Spartan Engineer

VOL. 7
NO. 2
JANUARY, 1954

Only STEEL can do so many jobs so well

World's Largest Double Swing-Span Bridge. The George P. Coleman Memorial Bridge spans the deep swift York River between historic Yorktown and Gloucester Point, Va. Two 500-foot swing spans, each weighing 1,300 tons, pivot horizontally on piers 44 feet in diameter, swinging open simultaneously to provide a 450-foot freeway that can accommodate the passage of even the largest vessel. This 3,750-foot-long bridge was fabricated and erected by U. S. Steel.

Landing at Sea. When a fighter pilot lands his plane on a flattop, one of his biggest problems is *stopping* the plane. To help him, a hook attached near the plane's tail engages one of the galvanized wire cables, mounted on spring brackets, that stretch across the deck. The resiliency of the cable, plus the bracket action, helps the plane to stop promptly and safely.

Ready to Roll. Trains move faster today, they carry heavier loads, they cover longer distances. This puts a premium on durability and safety in the *wheels* they roll on. U. S. Steel has been making wrought steel wheels for 47 years, has helped to bring the art of wheel-making to its present high level.

OPPORTUNITIES WITH U. S. STEEL

If you're thinking about what you're going to do after graduation . . . . if you're interested in a challenging, rewarding position with a progressive company . . then it will pay you to look into the opportunities with United States Steel. Your placement director can give you more details, or we'll be glad to send you the informative booklet, "Paths of Opportunity." United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

MANUFACTURED FROM USS STEEL UNITED STATES STEEL

UNITED STATES STEEL

This trade-mark is your guide to quality steel

For further information on any product mentioned in this advertisement, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

AMERICAN BRIDGE · AMERICAN STEEL & WIRE and CYCLONE FENCE · COLUMBIA-GENEVA STEEL · CONSOLIDATED WESTERN STEEL · GERRARD STEEL STRAPPING · NATIONAL TUBE
OIL WELL SUPPLY · TENNESSEE COAL & IRON · UNITED STATES STEEL PRODUCTS · UNITED STATES STEEL SUPPLY · *Divisions of* UNITED STATES STEEL CORPORATION, PITTSBURGH
UNITED STATES STEEL HOMES, INC. · UNION SUPPLY COMPANY · UNITED STATES STEEL EXPORT COMPANY · UNIVERSAL ATLAS CEMENT COMPANY

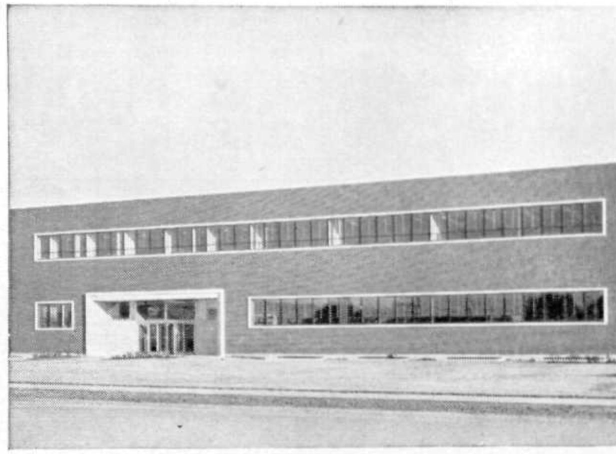
4-89

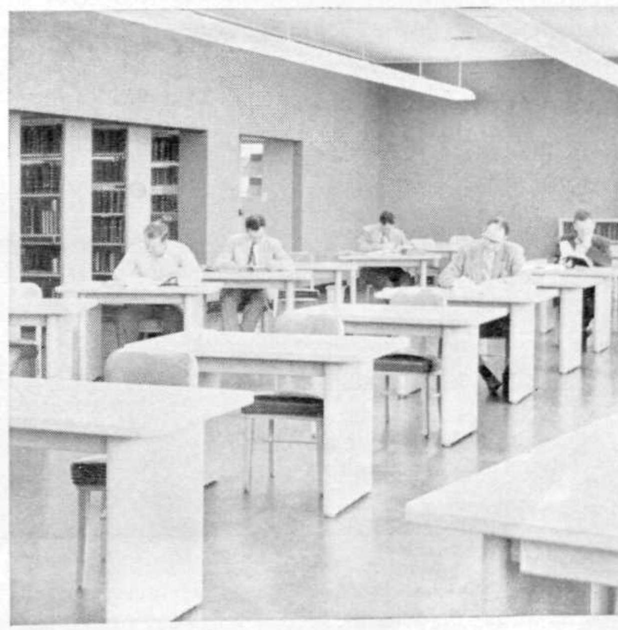
DOW

NEW DOW

Technical Library

ENABLES EMPLOYEES TO FURTHER STUDIES





These modern facilities provide an extremely wide range of scientific material including current information on all fields of research

The desire to provide complete technical knowledge for Dow personnel, together with intelligent planning, has produced at Midland, Michigan, one of the most comprehensive of all industrial libraries. This modern, air-conditioned structure contains over 35,000 books and over 600 magazines. New books are added regularly, and both foreign and domestic abstracts are made available.

Most of the material is highly technical. The most extensive coverage is given to material in the fields of chemistry, electrochemistry, biochemistry, agricultural chemistry, chemical engineering, physics and nuclear physics.

In addition to published material, the library also furnishes an index of all research work conducted by all divisions of The Dow Chemical Company.

This new library is but one example of Dow's efforts to offer the finest facilities for work and recreation to its employees. THE DOW CHEMICAL COMPANY, Midland, Michigan.

Dow's Booklet "Opportunities With The Dow Chemical Company", especially written for those about to enter the chemical profession, is available free, upon request. Write to The Dow Chemical Company, Technical Employment, Midland, Michigan.

you can depend on DOW CHEMICALS DOW

A MESSAGE TO
COLLEGE ENGINEERING
STUDENTS

from R. S. Kersh, Vice-President,
Northeastern Region,
Westinghouse Electric Corporation

To the young engineer eager for a sales career

Show me an engineer with a friendly attitude, and an eagerness to help people solve their problems and I'll show you a good sales engineer.

There's nothing mysterious about this job of being a sales engineer. To apply the products of his company to his customers' needs, he must be a good engineer.

To gain the confidence of his customers he must be a good salesman. This means simply that he should have an inquisitive nature, the desire to help others, and the quality of enthusiasm.

The Westinghouse sales engineer works with our design engineers, production engineers and engineering departments of our customers. He is a highly important and valued professional man.

What are the opportunities at Westinghouse for a young man eager for a career in sales? They are just about what you want to make them! This company's 30 divisions make over 3,000 products, totaling over $1½ billion in sales annually. Westinghouse is looking to the future with a vast expansion program. We are a fast-growing company in the dynamic field of electrical energy.

If your sights are set on a sales career, I am sure you will find the training and opportunity you seek with Westinghouse.

G-10272

YOU CAN BE SURE...IF IT'S
Westinghouse

For information on career opportunities with Westinghouse, consult Placement Officer of your University, or send for our 34-page book, *Finding Your Place in Industry*.

Write: Mr. R. A. Warren, Regional Educational Co-ordinator, Westinghouse Electric Corporation, 306 Fourth Ave., Pittsburgh 30, Pennsylvania.

Spartan Engineer

ARTICLES

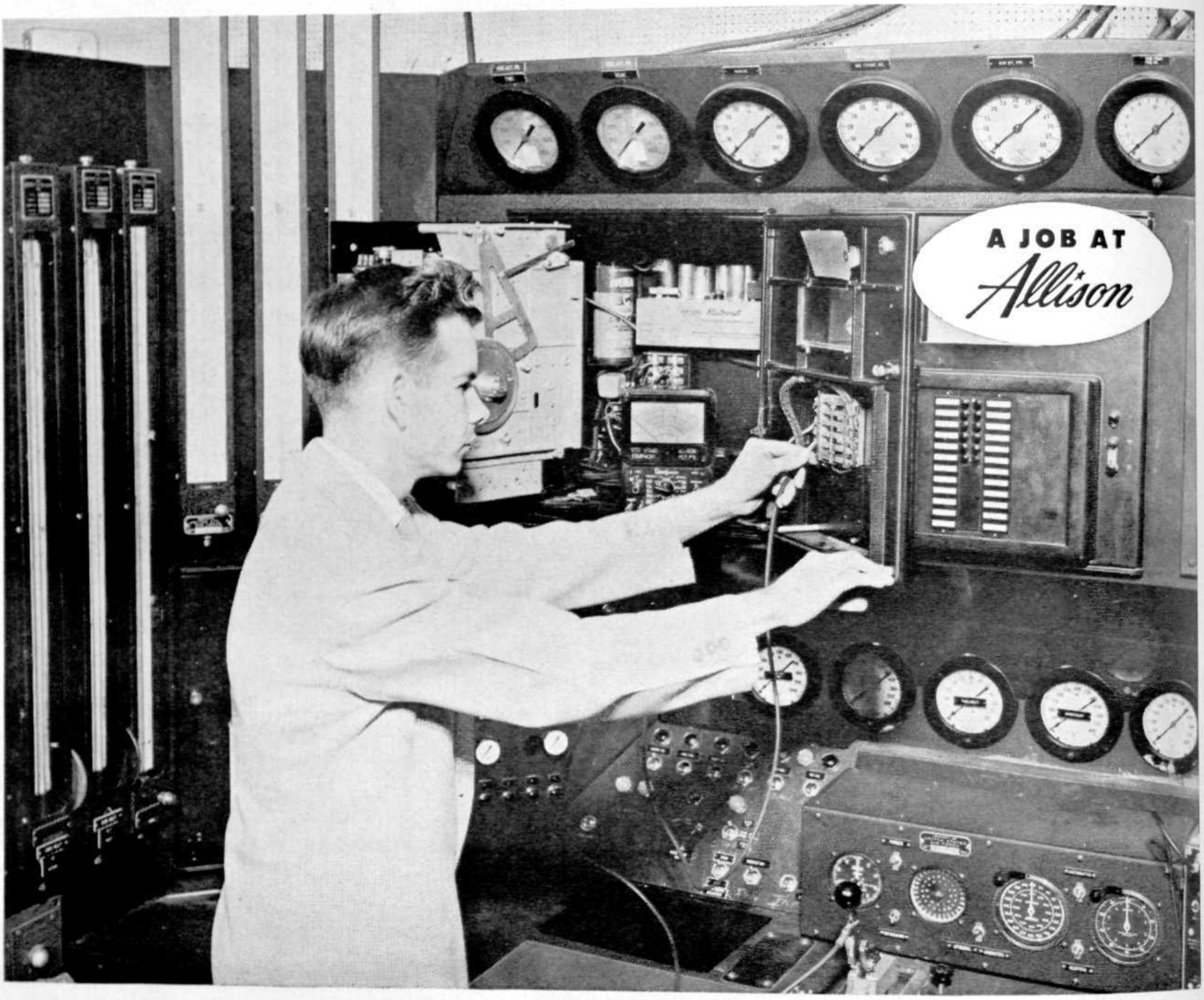
FEATURES

Published four times yearly by the students of the SCHOOL OF ENGINEERING, MICHIGAN STATE COLLEGE, East Lansing, Michigan. The office is on the third floor of the Union Building, Phone ED 2-1511, Extension 251. Entered as second class matter at the Post Office in Lansing, Michigan, under the act of March 3, 1879.

Address Mail to: P. O. Box 468, East Lansing, Michigan.

