which to transmit the waves. Thus, the experimenters conserve a considerable amount of time and expense.

To construct an operative model, a frequency of 4 giga-cycles per second ($4x10^9$cps) is used, since the wave length at this frequency is much shorter than the wave length at lower frequencies of propagation. The simulation of the lossy medium, the earth at low frequencies, is accomplished by using a 16 foot square salt water tank. The conducting medium, the ocean at low frequencies, is simullated by a large aluminum sheet. This is done because at high frequencies the salt water has high loss characteristics like the earth at low frequencies, and the aluminum is a near perfect conductor similar to the salt water of the ocean at low frequencies.

THE SALT WATER TANK USED TO STUDY GROUND PROPAGATION OF WAVES.



This is not an actual scale model of the environment as would be encountered in a practical application of this problem. The only components of the apparatus that are scale models are the wave length of the ground wave and the receiving antenna. To make an actual scale model; the permittivity, permeability, and the conductivities of the ocean and the earth would also have to be duplicated in the laboratory. The data obtained from this experiment cannot be directly applied to an actual problem, but the principles are analogous to those problems found at lower frequencies, and the results can be related to a problem that occurs at lower frequencies.

To make measurements of the energy carried in the wave, an unmodulated wave of one frequency is transmitted over the mixed path consisting of the salt water and the aluminum. The detector consists of a diode which is receiving an A.C. signal current of 1000 cycles per second. When the continuous wave reaches the diode, part of this wave is reflected back toward the wave generator. Since the reflected wave is scattered at a 1000 cps rate, the intensity of this reflected wave can be determined. The diode can then be moved to any position desired in the test area and the corresponding field intensity can be measured.

The knowledge gained from this experiment is expected to be useful in such problems as the navigation of ships and airplanes by electromagnetic waves. An electromagnetic wave can be transmitted from these vessels and corresponding field strength intensity can be measured. This is a practical method of determining their position with respect to the shore of an ocean, if the phase and amplitude effects of the discontinuity at the coastline can be appropriately estimated.

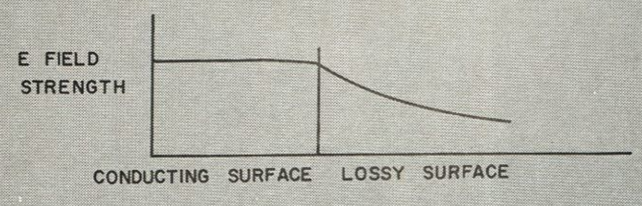


FIGURE 3

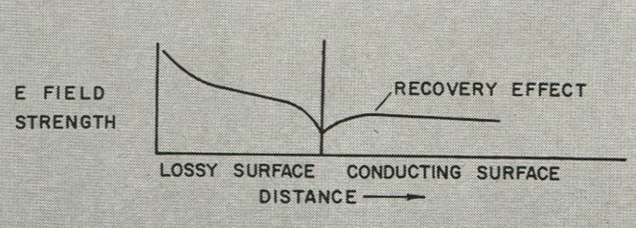


FIGURE 4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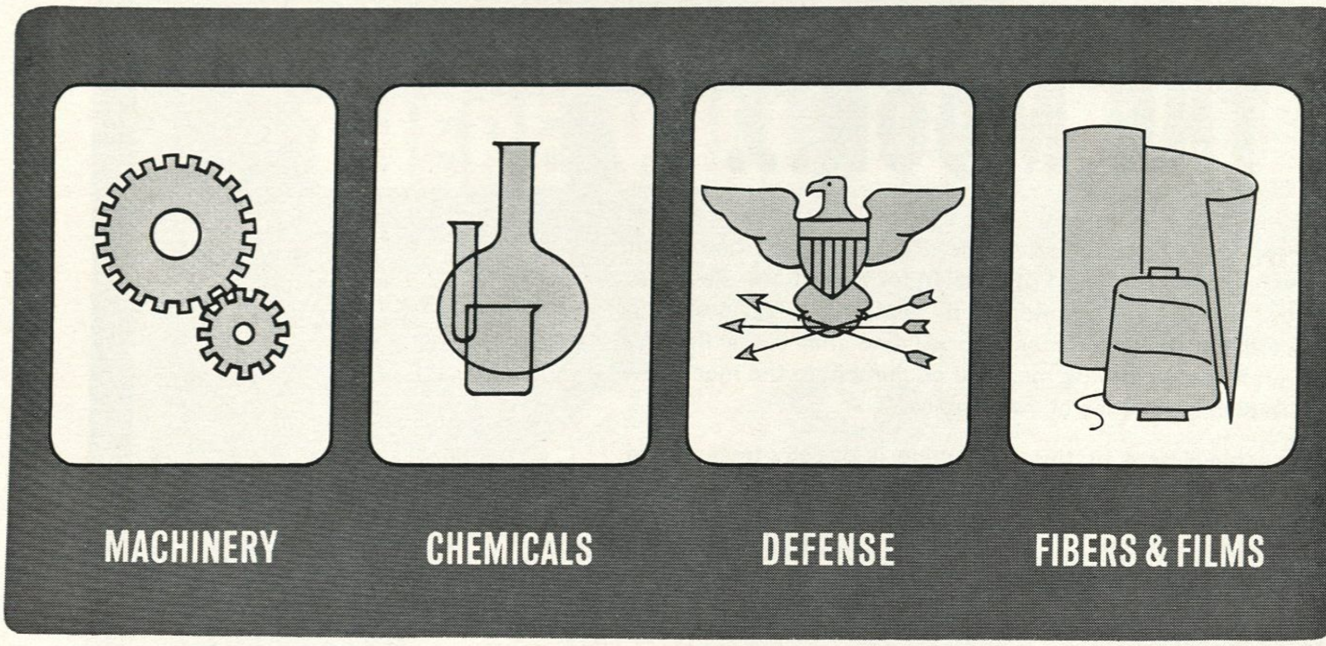

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ENGINEERING'S

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MARK SHERIDAN

Labor unions for professional engineers began gaining popularity around 1942. They became stronger in the early fifties, but about 1953 their growth rate began to show considerable decline. According to one article in an engineering union's journal, the total membership of engineering unions has not increased since 1954.[1]

There is one primary reason that labor unions have not become popular with most engineers; these men feel that professionalism and unionism are imcompatible. As professional employees, they do not believe that they can join what are considered blue-collar organizations and still retain white-collar status in their companies or in society.

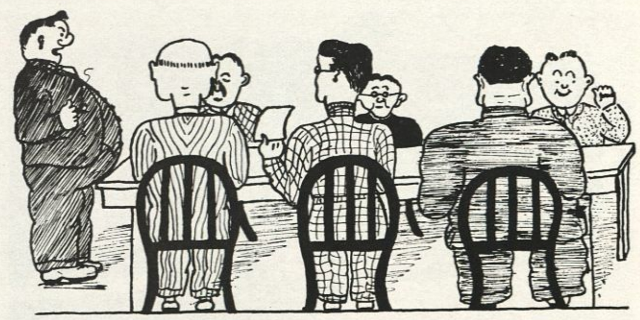
In most companies; engineers are treated with respect and consideration. For their academic training and their potential contribution to the company, they are well paid and in high demand. This is as it should be, since in most industrial companies, much of the management is taken from engineering ranks. Nevertheless, the management of a few companies look at engineers as simply another expense that is necessary if salesmen are to be kept well supplied with products. In other companies the engineer is so numerous, he is thought of as just another employee. Dissatisfied with their status in these companies, engineers have sought to gain more managerial recognition. Opinions vary among engineers on the best way to increase their position, and three main strategies have resulted. The American Federation of Technical Employees (AFTE), an engineering affiliate of the AFL-CIO, believes that "Engineers . . . and . . . technicians are . . . subject to the same economic conditions (e.g. labor supply and demand) as any other employees, regardless of the degree of skill they may have."[2] This union favors collective bargaining for its members, but the organization does not disregard the effectiveness of a strike if arbitration fails. It believes that engineers have become so numerous that they are no longer considered professional men.

The ESA

The Engineers and Scientists of America, largest of the many engineering unions, supports another strategy. It maintains that engineers do have professional status. The members feel that collective bargaining is the proper method of expressing their grievances to management, but oppose strikes.

National engineering societies are against all engineering unions. They feel that unions serve no useful purpose to engineers and only degrade the profession. The National Society of Professional Engineers issued the following statement in 1959; "Collective bargaining for professional engineers is in conflict with the basic principles of a professional individual."[3] NSPE feels that unionization would, among other things, level salaries and make engineers hostile toward management. An article in *Chemical Engineering* magazine reflected the same viewpoint. It stated that "the threat of unionization to engineers is the separation of management and technical personnel that unionization implies."[4] The engineering societies support the third method of settling engineer's grievances: instead of unions, engineers should form "sounding boards" which are made up of managerial as well as engineering members. These boards are established on an informal basis to discuss mutual problems of management and engineers.

These sounding boards may seem similar to the ESA unions in that they merely discuss problems without



an actual threat of strikes; but the unions have a legal advantage over the sounding boards. When the engineers form a bona fide union, it is recognized by the courts as the official voice of its members. Management is required by law to arbitrate with this group, whereas sounding boards are informal meetings established and conducted through mutual cooperation of engineers and management.

Ridiculous as it may seem on first thought, no one is really sure what it takes to be an engineer. A few men feel that only those persons with state-awarded, certified engineering certificates may call themselves professional engineers. Most engineers believe that men who have college degrees should be called "professional," while some feel that anyone who is called in an engineering capacity can claim the title. This ambiguity has confused membership requirements and in doing so has resulted in the formation of many unions. The AFL-CIO views the affiliation of one million engineers in the United States as possibly the next step in unionization. Bringing a labor force of this size and importance into the fold would be a tremendous accomplishment for the AFL-CIO. To boost union strength in the engineering field, the AFL-CIO affiliations have lenient requirements for membership. They are willing to accept anyone who works in the field of engineering, while many unions similar to ESA are more exclusive. Legal definition of an engineer would clarify union requirements for membership and help establish the position of the engineer in industry.

