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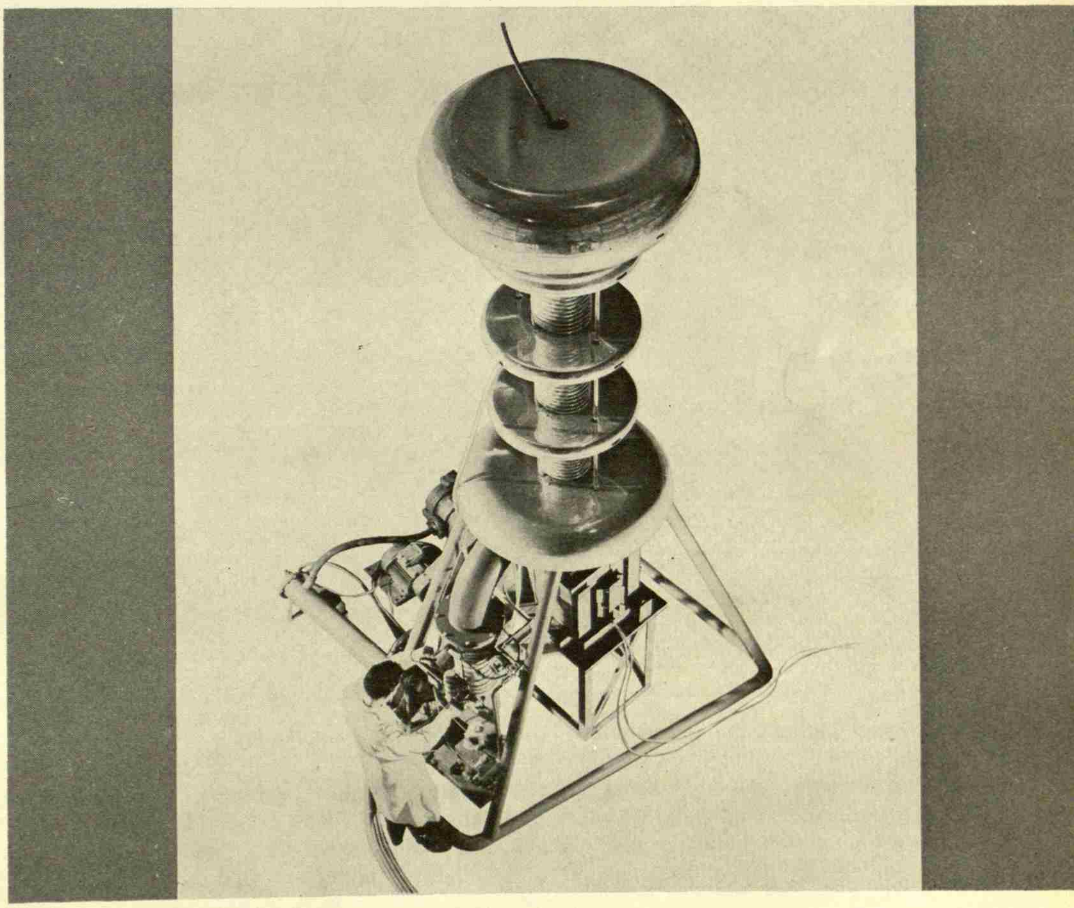
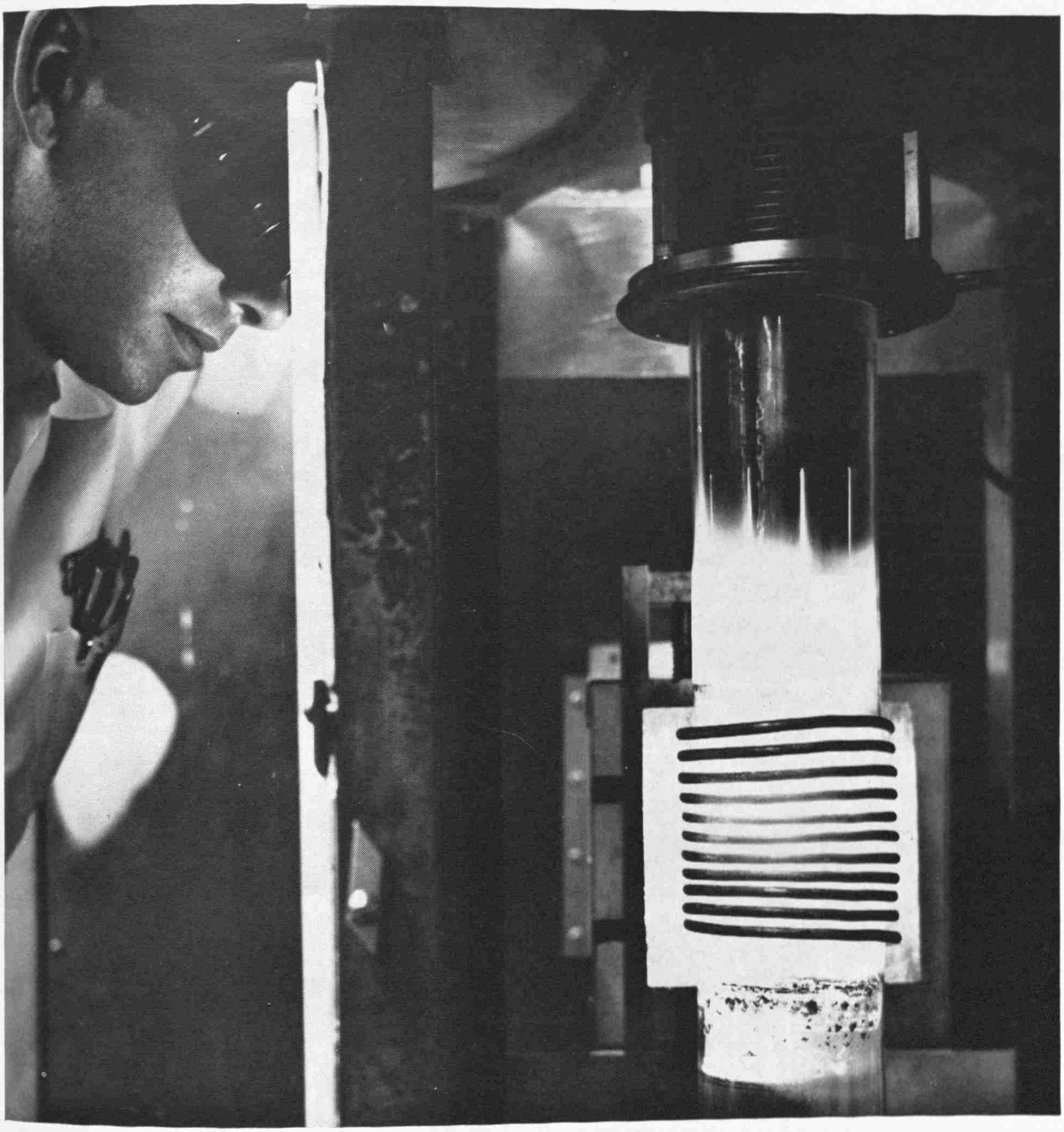
spartan ENGINEER

january 1962



600 KV Model S particle accelerator



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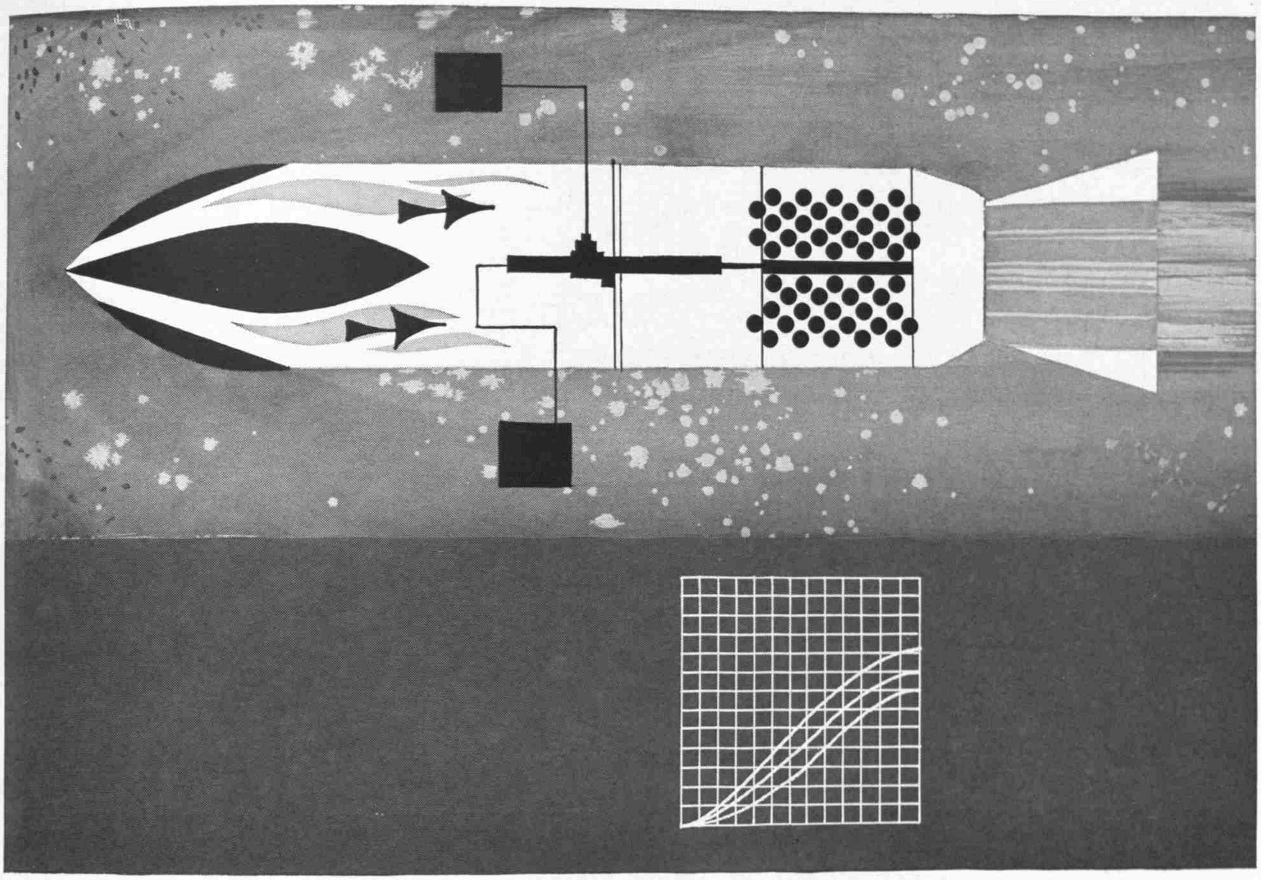

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Spartan Engineer

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Dean's Letter

To stand still in today's education is to move backward; to move forward an objective is needed. It is appropriate here to state certain tenets of educational philosophy, suitable as objectives and appropriate to a professional College of Engineering engaged in the broad education of engineers, and consistent with the general policies of Michigan State University.

It is the further development of the field of graduate study and its supporting research, which we believe worthy of adoption as a major objective of this college. Enhancement of opportunities for study leading to the doctorate is the foremost need of engineering education, and a program so directed, encouraged, and supported is well suited to our staff and facilities, and is fully consonant with the place of Michigan State University in the national and international scene.

In furthering the development of this objective in this College of Engineering, it seems desirable to emphasize that our primary duty is always to our students, and to the parents who provide their support. We owe to them the best possible education, in both technical and human fields, and suited to the needs of a professional life in a civilization dependent on continued technological and scientific advance. Our program should prepare our students for a lifetime of useful, profitable, and enjoyable technological leadership, and must also provide those qualities and viewpoints leading to a life as good citizens and recognized leaders of their communities.

In view of the present trends in all higher education, and in the light of the enumerated self-studies of engineering education and of the state of the profession, it must be concluded that an undergraduate program supporting a school of graduate study in engineering must emphasize the science base, the mathematical language, and the analytic abilities necessary to the graduate student, the researcher, and the engineering innovator of the future. In the carrying out of such an undergraduate program it will be necessary to emphasize and develop high scholarship, the willingness to learn, an innate curiosity toward things and people, the engineer's dissatisfaction with things as they are, and an appreciation of the responsibilities of an educated man.

With such objectives, and with a teaching staff oriented in such a direction, we can look forward to broadened programs, increased student appeal, and justify accelerated support which will allow us to gain and maintain our desired high place among the major engineering schools of the United States.

Adopted by the Faculty of the College of Engineering.

January 4, 1962

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Here Assistant Professor Aziz Fouad of Iowa State University's Electrical Engineering Department, University of Michigan student Nicolas Spewock and Detroit Edison Senior Engineer Ray Pillote examine a problem of extra high voltage transmission, using the System Analogue and Network Computer.

There's very little precedent to draw on in the area of 400 to 500 KV transmission voltage and much remains to be clarified about system design and integration, radio interference, line losses, relays, operation and performance.

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Chromatography

(New technology from old art)

by Martin Hawley
a masters' candidate
Chemical Engineering

Chromatography is used primarily as an analytical tool because it is an extremely expensive process to employ for a large scale operation. However, the technique is occasionally used on large scale in the pharmaceutical industry when extremely difficult separations are encountered.

Chromatography is a method of separating components from a mixture of chemical compounds by utilizing the differences of the adherence of these compounds to a solid surface. For example, if a solution of sodium chloride and water is passed through a column packed with diatomaceous earth, part of the sodium chloride is removed from the water, and adheres to the solid packing. This material can be removed from the solid by passing pure water through the column. If only a small amount of sodium chloride solution were injected into the column followed by pure water, the salt would take longer to pass through the column. However, the salt would take longer to pass through the column than the water because part of the time the salt is absorbed on the packing while the water is not affected by the packing.

If two salts were injected into the column, these salts would leave the bottom of the column at different times if one were held more tightly to the packing than the other. This type of separation is known as chromatography, and applied to both liquid and gas mixtures.