Publishers representative
Littell-Murray-Barnhill, Inc.
101 Park Avenue, New York
605 W. Michigan Avenue, Chicago

Subscription rate by mail $1.00 per year.
Single copies 25 cents.



● Wallace L. Carr was graduated from the University of Illinois with a B.S. degree in Electrical Engineering in 1951. After a short time with a large electric utility—where he was Junior Engineer in substation design—he came to Allison where he is presently Electrical Engineer in the plant engineering department, Aircraft Engine Operations.

Wally's job in this department varies from designing plant, lighting, and power layouts, and machinery electrical diagrams to electrical and instrumentation layouts of turbo-jet and prop-jet test cells. With a multimeter, he is shown above checking the thermocouple circuits on the control panel in one of the Allison test cells.

In jet cells, it is necessary to simulate all engine controls that appear in a jet plane, plus other controls which are necessary to check and evaluate engine performance . . . operating temperature . . . acceleration . . . speed . . . fuel consumption . . . oil flow, etc.

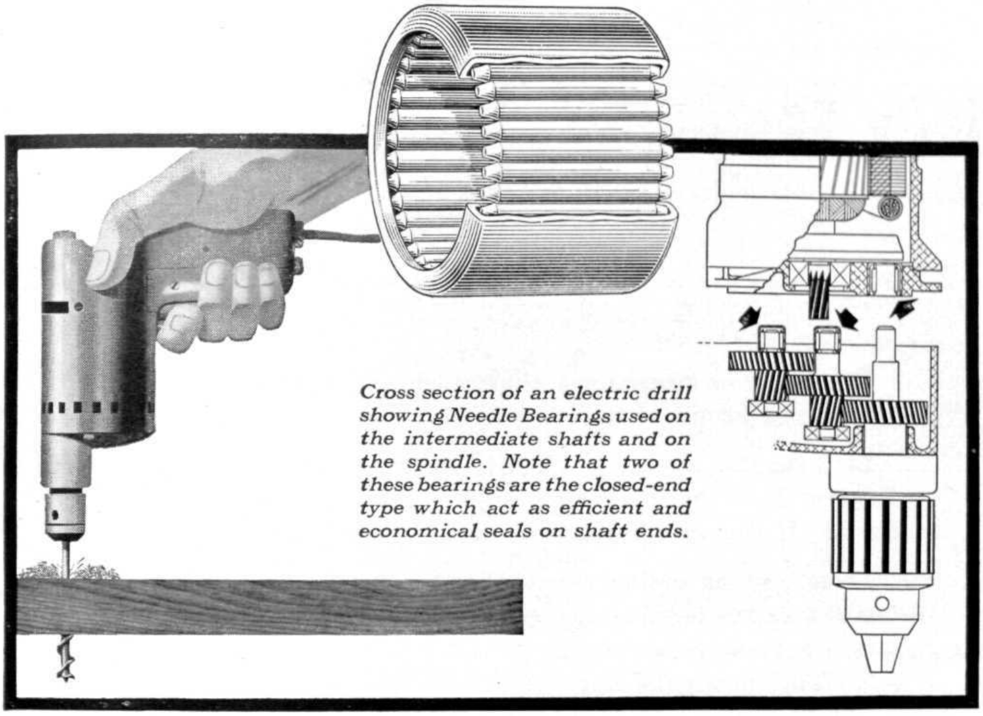
Electronic control of important functions of jet engine operation has made the electrical portion of test cell operation a complex and fascinating problem for the Electrical Engineer.

Allison, a leader in the field of turbine engines, offers unlimited opportunities to young graduates with degrees in Mechanical Engineering, Electrical Engineering, Aeronautical Engineering and Industrial Engineering. Why not plan early for *your* engineering career at Allison.

For further information about YOUR engineering career at ALLISON, discuss it with your Placement Counselor and arrange for an early interview with the ALLISON representative the next time he visits your campus. Or, write now for further information: R. G. Greenwood, Engineering College Contact, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

Allison **DIVISION GENERAL MOTORS CORPORATION • Indianapolis, Ind.**

Design, development and production—high power TURBINE ENGINES for modern aircraft . . . heavy duty TRANSMISSIONS for Ordnance and Commercial vehicles . . . DIESEL LOCOMOTIVE PARTS . . . PRECISION BEARINGS for aircraft, Diesel locomotives and special application.



Cross section of an electric drill showing Needle Bearings used on the intermediate shafts and on the spindle. Note that two of these bearings are the closed-end type which act as efficient and economical seals on shaft ends.

TORRINGTON NEEDLE BEARINGS

help make products more compact

These days, design engineers have to consider sales charts as well as blueprints and specifications.

Two portable electric drills, for example, may have the same capacity, the same speed, the same chucks and the same price, yet one may outsell the other. Factors like overall appearance, compactness, and light weight often contribute to product success.

Unique Design Promotes Compact Designs

The Torrington Needle Bearing has been used in many products because of the weight and space savings it affords. Its unique design—a thin hardened outer shell retaining a full complement of small diameter rollers—gives it maximum capacity in minimum space. In fact, for its size and weight, the Needle Bearing can carry higher radial loads than any other type of anti-friction bearing.

Permits Reduction in Size and Weight of Related Parts

In the electric drill shown here the small size of the Needle Bearing permits close shaft center distances to make for overall compactness. And, since Needle Bearings are press-mounted in plain round housing bores—without retaining rings or shoulders—housings can be made smaller and lighter. The fact that Needle Bearings require no inner race when running on hardened shafts results in further savings, without sacrificing capacity or durability.

Needle Bearings are in use on many other products where compactness and light weight are important design factors. Aircraft, small gasoline engines, hydraulic pumps and materials handling equipment are just a few of the products that utilize the Needle Bearing's high capacity and small size to good advantage.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS

Editorially Speaking

If you are a graduating senior engineer, your fifth step is going to be in one of two directions!

Let's suppose you are just an average senior, maybe not much different from the fellow that sits next to you in most of your classes. If you are, then this is what your fifth step will be:

Being just an ordinary guy, your first worry after graduation is going to be: When is Uncle Sam going to call me into the service? Your second and last worry is landing an engineering job. That's about the way YOUR fifth step will stack up.

Sure, you're an engineer; you don't have to worry about a job, too much. If you are not a veteran and are physically fit, you already have a job in the service for a few years.

Now, on the other hand, didn't Jim come to class this morning with a suit on because he said that he was taking an interview for a job after graduation? Jim is just an ordinary senior like yourself, but why is he wasting his time taking interviews?

Jim is just taking his fifth step in the other direction. Jim's first worry is getting that engineering job; his second concern is Uncle Sam.

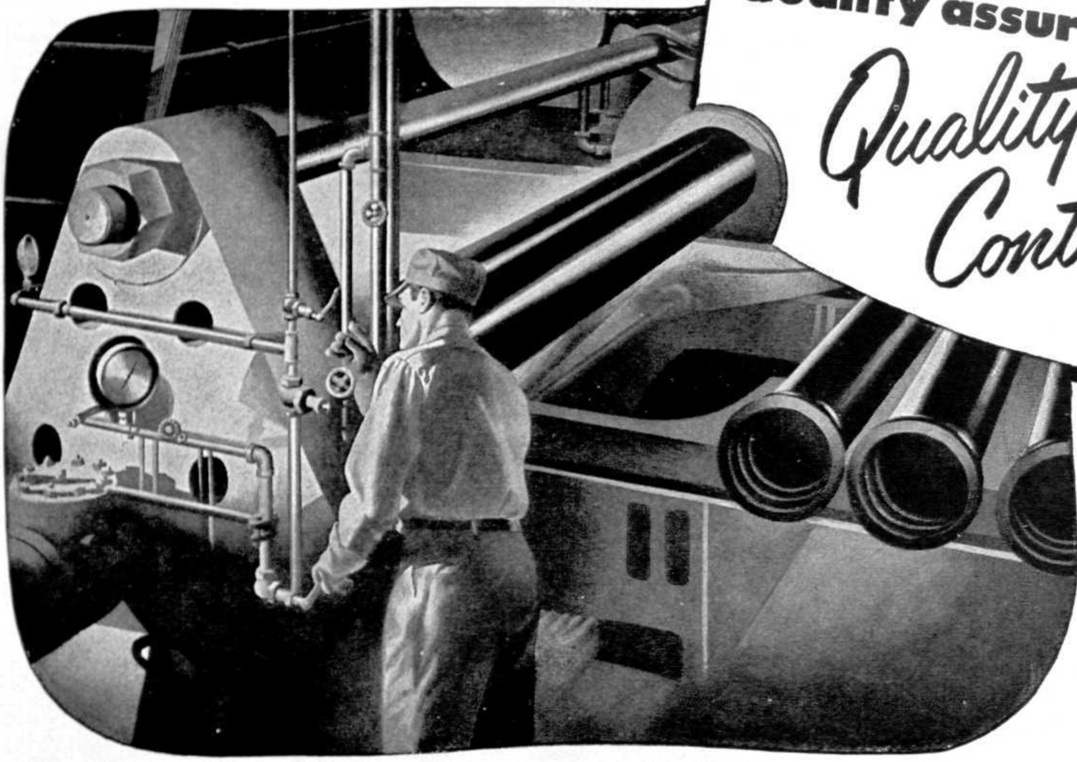
This is the way Jim puts it: "After I am discharged from the service, it isn't going to be easy to get a job without the help of the placement bureau. By taking my interviews and getting that job now, I will be getting some seniority and I'll have a job guaranteed for me with the company of my choice when I am discharged."

Maybe Jim's got something there.

How ARE you going to go about getting a job after you are discharged? If you didn't take any interviews at all while you were in college, you probably won't have any professional contacts or references. It may also be difficult to get a job a few years from now, when an increased number of engineering graduates will be competing for jobs.

How about it now? In which direction are you going to take your fifth step? Are you going to wait until you're discharged from the service to try to get a job? Or are you going to take your interviews and get that job now, so that you won't have to worry about it later?

Quality assured by *Quality Control*



THE HYDROSTATIC TEST

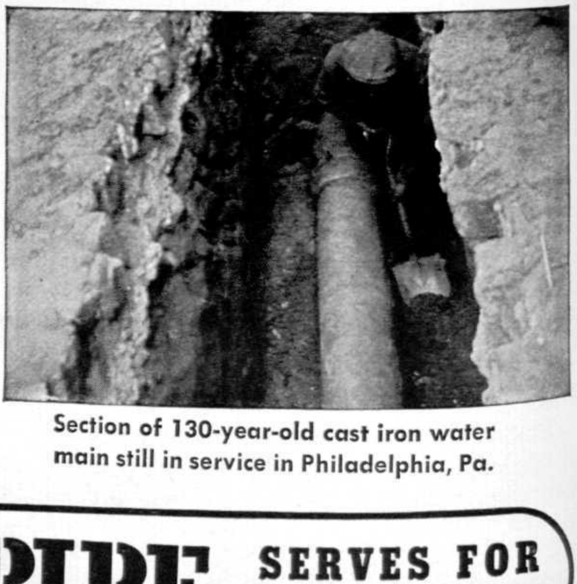
Nobody can buy a length of cast iron pipe unless it has passed the Hydrostatic Test at the foundry. Every full length of cast iron pipe is subjected to this test under water pressures considerably higher than rated working pressures. It must pass the test or go to the scrap pile.

The Hydrostatic Test is the final one of a series of routine tests made by pipe manufacturers to assure that the quality of the pipe meets or exceeds the requirements of standard specifications for cast iron pressure pipe.