Opinion Survey

The "average" engineer's opinion of unions was made clearer by a survey that the staff of *Machine Design* magazine conducted in 1958. They mailed 1,000 questionnaires to engineers who were not in managerial positions, of which 337 were acceptably returned. The forms asked three questions:

1. How do you feel about unions or collective bargaining associations for engineers and scientists?
2. How do you feel in regard to sounding boards?
3. What conditions do you think cause engineers or scientists to join unions?

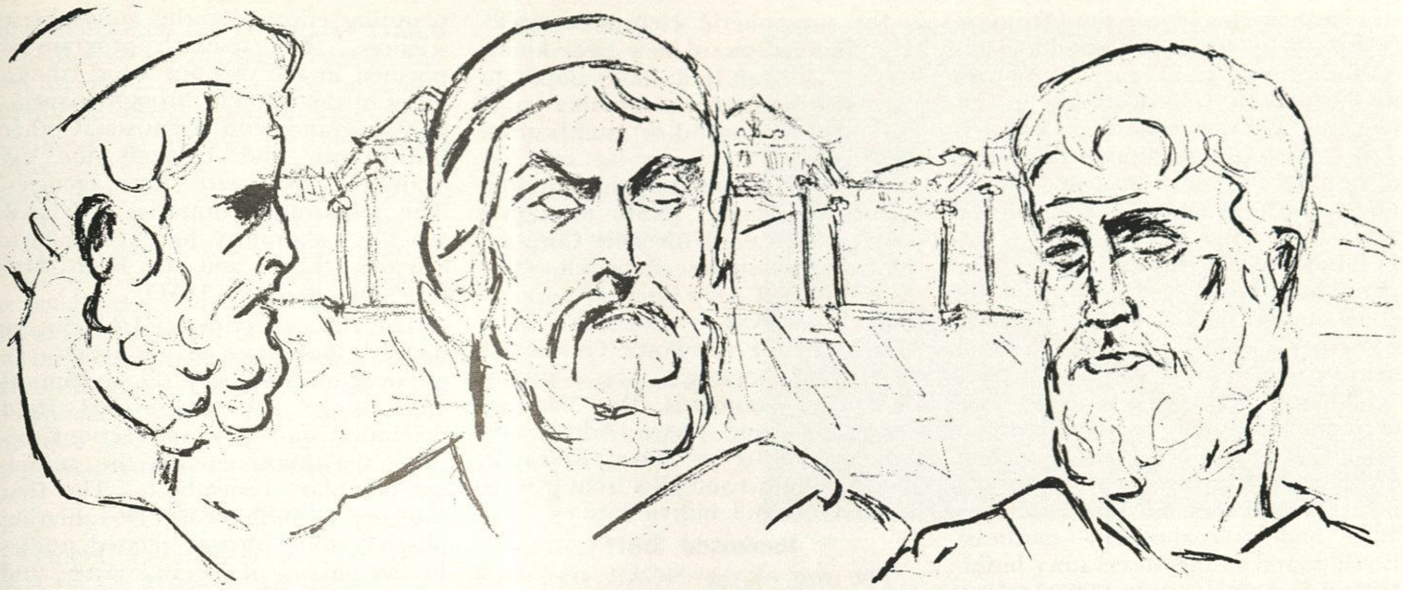
In reply to question 1, 54% were strongly opposed to the associations, 18% mildly opposed to them, 6% were neutral, 14% mildly favored membership.

In reply to question 2, 36% favored, 30% were neutral, and 34% were against the associations.

There were no predominant answers to question 3. The three most common answers were money, lack of recognition, and poor management.[5] Historically, engineer's unions have been much more concerned with lack of recognition than monetary rewards.

Of the one million engineers in the United States, 40,000 are represented by unions, but only 20,000 pay dues. If engineering unions are to become more popular with engineers throughout industry, there will probably have to be a drastic change in the management-engineer relationship. The great majority of engineers have never felt the need for unions. They seem to believe that any difficulties which arise with management may best be solved by mutual agreement with management rather than by arbitration and strikes, because by forming a union, engineers also form an entirely different concept of their place in industry.

B-52. 8-engine jet bomber with range of over 9000 miles. Backbone of the Strategic Air Command.



OF QUIET CONTEMPLATION

NICK NOSSAMAN

It is fairly disturbing to speculate about the number of us who will live our lives like the little silver sphere in a pinball machine: bouncing from event to event, being flipped about by the accidents of our existence, perhaps leaving some ephemeral evidence that we have passed through; but not really making our capabilities meet our opportunities, nor attempting to establish additional dimensions to our being. I refer in particular to the shortcomings in our development which are due to the lack of individual exploration of our minds—those structures which we, as human beings, possess uniquely among all animals.

I venture to say that if one were to ask a number of people (Americans, let's say) to list ten of the activities that give them the most pleasure, you would find less than one in twenty who would include "sitting alone and quietly contemplating", or words to that effect. . . . In fact it is generally considered a waste of time to simply put aside all activity for awhile and—without any artificial stimuli bombarding the senses—*just plain think.* It seems we must constantly be either experiencing some type of entertainment, "getting something done," or getting some sleep.

A portion of one's time spent in quiet thought could perhaps provide some answers as to where an individual's wild rush through life is taking him, and if, in fact, that is where he wishes to go. Many people have told me, and many more have given me the impression, that they don't particularly care to analyze the way they are conducting their lives at a given time. They simply guide themselves by determining what seems to fit in with the current situation. I feel that this attitude helps to account for the intellectual homogeneity of our society: the scarcity of real individuals. Were there more people who took the time to look more deeply inside themselves, there would be more people realizing, and possibly developing, their capabilities. There would also be more people discovering that some of their basic interests are more meaningful than others, and realizing that their life is not being directed as they would ideally have it. For we must keep in mind the fact that we are virtually strangers to ourselves: the more we find out about ourselves, the more we realize that there is to know.

Just as the adult attitude seems to be that "just quietly thinking" is sort of ridiculous, we see parents squelching tendencies in their children toward wanting simply to be alone and undisturbed. Of course the argument that goes "The unoccupied mind of youth will discover trouble," cannot be *completely* ignored, but a child left to himself at times instead of being constantly provided with gimmicks (or playmates) to occupy him, will learn some resourcefulness. He will also—on his own scale, of course—begin to seek the answers to some of his questions about himself and his world.

We spend a great deal of time loading our minds with raw facts and concepts concerning our surroundings. We also are exposed to the theories of those who have lived before us, and who have been moved enough to tell us what they thought life was all about. As one progresses, he must give himself a chance to fit these items together to help construct an outlook and basis for living that is uniquely his own. This opportunity for personal construction does not often occur in a life that is constantly occupied with matters of the moment.

Naturally, we are not all potential Bertrand Russells, just waiting to be hewn out of the rough by our introspection; but we *are* beings of more depth than we normally allow ourselves to discover

Next time you realize you have watched two or three television programs on end, shut the set off for awhile and go for a walk . . . or the next time you find yourself continuously rushing from one activity to another, make an effort to take some time to find a shady spot in the garden, or under a tree somewhere—then drain your mind of immediate urgencies and go exploring *into* your mind . . . You may find that you are not as well acquainted with yourself as you thought.

The new home of the National Center for Atmospheric Research (NCAR) will stand on one of the most naturally beautiful sites in the foothills of the Colorado Rockies. The Center will be located southwest of Boulder on beautiful Table Mountain, which stands 600 feet higher than the center of the city. The buildings, which will become the first permanent home of NCAR, will include offices, laboratories, a large computer, library, meeting rooms, exhibit space, cafeteria, and shops. NCAR presently occupies, under lease or rental, four buildings of the University of Colorado. A major portion of the work is presently accomplished in two buildings which are located at 30th and Arapahoe in southeast Boulder and in the observatory building on the main campus of the University.

NCAR was established in 1960 . . . "to conduct and foster basic research in the atmospheric sciences, to supplement and augment the research and educational programs of universities and research groups in the United States and abroad, and to work toward increasing the potency of atmospheric research efforts as a whole."[1] The Center's establishment is part of an increased national effort in the atmospheric sciences to accelerate progress toward new basic knowledge. This can lead, for example, to a realistic assessment of whether large-scale weather control or modification is possible.

NCAR is sponsored by the National Science Foundation (NSF) through a contract with the University Corporation for Atmospheric Research. The majority of NCAR's financial support comes from NSF. Additional funds come from the Air Force Cambridge Research Laboratories, the National Bureau of Standards, the National Aeronautics and Space Administration, the Office of Naval Research, and from grants and gifts from private foundations and individuals.

Increased Staff

The size of the NCAR staff will depend on the needs of the atmospheric sciences and the benefits which are gleaned from NCAR by the scientific community. Present estimates call for a staff of around 500 people, both permanent and visiting, when the maximum level of operation is reached. The Center presently employs about 300 full-time people.