Some of the technical problems involved in chromatography are evident by considering a concentration—time-distance plot for a pulse of sodium chloride as it passes through a column (see Figure 1). At the injection point the sodium chloride is in a sharp bend, but as it passes through the column this band spreads out. Therefore, in separating two components it is necessary to know both the average time when each band of salt will exit the column, and the amount of spread or dispersion of each band. The dispersion is caused by the absorption and by mixing within the column. The latter effect is referred to as axial diffusion. The present work is an investigation of the degree of dispersion of a solute in a chromatographic column due to axial diffusion alone. Axial diffusion is caused by channeling, molecular diffusion, eddy diffusion, stagnant pockets of solvent, and inter-particle diffusion. Channeling is characterized by a path in a packed section of a column which has a lower resistance to flow than the rest of the packed section by molecular action. As an

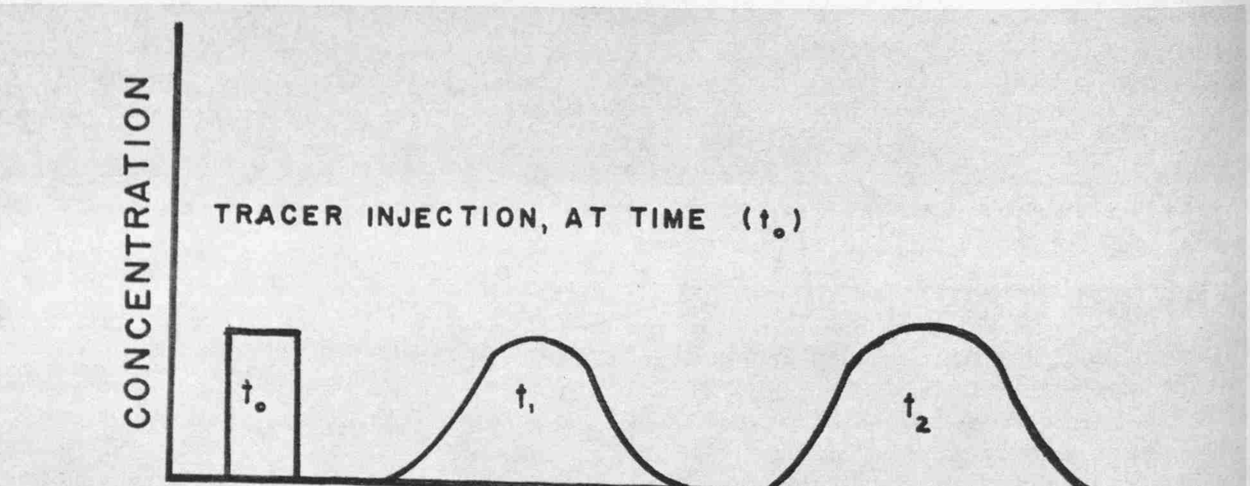
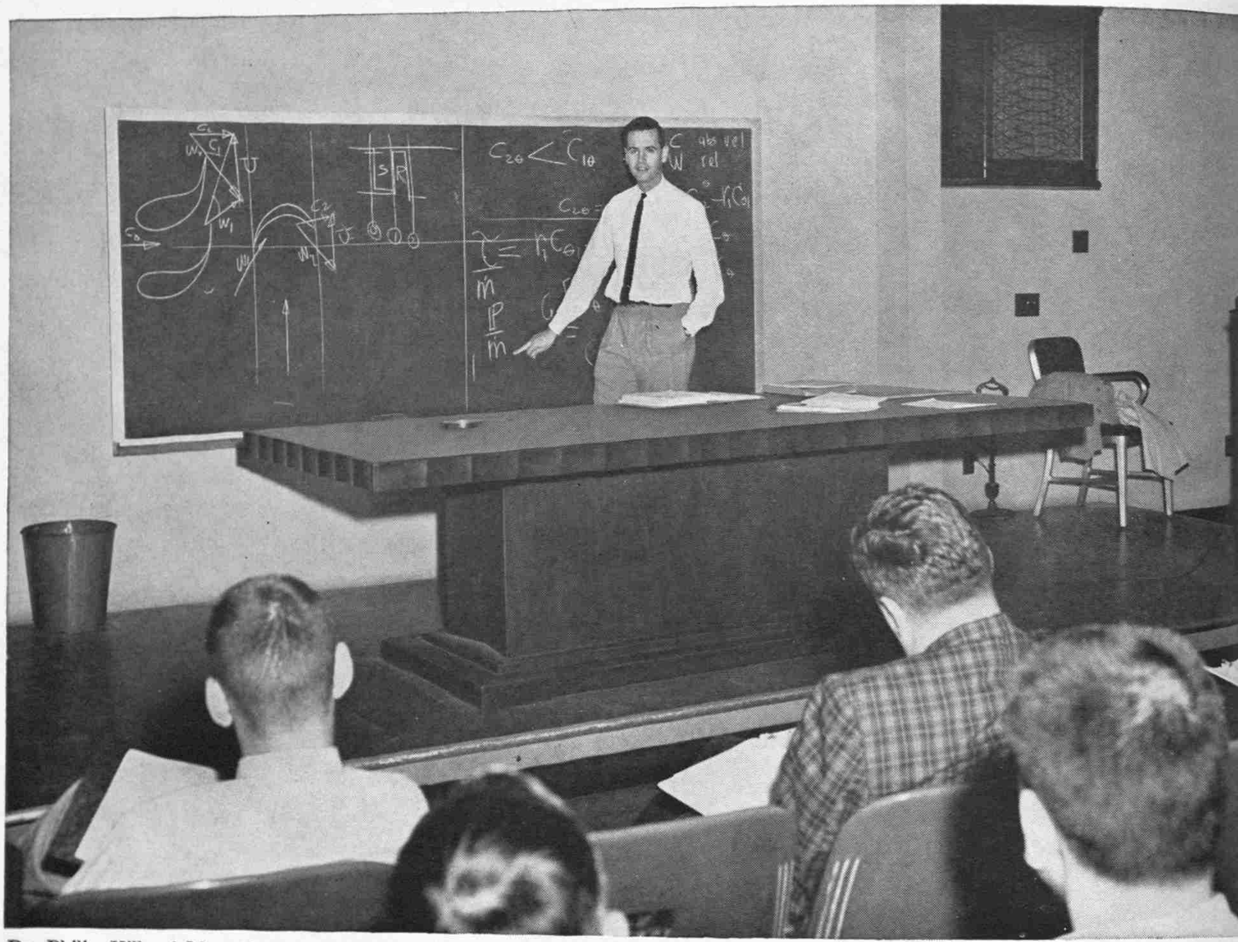


FIG. I

(Continued on Page 44)



Dr. Philip Hill, of Massachusetts Institute of Technology, conducts a Hamilton Standard Management Development course in Fluid Mechanics.

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Einstein's

A Philosophy as well as a Science

by Roberta Huffmaster

EINSTEIN'S THEORIES of Relativity, when mentioned today, immediately brings to mind a picture of a white-haired man who changed our concepts of the physical world. Yet, he did more than develop a new system of the organization of natural phenomenon.

His theories had a social impact long before the physical-world effects were felt.

Are the physicists also interested in Einstein's theories?, asked the bishop.

This today sounds like a foolish question, but it meant much around 1910. Both the philosopher and the theologian discussed the new concept.

For an understanding of why such an impact was felt, the history of the interlocking of science and philosophy should be considered.

DURING THE Middle Ages men had an organismic view of their surroundings. That is, behavior depends on its nature. A rock fell to the ground because it was right for the rock to remain on the earth, and not in the air. Birds flew because they were supposed to.

With Newton, order was introduced into the study of natural phenomenon. The universe could be explained in terms of a mechanical analogy; using the word "mechanical" in an engineering sense. Nature obeyed certain laws, and was not flighty.

Through Newton's equations, the past as well as the future of the universe could be determined. This idea of the "knowability" of the world helped free man from the bonds of the Middle Ages' intellectual slavery.

The philosophers took up the idea of the universe being organized and run like a machine and fashioned a philosophy to include this machine. They expounded the idea that progress could be made to alleviate, or even eliminate the troubles of the world. Since the past and future of an event could be known or predicted according to Newton, an argument for a destiny mapped out by an unseen power was raised.

Theologians also incorporated this theme in their beliefs.

A jarring note was struck around 1900, when it became clear that some processes in chemistry and physics did not occur in a way that was valid for the mechanical view of nature. When this happened, people felt a "bankruptcy" in the Newtonian science, along with the philosophies based on it.

This collapse of the mechanical picture was interpreted by some as a failure of man's emancipation from the Middle Ages. And they accordingly argued for a return to the organismic idea of nature.

Einstein stepped into this confusion and offered a different solution to the chaos—his special theory of relativity, and a few years later, his general theory of relativity.

In philosophy and religion, the revolution of a disillusioned people was given an impetus by Einstein's newly developed ideas of time, space, and causation.

To understand why such deep feelings were aroused over the theories, one must have some knowledge of them.

The special theory is stated in two parts: (1) If two systems move relative to each other with constant speed, the laws of mechanics (Newton's Laws) that are valid in the one system, are also valid for the second system, (2) The speed of light is constant.

From these seeming simple statements, Einstein was able to draw some very important conclusions: the connection between mass and energy; and probably one of the most fascinating ideas in science; time, length, and mass are not absolute measurements.

The relativeness of these measurements have to follow, if the speed of light is accepted as being constant, and at a maximum. In most systems we normally come across, the familiar way of dealing with movements in the system (a swimmer in a stream, or man walking on the deck of a moving ship) is to use the theory of added velocities. A stream flows at a speed of 10 miles an hour, a boy swims upstream at 2 mph. The speed of the water, relative to the boy is 12 mph, but if he is swimming downstream at the same speed, the river seems to be moving at only 8 mph.

THE QUESTION can then be asked, why doesn't addition of velocities work for particles traveling at the speed of light? The only answer is that as a system increases its speed, the devices for measuring this speed; i.e., a rod and clock, change. The clock slows down and the rod shrinks. This shortening and slowing down have nothing to do with the construction of the devices themselves, and to anyone in this same system, the original length of the rod and time of a

Revolution

second seem to remain unchanged. A stationary observer, relative to the moving system, would notice these changes with respect to his stationary units of time and length. But for velocities less than 1/10 the speed of light, these changes are too small to be measured.

According to Newton, it should take the same force to increase the speed of a mass already moving close to the speed of light as it would to increase its speed when the mass is at rest. However, since the speed of light can not be exceeded, the only explanation of the impossibility of acceleration is that the mass increases with the speed, and becomes infinite as its speed approaches that of light.

Einstein's general theory of relativity dealt with the nature and effects of gravity. Newton's second law stated that the same force exerted on two masses of varying size will produce two different accelerations. But when these same two masses are dropped, their accelerations are the same. It would seem that Newton's law only holds true for forces in a horizontal plane. He got around this problem by stating that a mysterious force called gravity exists and that its attractive force increases with an increase of mass, i.e., inertia.

Einstein didn't accept this. He created a special imaginary situation to see what would happen if forces were eliminated or applied.

He pictured an immensely tall building with an elevator at the top with men in it. The elevator falls freely down the shaft with an acceleration equal to that of gravity. A comb drops from one man's hand, and remains floating in mid-air. The people inside the elevator imagine themselves to be in empty space with no gravitational forces acting on them.

The scene shifts to empty space. The same elevator with the men still in it suddenly is pulled up by a huge cable. the men feel this constant motion upward of the elevator as a downward force on them. A comb drops, but this time it falls to the floor. If there are no windows or doors in the car, the men will assume that they are in a gravitational field. There is no way of telling a gravitational force from a constantly accelerated ascent through empty space.

If the elevator is attached to the outside of a merry-go-round in outer space, a force is again felt by the men inside the car. But the force they feel due to centrifugal force is interpreted by them to be gravity. If nothing in the car indicates which plane is the floor, the "floor" becomes what an outside observer calls a wall. And this force is also called gravity by the men inside.

From these imaginary pictures, Einstein drew the conclusion that there is no way to distinguish the motions produced by acceleration, centrifugal force, etc.; from the motion produced by gravity. Absolute motion does not exist, both uniform and nonuniform motion can only be judged with respect to a system of reference.

ANOTHER RESULT of the general theory was the prediction of the effect of gravitation on light.

For this conclusion, Einstein went back to the picture of an elevator falling freely from the top of a tall building.

There are two holes in the walls, opposite one another. A flashlight beam is aimed through the one hole and passes out the hole on the other side of the elevator.

To an observer inside the elevator, the light beam proceeds in a straight line across to the opposite hole.

To an observer outside the elevator, however, the car is not stationary, but moving downward with constant acceleration. He doesn't see the beam move in a straight line, but because the car has moved downward in the time it takes the beam to move across the distance to the other hole, he sees the path of the beam curve downwards. He would say that the light beam is deflected by the gravitational field he himself is in.

Since light is a form of energy, and energy has mass according to the equation $E = mc^2$, the energy will be deflected in a gravitational field as a particle would be.

This theory was tested by observing the position of stars in the vicinity of the sun during a total eclipse, and comparing these to the stars' positions when the sun had moved farther away from them. The stars position can be found by looking at the beam of light it sends to the earth. If the sun's gravitational field exerts a force on this beam, the stars will appear to be in slightly different positions than when the sun is far enough away to exert no force on them. The results were conclusive. The stars did seem to be in different positions.

This has been in no way even a semi-complete presentation of the work of Einstein and his effect on men and science. Maybe this light touching upon the revolution of Einstein's will serve as appetizer for a more detailed and rigorous account of these theories.

TURBINE FLOWMETERS

A Big Advance in the Petroleum Industry

by Loren Nelson

Measuring fluid volumes accurately has long been a problem in the petroleum industry. Originally volumes were measured by tank gauging. But accurate determination of tank volumes was difficult, due largely to temperature variation and substantial loss from evaporation at the free surface.