Few engineers realize the extent of the inspections, analyses and tests involved in the quality-control of cast iron pipe. Production controls start almost literally from the ground up with the inspection, analysis and checking of raw materials—continue with constant control of cupola operation and analysis of the melt—and end with inspections and a series of acceptance and routine tests of the finished product.

Members of the Cast Iron Pipe Research Association have established and attained scientific standards resulting in a superior product. These standards, as well as the physical and metallurgical controls by which they are maintained, provide assurance that cast iron pipe installed today will live up to or exceed service records such as that of the 130-year-old pipe shown.

Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction. Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3, Illinois.



Section of 130-year-old cast iron water main still in service in Philadelphia, Pa.

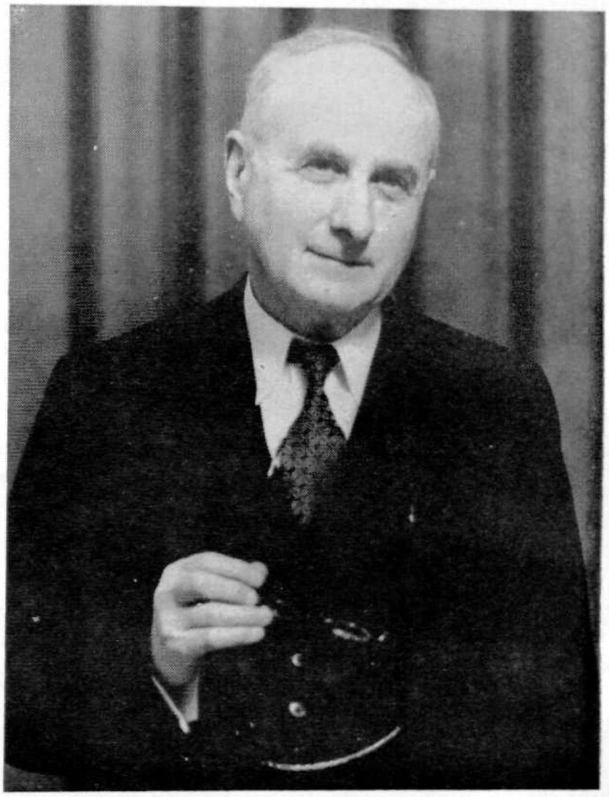
CAST IRON PIPE SERVES FOR CENTURIES

INTRODUCING

Dr. Andrey A. Potter

Warmth, sincerity, friendship . . . and much more . . .

There are people who radiate a kind of glow when you meet them. What constitutes that glow—warmth, sincerity, friendship—whatever it is, no one can say for certain. But we at Michigan State College can say that among us we have at least one such person. That person is Dr. Andrey A. Potter.



Dr. Potter, technically, is consultant to college president John A. Hannah in charge of the school of engineering. But as he himself says, his job more specifically is to select a successor to Lorin G. Miller, who retired as dean of engineering here last July, and to "give the engineering staff and administration the benefit of his experience in the field of engineering."

Included in the experience Dr. Potter has had are three years spent working with the General Electric Company, 15 years at Kansas State College, and until his retirement last July, over 30 years as dean of the school of engineering at Purdue University. Also for the last thirty years, Dr. Potter has served as a consulting power engineer, and as he says, being a "supposed expert" on that subject, has written several books and over 300 articles and papers on power engineering, thermodynamics, and farm motors.

Dr. Potter was born in Europe on August 5, 1882, and came to the United States when he was 15. He entered the Massachusetts Institute of Technology and was graduated from there in 1903 with a Bachelor of Science degree. Since then, he has received honorary doctoral degrees from six universities and technical institutions.

Besides his work as an educator, Dr. Potter has served the United States government almost continuously since 1936. He is a member and past officer of several organizations devoted to engineering and engineering education, and has twice been honored for his outstanding service in these two fields.

Even with this long list of achievements to his credit, however, Dr. Potter's main interest seems to be in the young engineers trained by the institutions he has served. In talking about an engineering education for today, Dr. Potter indicated his preference of a general program over a more specialized one. Although he disagrees with the idea that today's engineering education might become tomorrow's liberal arts, he does believe that the great demand for engineers prevalent in industry today is partially due to the broad training program given to engineering students. To emphasize his point, Dr. Potter cited several instances in which some of his most outstanding students turned up in later years doing something entirely unrelated to engineering. He particularly delighted in recalling two cases in which engineering students became ministers, and one where the engineer became a priest.

About the college of engineering here at Michigan State, Dr. Potter felt it to be a very good and improving department. He especially lauded the faculty for its excellence, and said he thought that the teaching staff here is among the finest in the country.

Part of that excellence, we believe, has been due to Dr. Potter's presence here at Michigan State College. Throughout his stay in East Lansing, he has met several times with the engineering faculty and staff, and has talked to a few of the student organizations. All concerned, we also feel certain, have been left with the same feeling: that however long Dr. Potter remains here, it will be a short-lived visit.

A challenge to leaders

by: John Rood, E. E. '55

The Tau Beta Pi Fall Initiation Prize Winning Essay

A growing and expanding body of professional men requires great leadership and foresight. Engineering is a rapidly growing and expanding profession. Much fine leadership has been, and is now promoting and developing the interests of professional engineers. In the future, this growing field will need new leaders, have new goals, and maintain still higher standards of achievement. Today's engineering students have a responsibility to their chosen profession. Their responsibility lies in developing their own skills and attitudes along lines which will strengthen and promote their profession.

I think it is appropriate to ask, what are the features of preparation which are most important in molding an engineer who will make a significant contribution to the engineering profession? In other words, what is the best way to prepare engineering students for responsible positions of leadership in their profession?

Probably the first aspect of engineering training is the technical skill and knowledge which must be mastered by the student engineer. Great strides have been made toward developing, not only highly technical specialists, but men who also possess a general understanding of basic engineering problems and practices in all branches of the profession. For instance, knowledge of the principles of statics, dynamics, strength of materials, surveying, chemistry, electric circuits and machinery, thermodynamics, machine shop and factory operation and drafting is an essential part in the training of any engineer. These subjects, representing the major branches of engineering, are a common denominator to engineers and are equally as important as the specialization which is promoted by individual departments. The need for specialized men who have an understanding of fundamental engineering practices has been foreseen and has received much attention in the engineering colleges. In addition to technical preparation for the engineering profession, I feel that there is another important aspect of preparation for leadership in the engineering profession which should receive attention in engineering colleges. Perhaps a definition would be an appropriate way to introduce the line of thought which I wish to develop.

PROFESSIONAL:

> Pertaining to a calling or occupation requiring a superior education.

It seems to me that a superior education should not stop with the attainment of technical excellence. Some basic principles of human interaction need to be understood in order that professional leaders will have a common knowledge of human relationships, just as engineers have a common knowledge of basic engineering practices.

Men who have a common ground of understanding can communicate ideas and developments which stem from this common understanding. Thus the exchange of successful techniques will tend to improve the quality of the leadership which these men can impart to their profession. An understanding of man and his relationship to his social and physical environment is essential to a leader of any profession. The following quotation from the Michigan State College catalogue describes a line of study which I think might provide some of this fundamental knowledge of man.

> **The sources for this study of man are drawn primarily from the fields of history, philosophy, religion, literature, and the arts.**
>
> **. . . the course endeavors to enlarge and to enrich the student's comprehension of his historical heritage, to deepen the degree of his intellectual maturity, to enhance his sensitivity to humane values in all fields of man's thought and endeavor, to elevate his ethical outlook, and to make him intelligently aware of his own worth and dignity, his obligations and responsibilities, as an individual human being.**

also

> **An effort is made to bring to the student more awareness of his role in social change in order that he may participate more effectively.**

The engineering profession needs leaders who are well equipped with the tools of human interaction; men who hold in common a knowledge of human relationships. These are the men who can give stable, sagacious leadership to a profession which is steadily growing in importance to our present day culture. Men who can understand and enjoy the beauty of human relationships as well as the beauty of physical achievement, will be the leaders of tomorrow's great body of professional engineers. This is the challenge to engineering students and thir educators.

Creep in metals

by: Zigurds J. Levensteins, M. E. '54

Creep is a continuous, time dependent deformation of a material subjected to stress. Although the phenomenon of creep was known already by the ancients in observing the stretch of the unsupported lead pipes, it was not until the beginning of the Twentieth Century that creep attracted scientific investigation. The early workers in this field were Phillips who made observations with rubber, glass, and metal wires, and Andrade who studied the stretch of metal wires made of different pure metals.

At that time it was thought that creep occurs only in soft metals, the hard ones, mainly steel, being free from it. For this reason it was neglected by engineers. However, the results published in 1922 from investigations by Dickenson showed that steel when subjected to stress for a long period of time, especially at elevated temperatures, fails by rupture at a much lower stress value than in a short-time tensile test at the same temperature.

The increasing amount of applications of materials at high operating temperatures, for instance the development of the gas turbine, has made the creep phenomena extremely important to the design engineer. Therefore, much effort has been made in the last twenty-five years to study the properties of different alloys with respect to their creep resistance. The best proof of success in this work is the jet engine, which would not be possible without good creep resistant materials. The largest part of the work of investigation has been in the practical field—development of new creep resistant alloys and determination of their properties, while the purely theoretical investigation in the mechanism by which this type of plastic deformation occurs has been lagging.

Characteristic Creep Curves

The great number of creep tests conducted has established the fact that the creep deformation is a function of time, stress, temperature, and material under test. If tests are conducted at constant load and constant temperature on various simple alloys, then the data when graphed will give curves that all have certain features in common. An idealized curve is shown in Figure 1.

Such a curve can be divided in four parts: an initial extension, a decelerating creep rate stage, generally called primary creep, an approximately constant creep rate stage called secondary creep and a stage with accelerating creep rate, leading to fracture called tertiary creep.

The duration of each stage is varied considerably as either the stress or the temperature is changed. This is well illustrated in the graphs shown in Figure 2.

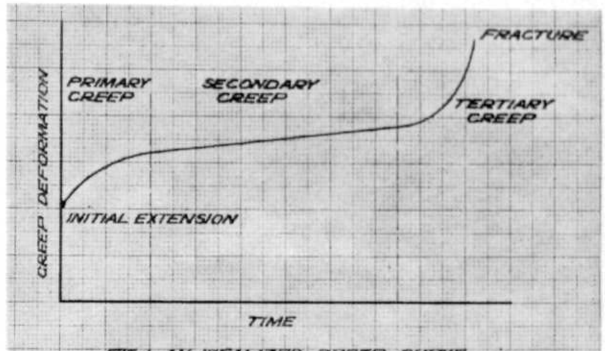


FIG. 1 AN IDEALIZED CREEP CURVE

This also very well brings out the great dependence the creep deformation has on stress and temperature. At low stresses and low temperatures secondary creep plays the most important part, while at high stresses and high temperatures the creep curve practically consists only of the primary and the tertiary stages.