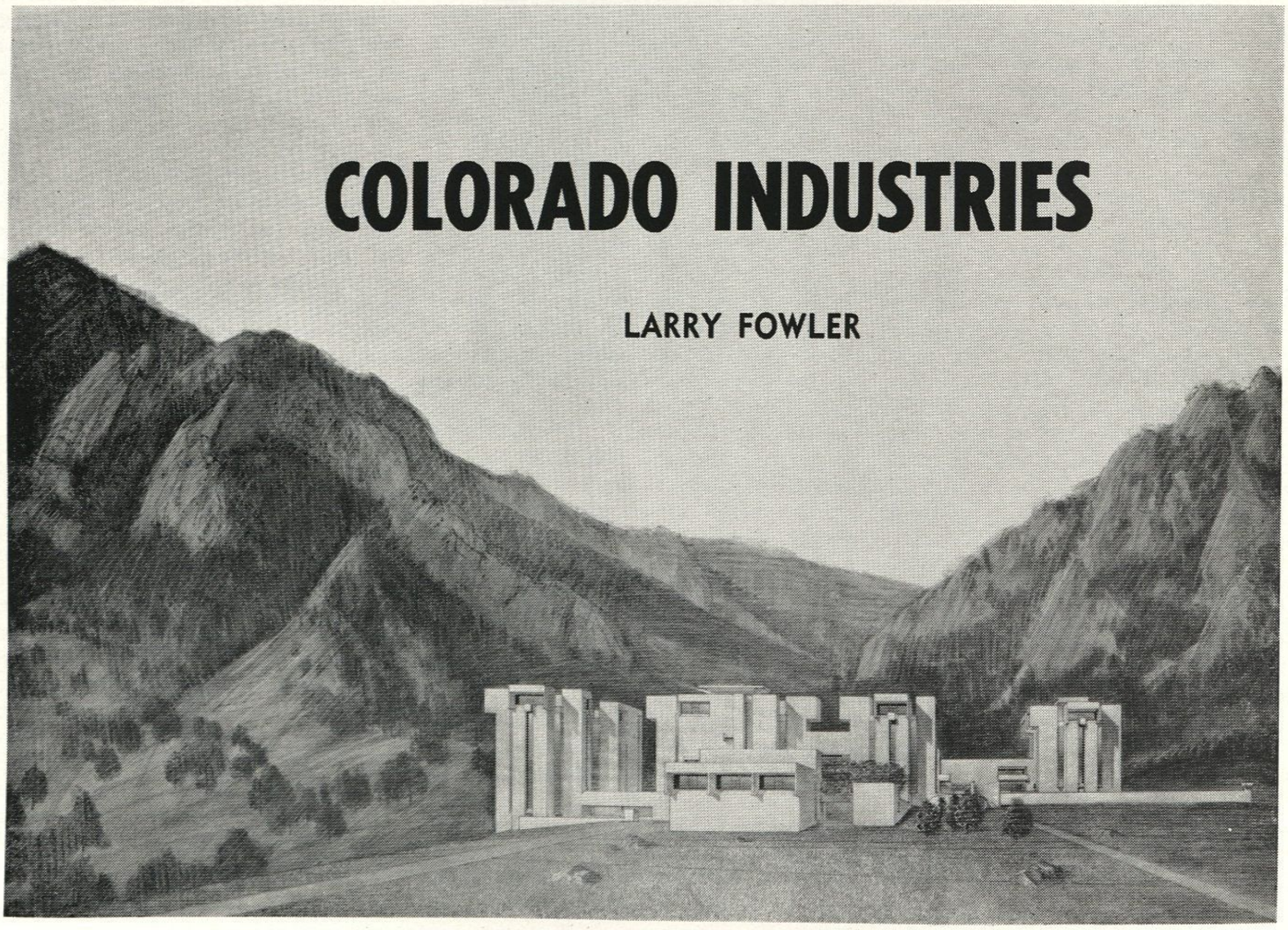
The Center's mission is three-fold; it includes the research program, the facilities program, and a program of encouragement and assistance in planning efforts for the atmospheric sciences. The research program is pursued in the two operating laboratories of the Center, through cooperative programs with scientists at other institutions, and through the exchange of visits with other agencies. The operating laboratories at NCAR are the Laboratory for Atmospheric Sciences (LAS) and the High Altitude Observatory (HAO).

The research effort at LAS can be divided into three major areas: (1) physical meteorology, (2) dynamical meteorology and geophysical fluid dynamics, and (3) interactions between the atmosphere and the ground-sea boundary beneath it. The first category includes work in radiation physics, cloud physics, related studies in the physics of ice and water, and atmospheric chemistry.

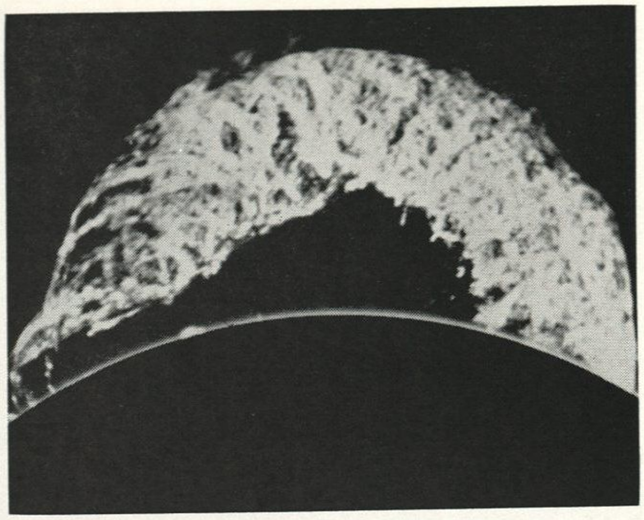
One of the projects in physical meteorology is concerned with measurement of the vertical distribution of ozone (0_3) in the atmosphere. The principal cause of atmospheric ozone is the interaction of molecular oxygen with ultra-violet radiation from the sun. Ozone also returns to oxygen through a similar interaction. The wavelength of the radiation determines whether the reactions will occur, and the extent of the equili-

COLORADO INDUSTRIES

LARRY FOWLER



brium between the reactions. Ozone distribution predictions, based on the equilibrium condition, can be made. Predicted distributions indicate a geographical maximum in the earth's equatorial region; seasonally the maximum is predicted for summer. Nevertheless, observations of actual distributions reveal a geographical maximum in subpolar regions and a seasonal maximum in the early spring. Research seeks the ultimate goal of a complete space-time picture of the distribution of ozone. If this is accomplished, atmospheric ozone can be used as a tracer in studies of the general circulation of the atmosphere.



THE LARGEST ERUPTIONS OF THE SUN'S SURFACE EVER OBSERVED. PHOTOGRAPHED JUNE 4, 1946 BY THE HAO CORONAGRAPH.

Circulation Studies

General circulation studies are a part of the research program in dynamical meteorology at LAS. Even the casual observer is aware that atmospheric conditions in one geographical area today contribute to the condition in another area tomorrow. Scientists at NCAR are seeking mathematical descriptions of the general atmospheric circulation which will yield a more complete understanding of the casual relationship between conditions in different areas. The descriptions which are extant do not have the needed reliability.

Improvements in these descriptions arise from the building and testing of atmospheric models. The reliability of these models is tested through comparison of their simulated histories to actual meteorological history, To obtain this comparison, known conditions of a given period of meteorological history are coded and fed into a computer which contains the mathematical model. The computer imposes the restraints of the model on these initial conditions and simulates the passage of time. The final model conditions can then be compared to the actual final conditions. This comparison can point to weaknesses in the models and lead to their improvement. Of course, the entire effort at NCAR can contribute significantly to model improvements. As new fundamental knowledge is uncovered, it can be incorporated into atmospheric models.

Other research at the Laboratory for Atmospheric Sciences includes effects of shock waves on cloud droplets, the possible roles of lasers in measurements of phase changes in water, studies of vertical turbulence caused by interaction between the atmosphere and its ground-sea boundary, and theoretical studies of thunderstorms.

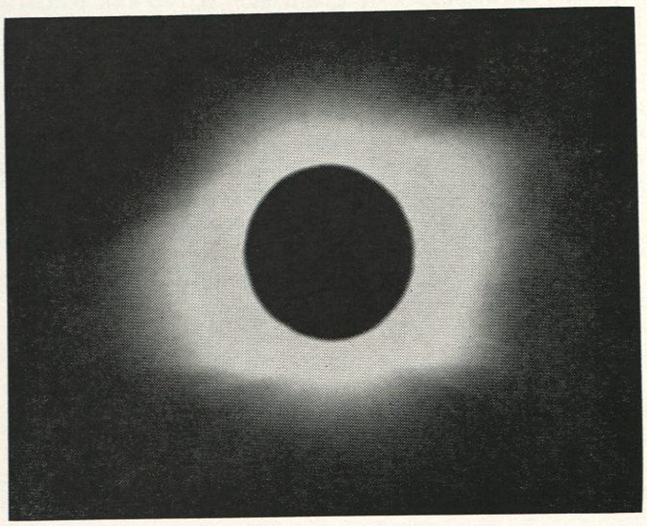
The High Altitude Observatory, although a part of the newer NCAR, has existed for nearly 20 years. HAO research concentrates on solar physics, planetary studies, and solar-terrestial relationships. The Observatory maintains teaching connections with the University of Colorado, and University graduate students participate in the research work of the observatory. There are also joint scientific programs with the University of Hawaii, the National Bureau of Standards, and the Sacramento Peak Observatory, where HAO keeps a small staff.