As extended pipeline systems came into wider use, it became inconvenient for both control and accounting purposes to discharge the liquid throughout whenever measurement was necessary. An additional disadvantage of this practice was the loss of pressure head driving the liquid.

Another drawback of tank gauging was the difficulty of obtaining true average tank temperatures. In principle, accounting is by weight but in reality, it is by equivalent product volume at some agreed upon base temperature (60°F.).

At present displacement type flowmeters are used predominantly in liquid volume control and accounting. Displacement flowmeters are essentially low head loss piston motors. In these meters the number of separate liquid volumes displaced is recorded on a cumulative totalizing register. The register is driven by a variable-ratio gear mechanism, automatically reducing the rising count total to its numerical equivalent at the accounting base temperature.

Most displacement meters, except the smaller sizes, are of the rotary piston type. For reasons of low head loss and frictional wear, the pistons are not packed but move with a fine clearance, in the order of a few thousandths of an inch.

Since laminar leakage varies with both flow rate and liquid viscosity, displacement meters must frequently be calibrated because frictional wear causes changes in both piston clearance and frictional torque.

In actual practice, the best rotary piston meters (at flow rates between a few gallons and 1000 gallons per minute) exhibit errors of only a fraction of one percent when measuring flows above 20 percent of capacity. But even the best displacement meters fail to measure accurately gritty fluids, such as crude oil, without excessive wear and calibration changes. Displacement metering becomes intolerably bulky and expensive at present flow rates in the order of tens of thousands of gallons per minute.

The disadvantages of displacement meters led engineers at Rockwell Manufacturing Company of Pittsburgh, Pennsylvania to investigate turbine type meters. Turbine meters were already being used in less exacting service. A study of these turbine meters showed an unexpected calibration characteristic. All curves exhibited an unexplained *decrease* of percentage of error as lower flow rates were metered. This, of course, showed up before performance became unacceptable at very low flows.

The reason for this mysterious decrease in error at low flows—which could not possibly have been due to mechanical friction—has now been found. The problem was solved only after several years of intensive analysis, design changes, and model testing.

The result was a complete theory[1] of turbine meter principles, enabling them to build metering turbines that surpass the best displacement meters in accuracy, repeatability, retention of original calibration, and long service life under high flows of gritty liquids such as crude petroleum oils.

Suppose a theoretical turbine meter with annular blading set at an angle (Ø) inclined away from the direction of flow and with annular blade area (A) were put in a pipe with liquid flowing in it. Assuming no friction, the fluid would strike the blades with velocity (V) and the rotor would be accelerated to a steady rim speed (u) proportional to the axial velocity (V) of the fluid. The rim speed (u) could then be recorded and converted to flow rate.

(1) $V = Q/A$
(2) $u = V \tan Ø$
(3) $Q = VA = uA/\tan Ø$
$= \omega rA/\tan Ø$

Where:
- Q = flow rate
- r = radius of rotor
- ω = angular velocity of rotor

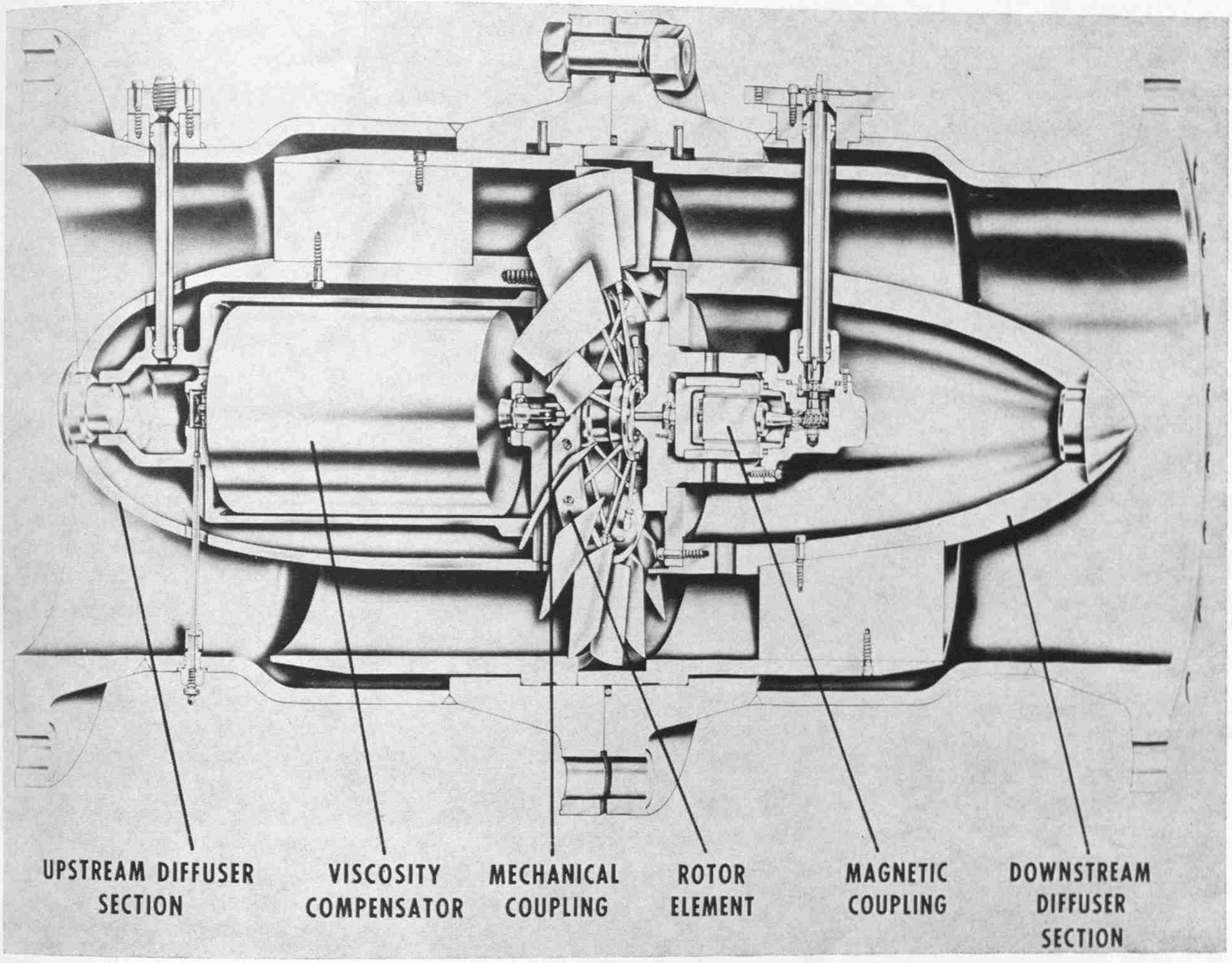
However, in actual practice, both mechanical friction (bearing friction) and a fluid friction (drag) will oppose blade rotation, requiring "bending" of axial flow. In other words the direction of fluid flow will be changed slightly due to friction in the system. This component of change in velocity (ΔV) divided by the velocity (V) is equal to the percentage of slip in the blades.

By careful design, mechanical friction can be made negligible in the operating range of 100 to 20 percent of capacity but nothing can be done to reduce blade drag and the meter is still not accurate. Therefore, the analysis must be concentrated upon the variation of blade drag with flow conditions.

In steady state rotation, the resultant tangential force is, by definition, zero. Thus, Newton's Second Law, or the general definition of force as the time-rate of change of momentum

$(F = d[mV]/dt)$

[1]Karlby, Henning and Lee, W.F.Z., A Study of the Viscosity Effect and Its Compensation on Turbine-Type Flow Meters, (59-A-105) Transactions ASME, Series D, *Journal of Basic Engineering,* Sept. 1960.



A CUT-AWAY VIEW OF A TURBINE METER

gives the driving force as the mass rate of flow

$(dm/dt = \dot{m} = \rho VA)$

times the change of tangential velocity ($\triangle V$). This must equal the tangential component of drag (D sin Ø), where drag is conventionally (Cp) times the area exposed to drag. In this case of blade motion nearly parallel to the flow ($\triangle V/V$ small), the exposed area is the blade surface area ($\acute{A}$).

Transposing the force equation reveals that the slip ($\triangle V/V$) is directly proportional to the drag coefficient is a function of the Reynolds number(R) of the blade passage alone ($R = LV/\nu$, where L is the blade chord and ν is kinematic viscosity).

The work of Ludwig Prandtl et al showed, in brief, that the drag of a flat plate through a fluid can be treated as if the fluid were frictionless, except in a skin (or boundary) layer dragged along by the plate due to viscosity.

At low velocities and/or high viscosities (at Reynolds numbers below a critical value, R*), the entire flow is laminar. Therefore the boundary layer must also have laminar characteristics. The drag coefficient (according to Blasius) is a constant divided by the square root of Reynolds number

$(C_D = K/\sqrt{R})$.

Unfortunately, this means that slip

$(\triangle V/V = KC_D)$

is *not* constant, and a turbine must be useless as a flow meter in laminar flow.

Fortunately, the majority of industrial pipeline flows are turbulent, or at least not fully laminar. This means that the boundary layer will remain laminar near the leading edge of the blading, but break into turbulence further downstream at a distance (X) which varies with blade Reynolds number ($X = \nu R^*/V$). Thus, the blade drag coefficient becomes the sum of a laminar and a turbulent drag coefficient, each applied to its proper blade area. This is expressed in the Prandtl-Schlichting transition formula

$(C_D \approx K - [K/R])$

which for very large Reynolds numbers approaches a constant value.

To be of value as an accurate flow meter the turbine meter must have essentially constant slip. This means that the drag coefficient (according to Blasius) is a constant divided by the square root of Reynolds number

$(C_D = K/\sqrt{R})$.

Unfortunately, this means that slip

$(\triangle V/V = KC_D)$

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(Continued on Page 42)

SYSTEMS ENGINEERING

MSU pioneers in prototype systems laboratory

by Hinrich R. Martens
a graduate student

Under the support of the National Science Foundation a prototype Systems Laboratory is under development in the Department of Electrical Engineering, at M.S.U. This laboratory is unique in that it represents a truly interdisciplinary laboratory, placing equal emphasis on the study of electrical, mechanical, hydraulic and pneumatic components and systems made up of such components. With modern instrumentation, electrical, hydraulic, pneumatic, and mechanical variables are measured with equal facility. Recording devices, such as X-Y plotters and time-base recorders are available as standard equipment for automatic recording of all variables.

The new prototype systems laboratory is designed around the systems concepts developed over the past several years in the E.E. department and which are now included as part of the E.E. curriculum in the senior year. These engineering concepts apply with equal facility to the analysis of all types of physical systems made up of discrete patameter components.

To fully implement the system concepts in the laboratory, facilities quite different from the traditional electrical engineering laboratories are necessary.

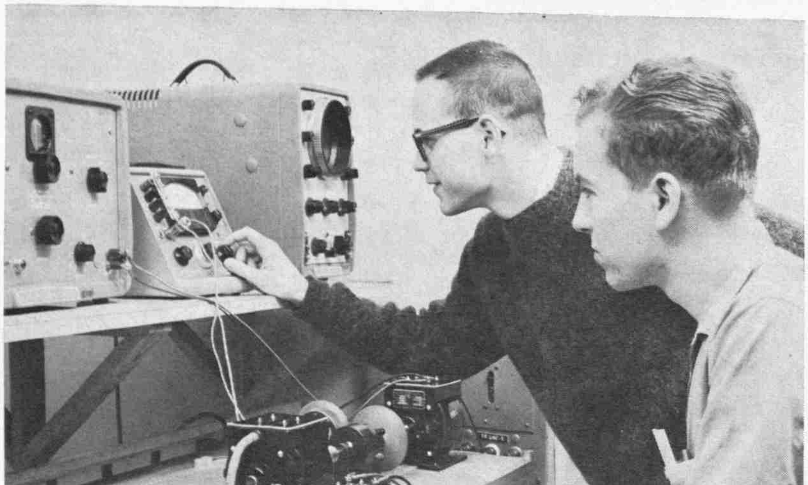
The first phase of the laboratory development program consistant with the new systems concept was completed approximately two years ago when the conventional electrical machinery laboratory program was combined with the servo-mechanisms laboratory to form an electro-mechanical systems laboratory. The second phase of the development, which was initiated in June 1961, is scheduled for completion in June 1962, and is directed at extending the electro-mechanical systems laboratory to include hydraulic components and systems such as servovalves, hydraulic motors, activators, etc.

The facilities that must be provided in the prototype systems laboratory are implemented by the educational objectives of the laboratory program. These basic objectives can be stated as follows: (1) to develop skills and techniques in the art and science of instrumentation; (2) to develop techniques and skills in establishing mathematical models of physical components and systems; (3) to develop the art of "making a system work," i.e. establish proper operating points, providing protecting devices and eliminating noise and; (4) to develop a "vocabulary" of typical system components and systems and their characteristics.

In keeping with the first objective as stated, the prototype laboratory includes some of the most modern and sophisticated instrumentation techniques known.

Since all electronic recording devices respond only to electrical signals, transducers are employed to convert the force, torque and displacement signals to corresponding electrical signals. A strain gage force transducer, for instance, designed and built at M.S.U., is employed in connection with a bridge circuit and amplifier to measure force. A slide wire potentiometer is used to electrically measure displacement. Such transducers are used in conjunction with X-Y ultraviolet photographic recorders and oscilloscopes to record automatically the force vs. displacement characteristics of mechanical components. Periodic deflection of such mechanical components as springs, dampers, etc. are generated by means of a hydraulic actuating system driven from a standard electronic function generator.