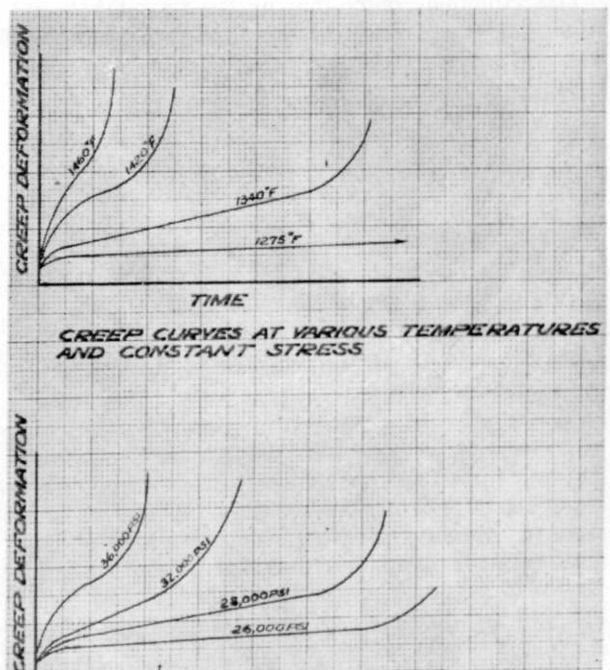


FIG. 2

Already the early investigators of creep at the beginning of this century observed that the creep deformation consists of an initial extension followed by a continuous stretch of decreasing rate. The first systematic and thorough investigation of creep of different metals and alloys over a range of stresses and temperatures was made by Andrade. The results were published in 1910 and 1914. Andrade worked with various pure metals of different atomic space lattice types. From the great number of creep curves of pure metals he found that irrespective of their crystal structure the relationship of the variables within the investigated range could be expressed in a formula:

$$l = l_o \left(1 + \beta t^{\frac{1}{3}}\right) e^{kt}$$

lo, B and k are constants, lo being the length of the specimen immediately after loading, t is duration of stress.

Andrade also showed that this empirical relationship is due to two different types of flows occurring simultaneously in the material undergoing creep. One type is connected with the constant B. Considering the case when k = o, the equation becomes:

$$l = l_o \left(1 + \beta t^{\frac{1}{3}}\right)$$

The rate of creep is:

$$\frac{dl}{dt} = \frac{1}{3} l_o \beta \frac{1}{t^{\frac{2}{3}}}$$

This equation shows that as the time t becomes large, the creep rate decreases and eventually vanishes. This type of creep is called the transient creep.

The other type of creep is connected with the constant k. If B = o then:

$$l = l_o e^{kt}$$

The creep rate is:

$$\frac{dl}{dt} = k l_o e^{kt} = kl$$

The length l can be considered approximately constant, since the extension is very small relative to the length of the specimen. Therefore, the creep rate can also be considered approximately constant. Andrade calls this type of flow viscous creep. However, the term is misleading since the viscous creep does not conform with the Newtonian viscosity that the flow is proportional to the stress. Andrade's results shown in Figure 3 prove this.

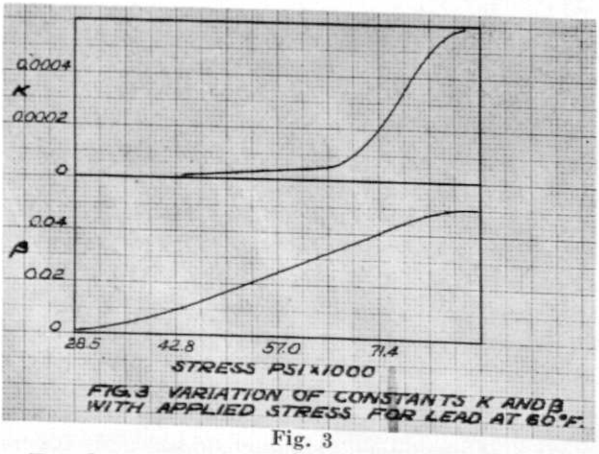
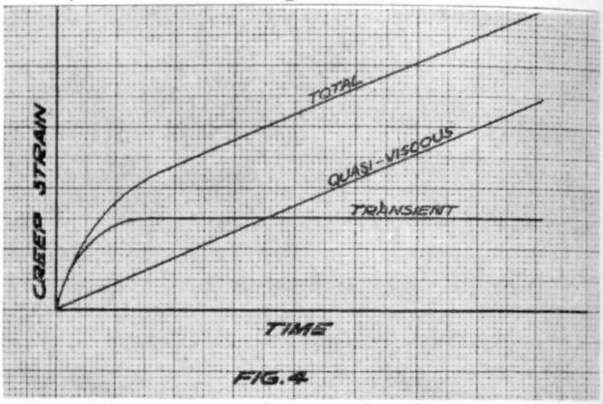


Fig. 3

For this reason the more proper term for viscous creep is quasi viscous creep, which is now generally used.

Figure 4 shows that the two creep components add up to the usual creep curve.



From Figure 3 it can be seen that the flow associated with the constant B or transient creep is more important at low stresses than at high. On the other hand, at high stresses the quasi viscous flow becomes the dominant one. Andrade has shown that the same is true for temperatures; transient creep is more important at low temperatures, quasi viscous creep at high temperatures.

Other investigations made by Dushman, Dunbar and Huthsteiner in the 1940's have shown that the relation between the creep rate u applied stress o and absolute temperature T is following:

$$\ln\left(\frac{u}{T}\right) = -\frac{a}{T} - b + \gamma\sigma$$

a and b are constants and y is a function of temperature, but not of stress. At constant temperature the equation becomes:

$$u = Ce^{\gamma\sigma}$$

C is a constant, and y is also a constant since the temperature is constant.

This relationship is quite similar to that developed by Andrade some thirty years earlier. It indicates that Andrade's early findings and conclusions were true.

At constant temperature, therefore, the logarithm of the creep rate is proportional to the stress, if the creep rate is measured in the quasi viscous stage of creep. This relationship is commonly used in interpreting the creep test data.

Characteristics of Creep Deformation

Much work has been done in recent years by creep investigators in trying to establish the mechanism by which the creep deformation comes about. A great deal of knowledge and understanding has been gained in the transient creep phenomena, less is known about the quasi viscous stage and very little about the accelerating tertiary creep.

Dislocation Theory

If the metal crystals had perfect atomic space lattice, the metals would be 1,000 to 10,000 times stronger than they actually are. The great theoretical strength is due to the fact that slip can only occur if the forces of all the atoms in the slip plane are overcome at once. The theory of dislocation, which at present time is well accepted, suggests that only a few atomic forces are overcome at a time due to lattice imperfections. A dislocation is a defect in the periodicty of the atomic lattice. For instance, if there are n atoms in one plane, there are n plus 1 atoms in the adjacent plane. Such a dislocation is called an edge dislocation and it can move by a process with only one atomic movement at a time. The net result of such movement in a crystal up to its boundary will be a shear of one atomic distance. The most important property of a dislocation is that it can be moved by a stress that is much lower than that required to move an atomic plane one atomic distance as a whole.

The existence of dislocations in a metal is inevitable, since all metals are weaker than the theoretical strength. The dislocations originate around crystal boundaries or at points in the crystal where the atomic orientation is slightly different. Other places where dislocations could be produced are foreign inclusions and particles of precipitate.

Figure 5 shows a simple representation of edge dislocations. The atomic planes are running perpendicular to the paper. (a) is thought of as a positive dislocation, the compressed region with one more atomic plane being above the expanded region with one less. (b) is the inverse of (a) and is called a negative dislocation. It is thought that positive and negative dislocations are produced in approximately equal numbers. Each dislocation is surrounded by a region of localized strain and atoms in this region are subject to internal stresses. The stressed regions exert force on each other, the force being attractive in case of dissimilar dislocations and repulsive in case of similar. Thus, the dislocations are kept in equilibrium by their mutual forces of attraction and repulsion.

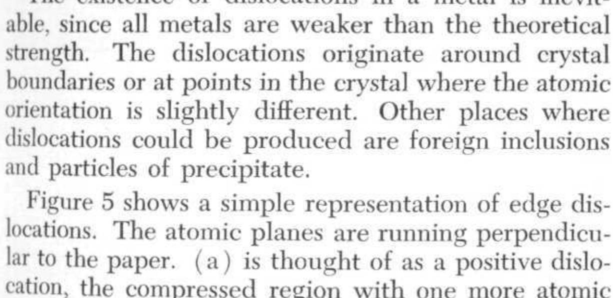


FIG. 5 POSITIVE AND NEGATIVE EDGE DISLOCATIONS

A dislocation would move upon reception of sufficient activation energy that would enable it to surmount the adjacent potential energy barrier. There is always a finite probability that a dislocation may receive sufficient energy from thermal fluctuations. It has been shown that the probability varies with the absolute temperature T and the activation energy

$$\phi \text{ AS } e^{-\phi/kT}$$

where k is the Boltzmann constant. Thus the probability increases exponentially with temperature.

An applied stress in effect reduces the potential barrier and if sufficiently, increases the probability of activating a dislocation to a point where it occurs with such a frequency as to produce slip in the crystal.

It has been proven that dislocation can move through the crystal lattice with a velocity that is approximately the velocity of sound in the crystal. Also that the dislocations can be reflected at obstructions. Thus the same dislocation can traverse the crystal many times, each time producing a slip of one atomic distance.

The dislocation theory has been applied quite successfully to explanation of creep phenomena.

Dislocation Theory Applied to Transient Creep

For the transient stage of creep several investigators by making reasonable assumptions have worked out equations that take into account the stress and temperature dependence of creep and agree well with the empirical relations that Andrade arrived at in his earlier considerations taken from experimental data. In transient creep the dislocations that were in the metal before loading move under the applied stress. Gradual exhaustion of the available dislocations accounts for the decelerating rate of deformation in the transient stage.

Dislocation Theory Applied to Quasi Viscous Creep

The theoretical treatment of the quasi viscous or constant rate creep stage is not nearly as well established as that of the transient stage. It was thought that the amorphous grain boundary is responsible for the quasi viscous stage of creep. Experiments and theoretical considerations show that the grain boundaries exhibit true viscous flow, but it was proven that the deformation possible by such flow is very small before interlocking of grains would occur which would prevent any further deformation.

At present time the quasi viscous creep is also explained by the dislocation theory. During this stage new dislocations are generated and the process is thought of as a rate process. It is explained as an equilibrium condition where the rate of generation of dislocations is equal to the rate of exhaustion. Thus the deformation is not governed by the rate of movement, but by rate of formation of dislocations.

However, there are still many phenomena in the constant rate stage that are observed experimentally, but have not been accounted for theoretically. For instance, why at high temperatures much localized deformation occurs in the grain boundaries while at low temperatures the deformation is primarily within the crystal.

Tertiary Creep

Little is known about the last stage of creep deformation. Some workers have expressed the thought that the accelerating stage is not a true creep phenomenon at all, but is simply a result of stress intensification due to reduction of cross sectional area. In cases where fracture is preceded by necking of the specimen, this may seem so. Also in cases where there is no apparent necking, the microphotographs taken from specimens in this stage show that there are many intergranular voids in the metal that would

Continued on page 52

75 Years of electric railroadin'

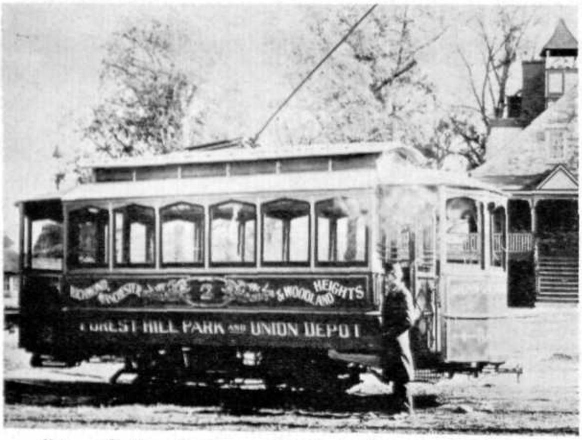
Although transportation people tend to think of the electrical way as being the modern way, it actually dates back three-quarters of a century.