Climax Observatory

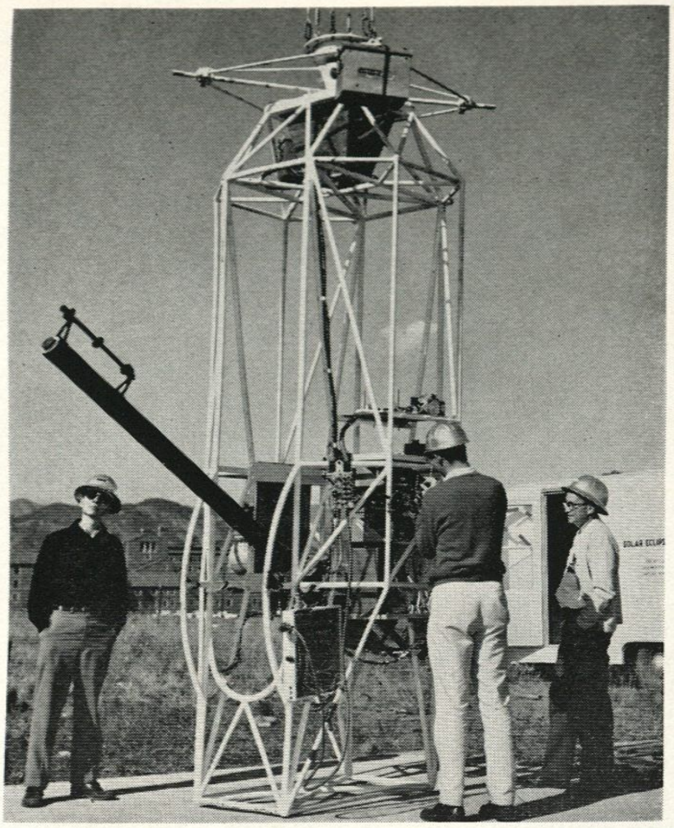
Studies of the solar atmosphere depend heavily on observations made during solar eclipses and on daily observations made with coronagraph techniques, from the Climax, Colorado, observing station. A radio astronomy station, north of Boulder, allows other types of observations to be made. Measurement of solar parameters is accomplished to an extent through a study of the intensity of the sun's electromagnetic radiation as a function of its wavelength. This type of analysis is similar to the spectral analysis used in the identification of chemical elements.

An interesting phenomenon which is undergoing scrutiny at HAO is the relatively high temperature of the sun's corona and the causes of the sharp temperature difference between the photosphere and the corona. If the sun is pictured as a planar disc composed of three concentric circles, the area within the smallest circle corresponds to the photosphere, which is the principle source of visible solar radiation. The area between the inner and second circles corresponds to the chromosphere; the area between the second and outer circles corresponds to the corona. Temperatures at the edge of the photosphere are in the vicinity of 5000° Kelvin (8550°F) and rise to approximately 50,000°K in the chromosphere; on the other hand, temperatures in the corona are on the order of 1,000,000°K (1,800,000°F). Scientists at HAO are seeking to determine more exactly the coronal temperatures and the cause of coronal heating.

A study of the corona is difficult in view of the much higher brightness



SHOT OF THE JULY 20, 1963 TOTAL SOLAR ECLIPSE MADE AT TALKEETNA, ALASKA. (HIGH ALTITUDE OBSERVATORY, BOULDER, COLORADO)



Preparation of the Balloon Carriage to be Used in the February 1964 Coronagraph Studies. (*High* Altitude Observatory, Boulder, Colorado)

of the photosphere as compared to the corona. At one time coronal observations were limited to times of total solar eclipses when the moon effectively blacked out the photosphere. Today the coronagraph, a device which blacks out the photosphere using ingenious optical arrangements, allows continuous observation of the corona within certain limitations.

These limitations arise when observations of the outer corona are attempted and are imposed by the brightness of light scattered by atmospheric dust. HAO is attempting to obviate these difficulties through the use of balloons. Observatory scientists hope to float a coronagraph to altitudes which are above the majority of atmospheric particles. At these altitudes scattered light should be negligible and more accurate observations of the entire corona possible. A flight in 1960 at an altitude of 80,000 feet was unfruitful and demonstrated that higher altitudes and improved coronagraphs were necessary. A flight to 100,000 feet was planned for February, 1964.

Other areas of research at HAO include sun flare theory, sunspot theory, solar rotation, interplanetary space, and upper atmsophere studies.

While research at the National Center for Atmospheric Research does not presently encompass all major areas of the atmospheric sciences, the number of studies carried on there indicates that the contributions of NCAR research will be highly significant in the overall effort.

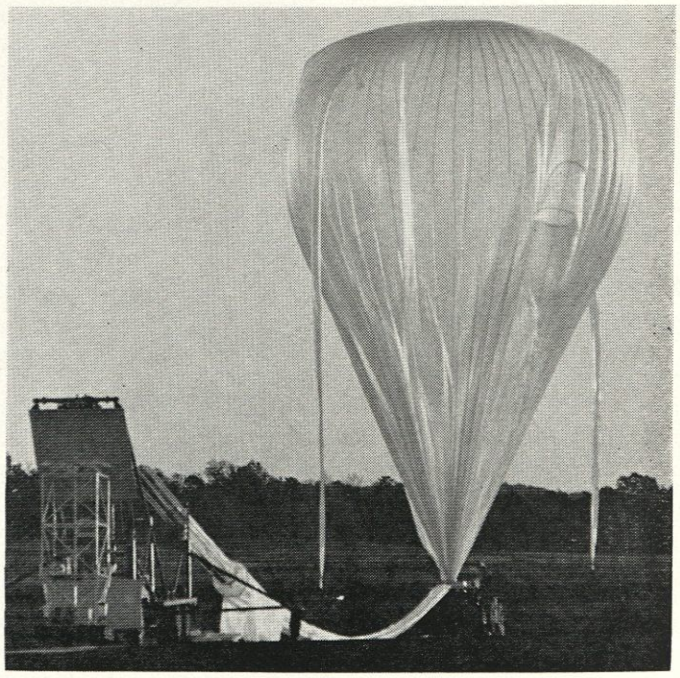
The Facilities and Administration division of NCAR was established to carry out the second part of the overall mission. This division is principally concerned with planning, establishing, and often, operating national facility programs. Additionally, this division provides support services for the Laboratory for Atmospheric Sciences and the High Altitude Observatory.

The national facilities program was instituted to serve the needs of the scientific community at large by developing capabilities for atmospheric observation on all scales and by operating research service activities. In particular, facilities which cannot be adequately provided by other agencies, are the prime targets of this program. The National Scientific Ballon Flight Station, located at Palestine, Texas, is the first such national facility to be developed.

This facility lessens the need for compromises which arise when individual agencies require balloon flights for scientific research. Facilities and services provided by the station include: a permanent staff trained in all facets of balloon launching, office space, a machine shop, photographic laboratory, a 3-foot by 3-foot temperature and pressure controlled environmental test chamber, electronic test equipment, launch equipment, tracking aircraft, recovery services, and flight forecast services. The high utilization of the station has demonstrated its need.

Additional facilities, either under consideration or in planning, include a national aircraft facility; an additional winter balloon flight station at Page, Arizona, the site of Glen Canyon Dam; and a network of meteorological observation stations much denser than the present network.

In support of the third arm of the mission NCAR sponsors or co-sponsors national planning conferences and special interest research conferences.



Preparation for Launching of Test Flight on November 2, 1963 at the Palestine Flight Facility.

ALUMNI NEWS

CHUCK HANSEN

WALTER W. LEWIS

Dr. Walter W. Lewis, BSEE 1907, has been named an honorary member of the Japanese Institute of Electrical Engineers. This is the highest honor awarded by the JIEE.

Dr. Lewis is a retired Union College professor. He pioneered in the protection of electrical power transmission against lightning. Dr. Lewis worked for General Electric Co. from 1907 until his retirement in 1946. He then taught electrical engineering at Union College until 1952. After a second retirement he was called back to teach in 1955.

Dr. Lewis has written some 60 professional papers and several texts, two of which are well known and widely used in Japan and The United States. The first of these texts—"Protection of Transmission Systems Against Lightning" — was published in 1950 and was followed in 1958 by "Basic Electric Circuit Theory." He is credited with the "alpha, beta, zero" concept of calculating complete and partial short circuits in multiphase power systems. His calculations have enabled power companies to design circuit breakers and other controls that combined safety with maximum dependability. As a result, prolonged interruptions in electrical service due to temporary overloading of power lines—such as when they are struck by lightning—are less frequent today.

Dr. Lewis holds an M.S. degree from Union Collgee and an honory Sc. D. from Colorado in addition to his original degree.

DOLPH CAMPBELL

Dolph Campbell, BSCE 1934, is sales manager of the Pacific Coast District of E. I. du Pont de Nemours & Co. This district includes Alaska, Washington, Oregon, Western Montana, Northern Idaho, Nevada, California and Hawaii. He is primarily concerned with sales of explosives in these areas.

Campbell joined DU Pont in 1940 and he has been in technical sales areas since that time. In 1958 he was involved in the world's largest explosive job—the Ripple Rock explosion in Seymour Narrow, Canada. This one project required 2.75 million pounds of explosives. Campbell was appointed to his present position in 1960.

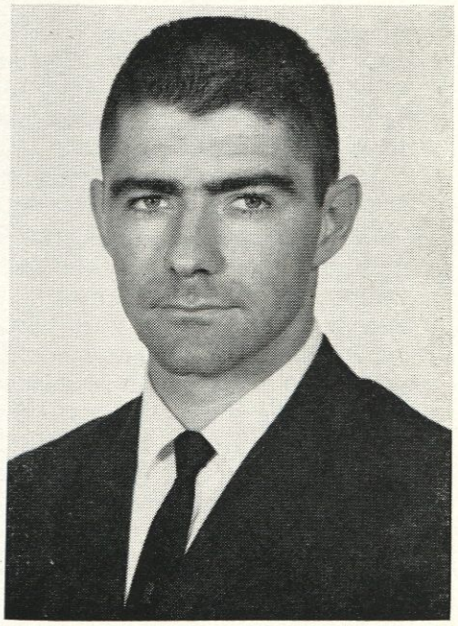
In addition to this job, he operates a vessel called the "Vitanic," on which explosives are shipped from the dynamite-manufacturing plant at Fort Lewis, Wshaington, to Alaska.

WILLIAM W. STILES

William W. Stiles, BSChemE 1930, has been elected president of the Military Government-Civil Affairs Public Health Society at their annual meeting in Kansas City in November. This organization is concerned primarily with the military aspects of preventive medicine and public health. Stiles is a professor of public health at the University of California in Berkley.

GEORGE S. PENWELL

George S. Penwell, BSME 1957, has joined the Trane Company of Los Angeles as a sales engineer. Trane is a manufacturer of air conditioning, heating, ventilating and heat transfer equipment for commercial, residential and industrial applications. Prior to this assignment, Penwell completed the Trane specialized graduate engineering training program. The program consists of instruction on Trane products and their specialized heat transfer theory and practice.