One of the most difficult problems encountered in the development program, curiously enough, is that of



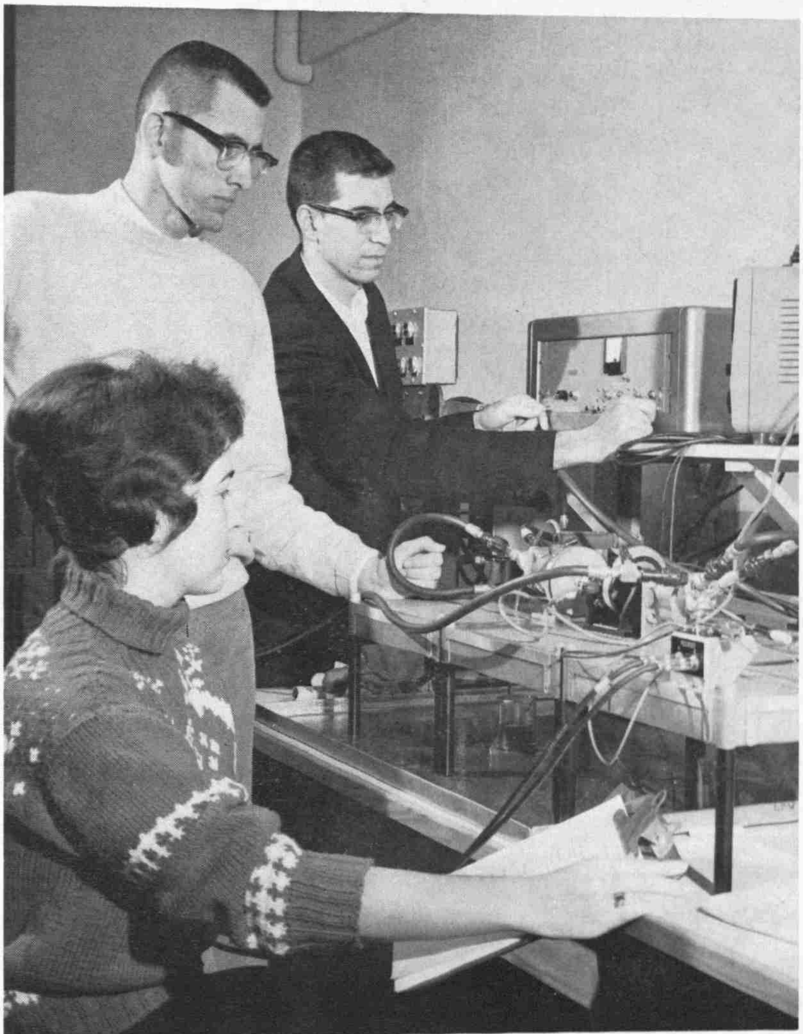
Richard Meyer and John Thornton measure the terminal characteristics of a D.C. machine.

providing for the convenient and accurate recording of flow rate. To provide the information required to model the dynamic characteristics of hydraulic components, it is necessary to record instantanious flow rate, both positive and negative. The transducer presently offering the greatest possibility is a pressure transducer placed across the terminals of a standard orifice, much the same way a voltmeter is connected across a standard resistor to record current. Through the use of pressure and flow rate transducers, time varying hydraulic signals are measured with the same instrumentation and with the same ease as electrical signals.

To provide facilities for developing the concepts and techniques involved in establishing mathematical models of physical components, provision is made for conveniently setting up electrical, mechanical, hydraulic, electromechanical, hydromechanical, and hydroelectrical test systems. The required mechanical flexibility is provided in the use of relatively small components, all electrical and hydraulic motors being in the order of 1/16th horsepower. All components are mountable on aluminum grids with a standard shaft height. Electrical, mechanical, and hydraulic connections can be made, easily and quickly. All hydraulic hose connectors are self-sealing so that the spillage of oil is almost completely eliminated.

In the interest of developing a "vocabulary" of typical system components, "real life" components are used wherever possible, and provision is made for recording the characteristics of these components as they really are—linear or nonlinear. Any linearizations appear as approximation made in establishing a mathematical model of the component.

To provide for maximum flexibility in developing typical electromechanical, hydromechanical, and hydroelectrical systems, all components are designed to be computable to terminal rating and physical size. Consequently, a great variety of systems may be constructed, and any one of many different systems can be put together to realize the same overall design objective. For example, a position control system can be composed of primarily electromechanical components, or, if one wishes, of primarily hydromechanical components, and in as far as the objectives of the laboratory are concerned, the student can take his choice.



Senior E.E.'s John Nelson, Barb Kroupa, and Greg Hudak demonstrate how "to make a system."

Finally, to provide each student with opportunity for developing his skills in the techniques of instrumentation and the art of "making a system work," the systems laboratory as planned will include an identical set of facilities for each group of three students in the laboratory at any given time.

An analytical study of physical systems invariably involves the solution of one or more simultaneous linear or nonlinear algebraic and/or differential equations. To provide the facility the systems laboratory has, since its inception, included a desk size computer for each group of students. The computer can be used for providing system simulation and solutions or as a transfer function generator (controller) in feedback control systems. The solution to large-scale nonlinear system problems is provided by the use of a general purpose compiler program recently developed for the digital computer.

Although the primary function of the new systems laboratory is to provide undergraduate instruction, the laboratory also serves as research facilities for graduate students and undergraduate students interested in special problems. Future plans for developments in the systems laboratory call for the inclusion of inertial guidance equipment, such as gyroscopes and stable tables. Small size digital computers will eventually be incorporated as a component in a typical control system to function as digital controller. Such a facility provides a basis for introducing digital to analog conversion techniques, adaptive systems and self-optimizing systems. However, because of the mathematical complexity involved in the analysis and design of such systems, much of the latter study

(Continued on Page 44)

Small Missile Aerodynamics

A Simplified Approach to Model Rocket Design

by John Thornton, E.E. '62

When most people read about amateur rocketry, they think of experiments with various explosive fuels. Unfortunately, many amateurs seem to have this point of view also. But this is faulty thinking. By far, most of the spectacular achievements of amateur rocketry are due to the proper aerodynamic design of the missile.

The actual applied theory of aerodynamics of small fin-stabilized rockets is much simpler than most amateurs realize. It is quite possible to increase performance by at least 10% by using a few basic rules of aerodynamics.

A great deal of the stabilty in flight of an amateur rocket is due to its high, initial acceleration. But once the fuel is exhausted, the rocket's flight will be governed by the laws of free bodies moving in a fluid.

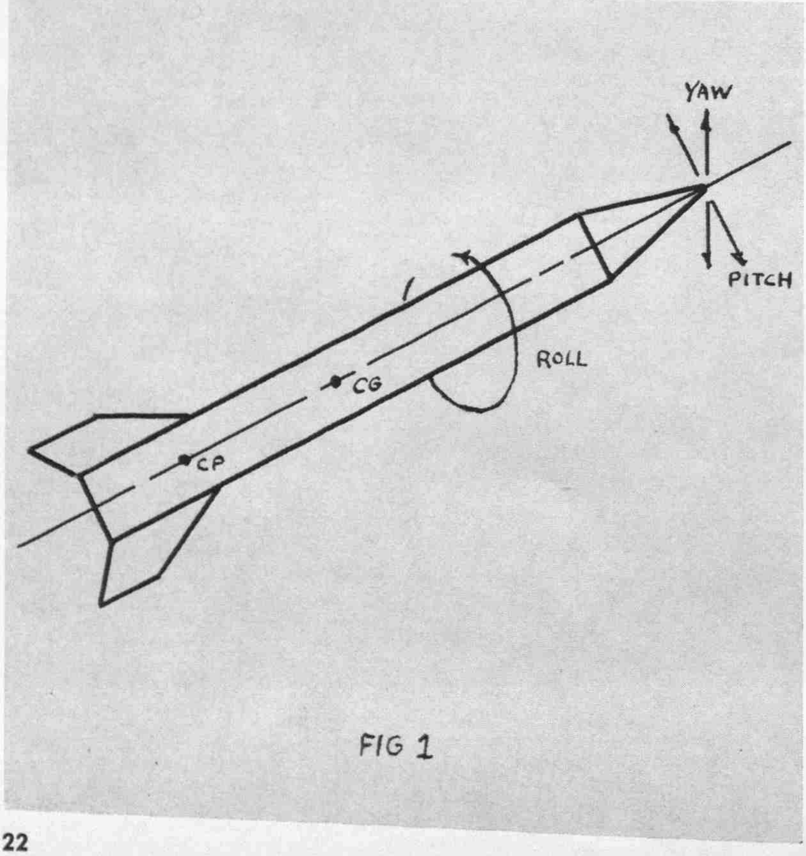


FIG 1

During flight, the motion of a rocket can be divided into three periods consisting of the period during launching, the period of powered flight after the rocket has left the launcher, and the period of motion after the burning has terminated. Although the second period is generally of interest to most amateurs, there is no distinct division between this second period and the third period of unpowered flight.

As the burning period ends, a small amount of combustion products remain in the combustion chamber. Instead of the forces immediately dropping to zero, they gradually diminish in magnitude.

In rocket design, there are two basic points with which the amateur need be concerned. The first is the center of gravity, or the point at which the missile body balances. Whenever a force acts on the rocket body, the body rotates around the center of gravity.

The second point, the center of pressure, is the point where all aerodynamic forces act on the missile. This point actually exists in theory as the point where the sum of all movements due to these aerodynamic forces act to change the flight path.

When a missile is in flight, it assumes several types of attitude changes with respect to the trajectory (Fig. 1). These attitude changes are commonly known as roll, pitch, and yaw. Rolling is a spinning action where the missile body rotates about its longitudinal axis. Roll is generally neglected in amateur rockets since the rate of roll is usually of small magnitude. However, if a rocket is stabilized by spinning, the effect of roll must be taken into account. Rolling, because of its gyroscopic action, has a stabilizing effect which tends to reduce yaw.

Yaw is the deviation of the longitudinal axis of the rocket from the vertical plane lying on the original line of motion.

Pitch is a similar motion except that the rocket's longitudinal axis deviates from the horizontal plane on the original line of motion.

The effect of pitch and yaw is to turn the rocket nearly clockwise in flight. Because of this, air resistance increases and the flight becomes erratic.

Before we see how these effects are compensated for in flight, let us examine the various forces that act on a rocket during powered flight.

As a rocket travels along its trajectory, the longitudinal axis of the rocket does not always coincide with the direction of motion along the trajectory, but may form a slight angle of attack.

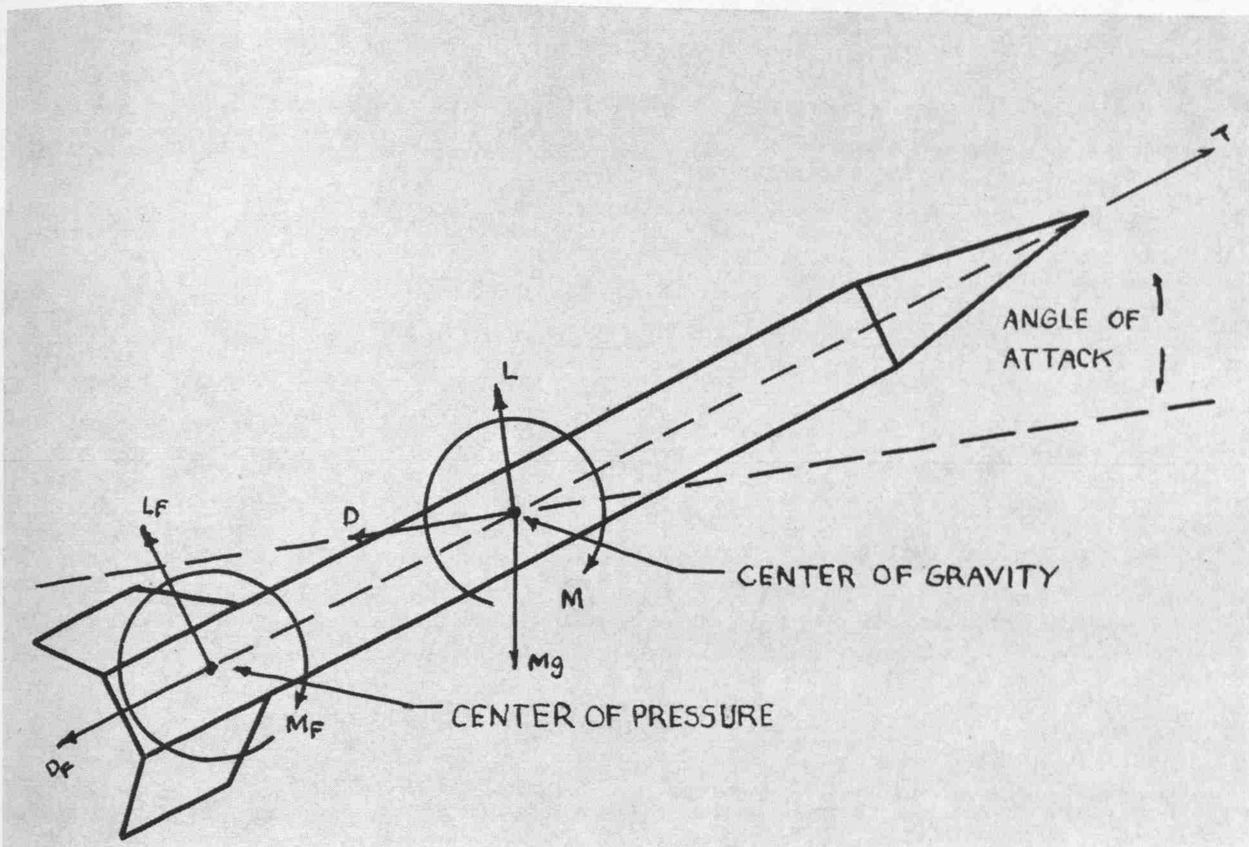


FIG 2

While in flight, the rocket is acted upon by several aerodynamic forces (Fig. 2). The total aerodynamic force acting on the rocket is the resultant of these individual forces.