The G-E heritage in land transportation, however, dates back to 1880. In that year, Thomas Edison, aided by many of the same people who helped him bring light to darkened homes and cities, built and operated his first experimental electric locomotive. Two years later, his second electric locomotive sped down Menlo Park's tracks at the amazing "speed" of forty miles an hour.

Early History

From this early beginning the use of electricity to help solve America's transportation problems spread rapidly. By 1887, F. J. Sprague was operating his famous street-car line in Richmond, Virginia . . . the first commercially successful application in the United States. The outstanding contributions of inventor Charles J. Van Depoele also spurred development of these early electric transit vehicles.

PICTURES COURTESY OF GENERAL ELECTRIC



One of the first overhead trolley cars in the United States, which began operation at Richmond, Virginia, in 1887.

By 1900 a great network of city and interurban electric transit systems blanketed the country. For the next 30 years electrically-driven vehicles were the primary method of moving people on city streetcar lines and in subways. Even today, with the millions of privately-owned motor vehicles on city streets and highways, public transit still provides convenient, time-saving transportation at low cost.

Electric Railroadin'

Electricity also went to work on the railroads. In August, 1895, three 96-ton, 360-horsepower, straight-electric locomotives began hauling trains in the Baltimore Tunnel of the Baltimore and Ohio Railroad. Their application marked the beginning of heavy railroad electrification in the United States.

Several decades after the building of the first electric locomotives, electricity joined hands with the diesel engine. The first practical diesel-electric locomotive was placed in service December 17, 1924 by the Central Railroad of New Jersey at Bronx Terminal.

Today, straight-electric locomotives operate over electrified systems totaling 2600 route-miles on 17 Class I railroads in the United States. Diesel-electric locomotives have become so popular during the past decade that they are making the steam locomotive virtually extinct. During the 12 months ending November 1, 1952, the American railroads removed 5,742 steam locomotives from their inventory and replaced them with 2,425 diesel electrics. In 1952, diesel electrics also outranked steam by performing two-thirds of the gross-ton miles . . . over 70 percent of passenger car-miles . . . over 75 percent of switching locomotive-hours.

The Electric Way Invades Industry

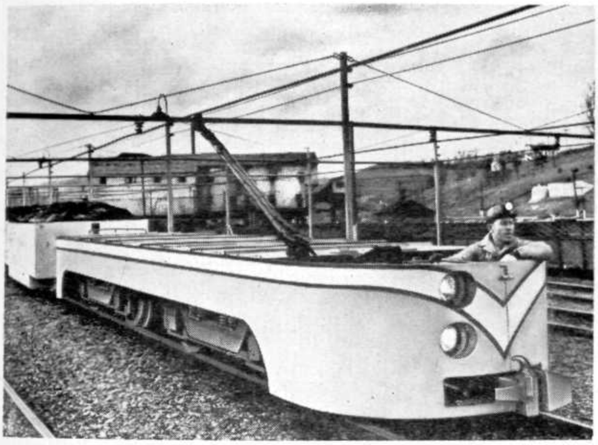
It was only natural that electricity should find its way into the transportation equipment of other industries. In 1887 the Lykens Valley Colliery of the Pennsylvania Railroad produced the first mine locomotive. An Edison 40-horsepower, body-mounted motor was connected to the drive wheels by chain and sprocket drive. The frame was of heavy wooden timbers, and a metal brush bearing on the rail completed the circuit from the trolley wire through the motor to the grounded rail return.

The third mine locomotive, which was built in 1891 and called "Terrapin Back," was constructed with cast-iron side and end frames and was driven by a bi-polar motor with side rod connections. In 1892 the General Electric Company announced its factory line ranging in sizes from 1¾ tons to 11 tons, equipped with motor capacities ranging from 15 horsepower to 150 horsepower, and speeds ranging from 6 to 10 miles per hour.

Modern mine locomotives vary in size from 4 to 40 tons, with speeds ranging from 6 to 35 mph. They have played an important part in lightening the miners' burden and in replacing mules in the mine. They have helped get out coal and other mineral deposits with greater speed, economy and safety, and have been instrumental in the mining industry's success in keeping pace with the great American industrial expansion of the past half century.

A Modern Industrial Revolution

While electricity was successfully put to work underground in the mine, it also worked above ground in locomotives for industry. At the same time that mine locomotives began to appear, factory locomotives (as they were then called) were being built. They were plain electrics, but destiny had them slated as fore-runners of a great revolution in American industry.



A modern high-speed, 30-ton mine locomotive hauls loaded coal cars from gathering tracks to coal tipple economically, quickly, and with a high degree of safety.

In the 1920's, successful switching locomotives were built primarily for railroad work. They used diesel engines of the high continuous duty type operating in the 500 to 1000-rpm speed range. Such locomotives were heavy and expensive, and could only be economically justified in service where the load factor was high. Industrial switching, with its usual low load factor and often low utilization, was no place for them.

In the latter half of the 1930's engine builders achieved quantity production of low-cost, high-speed automotive diesels. These quickly proved successful in the automotive field. Simultaneously, low-cost, high-speed electric drives were developed for the larger sizes of these new engines.

Here were the two components long awaited by locomotive designers. When the two were combined and applied to an industrial switching locomotive, the revolution began. More than 2000 G-E industrial diesel-electric switchers have been placed in service since 1937 and have enabled industrial plants to do a better switching job at less cost.

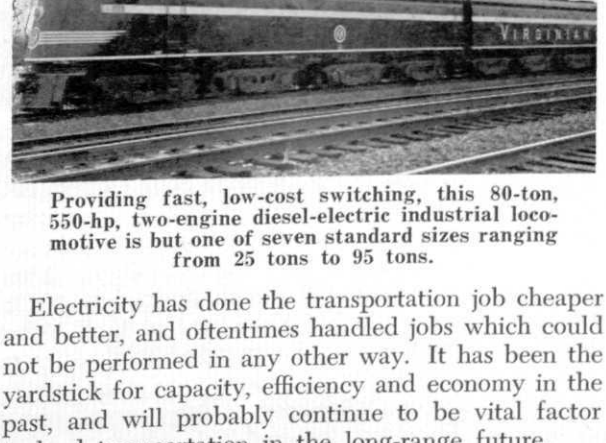
The Years Ahead

In 1948, electricity was again harnessed to a new prime mover . . . the gas turbine. Result was the first gas turbine electric locomotive in America. Although this type is still considered to be in the developmental stage, orders have been placed for 25 locomotives. Six are now in operation on the Union Pacific Railroad.

After more than half a century, the electric locomotive is still prominent in modern railroading. Ten rectifier-type locomotives were ordered in 1952 by the New York, New Haven and Hartford Railroad. This will be the largest application of rectifier locomotives in this country. The electric equipment on this locomotive converts alternating current from the overhead wire into direct current for driving the traction motors on the locomotive's axles. Rectifier tubes are the heart of this conversion system.

Built to do a railroad's toughest jobs, this present-day 500-ton, 11,000-volt electric locomotive was constructed for heavy mountain freight haulage.

The past 75 years have seen electricity applied to most types of motive power and numerous other equipments for land transportation. Modern locomotives . . . whether they be diesel-electric, straight-electric, or gas-turbine electric . . . differ principally in the manner by which electric power is furnished to the driving motors. The final drive is electric, thus all might be considered electric locomotives. Experts believe that even the application of atomic power to railroading will resolve itself into converting that power into electricity which can then be used to drive the locomotive.



Providing fast, low-cost switching, this 80-ton, 550-hp, two-engine diesel-electric industrial locomotive is but one of seven standard sizes ranging from 25 tons to 95 tons.

Electricity has done the transportation job cheaper and better, and oftentimes handled jobs which could not be performed in any other way. It has been the yardstick for capacity, efficiency and economy in the past, and will probably continue to be vital factor in land transportation in the long-range future.

AN INTERVIEW

Dr. R. A. Smith

by: Albert Sommers, Geology '54

In an interview with Dr. R. A. Smith, the former State Geologist and Chief of the Geological Survey Service, he was asked three questions:

1. **How did you happen to choose geology as your career?**
2. **What were some of your more interesting experiences as a geologist? (Dr. Smith confined his experiences to the oil phase of geology as the outstanding experiences of his nearly forty years as a geologist. His experiences would fill a volume.)**
3. **What advice would you give a young person?**

Dr. Smith started out to be an accountant (that was the vogue of that time) and graduated from Lansing Business University in 1893. But those were hard times and the depression of '93 was in full swing. After graduation he almost took a job as a bookkeeper at eight dollars a week.

Instead, he obtained a third grade teachers certificate and taught school for four years near Lansing.

At the end of these four years, Dr. Smith went to State Normal College to study more for a higher position in the school system. Among the courses there that he took were physiography and meteorology. These two interested him very much.

At the end of his stay at State Normal, he obtained the job as School Superintendent at Palmer in the U.P. At Palmer, he was in mining country and there he started to collect rocks and minerals. Two years later, he went to the town of Quinisic. A short time after his arrival at Quinisic, the town burned down and Dr. Smith decided to go down to the University of Michigan and do some more studying.

There he took up physiography and became interested in geology. Later he decided to become a geology professor.

At this time, R. C. Allen was one of his professors. When Smith was in his senior year, R. C. Allen became the State Geologist and gave many lectures to the students upon geology.

After graduation, Dr. Smith (then Mr. Smith) obtained a position at Pennsylvania State College but was forced to resign because of lack of knowledge on certain phases of minerology. He enrolled in the University of Michigan for advanced studies. After some advanced work, Dr. Smith decided to go to Wisconsin as a geologist. Knowing that R. G. Allen was from Wisconsin, Dr. Smith asked R. C. Allen to write up to Wisconsin and use his influence for the obtaining of a job. Allen agreed. After several weeks of no reply, Dr. Smith cornered R. C. Allen and asked him if he had written the letter. The reply was this, "No, Smitty, couldn't do it, wanted you myself."

Thus R. A. Smith became the Assistant State Geologist in 1911. Allen's main interest was in iron and copper, and it fell to R. A. Smith's lot to take care of the other thirty-five minerals of the State of Michigan. In his own words, Dr. Smith said, "I didn't know enough about them to write a fly leaf for an almanac." This started some more intensive study.

Allen's opinion was that the Service was a public service. Much of this was caused by the fact that many of the geologic reports were written up in such technical form that only professors could understand it. Allen wanted the professors to do the research and then have the Geological Survey Service write up the report so that Johnny Q. Public would be able to comprehend it.

The State Tax Commission, about this time was attempting to appraise the mines. Although the appraisers were learned and skilled geologists, they weren't able to place a value upon the mines, according to Michigan Law. R. C. Allen was asked how much he thought it would cost to have the Geological Survey appraise the mines. Allen guessed about ten thousand dollars per year. The Tax Commission was stunned. It had cost them forty thousand and thirty thousand in the two previous years.

The Service had a lot of trouble with real estate agencies selling land to shop men for chicken farms. The soil was only sand, and the public was being gypped. It was said of the land that one couldn't raise a tail feather on it. There was much good land that these ten could have had for just a little more.

A bill was put through to organize a Soil and Economic Survey to make an inventory of all the natural resources, especially to soils and their uses. The governor failed to validate the appropriation. However, in about 1920, the Land Economic Survey was organized for the analysis of the soil and mineral wealth. This was a cooperative effort between M.S.C., U. of M., Department of Agriculture and the State Geological Survey. It was a job well done by all parties concerned.