George S. Penwell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DEAN'S COLUMN

DEAN PETERS

At 10:35 a.m. on Monday, January 20, 1964, Governor John A. Love dug the first shovelful of earth to mark the beginning of the construction of our new University of Colorado Engineering Center. Thus, we are now started on the construction of the major Engineering facility at the University toward which we have been working for the past five years. This project is going to be of tremendous importance, not only to the education of Engineers at the University but, also, to the entire economic and scientific future of the State of Colorado.

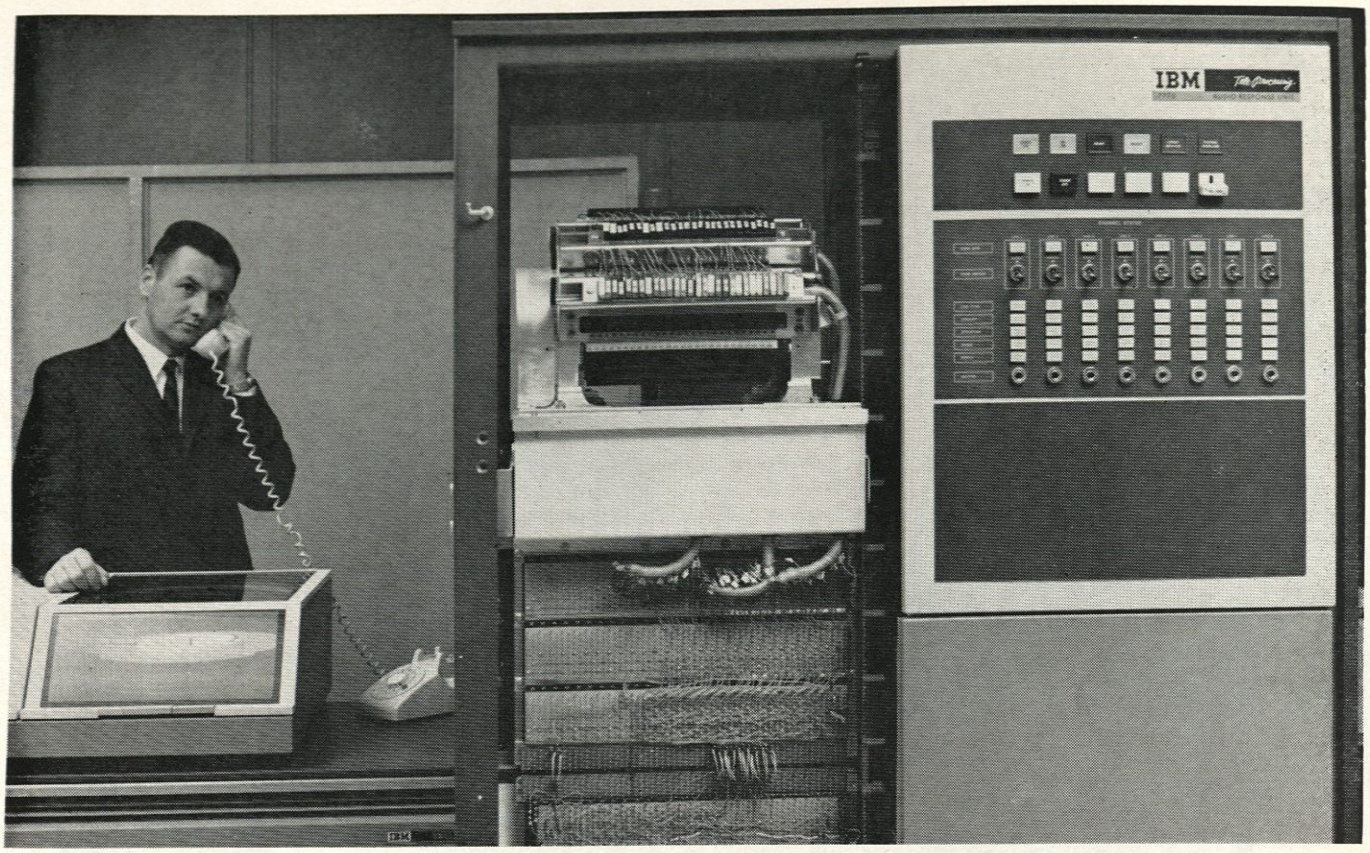
The start of the construction of the new Engineering Center is a clear indication that the State of Colorado intends to be a major center of Engineering education and research. The University of Colorado has long had a strong Engineering program, particularly, on the undergraduate level with the first B.S. degree in Engineering being awarded in 1897 and the 10,000th B.S. Engineering degree to be awarded in 1964. To meet the needs of modern Engineering education in the State, it was apparent by the early 50's that a great expansion of the graduate and research programs in Engineering at the University would be required. An increase of 30% in the number of graduate students in Engineering at the University during the past year, including an increase of more than 100% in the number of Ph.D. candidates, shows the results that have been obtained in the added emphasis on graduate and research work in the College of Engineering.

An emphasis equal to that in the development of the graduate and research program has been placed on improving and modernizing the undergraduate Engineering program. A new undergraduate instrumentation laboratory in Elecerical Engineering, a new measurements laboratory in the Superior Students Program, and expansion of undergraduate research activities are typical of the developments that have been occurring in the last year relative to the undergraduate activities.

In addition to the modernization of the teaching programs in Engineering and an increased emphasis on research work, positive steps are being taken to recognize the importance of Humanities and Social Sciences in the education of our Engineers. For the first time, this year the College of Engineering will give special recognition to one of its seniors who has most successfully combined proficiency in his major field of study with notable achievement in the Social Sciences and Humanities. The new award is designed as the Hamilton Watch Award and will consist of a specially engraved Hamilton electric watch. Professor S. Mandel, of the English in Engineering Department and Editor for our Graduate Research Center, is Chairman of the committee to choose the awardee. The purpose of the award is to encourage a greater understanding of the Social Sciences and Humanities among Engineering students. The award will be made at our Honors Convocation during "E" Days.

Our College of Engineereing thus continues to move forward with positive steps being taken to provide adequate Engineering educational facilities, a determined effort to provide the best type of modern Engineering education on the graduate level and undergraduate level, a realization of the importance of research activities in Engineering education ,and a determined effort to give our students the best education in Engineering as well as a relization of the importance of the Social Sciences and Humanities.

Max S. Peters
Dean



THE NEW IBM 7770 ANSWERS A DIALED INQUIRY WITH A SPOKEN RESPONSE.

THIS TODAY

ROBERT BARRY

MAKING COMPUTERS TALK

International Business Machines Corporation has introduced a new system that provides information from a computer in the form of spoken words. The new IBM 7770 audio-response unit makes possible immediate telephone access to millions of facts on file in a business computer. The 7770 is designed for use with any of five IBM computers.

An inquiry is telephoned to the 7770 by dialing a number identifying the desired information—an inventory part number for example. The verbal answer is immediately transmitted back to the dialing phone. With special arrangements provided by a common carrier any telephone can be used to contact the 7770.

The 7770 audio-response system is comprised of three sections which control performances – inquiry, digital control, and the audio output. The inquiry section of the 7770 receives the telephoned information request and translates the digits into binary coded form. It then stores the message in a buffer associated with the inquiring line. The digital control section regulates the data flow between the 7770 and the computer. When an inquiry has been completed the control unit moves the information from the 7770 buffer to the computor where the inquiry is processed and a digital response in the form of a series of vocabulary drum word addresses is returned to the 7770. There, it is again stored in the buffer associated with the line from which the inquiry was made and is checked for errors. From the buffer the message is forwarded to the audio-output section one word at a time.

The audio-output section contains the vocabulary which has been recorded on a magnetic drum. It also contains magnetic read heads to retrieve the vocabulary words and equipment to arrange the words in order. The drum, on which the vocabulary is recorded is four inches in diameter and ten inches long. It can hold as many as 128 word tracks. As the drum rotates the recorded signals are picked up by the "read" head on each track. A timing track on the drum signals the digital control section when a word is located and it is ready to accept the next word address. When all the words in a message have been selected and the audio signals have been checked for accuracy, the message is amplified and transmitted as a voice message back over the phone.

The 7770 has a voice vocabulary of 32 words which can be expanded to a maximum of 126 words. While all vocabularies include digits and the letters of the alphabet, the words in each vocabulary can be chosen to suit the needs of the specific user.

The 7770 is expected to be put to use in a number of businesses and industries where quick access to information is necessary to the efficient transaction of business. Applications in the field of insurance, banking, finance, manufacturing, and retailing have already been projected.

PHOTOCHROMIC GLASS

In a paper recently presented to a meeting of the American Physical Society, Dr. S. Donald Stookey, director of fundamental chemical research at Corning Glass Works, announced the invention of glass which darkens when exposed to light and clears when the light source is removed. This unique product, known as photochromic glass, is still under laboratory development but many proctical uses are enivisioned. Dr. Stookey and Dr. William H. Armistead, a Corning vice president, are co-inventors of the new glass.

According to Dr. Stookey, this is the first time that a photochromic glass has been developed which does not loose its ability to clear or darken quickly. Earlier glasses of this type either took a long time to change color or they lost the property of reversibility. After more than two years of testing, the new glass has not lost any of its photochromic properties.

Near ultraviolet wavelengths of light produce the most darkening in the glass. The composition of the glass, however, determines the effect of other wavelengths. A typical photochromic glass darkens instantly on exposure to intense ultraviolet light and within a few seconds in sunlight, but will not darken under most indoor lightning. The glass requires anywhere from less than a minute to several hours to recover its transparency. The clearing rate increases when the temperature is increased. The color of the darkened glass is usually gray, but it may also be brown or purple. Before darkening, the photochromic glass is as clear as standard window glass.