The drag is a force whose direction is tangent to the trajectory or line of motion of the center of gravity. This force always acts opposite to the direction of motion. While the rocket is in flight, air molecules bunch up at the nose, causing the pressure to rise above atmospheric pressure. This pressure increase is the cause of the drag, D. In addition, when the rocket pitches or yaws, the pressure acts against the rocket body causing the drag to increase.

Another force, the lift force L, is caused by the slight angle of attack of the rocket during flight.

Besides the thrust T, there is an additional force due to the action of the jet exhaust. As the rocket moves through the atmosphere, a vacuum is left behind the rocket. Although air tends to fill this vacuum, it cannot do so rapidly enough to maintain atmospheric pressure on the tail. A suction effect is produced, which tends to decrease the rockets velocity.

In addition to these forces, the force of gravity, Mg, produces a downward pull on the rocket.

All of the above forces act through the center of gravity. These individual forces combine to produce the total aerodynamic force and a moment M. The magnitude of the moment depends on the point of application of the total aerodynamic force.

Another system of forces on the rocket body exists due to the steering effect of the fins (Fig. 2). These forces act through the center of pressure.

There is a frontal drag on the leading edges of the fins which tends to slow the rocket down. This force, commonly known as the fin drag, Df, acts opposite to the direction of motion of the rocket axis.

Another force, Lf, acting perpendicular to the rocket axis, is a lifting force. This force acts as a steering or control force.

As with the aerodynamic forces, these forces can be combined into a moment, Mf. The magnitude of the moment depends on the point of application of the resultant of the two components acting on the fins. The moment is referenced with respect to the center of pressure.

Basically, there is one main law that determines whether a missile flight will be stable. For positive stability, or stable flight, the center of pressure must always be located as far behind the center of gravity as possible. If the rocket axis deviates from the direction of flight, producing an angle of attack with respect to the flight path, then the forces acting on the fins create a restoring moment that reduces the angle of attack.

If the center of pressure is ahead of the center of gravity, then a condition of negative stability exists. A moment is created which tends to increase the angle of attack, resulting in an unstable flight.

During flight, external forces such as air pressure act against the fins and body, causing the rocket to pitch or yaw. Aerodynamic forces acting through the center of pressure cause

(Continued on Page 34)

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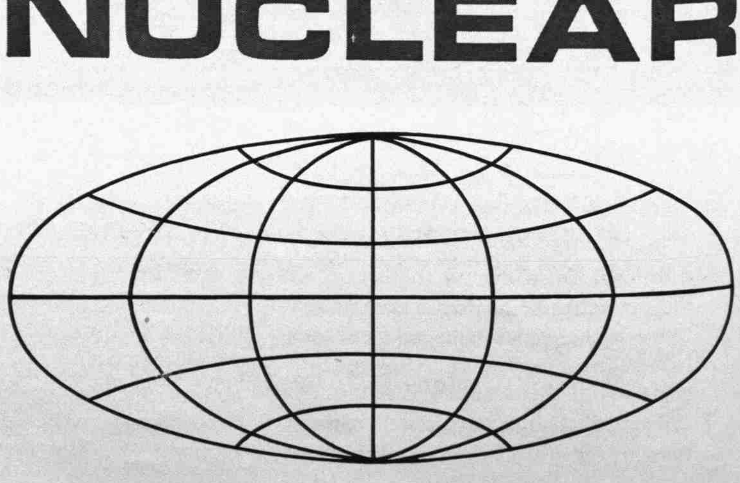

THE DIGITAL COMPUTER

ITS APPLICATION TO SYSTEMS ANALYSIS

by John L. Wirth
a graduate student

Although the abilities of the digital computer have been somewhat overexaggerated by popular journalism, some of the results achieved through the use of the computer have been nonetheless remarkable. For example, a noted manufacturer of steam turbines has programmed a computer to calculate not only the shape of the turbine blades to meet a given specification, but also to produce a punched paper tape which directs automatic machinery to construct the blades.

Another company has written a computer program which, when given the topology of a lumped parameter mechanical system, i.e., the arrangement of springs, masses and dash pots, etc., calculates the complete transient or frequency response for the system.

Still another firm uses a general purpose program to determine the stresses existing in the individual members of a steel structure. The input data for this program consists only of the geometry and interconnection pattern of the beams, the type of steel being used, and the various loads on the structure.

The computer programs cited here are significant not because they represent the solution of any one particular problem, but because they represent the solution to any one of a general class of problems. It is in this capacity that the digital computer is of great value. In other words, once the analysis of a general class of problems is completely understood and programmed on the computer, this class of problems can, in a manner of speaking, be forgotten. One need only provide the computer with a relatively simple specification of the problem and the solution follows automatically.

By and large, most of the programming done to date has been restricted to applying computer methods of solution to the same mathematical models that one would use if he were doing the problem by hand. Although substantial progress has been, and still can be made in this direction, major savings in both programming and computation time can be realized by (1) using formulation methods which result in a mathematical model specifically suited to solution by computer techniques, and (2) by expanding the range of applicability of future computer programs.

In the interest of these two objectives, many of the engineering concepts and procedures required in the analysis and design of such systems as electrical networks, discrete mechanical and hydraulic systems, trusses, airframes, etc., have been re-evaluated. Among other things, this re-evaluation has shown that for analysis of physical systems can be roughly divided into two parts; (1) formulating a mathematical model of the system under study and (2) obtaining a solution to this mathematical model.

Current research is concerned specifically with developing procedures for formulating mathematical models for systems of all types of discrete physical components. In order to take full advantage of modern computers and their abilities to obtain numerical solutions, the mathematical model of the system must be of certain forms. Further, if the process of formulating the system model itself is to be carried out by the computer, the formulation procedure must also be extremely precise, well defined and very orderly —the computer can only follow a predefined set of rules, it cannot "think."

The formulation procedure currently under development begins with two essential pieces of information; (1) the interconnection pattern of the components and (2) the measured characteristics of each of the components.

The first step in the formulation of the system model is to reduce the information contained in the interconnection pattern of the components to two sets of relatively simple algebraic equations relating the component terminal variables. These equations are referred to as the circuit and segregate equations and, for example, are a mathematical statement of the fact that the sum of the displacements around a closed circuit is zero and the sum of the forces at a point is zero. It has been found that the two sets of equations apply in general to an appropriately developed "graph" of any physical system of discrete components.

The second step in the process of formulating a system model is to generate a set of algebraic and/or differential equations, called terminal equations, relating the terminal variables of the component. This step in itself sometimes represents a significant research effort when dealing with unfamiliar components. However, for many of the components, such as the spring, vacuum tube or hydraulic valve, these equations are well known and can be considered as the starting point in the analysis.

Traditionally the Electrical Engineer has effected a partial solution of the circuit, segregate and component terminal equations in such a way as to generate what are called the mesh or node equations. While the mesh and node equations represent effective and convenient models to use as a basis of

(Continued on Page 34)

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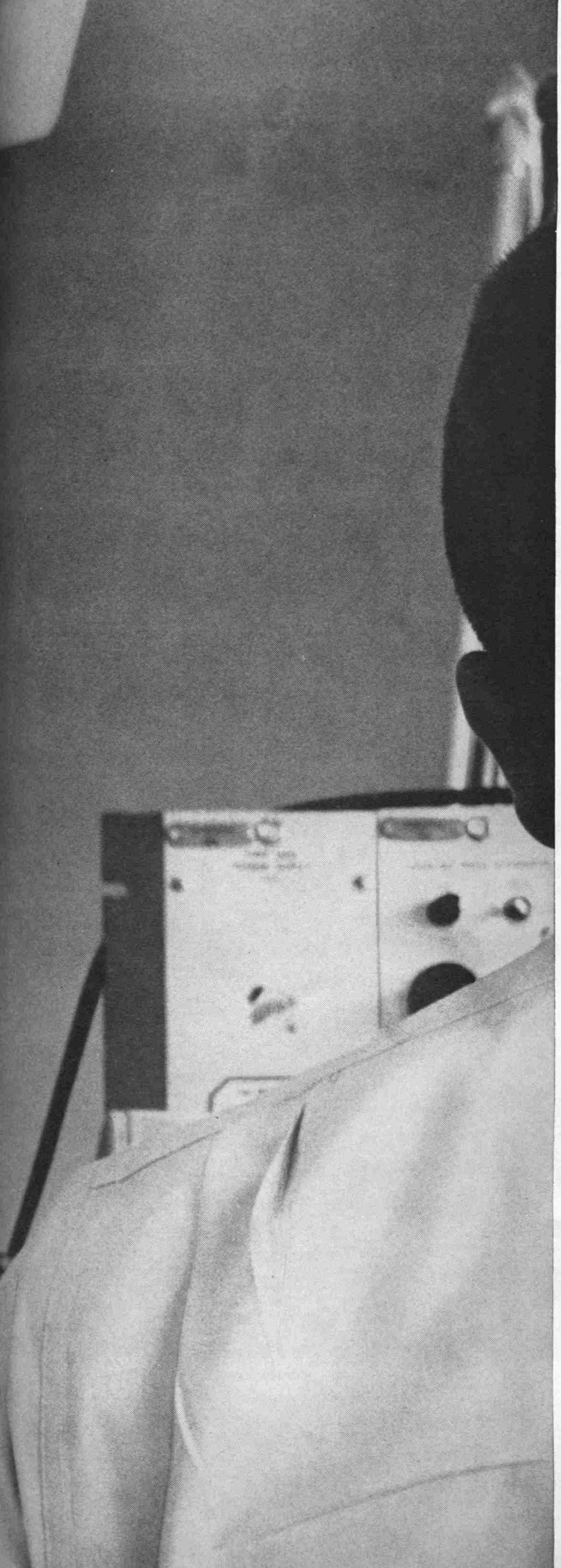

Harley A. Cloud (B.S.E.E., Penn State '58) is a group leader in the development of simulation testing equipment for a new airborne computer which IBM is building for the Air Force.

TRIPS THROUGH THE STRATOSPHERE WITHOUT LEAVING THE GROUND

A computer will be the heart of the navigation and control systems for future aircraft designed to operate in the stratosphere.

Such a computer is now being built by IBM for an advanced aircraft under development for the Air Force. Harley Cloud, an IBM engineer, is developing simulation equipment which will put the computer through its paces. His equipment will simulate the systems functions encountered by the 250-ton aircraft at Mach 3, fourteen miles up, with potential adversaries in wait.

Without the airplane leaving the ground, his testing equipment will simulate such inputs to the computer as acceleration in the inertial system, velocity in the doppler radar, and air pressure in the air data subsystem. These simulation techniques will help protect lead time for the entire project.

Responsibilities Are Large. As a group leader, he is directing the design, laboratory breadboarding, electrical drafting, testing and evaluation of this ingenious equipment. It's a very responsible job for a man out of school less than four years.

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Thermoelectricity

Ever increasing demand for thermocouples

by Joe Strbik

Before 1970 you may be able to heat your home in the winter, cool it in the summer, and provide your own electricity. Millions of people in underdeveloped areas of the world can have new hope for an improved standard of living.

This prospect flows from the now rapid advance of thermoelectricity; the direct transformation of heat energy into electricity, and the reciprocal transformation of electrical energy into heat and work.

Thermoelectricity is not new, in fact, it is just as old as the electromagnetic effects upon which electrical technology is based.

In the year 1821, Thomas Seebeck announced his observation that a magnetic needle held near a circuit made up of two different conductors, is deflected when part of the circuit is heated.

For a century the marvelous possibilities of thermoelectricity remained asleep. But, in 1926, a U. S. engineer named Lars O. Grondahl showed that an oxidized copper plate conducts an electric current easily in one direction, but offers a very high resistance in the other direction. It was next found that if such a plate is heated, a current is produced.

Essentially a thermoelectric conductor is an electron pump which uses heat energy as its driving force. Heating one end of a thermoelectric material causes the electrons within it to crowd to the cool end, where they build up as an electric charge.

Joining together two materials which differ in the magnitude of this effect, and heating their junction, causes a continuous flow of electrons through an electrical device connected to the cool end of the pair of materials.

Westinghouse Electric Corporation has taken these basic ideas and have built a prototype of a self-contained electric power plant and pumping unit. The power plant has a 50-watt output. It was developed in cooperation with the Solar Energy laboratory of the University of Wisconsin. The experimental unit taps the heat energy of sunlight and converts it directly into electricity by means of a thermoelectric generator. The power generated drives an electric motor which in turn drives a waterpump. The motor and waterpump contain the only moving parts in the whole irrigation system.

A larger solar-thermoelectric system, scaled up from the 50-watt version, is now under development and has been operated at part power. It will pump enough water from a depth of 20 feet to irrigate approximately four acres of land at the rate of 24 inches of water a year. This is about the average annual amount of precipitation in Minneapolis, Minn., or Honolulu, Hawaii. The unit can supply the personal needs of 1200 people on the basis of five gallons of water per person per day.