Dr. Smith's first job was to go over to Port Huron in 1911 and inspect some oil wells. There he found twenty-one wells on some twenty acres. These were the first wells he had ever seen and were owned by a grease making firm. The wells were small producers, and Dr. Smith was of the opinion that Michigan should have some big oil fields such as Canada across the river and Ohio across the line. After all, rivers and political boundaries don't stop a geologic structure.

In 1912, he started a report, it was the first little monograph of the oil possibilities of Michigan.

Five wealthy men came down from Saginaw. They knew that the timber and milling industries were exhausted around the Saginaw valley and something else had to be found or Saginaw would become decadent. They had heard that Saginaw had favorable conditions for gas and oil. Dr. Smith confirmed what they had heard and showed them a good spot to drill. They wanted two wells into a "salt sand" and another just as deep as they could drill.

In the Spring of 1913, Dr. Smith went to the Upper Peninsula to check on some high grade limestone that wasn't supposed to be there but was. On the way back, he stopped in Saginaw to see about the well. He was told the well was dry. One can further understand his surprise when he was told that they would drill the next well at the place he had indicated. It turned out that the well had been sunk seven miles down the river from his indicated spot because one of the backers wouldn't invest any money unless the well was drilled on his land.

A well was sunk at Dr. Smith's location and gas was struck in the Berea formation. Some gas and oil was obtained and farther down in the Traverse and oil under high gas pressure was struck farther below. The well started out with two flows totaling about 85 barrels. With a pump it went down to about five barrels a day. The pay formation was only one foot thick and R. A. Smith thought the well as an "edge well." That is, a well near the edge of the formation.

The Saginaw men decided they would triangulate. Another well was drilled nine miles to the northwest of town. This was about as foolish as drilling a well seven miles too far to the south. The well was dry. Another well was to the northeast of Saginaw. Gas and traces of oil were found. They also tried another well to the north of Saginaw. They were only two blocks off the formation. Another well was drilled to the south of town. It also was dry and the would-be oil tycoons gave up after drilling 12 wells.

One of the "tooleys" on the Saginaw venture went out west and became an oil promoter. He made a lot of money and stopped after his first million was made. Later in Florida, this promoter met some of this Saginaw group. They wanted him to come back and reopen the Saginaw project. He refused but said he would put up as much money as any other one of the men.

They located the well by an oil locater. This oil locating man had discovered that the eminations from the oil affected him. He brought in a twenty-five barrel well. This brought in the whole field, which went far into downtown Saginaw. Many bought up city lots and started "lot drilling." The only thing wrong was that "lot drilling" isn't even good over a good oil pool. The pay sand here was thin, tight and "broken" and in almost all the cases didn't pay It was reported that only one man made any money on this field. Many lost because of overdrilling on too small of land tracts.

The next oil pool was the Muskegon field. A tailor by name of Stanley Daniloff became interested in oil. Well logs of many wells drilled for oil, gas, and brine were checked, and the region around. Muskegon was shown to be favorable for oil and gas production. Stanley went off to Illinois to get some money off his friends. Dr. Smith advised Stanley Daniloff to drill north of the river, but the oil locator of Saginaw fame told Mr. Daniloff to drill south of the river. The well south of the river was dry. The next well was drilled to the north of the river and a well of 320 barrels natural was brought in. This turned out to be worse than Saginaw. Lots sold for up to $2500 apiece. Lot drilling was practiced and the field was butchered. There was lots of gas and it was though that the gas had to be blown off to get the oil. It is a known fact that the gas must be utilized to bring up the oil and that it can and is used many times over.

"There was so much gas in the air that I complained to Governor Green," said Dr. Smith. "He said to go up these and scare them." Dr. Smith tried but they had an injunction put up against the State. R. A. Smith didn't dare go near Muskegon for a while. They only replied by turning on the gas to wide open and within forty-eight hours they were pumping water. Needless to say, they went running to Dr. Smith.

One gas well ran a test of 21,000,000 cubic feet of gas a day on a small acreage.

One day the Studebaker plant called up the office and wanted to know if a gas line could be laid easily to Muskegon. Dr. Smith replied yes and asked why. Studebaker replied that one producer had guaranteed them 5,000,000 cubic feet a day. Dr. Smith asked the name of the producer. He was told and replied that the well would probably last for two or three weeks. No pipe line was laid.

The house committee then had passed a bill so that they couldn't waste so mch gas. They couldn't drill within 200 feet of a property line except where the lot would permit. Said Dr. Smith, "The Muskegon was certainly a field that was badly messed up.

"About this time the geologists of Pure Oil Company came to me. They were only interested in oil reserves and I gave them the potential spots. I told them the Dow Chemical salt well logs would furnish much if one could see them. Sometime later, a young geologist came in with the logs and the engineers maps." This amazed Dr. Smith because he was not allowed to utilize them. The young geologist had gotten them through the influence of his superiors.

"He was excited because he realized he had handed to him some oil structures," said R. A. Smith with his eyes beaming happily.

The structures were drawn up from the Dow Maps and the first well was put down by Pure Oil. It was a sixty-five barreler. This was to become the Mt. Pleasant field. Pure Oil were good operators, one well to every ten acres. This caused the others to follow suit. The Mt. Pleasant field has produced

Continued on page 54

High Voltage electric

Power Transmission

by: Philip Sporn and A. C. Monteith

Reprinted from AIEE BULLETIN, Tidd 500 Kv Test Project

Much interest is being shown in the high-voltage investigation project now being carried out on the American Gas and Electric Company system near the Tidd station of The Ohio Power Company at Brilliant, Ohio. This symposium has been arranged to present the thinking that led to it and the program itself, so that as the results of the investigation become available they can be interpreted intelligently by all those interested, and also the extent of completion of original objectives determined.

The first logical question is: Why any tests? Other questions are: What tests are contemplated, and how are they to be conducted? What are the design characteristics of the equipment to be tested and of the equipment used for carrying out the testing program?

This paper will attempt to answer the first question; the others will be discussed in companion papers.

Reason for Investigation

Past experience in the development of power systems and their concomitant transmission lines and analytical examination of the economic considerations of the transmission of increasingly larger blocks of power indicate the desirability in some cases of going to higher voltages than have been used heretofore. However, the cost of building a transmission system—line and its related terminal equipment—increases rapidly with increasing voltage. The use of increased voltages requires effectively larger conductors, larger towers, higher insulation levels, and more expensive terminal equipment. With these costs increasing very rapidly with higher voltage, it becomes increasingly important to design the system so that the maximum use is made of the capabilities of the equipment. This is another way of saying that as voltage increases it becomes more than ever necessary to design for the very minimum proper margins of safety. But before this can be done for extra high voltages—before systems can be designed with close margins, yet without sacrificing the requirements of reliability—engineers need more information than is now available.

The projection of higher voltage transmission is not only beginning to be a pressing problem in planning of electric power systems, but the problem is beginning to assume more or less universal proportions. The United States, and as a matter of fact all the countries of the world possessing or aiming to develop industrial potential, is witnessing the greatest expansion in the use of electricity that ever has taken place, and, if present predictions materialize, this expansion will continue for some time. This, of necessity, involves expansion of transmission facilities. The justification for transmission and the distances involved vary in different sections of the United States and in the different countries. It is, however, quite apparent that in some localities, where fuel is scarce and remote undeveloped hydro energy plentiful, long-distance transmission will be used. Also, it is quite apparent that there are systems in the United States where transfer of much larger blocks of power than any heretofore involved will be required, both for base load and for co-ordination of large integrated systems and for interchange between them and contiguous systems.

In the United States a transmission system of 287 kv rated, 302 kv maximum, is in use and there has been some discussion of the use of a transmission voltage of approximately 345 kv rated, 362 kv maximum. On the American Gas and Electric Central System, the need for higher voltage transmission facilities than the existing 132-kv backbone transmission has been accelerated by the unprecedented war and postwar growth in load. The French have built some double-circuit 220-kv lines, which may be converted later to a single circuit with bundle conductor to operate at approximately 385 kv. China has discussed the use of 345-kv transmission and Sweden now is considering a nominal 350-kv, maximum continuous operating voltage 380-kv development to transmit power from their abundant water supply to their industrial center some 600 miles away. With this pressing interest in high-voltage transmission, it is logical to review its status and see what factors need further study to secure the most economical line design in the light of present-day knowledge and practice. All this has prompted a close study of this field, and this has resulted in the investigation program being carried out at the Tidd station of the American Gas and Electric Company.

Numerous factors have to be evaluated before reaching a decision to use a particular high voltage and before the details of the design that will be used can be fixed. The selection usually involves a study of anticipated loading conditions for the degree of reliability necessary for the project. From a consideration of load, distance, reliability desired, and other influencing factors, the voltage level, number of circuits, and circuit arrangement can be determined. All of these will affect the economics of the project, but the one single factor that perhaps will affect the economics to the greatest degree is the insulation level adopted for terminal equipment and the insulation level and spacing for the line. These levels naturally will be influenced by the type of grounding adopted for the system. It has been the practice in some cases on lower voltage systems to operate lines with ground fault neutralizers. It is the opinion of the authors, however, that in the case of extra high voltage transmission, above 230 kv, the lines ought to be grounded permanently and solidly at all transformation points, which will permit the use of reduced-voltage arresters. Coupled with the use of interrupting devices, which will open the circut with not more than a single restrike, this solid grounding of the system will limit the magnitude of voltage in switching transients to which line and equipment will be subjected, and will permit the use of insulation of a lower level than that thought possible in any previous consideration of the problem.

TABLE I.

Comparative Insulation Characteristics of Steel Tower Transmission Lines in the United States.

Kv Class	Number of Insulators*	Minimum Impulse Level, Kv, 1½x40 Wave*	60-Cycle Dry Flashover, Kv RMS*	Times Normal Line-to-Ground Operating Voltage*
69	(4–8) 5	(475–780) 550	(280–500) 320	(7–12.5) 8
138	(8–12) 10	(780–1100) 940	(500–710) 600	(6.3–8.9) 7.5
230	(14–20) 16	(1270–1770) 1450	(810–1140) 910	(6.1–8.3) 6.8
287	24	2110	1350	8.1

*Range of values is in parentheses. Most common construction is figure following parentheses.

TABLE II.

Comparative Insulation Characteristics of Various Transmission Line Construction Considered in This Paper for Transmission at Extra High Voltages.

No. of Standard Insulators	Actual	Equivalent	Minimum Impulse Level, Kv	60-Cycle Dry Flashover in Kv RMS** Actual	Times Normal Line-to-Ground Operating Voltage, 345 Kv	400 Kv	460 Kv
20	27*	34	1,770	1,140	5.7	4.9	4.3
24	33*	41.5	2,100	1,350	6.8	5.8	5.1
27	38	48	2,380				
30	43	54	2,600	1,700	8.5	7.3	6.4
35	51.5	65	3,100				

All single-circuit flat steel constructions with 1,000 foot spans.

*For certain tower construction and types of conductor, these spacings might be as high as 33 and 37 feet, respectively.

**Wet values will be approximately 70 per cent of these ratios.

Of the many factors influencing the design of a high-voltage line, some are well understood and others require more investigation. Reliable information is available on lightning surges, switching surges, and line reactance and capacitance, but insulation levels, as pointed out before, need to be considered thoroughly. Much information is needed on corona and radio influence, and how they are affected by size and type of conductor, spacing and height of ground wire, and atmospheric conditions. It seems appropriate, in this introductory paper to this symposium, to review briefly the known factors in line design and by the process of elimination develop in a little greater detail the significance of the elaborate set of tests now in progress. The following is, therefore, a discussion of the significant factors, their economic significance, and a summary of where additional information is required for use in future designs of extra high voltage transmission lines to secure a well balanced design with all factors engineered to the best of our ability.