The photochromic glasses are formed by conventional glassmaking methods. The materials are silicate glasses which contain submicroscopic silver halide crystals. The crystals, which give the glass its photochromic properties, are precipitated during the manufacturing process.

FOAMING PLASTICS WITH HOT SPOTS

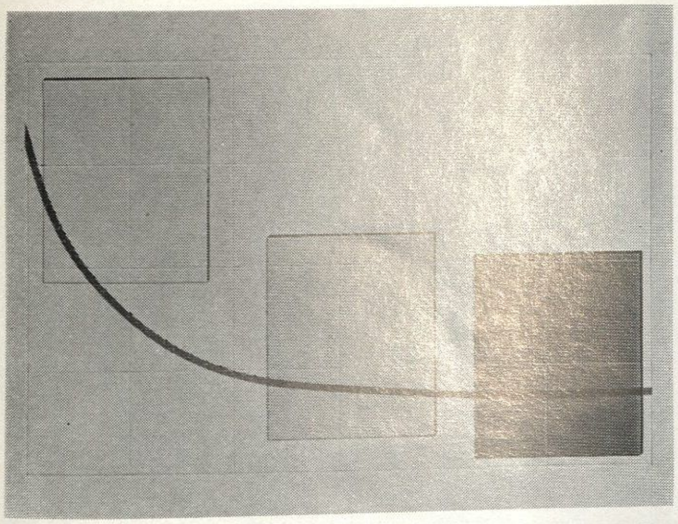
Dr. Ralph H. Hansen of Bell Telephone Laboratories has developed a new technique for foaming plastics for use as wire insulation and other purposes. The technique is based on the fact that the more hot spots in a plastic, the more bubbles created in it, and the better its insulating properties. The foamed plastic not only has better insulating properties but also is less expensive than unfoamed plastic since gas bubbles replace the relatively expensive plastic. The fine celled plastics foamed by Dr. Hansen's hot spot technique also have better dielectric properties than those foamed by "blowing agents."

The new technique is a modification of the extrusion process for foaming plastics which has been in use for some time. In the past organic compounds, known as blowing agents, which release gaseous products on decomposition have been used to foam the plastic. However, unless the blowing agent decomposes at a certain rate the plastic obtained has undersirable properties.

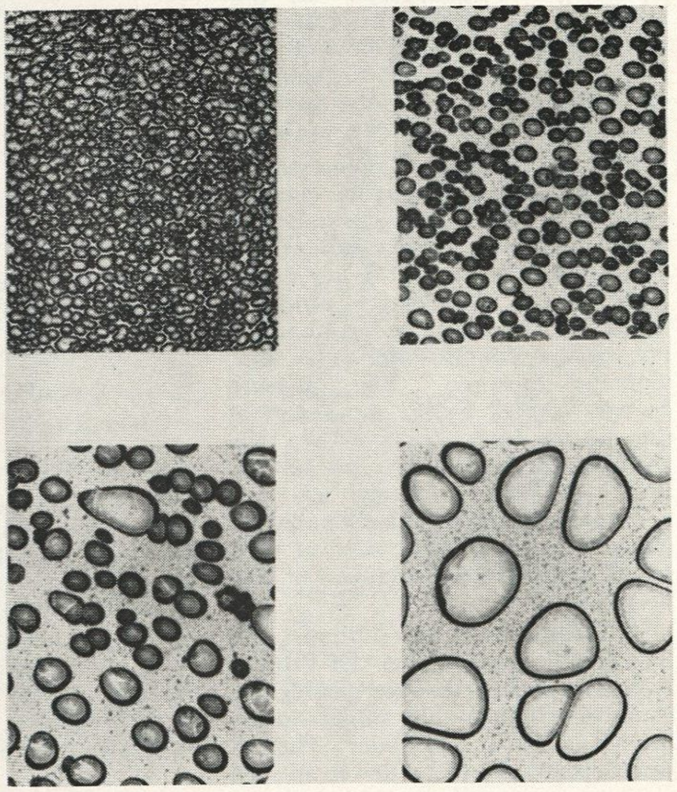
The modified extrusion unit used by Dr. Hansen consists of a tubular barrel several feet long and a few inches in diameter with a funnel at one end and a die at the other. A gas injection port is located near the middle of the barrel. Plastic pellets are poured into the funnel and a screw inside the barrel pushes the plastic through the barrel where the plastic is heated and melts. Gas introduced at the injection port dissolves in the plastic.

Dr. Hansen found that certain organic materials added to the plastic create hot spots in solutions of gas in the molted plastic. These hot spots greatly increase the number and decrease the size of the bubbles formed in the plastic. When the hot spot materials are used, gases such as nitrogen or air, which enter the barrel through the injection port, expand the plastic and take the place of a blowing agent.

The solutions of gas in the plastic become supersaturated and unstable



Above: Light Transmission Decreases as Photochromatic Glass Darken from Exposure to Ultraviolet Light.



Right: Effect of Increasing Number of Hot Spots at the Moment of Formation of a Supersaturated Solution of Gas in Molten Polymer.

when the pressure decreases as the plastic emerges from the barrel of the extruder. If the supersaturated solution of dissolved gas is nucleated immediately, many small bubbles are obtained. The formation of hot spots in the plastic as it leaves the extruder results in such nucleation. The hotter the spots and the more of them, the more effective the nucleation and the better the dielectric properties of the foamed plastic.

ROCKET-NOISE SIMULATOR

MB Electronics, a division of Textron Electronics, Inc., has received a contract from the Air Force to design and build a dynamic pressure chamber which will simulate the noise of rocket engines producing millions of pounds of thrust. The chamber will be used to study human tolerance of these noises.

Test subjects will feel much of the noise rather than hear it. The human ear cannot detect sounds below about 20 cycles per second; the frequency generated by the chamber will range from 1 to 30 cycles per second. In the research chamber pressure changes ranging from 104 to 174 decibels will be generated.

Up until now no source, which could be used for research work, of this low frequency, high-intensity noise has existed. As a result, safety levels for working with the mammoth boosters are unknown. Scientists will use the chamber to determine these human safety limits, tolerances and psychological performance in this environment. The results of the tests will be used in the selection and planning of launch sites and the solution of problems concerning the safety of astronauts and missile site workers.

The test chamber is mounted on trunnions so that it can be used in either a vertical or horizontal position. This way the test subject can be standing, sitting, or lying down. The pressure changes are produced by two 20,000 pounds-of-force hydraulic shakers which vibrate six foot diameter pistons. The pressure changes created by the movement of the pistons are conducted to the chamber through ducts to an air vent in its floor. Pressure seals can be mounted inside the chamber at either the test subjects' waist or neck for tests involving sections of the body.

Elaborate safety precautions will be taken to protect the test subject. A control switch mounted inside the chamber will allow the subject to terminate a test at any time. The hydraulic shakers will be driven in such a way as to make it impossible to exceed a preset pressure. An electronic circuit that senses the rate of pressure change will cause an emergency shutdown if this rate passes the pre-set value.

Instruments connected to the test subject or chamber will take physical and physiological measurements, including sound pressure levels, blood pressure, pulse rate, respiratory responses, and body temperature. Motor and mental studies will be conducted inside the chamber ,and the subjects will undergo medical examinations before and after each test.

TRIESTE PROPULSION PROBLEM

General Electric motors and oil are key factors in the design of the populsion unit of the Navy Electronics Laboratory's bathyscaph *Trieste,* which was used to search the floor of the Atlantic ocean for the nuclear-attack submarine, *Thresher.* The *Trieste,* which was built in Italy and subsiquently modified by the U.S. Navy, is capable of descending to any depth and is designed for use in underwater studies which are expected to extend man's knowledge about the ocean's bottom beyond all present frontiers.

The propulsion system is comprised of several special submersible electric motors which are mounted on the exterior of the vessel. Extreme pressures and low temperatures encountered during the *Trieste's* explorations created a difficult engineering problem relating to the motor design. Some way had to be found to equalize the pressure inside and outside the motors, watertight enclosure to prevent it from collapsing into the spaces between it and the motor.

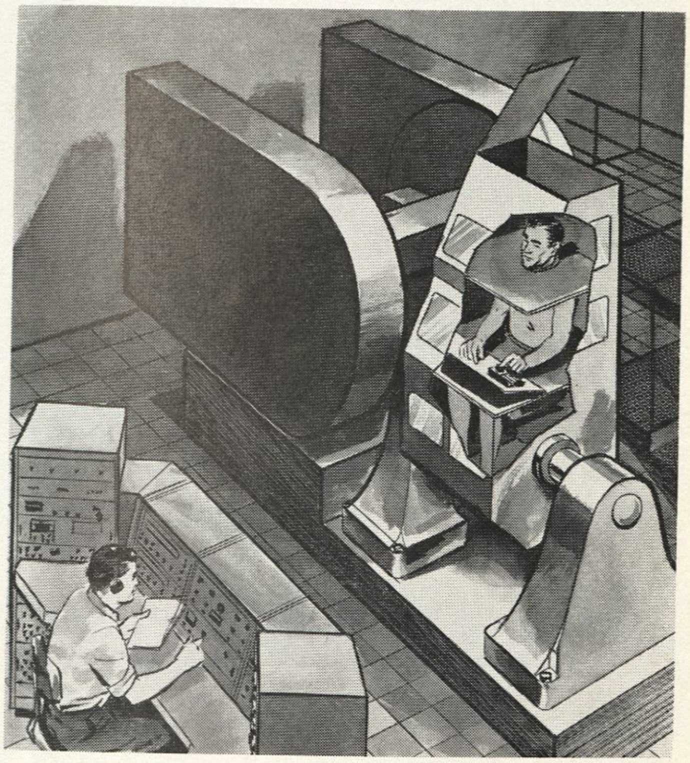
The method selected to achieve this purpose involved filling the enclosure with an oil and sealing the motor inside. Protruding from the tank is a rubber hose. Water pressure is transmitted via the collapsible hose through the oil to the interior of the enclosure to equalize the internal and external pressures.