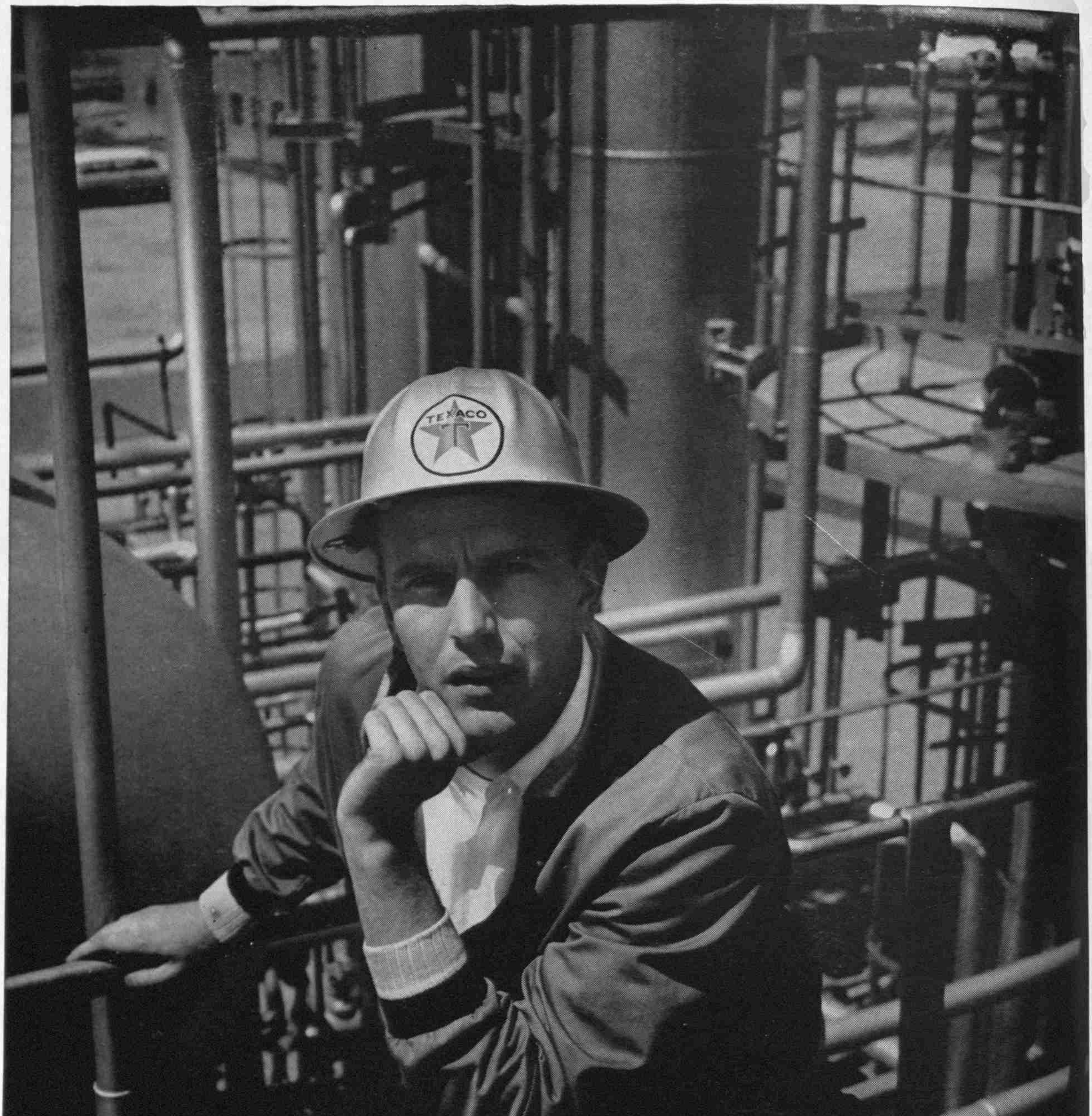
To provide the stated amount of water, the system must operate 10 hours a day for only 250 days of the year. This leaves a safety margin of about one-third of the year to provide for cloudy weather, when the solar-thermoelectric generator would not operate.

The solar-thermoelectric system uses an eight-foot saucershaped (parabolic) mirror which gathers the sunlight and focuses it on the thermoelectric generator. The generator is a metal box about eight inches on a side and about two inches thick. One face is black, to more efficiently absorb the heat of the sunlight shining upon it.

Another experiment carried out by Westinghouse is the development of a small electric (thermoelectric) outboard motorboat motor. It uses bottled gas for a heat source, and a thermoelectric generator converts the heat of the flame directly into electricity, which in turn drives a standard trolling motor that drives a twelve foot boat.

Not only could this thermocouple generator run the boat for the fisherman, but it could provide electric lighting for his remote campsight.

As can be seen, the solar-thermoelectric generator is a simple, reliable, maintenance free, static system, requiring little technical skill to install or keep running. In the years to come, thermoelectricity is going to become more and more important in our society.


TEXACO

DIGITAL COMPUTER

(Continued from Page 26)

analytical studies based on the Laplace transform, they are not generally acceptable for computer solution. To obtain a solution of the system model by computer methods, it is expedient, if not necessary, that the system equations be in what is call normal form, i.e., of the form

$$\frac{dx_i}{dy} = f_i\,(x_1, x_2, \ldots, x_n, y)$$

$$\text{for } i = 1, 2, \ldots n$$

This is of particular importance when the system equations are nonlinear.

Methods for formulating the system model in normal form are now known for all types of linear systems and certain classes of nonlinear systems. One phase of current research is directed at extending the range of application of these methods to include the more general nonlinear cases.

To the extent that they are known, the formulation procedures are also currently being programmed for the digital computer. However, more than a year will be required to complete this phase of the project. In the meantime, certain phases of the program are complete and are currently in use as an analysis tool. This tool exists in the form of a compiler type program which enables the user to obtain a solution to a set of simultaneous ordinary differential equations in normal form without becoming involved in extensive programming time and labor.

Upon completion of the project, the program will both formulate and solve the system model. That is, given a simple statement of the interconnection pattern of the components and their characteristics, the solution will be furnished automatically by the computer.

There is considerably more at stake here than just being able to solve automatically the same problems that can be solved by hand. Although theoretically nothing can be solved on a computer that cannot be solved by hand, this is not born out by practice. For example, the problem of formulating and solving twenty simultaneous algebraic equations can be carried out by a modern computer in one second or less. This same problem would not only take a day or more to solve by hand, but even when completed, the answer would probably be in error either because of an error in formulation or solution or both. Thus, through the use of the computer one has essentially acquired a new kind of ability—one which has a very direct and real bearing on the type of activity an engineer of today and tomorrow is involved in.

With this new kind of ability not only can the traditional engineering problems be solved automatically but their same general methods of solution can be applied to problems which are of several orders of magnitude more complex. Of equal or perhaps more importance is the fact that this new ability enables us to use many of the techniques of analysis and solution developed in mathematics which have not been used heretofore in engineering analysis because of the extreme amounts of numerical calculation they require. Thus, by using the computer, the general class of solvable problems can also be significantly expanded.

SMALL MISSILE

(Continued from Page 23)

the rocket to rotate on its center of gravity, thereby reducing the pitching and yawing motion of the rocket.

As the rocket body again assumes a zero angle of attack, the steering forces also approach zero. But due to a small amount of angular velocity, the rocket body swings across the flight path, producing an angle of attack in the opposite direction. Steering forces are created in order to bring the angle of attack to zero and stabilize the flight. This produces an oscillatory motion as the rocket travels along the flight path. The oscillatory motion gradually decays due to dampening forces.

As a good illustration of what a negative stability condition can do, the following example of an experiment by the author is pointed out. A small missile was fired from a launching rack in a near vertical position. This particular model was weighted so that the center of pressure was ½ inch forward of the center of gravity. When launched, the rocket immediately began to describe a series of spirals about 50 feet in diameter. Finally, it skidded across the ground until the motor burned out.

This is a fairly extreme example. But a small amount of pitch or yaw can soak up a large percentage of energy, consequently reducing the rockets altitude and range.

There are several ways in which a positive stability condition can be obtained. The first is to bring the center of gravity forward by adding to or redistributing the weight of the nose cone. But this is difficult to do without adding a lot of weight, since the fuel tends to force the center of gravity to the rear of the rocket body.

Another way is to bring the center of pressure as far back as possible by increasing the fin area. This method is effective up to a point. Beyond this point, additional fin area does not add to the stability, but actually increase the drag forces. A good approximation of the minimum fin area required can be found from the following formula, originally published in the book *Rocket Manual for Amateurs* by Captain B. Brinley of the U. S. Army. The formula is

$$A = \frac{(d + 0.5) \times L}{6}$$

where: A is the individual fin area.
d is the outside diameter of the rocket.
L is the length of the rocket including the instrument section.

The width of each fin should be greater than 1.25 times the diameter of the rocket body. Actually the amount of fin area required for stable flight is not very great.

In most amateur rockets, a combination of these priniciples are used to obtain positive stability.

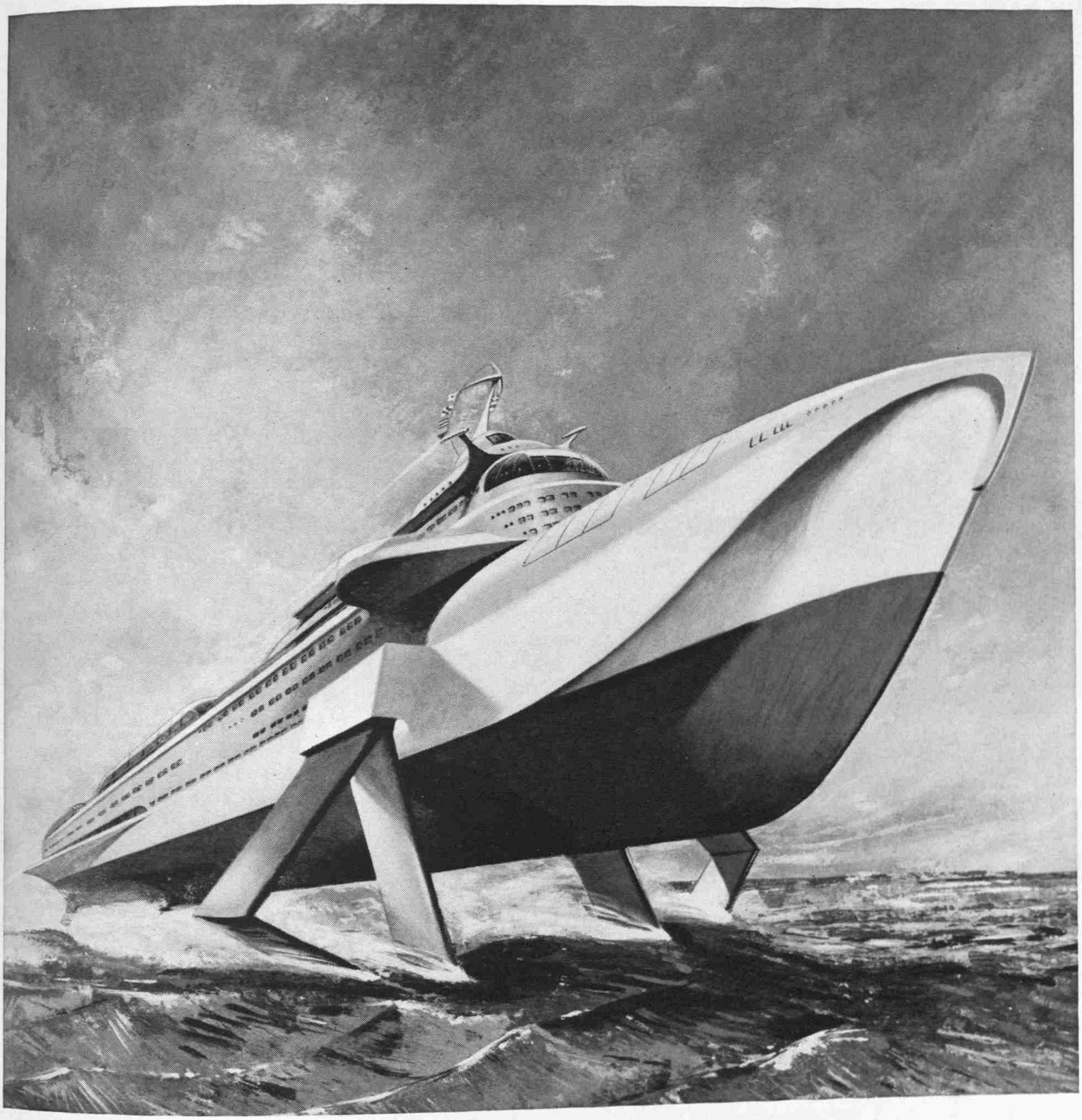
Another common way used to increase stability is the spinning of the rocket around its longitudinal axis. One disadvantage exists in regard to instrumentation. Most electronic or photographic equipment cannot be used for external measurements when a high rate of spin is used.

A more mathematical discussion of the above principles is given in several of the books listed below.

Feodosiev, V. I. and Siniarev, G. B., **Introduction to Rocket Technology,** London, Academic Press, 1959.

Brinley, B. R., **Rocket Manual for Amateurs,** New York, Ballentine Books, Inc., 1960.

Burgess, Eric, **Rocket Propulsion,** London, Chapman & Hall, Ltd., 1952.



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Garrett has been working with the Air Force and the Atomic Energy Commission on SPUR as the prime contractor for more than one year and has more than five years of experience in space nuclear power development. Also an industry leader in high speed rotating machinery, heat transfer equipment, metallurgy and accessory power systems, the company is developing design solutions for SPUR in these critical component system areas.