To make some specific comparisons for extra high voltages, three voltage levels are used, namely, 345, 402, and 460 kv. Table I gives typical insulation characteristics of higher voltage steel tower lines used in the United States. Table II gives comparative insulator characteristics for various lines over the range of extra high voltage transmission.

Lightning Performance

For the voltage classes so far used in the United States, lightning protection has been the primary consideration in the choice of transmission line insulation levels. However, sufficient knowledge and experience with lightning and lightning protection now has been gained to show that there is a definite upper limit of insulation required for lightning protection, which already has been exceeded by numerous higher voltage lines in use today. Normal steel construction with spans of the order of 1,000 feet or less and effective tower-footing resistances of 20 ohms or less should experience substantially no flashovers from direct strokes when the phase wires are shielded by overhead ground wires and the equivalent of 16 or more standard suspension insulators are used.

However, the principal source for the higher surge voltages that can appear at the terminals of a highly insulated line is thought to be strokes that actually contact the phase wires through lack of complete shielding. Both theoretical considerations and model studies show that, although the frequency of direct strokes to phase conductors can be made quite small at shielding angles of 25 to 30 degrees, it cannot be eliminated entirely with only one or two overhead ground wires. The model studies indicate that with a shielding angle of 25 degrees on a conventional 2-ground-wire 230-kv steel line about one out of every 900 strokes might contact a phase conductor. The rate of decrease with decreasing shielding angle below 25 degrees is quite low.

Further verification of the foregoing viewpoint is provided by actual experience on several of the higher voltage lines. Excellent data of this type are provided by the detailed studies of the Pennsylvania Water and Power Company in which records of all strokes to their lines are being obtained with magnetic surge crest ammeter links correlated with a careful inspection program. On the 220-kv lines three flashovers have occurred, two from lack of shielding and one at a tower having a tower-footing resistance of about 60 ohms. The data on the 230-kv lines show that even with two overhead ground wires providing a shielding angle of 20 to 25 degrees, about one stroke in 700 mile-years of operation may be expected to contact a phase wire directly. The average stroke density of these lines which lies in isokeraunic levels ranging from 25 to 40 storm days per year, has been found to be about 100 strokes per 100 miles per year. This indicates that about one out of every 700 direct strokes will contact a phase conductor which agrees quite well with the model tests.

Calculations have been made of the probability of a given crest surge voltage appearing at a substation connected to well-constructed high-voltage lines with various amounts of line insulation. These are based upon our present knowledge of the magnitude and wave shape of lightning stroke current and the assumption of 100 strokes per 100 miles of line per year. They take into account voltages that might be induced by indirect strokes, by strokes contacting the ground wire, and by strokes that contact a phase conductor.

Insulation Co-ordination

It is of interest to consider the probability of experiencing a surge in the station in excess of the strength of the apparatus. Values derived from present standards, are

Operating Voltage, Kv	Basic Impulse Level, Kv
230	1,050
287	1,300
345	1,550

The present standard basic impulse levels are based on system operation with a fully rated lightning arrester. A large number of high-voltage solidly grounded systems are in successful operation with equipment insulation levels one step below standard values. If the extra-high-voltage range is approached on the basis of soliding grounding and the practice of using a reduced voltage rating lightning arrester is followed, then, considering the higher impulse value of equipment dealt with, the successful practice of one lower class insulation is not only sound practice but may be improved upon by further lowering of insulation. This seems entirely practicable for several reasons. By reliance on the solid grounding of the system's transformation point and controlling the voltage, it is believed practicable to use a lightning arrester having a rating of about 75 per cent of normal voltage rating. Also, there do not appear to be any difficulties from an economic standpoint to shield adequately the line immediately adjacent to the substation so that there is practically no probability of ever getting in excess of 5,000 amperes through the lightning arrester. Again, it appears that it will be possible, without appreciably affecting the over-all economics, to resort to the use of diverter wires for a short distance from the terminals to give 100 per cent shilding in this zone. The basic impulse levels are

Operating Voltage, Kv	Basic Impulse Level, Kv
230	950
287	1,050
345	1,200
402	1,400
460	1,550

The authors merely are using these for discussion purposes but they believe that the basic impulse level values ultimately selected can be of this order. The final selection of values, including the selection of the proper steps (involving possibly the elimination of some of the present steps and the addition of other steps), after thorough discussion of all the facts available and the phenomena involved, undoubtedly can be handled best by committees representative of the electrical industry. Such committees are now in existence.

Switching Surges

It is of interest to consider the insulation necessary from a switching surge point of view. Modern high voltage breakers are designed to have not more than one restrike. For this switching operation, the maximum line-to-ground switching surge voltage that should appear at the substation is of the order of 3.0 times normal line-to-ground operating voltage on a solidly grounded system. Only the condition of solid grounding is considered, since it is believed that such high-voltage systems normally will be grounded. Table II shows that 24 insulators for operating voltages up to 460 kv provide a minimum 60-cycle dry flashover ratio of 5.1 or a wet flashover ratio of 3.6, which is considered adequate for these switching conditions.

Effect of Line Construction on Transmission Line Impedance

Shorter insulation strings make possible smaller line spacing, the spacings have, in turn, the beneficial effect of reducing line capacitive and inductive reactance.

Calculations have been made of the relative amounts of power that could be transmitted over a 200-mile line making the arbitrary assumption that stability considerations limit the line reactance angle to 30 degrees. The results of these calculations are presented in Table III. A rather arbitrary conductor size was chosen with two levels of insulation. This table shows that the increased power limit and charging kilo-volt-amperes obtained with the smaller spacing is appreciable. Bundle conductors may offer even greater savings as a result of decrease in line capacitive and inductive reactances.

Corona

The disruptive corona voltage and the corona power loss are very much affected by size of conductor and spacing. The greater the insulation level of the line and the larger the spacing between conductors, the higher will be the disruptive corona voltage and the lower the corona power loss. As far as lightning and switching surges are concerned, 16 insulators with normal spacing for 345 kv would appear adequate. However, an abnormal conductor size might have to be used or else the corona loss would be too high. This may be the factor that would set the lower limit on the dimensions of an extra-high-voltage transmission line. *Since this factor has considerable effect on* the cost of building a line, it deserves critical study.

A review of some of the published information indicates good data on corona losses at the higher corona levels for fair-weather conditions and for the effect of surface conditions, but does not include the effect of ground wires, insulator losses, and tower effects. The practical problem, therefore, is to design the line so that it will work on the flat part of the loss curve for much of the operating time. In the past, it has been the practice to design for a fair-weather corona loss of from one-half to one kilowatt per mile. This may be satisfactory for low-voltage lines, but it would appear economical to allow higher loss on the higher voltage lines if the increased corona did not produce excessive radio influence.

TABLE III.

Economic Benefits of Lower Line Insulation on Reducing Line Reactance and Increasing Line Capacitance on a 200-Mile Circuit

Operating Voltages, Kv	Insulator Units	Spacing, Ft.	v_1, Ohms Per Mi, 25 C	X_1 Ohms Per Mi	X_1', Megohms Per Mi	Power Delivered, Megawatts	Reactive Power Delivered, Megavolt-amperes	Per Cent X_1 Reduction L'd Base	Economic Benefits		
									Reduced Reactance#	Increased Reactive‡	Reduced Line Cost
345 Kv (1.61-in. conductor)	20	33	0.0887	0.789	0.1908	396	48.5	0.80	$ 48,000	$10,000	$480.000
	24	37	0.0887	0.801	0.1940	390	47.2				
400 (2.035-in. conductor)	20	33	0.0577	0.758	0.1838	561	49.2	1.54	$130,000	$21,000	$880.000
	27	39.5	0.0577	0.780	0.1891	545	46.6				
460 (2.5-in. conductor)	24	37	0.047*	0.750*	0.181*	752	55.2	1.14	$129,000	$18,000	$940,000
	30	42	0.047*	0.766*	0.184*	737	52.9				

*Estimated value. †Based on 30-degree angle with $Es = 1.05\ Er$. #Saving on terminal equipment due to reduced reactance. ‡Based on $8.00 per kilovolt-ampere of increased reactive kilovolt-amperes available at receiving end.

Before designing for higher fair-weather corona loss, it appears desirable to secure better data on corona losses under actual line conditions and for changing weather conditions. A few tests show that corona losses may increase under rain conditions to many times the fair-weather losses. Also, the effect of fog, humidity, and many other influencing conditions may effect the allowable corona loss materially. With better data available on these conditions, there will exist more scientific criteria for the design of a line than the fair-weather corona loss now used.

The bundle conductor presents advantages, as far as inductive and capacitive reactance and corona loss are concerned, but it not only presents new mechanical problems but economic questions also. It seems desirable, therefore, to secure more data on this type of conductor to see if it will contribute to a more economical high-voltage system.

Radio influence needs further study. Experience with some high-voltage lines has disclosed some objectionable interference, although these lines were designed to operate at relatively low corona loss level.

Before adopting the practice of decreasing conductor size to allow higher corona losses, it seems desirable to secure better data on several conductor sizes and spacings under actual service conditions, particularly under seasonal weather variations. It was believed, therefore, that tests should be made employing integrating instruments giving high-speed continuous recordings of these data under all weather conditions and involving all of the factors with a carefully co-ordinated study of the radio influence problem.

Effect of Line Insulation and Spacing on Corona Loss

To obtain a basis for discussing the corona loss performance of the various line constructions being considered here, fair-weathered corona loss calculations have been made using Peterson's formula. These are based upon the assumption of a smooth conductor, an altitude of 1,000 feet, a temperature of 25 degrees centigrade, and a surface factor of 0.9, which factor was found by Peterson to be applicable to general operating conditions for type *HH* cable at 220 to 287 kv.

For example, an operating voltage of 345 kv, limiting the corona loss to 0.65 kilowatt per mile, would require about a 1.75-inch diameter conductor for a line with 20 insulators, a 1.6-inch diameter conductor for a line with 24 insulators, and only a 1.45-inch diameter conductor for a line with 30 insulators. If, however, a 1.5-inch diameter conductor were used for all three line designs, the range of power loss would be 0.6 to 0.9 kilowatt per mile.

Briefly summarized, these indicate that with present knowledge, satisfactory operation should be obtained with operating voltages up to 400 kv with transmission line insulation corresponding to 20 insulators. At 460 kv, the minimum number of insulators probably would be 24. A more accurate determination of the best combination of line construction and conductor diameter requires an economic study of the cost of the various combinations, taking into account loss evaluation, but no final conclusions can be drawn until more is known about corona and radio influence. The decision on this point alone might affect the cost of extra-high-voltage transmission very appreciably and justifies more tests to give the line designers better data.

Economic Comparison of Line Construction For an Operating Voltage of 345 Kv

A simple economic review has been made to coordinate the foregoing discussions taking into account the effect of insulation levels on operating performance. The cost of a line varies so with local conditions that it is hard to generalize, but for this purpose $45,000 per mile was used as the cost of a 345-kv line employing 20 insulator units and a 1.75-inch conduc-

(Continued on page 48)

Special instruments measure washo roadtest data

by W. N. Carey, Jr., A.M. ASCE

Project Engineer, Highway Research Board
National Research Council, Washington, D.C.
Reprinted from, "THE CIVIL ENGINEERING MAGAZINE," October 1953

Trucks running day after day on the WASHO road test, near Malad, Idaho, are developing information of great economic value to the nation. It is information which may go far in helping to resolve the basic question in U.S. highway construction—What are the maximum loads on which it is economically feasible to base the design and construction of our roads?