The required properties of the oil included the ability to withstand pressures up to 15,000 psi and remain fluid at low temperatures. It was also necessary that the oil be light enough to provide some buoyancy. The final consideration was that, since the oil would come into contact with the motor windings, it could not have an adverse effect on insulation.

Trichlorethylene, which had been used in earlier designs, was ruled out because of its solvent effect on insulation. Other materials showed a tendency to thicken at low temperatures or had other undersirable characteristics.

A silicone fluid developed by General Electric and designated SF-96 (10) was eventually chosen. A clear, inert liquid, it possesses the buoyancy, superior resistance to compression, stable viscosity at low temperatures, and compatibility with insulation that the situation called for.

Sketch of the Dynamic Pressure Chamber for Rocket Noise Simelation.



BOOK REVIEWS

JOANN CRAM

A great deal of diversified material crosses my desk. I receive not only actual books and pamphlets, but also indexes and guides to every kind of recent literature from technical publishers all over the United States. In case these book lists should come in handy, they are in a special box in the *Colorado Engineer* office, Ketchum 20, for your use.

Individual companies also send me stuff, some of which is interesting. For instance, I have an extensive chart of "pH Ranges and Color Changes" from the Eastman Kodak Company. This looks like it would be a valuable piece of paper to someone, so if anyone wants it. . . . . .

Mariner: Mission to Venus

By the Staff of the Jet Propulsion Laboratory as compiled by Harold J. Wheelock, McGraw-Hill Book Company, 1963, $3.50, or $1.45 paperback edition.

"If intelligent life had existed on Venus on the afternoon of the Earth's December 14, 1962, and if it could have been seen through the clouds, it might have observed Mariner II approach from the night side, drift down closer, cross over the daylight face, and move away toward the Sun to the right." This encounter, lasting 35 minutes, climaxed a 180-million-mile, 109-day voyage of the first spacecraft to probe into the near-vicinity of another planet .

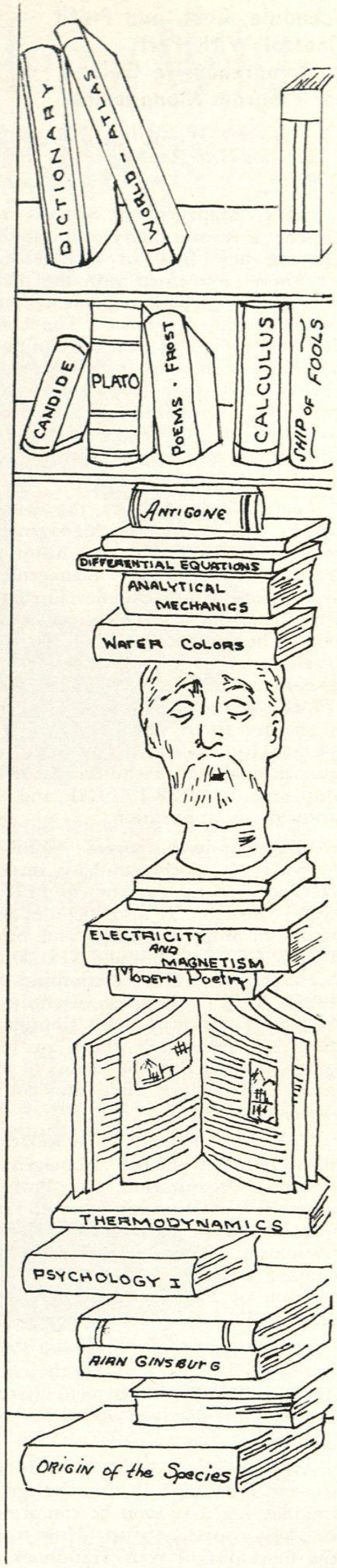
Surprisingly for a major venture, the preparations for the flight, from drawing board to launching, were compressed into only 11 months. The book shows how this rapid program was accomplished and traces the history of U.S. spacecraft and launch vehicles that were developed and adapted for the Mariner II project.

Although the weight of the spacecraft was critical, the engineers managed to pack into its 10-ft.-long by 5-ft.-wide hexagonal body a self-powered, navigable, scientific center equipped to relay data back to earth. From this information, scientists were able to revise their concepts of interplanetary space and the planet Venus. These findings are interpreted in the book. It now seems that 1 Venus day is equal to 230 Earth days. The planet's surface temperature, on both the dark and light sides, is around 800°F, and there is no water on Venus' surface. However, there may be lakes of molten metal The cloud layer surrounding the planet is about 15 miles deep.

But there was more to the Mariner II project than recording data transmitted from the spacecraft. Getting Mariner close to Venus involved a major feat of celestial navigation. The 447-pound spacecraft had to be catapulted from a launching platform moving around the Sun at 66,600 mph, and aimed so precisely that it would intercept a planet moving 11,700 mph faster than Earth, at a point in space some 180-million miles away, with only one chance to correct the trajectory by a planned midcourse maneuver.

How this precise navigation, and how tracking stations scattered across the world followed Mariner's flight is explained in *Mariner: Mission to Venus.*

PERT and CPM are new and increasingly important items in an engineer's vocabulary. They stand for Program Evaluation and Review Technique and Critical Path Method, and refer to scheduling and controlling large projects which will take many months or even years to complete. A CPM on a project can be done to obtain a minimum cost or a minimum time. The mathematics involved for these usually requires a large computer, but after the results are obtained, the Project Engineer makes up a master schedule (critical path) which he feels will do the job best. A new book has been published which discusses the PERT method in particular.



Schedule, Cost, and Profit Control With Pert: A Comprehensive Guide for Program Management

by Robert W. Miller, 222 pages, McGraw-Hill Company, 1963, $8.50.

PERT Management Systems represent a revolutionary and rapidly growing new field of management techniques concerned with the planning and control of complex, "one-time-through" programs. The book describes the use of PERT techniques not only as they apply to large-scale military and space development programs, but also as they apply to a wide spectrum of commercial, industrial, and other economic planning and control activities.

There are six chapters, the first of which—"The Modern Management System Problem"—is an historical treatment of earlier management systems and background developments PERT and CPM. The second chapter, "The Fundamentals of Network Technique," is a comprehensive, up-to-date treatment of CPM and PERT/TIME methodology. There follows a chapter titled "PERT/TIME Implementation" which discusses organizational and technical problems implementing PERT/TIME and the areas of its application.

Chapter four covers "PERT/COST." It places emphasis on the DOD or Federal government PERT/COST System. It also includes problems of implementation and other PERT/COST techniques. Next comes a chapter on "The Relationship Between PERT, Program Definition, Systems Engineering, and Configuration Management," where an integrated approach to the factors of program performance, time, and cost is discussed.

The final chapter, "The Relationship between PERT Management Systems, Organization, and Profits," covers this relationship for both commercial and government-oriented businesses. The second half of the chapter contains a discussion of the relation of PERT Management Systems to Incentive Contracting.

In short, *Schedule, Cost, and Profit Control with PERT* covers the entire field of PERT Management Systems as they have evolved up to the present.

Another handbook has made the scene. I wonder if the College of Engineering may soon be compressed into one course entitled "How to get the most out of your Handbook"?!

Handbook of Hydraulics: For the Solution of Hydrostatic and Fluid-Flow Problems, Fifth Edition

By Horace Williams King and Ernest F. Brater, 566 pages, McGraw-Hill Handbook Series, 1963, $15.00.

This handbook provides engineers with the fundamental concepts and tabular data essential to the rapid solution of hydraulics problems. In addition to covering the applications of hydraulics to problems encountered by engineers (with special emphasis on Civil Engineering aspects of hydraulic engineering), the revised Handbook contains a vast amount of new material on fluid-flow, oscillatory waves, high velocity transitions, and spatially variable and unsteady flow. The authors present the fundamental concepts, as well as test coefficients used in solving hydraulics problems, together with tables designed to simplify and expedite solutions.

The Handbook is divided into 13 specific sections: Section One is titled "Fluid Properties and Hydraulic Units." Section Two develops the principles of hydrostatics and presents applications and numerical examples. Section Three includes basic definitions and derivations of such fundamental concepts as continuity, energy and the Bernoulli equation and momentum. Section Four deals with flow through sharp-edged and rounded orifices, including such practical engineering structures as gates and culverts. Derivations of weir equations and discharge coefficients for various forms of weir are included in Section Five; Section Six presents methods of solving pipe problems and provides roughness coefficients and tables to aid in the solution.

Methods of designing channels for steady uniform flow, and the principles of rapidly varied and gradually varied flow are discussed in Sections Seven and Eight. Sections 9 and 10, and part of 11 represent recent development in the field of hydraulics, giving the equations and graphs needed to solve for conditions in contracting or expanding channels and in channel bends during super-critical flow; the basic equation for oscillatory and translatory waves; and selected aspects of spatially variable flow in open channels and water hammer in pipes.

Section 12 discusses the methods of measuring discharge in pipes and open channels, and the concluding section provides tables and logarithms and the trigonometric functions of angles together with illustrations of their use.

COLORADO Engineer

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NEGATIVE IONS

Jim Toevs, a senior in Engineering Physics, is a fourth-year participant in the Superior Student Program. He is a member of Sigma Tau, Tau Beta Pi, Sigma Pi Sigma, and Kappa Kappa Psi, and plays trumpet in the University Band. He spent the last two summers doing research under an NSF undergraduate grant, and is presently engaged in high-energy negative ion research at the University's cyclotron. Outside interests include music, tennis, mountain climbing, and a pretty medical student at the University of California. Jim plans to do graduate work in Physics.