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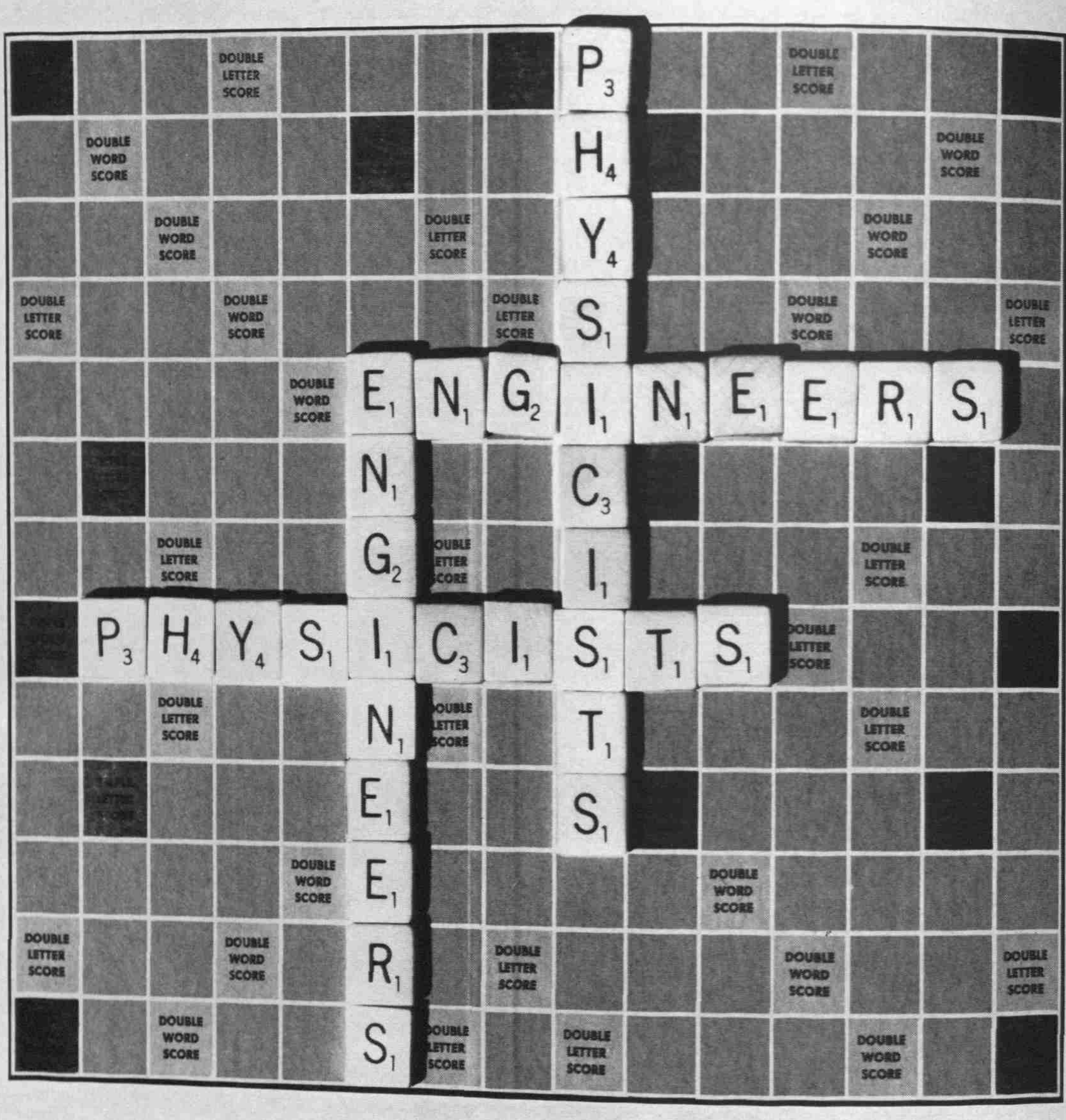

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BOSTON—Advanced Concepts Research and Development On-the-Job Training Program—AC's Boston Laboratory is engaged in development of navigational systems for manned aircraft, ballistic missiles and space vehicles.

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Steelmaking calls for volume production, complex and scientific, often highly automated. Steel companies make numerous finished products, too, from nuts and bolts to nuclear-powered cruisers. The Industrial Engineer finds

plenty to do around steel.

What's more, the above comments fail to make perhaps the most important point—interchangeability. We have found that there are endless opportunities for men with any one of the engineering degrees we have mentioned to handle jobs entailing great responsibility. The supervisor of a huge open-hearth department, or a giant rolling mill, might well be an M.E., a Ch. E., a Met. E., an I.E., or C.E.

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Shipbuilding—As the world's largest privately owned shipbuilding and ship repair organization, Bethlehem offers careers to Marine Engineers and Naval Architects, as well as to engineers in many other categories.

The Loop Course—This program was established some 40 years ago, to select and train well-qualified college graduates for careers in the Bethlehem organization. It was so named because of an observational circuit (or "loop") of a steel plant. After a five weeks' basic training period, which is held once a year at company headquarters, in Bethlehem, Pa., loopers receive their first assignments, which call for specialized training that may last for a few weeks or for as long as a year. Next comes on-the-job training, and the looper is on his way.

Big and Diversified—Because of its size and diversity, Bethlehem Steel offers unlimited opportunities to "get ahead." One of the nation's largest industrial corporations, with over 140,000 employees, we are engaged in raw materials mining and processing; basic steelmaking and the production of a wide range of steel products; manufacturing; structural-steel fabricating and erecting; and shipbuilding and ship repair. A new centralized research facility, the Bethlehem Steel Company-Homer Research Laboratories, costing in excess of $25 million, located in Bethlehem, Pa., rivals the finest in any industry.

Read our Booklet—The eligibility requirements for the Loop Course, as well as a description of the way it operates, are more fully covered in our booklet, "Careers with Bethlehem Steel and the Loop Course." It will answer most of your questions. Copies are available in most college placement offices, or may be obtained by writing to Manager of Personnel, Bethlehem Steel Company, Bethlehem, Pa.

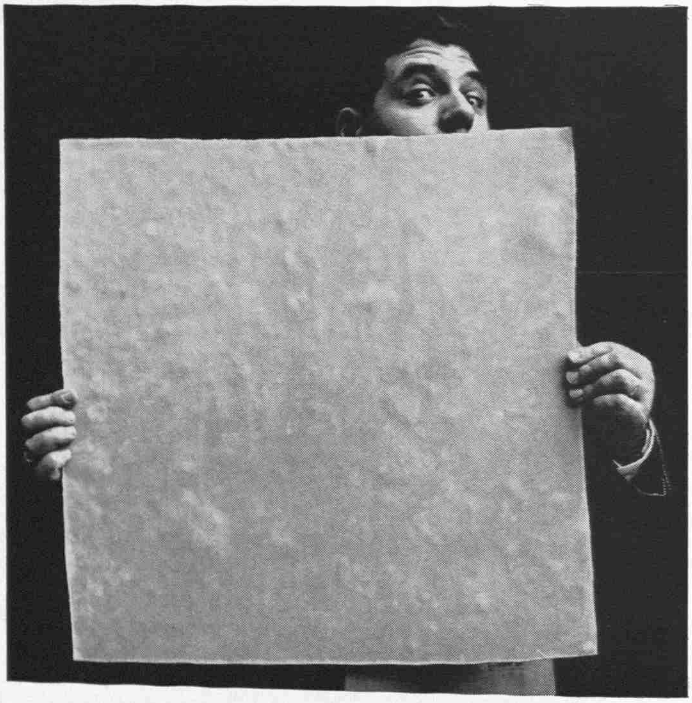
All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

Steel

BETHLEHEM STEEL

BETHLEHEM STEEL

Our new plastic stops a 30-cal. bullet cold (he hopes)



That plastic sheet is a scant 5/8" thick. But it'll stop a bullet in its tracks. Splaaaat.

Our model is actually one of the inventors, John J. Aclin. He knows it's infallibly bulletproof (but still finds the concept a bit hard to believe). It does work. Really. And the plastic scales in at 1/7 the weight of steel.

In addition to our bullet-stopping plastic, we're working on quite a few other "unbelievable" projects.

Like converting common clay into alumina (already a laboratory reality, now in the pilot plant stage).

Like a shotgun barrel made by winding 500 miles of glass fiber around a thin steel liner (now bagging its share of game around the world).

Like developing more powerful liquid missile fuels (will Olin's hydrazine get us to the moon?).

And getting back to Earth, a chemical agent that arrests grass growth (a long range project that lawn owners are rooting for).

Because we're moving so rapidly, promising graduates enjoy unique career opportunities with Olin. Research gets a healthy budget and research people, a healthy climate.

Most of our research facilities are consolidated in the new Olin Research Center in New Haven, Conn. Where scientists, engineers and technicians work with the men, the equipment and the responsibilities that can bring them to full potential quickly.

For further information on career opportunities, the man to contact is Charles M. Forbes, College Relations Officer, Olin Mathieson Chemical Corporation, 460 Park Avenue, New York 22, New York.

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WHAT'S NEW

NEW DEPARTMENT AT MSU

The college of engineering has a new department as of January 1.

It is the department of Metallurgy, Mechanics, and Material Science—an unwieldy title that will probably be changed later, according to Dr. A. J. Smith, head of the new department. It joins the older departments of metallurgical engineering and applied mechanics.

Dr. Smith explained that the union was feasible because both departments had been closely working together in the past.

Although undergraduates will be enrolled in this department, they will still keep their old curriculums. This is necessary because the students have already started in their programs, and the catalogs for next fall are completed without the department being included.

Dr. Smith said that the new program for undergraduates will be effective in the fall of 1963.

Graduate curriculums, however, have been completed. About 30 graduate students will be enrolled in the new department.

New materials such as semi-conductors, transistors, ceramics, and plastics are becoming increasingly important to the metallurgist today. The new department, as indicated by its name will incorporate the study of these materials along with that of iron, copper, brass, etc.

One of the problems confronting the metallurgist today, according to Dr. Smith is the inadequacy of materials in withstanding the demands placed on them, and their job is to develop materials that can stand up under the conditions imposed by an accelerated science.

MECHANIZED INDEXING

Scientific documents are now being swiftly and automatically indexed according to important words in their titles by an electronic digital computer at Bell Telephone Laboratories. The titles are fed to an IBM 7090 computer on punched cards, along with other cards containing the names of authors and identification numbers. The computer is programmed to scan these cards, reorganize the information, and print out a "Permuted Title" subject index.

The index is called "permuted" because each significant word of a title appears, in turn, as a "key" work in the index. The work is listed alphabetically at the index position in context with the other words of the title.

The computer is instructed to ignore unimportant words such as prepositions, conjunctions, articles, verb forms, adjectives, and some nouns which are considered to have little value as index words. A table of non-significant words is stored in the computer's memory and can be easily changed.

The computer stores each permuted title in its memory. When all the titles have been permuted, it reshuffles them and produces, on magnetic tape, an index in which all the titles are listed alphabetically according to the key word. This tape is fed to a high-speed printer which prints out the titles, in English, at a speed of 600 lines per minute. A feature of this system is that the pages from the high-speed printer can be reproduced by photo-offset and bound into an index book without the necessity of retyping or typesetting the information.

Also, the output tape from any index can be saved and later "merged" with subsequent tapes to produce a cumulative index. The merging program permits up to eight tapes to be merged onto one tape; thus monthly indexes can be easily cumulated into semi-annual and annual indexes.

In addition to the Permuted Title Index, the computer can be instructed to produce an alphabetical author index, a bibliographical list of all the indexed documents, and other indexes according to date, language, project, or other classifications which may be desired.

Considerable time and effort is saved by this method of mechanized indexing. It takes a clerk about two minutes to punch the title, author and project number on standard punched cards. The computer processes the information quickly. In one application, the computer took only 12 minutes to index 1700 documents according to title, author, number and project.

The index can be prepared so quickly and routinely, and can be updated so easily, that the technique is also being used to prepare a "bulletin" for publicizing new literature.

This type of subject index is particularly useful for locating a document when only one "clue" such as author, number, or one title word is known. Also, the appearance on the complete title in the index helps in deciding whether the document is the one searched for.

One interesting by-product of an index which relies on significant words in document titles is that authors will be encouraged to write more descriptive titles.

TURBINE FLOWMETERS

(Continued from Page 17)

Thus the blade drag coefficient becomes the sum of a laminar and a turbulent drag coefficient, each applied to its proper blade area. This is expressed in the Prandtl-Schlichting transition formula

$$(C_D \approx K - K/R)$$

which for very large Reynolds numbers approaches a constant value.

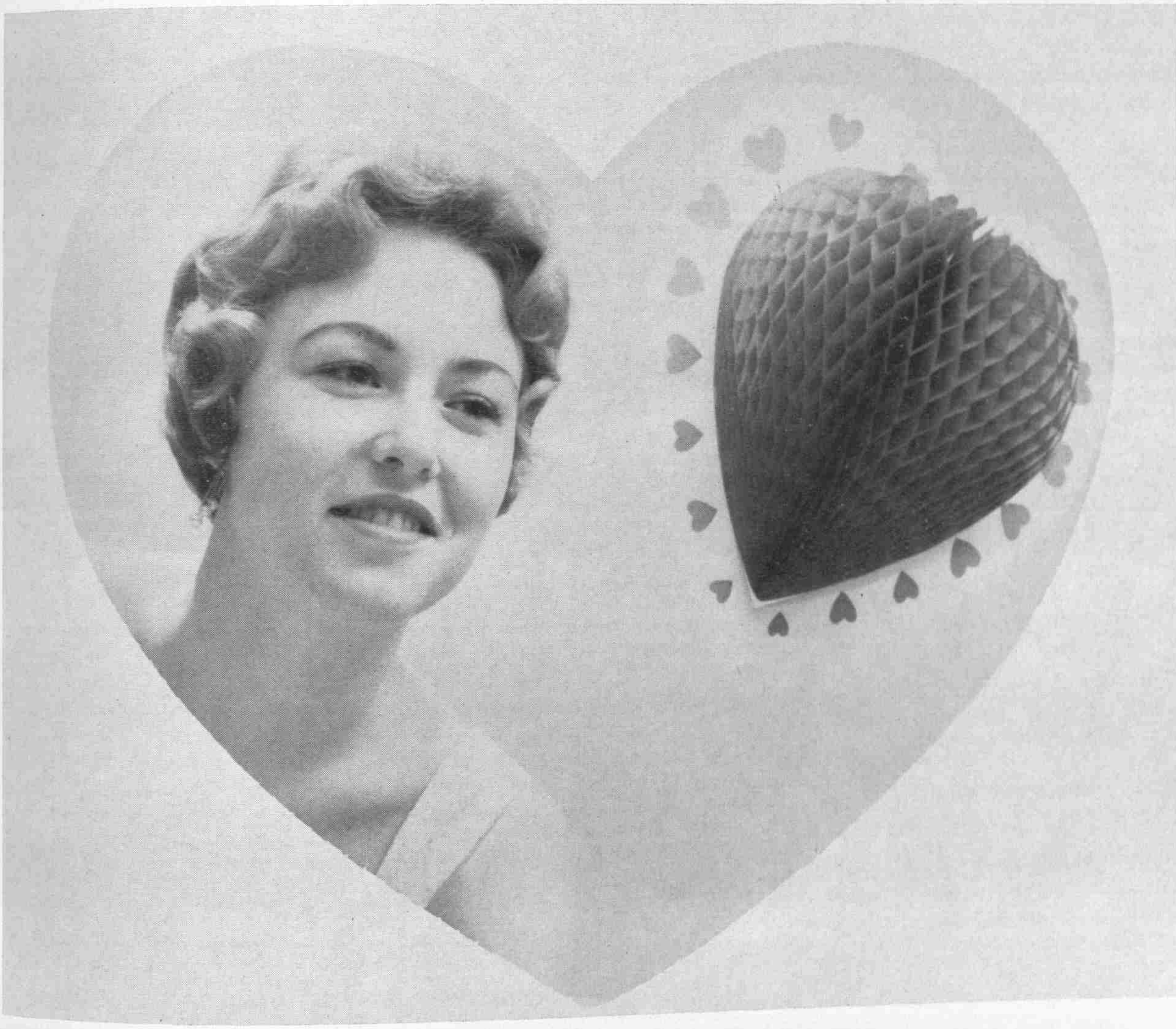
To be of value as an accurate flow the turbine meter must have essentially constant slip. This means that the drag coefficient must remain constant throughout the flow range. The Reynolds numbers in the practical range of flow are not large enough for the drag coefficient to approach a constant. Therefore, in order to hold the total drag coefficient constant some type of automatic cancellation of the variation (K/R) must be used. It is this variation which causes the decrease in turbine meter slip at moderate Reynolds numbers.