SALT WATER TO FRESH

Gary O'Keefe is a transfer student in his first semester at the University of Colorado, having previously attended Long Beach, California. He is presently a junior majoring in Civil Engineering. Summers he is engaged in materials testing work with the California Division of Highways. Tennis and handball are among his favorite activities and he hopes to get in some skiing while in Colorado.

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COMPRESSIBLE FLOW

Ellen Harris, a member of the Superior Student Program, is a junior in Mechanical Engineering. During the summer, she worked on an undergraduate research project attempting to discover the effective surface areas of certain plant specimens for the absorption of unidirectional radiation. Her home is near Falcon, Colorado, where her family ranches.

Grateful acknowledgment is hereby made to Professor Arnberg for his assistance in writing this paper.

APPLIED MATHEMATICS

I am a Junior in Engineering Physics and have been in the SSP program since I was a freshman. Last summer I worked in the undergraduate research program with Silas Gonzales in building a beta-ray spectrometer for a Sophomore physics lab.

My interests are strong and broad—ranging from art, music, and philosophy to humor, hiking, and of course, skiing. I was a freshman camp counselor last Fall and am president of United Christian Fellowship.

Charles A. Nelson

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GROUND PROPAGATION

Richard Lubinski is a junior majoring in Electrical Engineering. He has worked at The Martin Company in Denver for the past three summers, last summer as a student engineer. He is currently working as an assistant to Dr. J. H. Krenz in the Electrical Engineering department. His outside activities include skiing, swimming, and skin diving.

ACKNOWLEDGMENTS

The author wishes to thank Dr. S. W. Maley, Donald Dobby, Darrel Hadley, the National Bureau of Standards who is the sponsor of this research project, and special thanks to Ray J. King who supplied the information for this article.

LABOR PAINS

Mark Sheridan is a senior in the combined five year chemical engineering and business program. He is planning to graduate in 1965. Besides writing, he participates in the student chapter of A.I.Ch.E. and is a member of Alpha Chi Sigma, professional chemical-engineering fraternity. On the weekends he enjoys skiing or water skiing, depending on the season.

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OF QUIET CONTEMPLATION

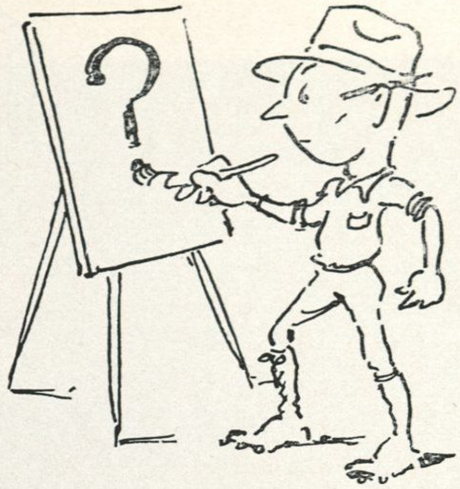
Nick Nossaman is a senior in Applied Mathematics, and Pre-Med, and is attending the University with the help of a Boettcher Scholarship. He is a member of Sigma Tau and Tau Beta Pi, and is a middle distance runner on the varsity track team. His outside interests include music, reading, and sports.

His older brother, Allen, was Editor of the *Colorado Daily* in 1960-61, and his home is in Durango, Colorado, where his mother is office manager of a local firm.

Nick plans to attend the University of Colorado Medical School in Denver, starting next Fall.

ADVERTISERS' INDEX

PUZZLE PAGE



LARRY HILL

(1) TWO-DIGIT NUMBERS:

(a) What number is twice the product of its digits?

(b) What number is three times the sum of its digits?

(c) What number is the square of its units digit?

(d) What number exceeds its reversal by 20 percent?

(e) What numbers plus their reversals sum to perfect squares?

(2) THE KITCHEN LINOLEUM. Mr. Houseman wishes to lay down linoleum on the floor of his kitchen, which is exactly 12 feet square. He has a piece of linoleum just sufficient for the purpose, in the form of a rectangle 16 feet by 9 feet. Obviously he will have to cut this piece to make it fit, but he doesn't want to cut it into any more parts than necessary. Fortunately, the linoleum is uniformly brown, without pattern, so that he can cut it in any manner he pleases without spoiling its appearance.

What is the least number of pieces into which the linoleum can be cut to solve Mr. Houseman's problem?

(3) ADAM AND EVE. If you order poached eggs on toast in a short-order lunchroom, the counterman will shout to the cook

```
A D A M
  A N D
  E V E
    O N
      A
-------
R A F T
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What the counterman probably does not know is that this phrase is really an ancient cabala invented by the Numerian astrologers, derived from a sum in addition by replacing each digit by the same letter throughout. Working backwards, you can find several examples of addition that will give this same result, but there is no doubt that the Numerians wished to make the raft as commodious as possible, so that the example they had in mind gives the largest possible total.

(4) THE TENNIS TOURNAMENT. If 78 players enter a tournament for a singles championship, how many matches have to be played to determine the winner?

ANSWERS TO PUZZLES IN THE JANUARY ISSUE

CUBE:

There is no way to reduce the cuts to fewer than six. This is at once apparent when you focus on the fact that a cube has six sides. The saw cuts straight, one side at a time. To cut the one-inch cube at the center (the one which has no exposed surfaces to start with must take six passes of the saw.

GEOGRAPHY:

Is there any point on the globe, besides the North Pole, from which you could walk a mile south, a mile east and a mile north and find yourself at the starting point? Yes indeed; not just one point but an infinite number of them. You could start from any point on a circle drawn around the South Pole at a distance slightly more than $1 + \frac{1}{2}\pi$ miles (about 1.16 miles) from the Pole—the distance is "slightly more" to take into account the curvature of the earth. After walking a mile south, your next walk of one mile east will take you on a complete circle around the Pole, and the walk one mile north from there will then return you to the starting point. Thus your starting point could be any one of the infinite number of points of the circle with a radius of about 1.16 miles from the South Pole. But this is not all. You could also start at points close to the Pole, so that the walk east would carry you just twice around the Pole, or three times, or more, toward a limit of an infinite number of circlings of the pole.

LUNARS:

The Volume of a sphere is $4\pi/3$ times the cube of the radius. Its surface is 4π times the square of the radius. If we express the moon's radius in "lunars" and assume that its surface in square lunars equals its volume in cubic lunars, we can determine the length of the radius simply by equating the two formulas and solving for the value of the radius. Pi cancels out on both sides, and we find that the radius is 3 lunars. The moon's radius is 1,080 miles, so a lunar must be 360 miles.

CHESSBOARD:

It is impossible to cover the multilated chessboard (two opposite corner squares cut off) with 31 dominoes and the proof is easy. The two diagonally opposite corners are of the same color. Therefore their removal leaves a board with two more squares of one color than of the other. Each domino covers two squares of opposite color, since only opposite colors are adjacent. After you have covered 60 squares with 30 dominoes you are left with two uncovered squares of the same color. These two cannot be adjacent, therefore they cannot be covered by the last domino.

Chips

JOHN BEDFORD

Why do elephants have flat feet? . . . From jumping out of trees.

Why is it dangerous to walk in the jungle between three and five in the afternoon? That's when elephants jump out of trees.

Why do alligators have flat heads? From walking through the jungle between three and five in the afternoon.

Why do ducks have flat feet? From stamping out forest fires.

Why do elephants have flat feet? From stamping out flaming ducks.

How can you tell when an elephant has been in your refrigerator? By the tracks through the jello.

How can you tell when an elephant has been in your bathroom. From the smell of ivory.

How can you tell when that's an elephant in the shower with you? You can smell the peanuts on his breath.

Why do elephants take Rolaids? To stop the drip drip of peanut oil in their stomachs.

How do you carve an elephant out of stone? Chip away everything that doesn't look like an elephant.

Why do elephants have long pointed tails? To make them more streamlined.

What's the black stuff between elephants' toes? Slow natives.

How do you get five elephants in a Volkswagen? Two in front and three in back.

Why do elephants wear green tennies? So they can hide in the grass.

Why do elephants wear red tennies? So they can hide in the strawberry patch.

Why do elephants wear pink tennies? Their red and green ones are in the wash.

Why do elephants have wrinkled ankles? From tying their tennies too tight.

Why do elephants have wrinkled knees? From kneeling to tie their tennies.

What's grey and has a tongue three feet long? An elephant's dirty tennis shoe.

What did Tarzan say about elephant lying in the grass? Nothing. He didn't notice them because they had their green tennies on.

How do you kill a blue elephant? With a blue elephant gun.

How do you kill a pink elephant? Beat him until he turns blue and use the same gun.

Why are elephants grey? So you can tell them from blue jays.

What's red and white and grey inside? Campbell's cream of elephant soup.

What's black and white and grey? Sister Mary Elephant .

How do you make an elephant float? Root beer + 1 elephant. (Straw optional)

How do you make an elephant fly? Go buy a zipper about two yards long.

What's the difference between elephants and grapes? Grapes are purple.

What did Jane say when she saw the elephants coming? "Here come the grapes!" . . . She was color blind.

What is purple and glows in the dark? An incandescent grape.

What's purple and conquered the world? Alexander the Grape.

What's purple and has four speeds? A sport grape.

What's purple and stamps out forest fires? Smokey the Grape.

What's Smokey the Grape's middle name? the.

What's purple and under 18? Statutory Grape.

What's orange and clicks? A ballpoint carrot.

What's purple and hums? An electric plum.

Why do bees hum? They don't know the words.

What has 18 legs and catches flies? A baseball team.

What's yellow and dangerous and sits in a tree? A canary with a cannon.

Why do cows have bells? Their horns don't work.

What burns five gallons of gas per minute and doesn't go anywhere? A Viet Namese monk.

What goes "mark, mark"? A dog with a harelip.

What's red and black and crawls through the forest? A charred forest ranger.

Now do you know why elephants really have flat feet?

How do you kill an elephant joke? With sour grapes.