The device used to cancel the variation in drag is a laminar drag brake termed a viscosity compensator. This device consists of a cylinder drum mounted on the rotor shaft with a small-clearance space between the drum and a stationary outer shell. This space is filled with the fluid to be metered.

The drum imposes a drag in linear proportion to both its rotational speed and the fluid viscosity. This drag varies inversely with the Reynolds number. With proper proportioning, drag exactly cancels the slip variation indicated by the Prandtl-Schlichting formula.

Tests show that turbine meters with this viscosity compensator are more accurate with higher repeatability than the best displacement meters. Regardless of the flow rates and gritty particles encountered in service, turbine flowmeters will operate *without calibration changes* over wide viscosity ranges (0 to 200 centistokes) for long periods of time.

Miss Engineer



Miss January Engineer is Lucy Reinberg

Lucy is a 5'6" blue-eyed blond from Midland, Michigan. Locally, she lives at Delta Delta Delta Sorority.

She is a junior, majoring in business education, so she finds "where the boys are," since the majority of her classmates are men. Even though in business, Lucy doesn't plan to become a young executive. She did state, however, she is looking for one.

SYSTEMS ENGINEERING

(Continued from Page 19)

must be delayed until the graduate program.

One of the greatest assets of the Systems Laboratory is the opportunity to obtain practical knowledge about typical systems components, the mathematical models of which can be effectively determined through the instrumentation in the laboratory.

CHROMATOGRAPHY

(Continued from Page 10)

example of molecular diffusion consider a stationary salt solution in which the concentration is not uniform. After a long period of time the concentration will become uniform due to molecular movement of the salt.

Eddy diffusion is analogous to molecular but it is caused by turbulence.

All of these effect are combined into one effect, axial diffusion and is described by Fick's diffusion equation for the rate of mass transfer.

$$N = -D \frac{dc}{dx}$$

Where

$N = \frac{\text{moles of material transferred}}{\text{Time area}}$

D = Axial Diffusion coefficient

$\frac{dc}{dx}$ = driving force of diffusion, or the concentration gradient.

To understand the meaning of the concentration gradient an analogy to heat transfer is made. Thermal energy is transferred as heat from a high temperature to a low temperature. The temperature gradient is the difference in temperature divided by the distance through which heat flows. Similarly, the concentration gradient is the difference in concentration of a high concentration area and low concentration area divided by the distance through which the material is transported. Consequently material migrates from a high to a low concentration.

Notice in Figure 1, after successively longer time intervals the dispersion of the concentration-distance plot increases due to the regions of high and low concentration. The diffusion coefficient is related to the degree of dispersion, and can be determined from concentration-time measurement at two positions downstream from a tracer injection point. The variance of each curve, defined as the radius of gyration squared of a curve about its mean, is a measure of the dispersion and is related to the diffusion coefficients by the following equation

$$= \frac{2D}{UL}$$

$\sigma_2^2 - \sigma_1^2$ = Variance of curve i

U = linear Velocity of fluid

L = distance between measuring points

The effects of the following variables on the diffusion coefficients are being investigated; column diameter, column length, packing method, type of packing, and fluid flow rate. At present these variables are being investigated in the absence of adsorption. Ultimately, the dispersion measurements obtained without adsorption will be correlated with those measurements including adsorption.

To eliminate adsorption, small glass beads are used as packing. The tracer is a dilute solution of sodium chloride in water, and the solvent which is fed continually to the column is water. Concentration versus time curves at three intervals below the points of tracer injection are obtained by means of electrical conductance.

We have designed conductance cells which are inserted in the packing in such a manner that the flow pattern through the column is affected to a large extent by the presence of these cells.

A low voltage AC signal is fed to these cells and the resistance of these cells is measured successively by a recording potentiometer.

The concentration versus time plot of each cell in the column is analyzed by putting the plot information; and also by the variables of the system; flow rate, column diameter, and length into MISTIC (the MSU digital computer). Values of the axial diffusivites are obtained by this method.

At the present, values of the diffusivity have been obtained in three different diameter columns, packed with two sizes of glass beads in which no adsorption is present.

Eventually diffusivites will be obtained in packing which does adsorb the tracer material and the values will be correlated with the previous facts.

With this correlation it is hoped to be able to predict better designs of industrial chromatography columns.

ADVERTISER'S INDEX

Kodak beyond the snapshot...

(random notes)

One use for an artificial duck

On Sunday evening, September 24th, a new associate of ours named Walt Disney broadcast from 168 TV stations a film called "Mathmagicland." It featured an artificial duck he owns named Donald. The film illustrated the mathematical unity of nature and man, while the duck quacked in order to reassure 20,000,000 viewers that there is no harm in such a discussion.

Lots of kids who were too young for it will be ready next fall. Movies can teach conic sections as easily as pie-throwing. Movie-makers with lesser resources than Disney can also teach laudably. What bothers the classroom teacher about 16mm movies is how to get the one she wants when she wants it instead of seven weeks later. Nobody is to blame. The can of film has too many classes to visit, but relief is on the way.

Enter the *Kodak Sound 8 Projector.* It projects 8mm movies with commentary from a magnetic stripe on the film.

The greatly reduced cost and bulk of 8mm film and equipment got home movies off the ground. The improvement of sharpness and color in the 8mm Kodachrome II Film introduced last year is making movies really soar as entertainment in the home. In the schoolroom 8mm sound movies can be expected to simulate the effect of the paperback on the book business. The teacher will be able to handle a teaching film more like a weekly magazine and less like a shipment of gold bullion.

A sharp eye for infrared

The decision to announce *f/1 Irtran-2 Aspheric Lenses* has been reached in struggle against inhibitions. In the photographic trade we are habituated to a longer silence before the first blast of the trumpets. Infrared technology hates to wait, however.

These lenses transmit usefully from 2μ to 14μ. Three focal lengths, 1-inch, 2-inch and 3-inch, are offered off the shelf. At *f*/1, we seem to have done well at providing high collecting-power for energy without undue sacrifice of sharpness. Sharpness was the goal. For all the lenses, the minimum circle of confusion *computes* at less than .001″ for any wavelength from 4.25μ to 10μ. Note italics.

In the 2μ-3μ region, the sharpness does not compute to be as good as farther out in the infrared. Yet we have customers who use the lenses there and are happy with confusion-circle minima as large as .008″.

In comparison with reflective optics hitherto used, Irtran-2 aspheres offer compactness and a wider field that doesn't even show appreciable deterioration as far as 2° off axis. You do give up the perfect achromatism of mirrors.

These remarks can be interpreted as a blatant offer here and now to sell these lenses for cash. (Address inquiries to Eastman Kodak Co., Special Products Division, Rochester 4, N.Y.) Irtran-2 material resists water and common organic solvents. It retains infrared transparency at high temperature.

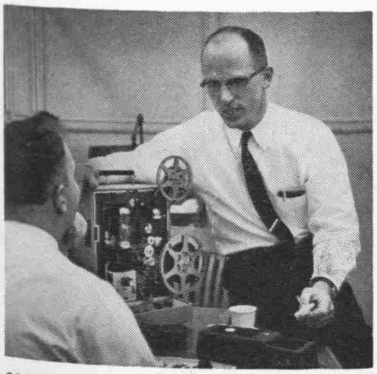
The carboxamide way to solvation

The joy that philosophers once felt in considering an irresistible force acting against an immovable object is as nothing to the joy of the peddler who carries in his pack both an inorganic substance that resists common organic solvents *(see left)* and a solvent which dissolves inorganic substances which common solvents fail to dissolve.

\$2.75 buys from Distillation Products Industries (a division of ours), Rochester 3, N. Y. 5 grams of *N,N-Dimethylbenzamide.* This comes as white crystals that melt at 42°C. It is a new member of a class of compounds of uncanny solvent power for high polymers, organometallics, and inorganics.

Solvation virtually demands the liquid state. Solubility also usually rises with temperature. Without the trouble and peril of high-pressure tactics, N,N-dimethylbenzamide can be maintained as a much hotter liquid than its cousins. It doesn't boil until 272°C, as compared with 152°C for N,N-dimethylformamide and 165°C for N,N-dimethylacetamide. Judged from some of the 17 other N-substituted carboxamides to be found among some 3900 Eastman Organic Chemicals we sell for research, it is probably a swell solvent. (Whether it dissolves Irtran-2 material, nobody yet cares.)

Note: Whether you work for us or not, photography in some form will probably have a part in your work as years go on. Now or later, feel free to ask for Kodak literature or help on anything photographic.



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One of a series . . .

Interview with General Electric's Dr. J. H. Hollomon

Manager—General Engineering Laboratory

Society Has New Needs and Wants—Plan Your Career Accordingly

DR. HOLLOMON is responsible for General Electric's centralized, advanced engineering activities. He is also an adjunct professor of metallurgy at RPI, serves in advisory posts for four universities, and is a member of the Technical Assistance panel of President Kennedy's Scientific Advisory Committee. Long interested in emphasizing new areas of opportunity for engineers and scientists, the following highlights some of Dr. Hollomon's opinions.

Q. Dr. Hollomon, what characterizes the new needs and wants of society?

A. There are four significant changes in recent times that characterize these needs and wants.

1. The increases in the number of people who live in cities: the accompanying need is for adequate control of air pollution, elimination of transportation bottlenecks, slum clearance, and adequate water resources.

2. The shift in our economy from agriculture and manufacturing to "services": today less than half our working population produces the food and goods for the remainder. Education, health, and recreation are new needs. They require a new information technology to eliminate the drudgery of routine mental tasks as our electrical technology eliminated routine physical drudgery.

3. The continued need for national defense and for arms reduction: the majority of our technical resources is concerned with research and development for military purposes. But increasingly, we must look to new technical means for detection and control.

4. The arising expectations of the peoples of the newly developing nations: here the "haves" of our society must provide the industry and the tools for the "have-nots" of the new countries if they are to share the advantages of modern technology. It is now clearly recognized by all that Western technology is capable of furnishing the material goods of modern life to the billions of people of the world rather than only to the millions in the West.

We see in these new wants, prospects for General Electric's future growth and contribution.

Q. Could you give us some examples?

A. We are investigating techniques for the control and measurement of air and water pollution which will be applicable not only to cities, but to individual households. We have developed, for example, new methods of purifying salt water and specific techniques for determining impurities in polluted air. General Electric is increasing its international business by furnishing power generating and transportation equipment for Africa, South America, and Southern Asia.

We are looking for other products that would be helpful to these areas to develop their economy and to improve their way of life. We can develop new information systems, new ways of storing and retrieving information, or handling it in computers. We can design new devices that do some of the thinking functions of men, that will make education more effective and perhaps contribute substantially to reducing the cost of medical treatment. We can design new devices for more efficient "paper handling" in the service industries.

Q. If I want to be a part of this new activity, how should I plan my career?

A. First of all, recognize that the meeting of needs and wants of society with products and services is most important and satisfying work. Today this activity requires not only knowledge of science and technology but also of economics, sociology and the best of the past as learned from the liberal arts. To do the engineering involved requires, at least for young men, the most varied experience possible. This means working at a number of different jobs involving different science and technology and different products. This kind of experience for engineers is one of the best means of learning how to conceive and design —how to be able to meet the changing requirements of the times.

For scientists, look to those new fields in biology, biophysics, information, and power generation that afford the most challenge in understanding the world in which we live.

But above all else, the science explosion of the last several decades means that the tools you will use as an engineer or as a scientist and the knowledge involved will change during your lifetime. Thus, you must be in a position to continue your education, either on your own or in courses at universities or in special courses sponsored by the company for which you work.

Q. Does General Electric offer these advantages to a young scientist or engineer?

A. General Electric is a large diversified company in which young men have the opportunity of working on a variety of problems with experienced people at the forefront of science and technology. There are a number of laboratories where research and advanced development is and has been traditional. The Company offers incentives for graduate studies, as well as a number of educational programs with expert and experienced teachers. Talk to your placement officers and members of your faculty. I hope you will plan to meet our representative when he visits the campus.

A recent address by Dr. Hollomon entitled "Engineering's Great Challenge — the 1960's," will be of interest to most Juniors, Seniors, and Graduate Students. It's available by addressing your request to: Dr. J. H. Hollomon, Section 699-2, General Electric Company, Schenectady 5, N.Y.

GENERAL ELECTRIC

All applicants will receive consideration for employment without regard to race, creed, color, or national origin.