General acceptance of the conclusions which will follow completion of the test is likely to be proportionate to the quality of the test records obtained. Measured facts are strong arguments. This brief description is therefore presented to set forth the WASHO test layout and some details of the instrumentation provided to measure and record the facts as developed. Some of the instruments used to measure primary variables are described; many others are used to measure special phenomena from time to time.

The WASHO test is sponsored by the Western Association of State Highway Officials (WASHO). The Highway Research Board was selected to supervise the construction of the test road and the test itself. The project is designed to answer some of the problems facing highway administrators and the transportation industry. By pooling their support under the direction of this independent institution, whch has no interest in the matter other than the development of facts and the acquisition of new knowledge, the state highway departments, U.S. Bureau of Public Roads, truck and trailer manufacturers and operators, petroleum industry and others, have demonstrated a sincere desire to acquire unbiased information on a problem of great mutual importance.

The Immediate Objective

The immediate objective of the test is to develop information concerning the relative effectiveness of several designs of flexible pavement varying in overall thickness from 6 to 22 in., under repeated applications of 18,000 and 22,400-lb. single-axle loads and 32,000 and 40,000-lb tandem-axle loads.

The test layout consists of two separate paved loops with tangents 1,900 ft. long and 24 ft. wide. The tangents in each loop are connected by superelevated turnarounds designed to permit the test trucks to operate at a constant speed in the neighborhood of 30 mph. The two loops are separated by a service area approximately 600 ft. long in which are located such facilities as the field office, truck maintenance facilities, instrument storage, weighing equipment, and road maintenance stockpiles.

Throughout all phases of the construction, from clearing operations to final pavement finishing, the engineers directed their efforts toward securing uniformity of the components. Normal construction practices were simulated instead of attempting to obtain extra-high densities or superconstruction of any type. Construction of the test project was completed September 30, 1952.

Pavement Thickness Varied

The pavement in the tangents of the test loops was varied in thickness as shown in Fig. 1. On one tangent in each loop the top 6 in. is made up of 2 in. of asphaltic concrete over 4 in. of ¾-in. granular base material. In the other tangent of each test loop, the top 6 in. consists of 4 in. of asphaltic concrete over 2 in. of granular base material. Thus, all four tangents have a 6-in. thickness of combined asphaltic concrete and base. Each of the four 1,900-ft. tangents is divided into five 300-ft. test sections with 100-ft. transitions between them. The only difference between these sections is in the thickness of the subbase, which consists of pit-run granular material ranging in size from 2 in. downward. One section in each tangent has 16 in. of granular subbase material, the next 12 in., the next 8 in., the next 4 in., and the last zero (that is, it is laid directly on the subgrade soil). Thus the total thickness of pavement over the subgrade soil varies from 6 to 22 in. on each of the four test tangents. To reduce delays caused by pavement maintenance, the turnarounds are all 22 in. thick. Three special test sections, each 200 ft. long, have been provided to study the behavior under heavy traffic of surface treatment, and of two thicknesses of road-mix bituminous surfacing.

For the purpose of the test, the 24-ft. width of the tangents is considered as two separate 12-ft. lanes. The outside lane is being tested under the heavier vehicles and the inside lane under the lighter vehicles. Since the two lanes were constructed at the same time, on identical soils and under identical conditions, it will be possible to compare directly the behavior of the outside lane with that of the inside lane. Differences in the behavior of one lane as compared with the adjacent lane can be attributed directly to differences in axle loads.

Test Vehicles and Loads

The test vehicles are tractor-semi-trailers. On the north loop, single-axle combinations are used, with 18,000-lb. axle loads running on the inside lane and

22,400-lb single loads running on the outside lane. On the south loop, tandem combinations are used, with 32,000-lb. tandem-axle lads on the inside lane and 40,000-lb. tandem-axle loads on the outside lane. Two vehicles operate in each lane; thus the test requires eight tractor-trailer combinations.

Traffic operation is scheduled on the basis of two 9-hour 10-min. shifts per day, six days a week. Each shift consists of nine 50-min. driving periods, seven 10-min. rest periods, and one 30-min. meal period. Thus, barring truck breakdowns, the test vehicles operate 15 hours per day.

The drivers are able to maintain an average speed around the entire loop of slightly less than 30 mph, and since this distance is 6,600 ft. (1¼ mile), a round trip takes about 2.75 min. Since there are two combination vehicles in each lane, the pavement is subjected to two heavy-truck loads every 2.75 min. At this rate each section undergoes about 650 truck-trailer applications per day, or 17,000 per month. Although it is planned to keep all trucks in the best possible condition, it is not likely that this theoretical rate of application can be maintained during the entire test period.

Accurate Instrumentation Provided

The construction and the trucks provide test sections with built-in variables known in advance, and with control over the size, frequency of application, and transverse position of the test loads. All that remains is to evaluate the relative effects of the various test loads on the different pavement sections. Because of th extreme susceptibility of the paving materials, and particularly of the subgrade soils, to variations in moisture content and temperature, a good deal of attention was given to measuring these phenomena. Complete routine weather records are kept at the site.

Of far greater importance than these routine records are the temperature and the moisture content of the pavement components as influenced by the weather. To simplify the problem of obtaining information of this type, thermisters and moisture cells were placed during construction in certain test sections at various depths down to 72 in. The thermisters consist of simple metallic oxide disks, the electrical resistance of which varies markedly as their temperature changes.

The temperature of the thermister, and thus of the material surrounding it, can be obtained at any time by reading its resistance as measured with a simple a-c ohmeter across the leads at a terminal board located at the side of the road. The portable ohmeter rests conveniently on top of the terminal board, and its leads are clipped to the leads of the thermister being read. Two men with an automobile can read all thermisters and moisture cells in the project in half an hour.

Buried beside the thermisters throughout the project are moisture cells. These are also of the electrical rsistance type, consisting of a sandwich of two electrodes separated by fiberglas (or nylon). The resistance between the electrodes changes as the moisture contnt of the filler changes. The moisture cells are read in the same manner as the thermisters, using the a-c ohmeter. However, they are not as direct or simple to use. The calibration process is extremely important and rather complicated. It is also tedious, requiring about a month for each soil, but reliable results cannot be expected by any other means advanced to date.

The method of installing the cell in the soil is also important if reliable results are desired in a reasonably short time. The moisture cells used on the WASHO test came to equilibrium within about two months. Given proper calibration and installation, it is only necessary to read the resistance, make a correction for temperature (taken at a nearby thermister), and read the moisture content from the calibration curve corresponding to the density of the soil in place.

In addition to the routine checks of moisture content taken by means of the moisture cells, detailed studies of moisture content in the base and subgrades are made whenever any part of the pavement surface is opened for any reason, and of course wherever pavement failurs occur.

One of the first indications of structural distress in a flexible pavement is the appearance of longitudinal rutting in the wheel tracks. This is often of small magnitude and hardly noticeable to the naked eye, yet for it to occur, something in the pavement structure has to give, and if the rutting progresses, serious damake will eventually develop. Furthermore, longitudinal rutting may be due to shifting or consolidation of the subgrade, subbase or base, or to shoving or compression of the wearing surface. Recognizing this, means were sought to detect such deformations early and to relate them to a definite part of the pavement structure.

It soon became apparent that, as a first step, innumerable transverse surface profiles had to be taken. This was accomplished by a special profilometer, designed and built by the engineers and mechanics of the Bureau of Public Roads. This profilometer is a double truss which spans the entire pavement. It is supported at the ends by pins driven 7 ft. into the shoulder, and steadied at the center by an adjustable third leg which rests on the pavement. Its bottom chords follow the pavement crown about a foot above the surface.

A motor-driven carriage hangs by three wheels from the truss chords and, in operation, moves across the pavement in about 30 sec. Suspended from the carriage by a pantograph linkage is a small steel wheel which rides on the pavement surface and, as the carriage moves along the truss, follows the transverse profile of the pavement surface. The vertical movement of the wheel is measured and recorded elctronically by mans of a linear variable-differential transformer (LVDT) and an oscillograph. Since the profilometer support pins do not change elevation, the truss acts as a reference plane throughout the test, and any difference between the oscillograph trace taken before the test and that taken during or after traffic operations, represents a change in the surface profile.

Profiles can be taken wherever support pins are provided. For the WASHO test, five sets per 300-ft.

(Continued on page 48)

Electricity for better living

The latest and perhaps most exciting chapter in the wonderful story of "Electricity for Better Living" has to do with man's eternal struggle against the tyranny of the weather in his own home. It concerns the development of an amazing all-electric machine called a heat pump that burns no fuel, uses no water, yet automatically heats and cools your home to the desired temperature.

The machine requires no attention. Once the thermostat is set to the desired temperature, your home is completely air conditioned throughout the year at the temperature you want. You just set it and forget it. Switchover from cooling to heating is completely automatic—from season to season, within the same day, and even hourly if the need arises. The Weathertron provides "push-button weather" for the home without even pushing a button!

Surprisingly, the broad outline for this new chapter in "Electricity for Better Living" was written one hundred and one years ago by the famous English physicist Lord Kelvin when he presented his theory on the heating and cooling of buildings with currents of air to the Glasgow Philosophical Society in Scotland.

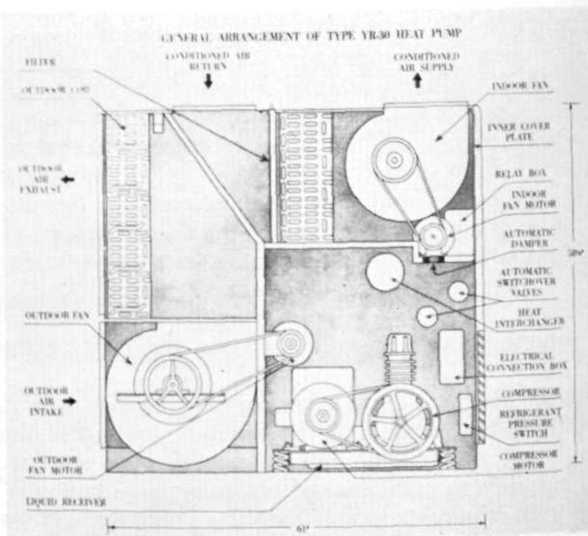
Lord Kelvin's theory suggested the possibility of heating homes with refrigeration systems, and also cooling them by reversing the system's cycle of operation. Interest in the idea remained very low until 21 years ago when advances in refrigerants and refrigeration indicated its practicality and work was undertaken by several companies to fill in the details of Lord Kelvin's outline with a practical machine.

But the chapter was not written quickly. There was much to be done in the way of development and field testing of equipment and ideas.

In 1932 the first practical installation of a Heat Pump in this country was made in an office in Salem, N.J. Since that time, hundreds of heat-pumps have been placed in homes in widely scattered parts of the United States. Performance under many kinds and climates and conditions have been studied, and in November, 1951, after 20 years of engineering development and field testing, marketing the first packaged air-to-air Heat Pump was begun.

The Weatherton, trade name of the heat pump, is what is known as an air-to-air unit. That is, nothing but air and electricity are used to provide the heating and cooling. As its rather prosaic but technically descriptive name implies, the Heat Pump, by the use of an ingenious arrangement of refrigerant and air flow, simply pumps heat from one place to another and in so doing either cools or heats the space it serves depending on whether the heat is pumped into or out of the house. Electricity provides the power for the pumping operation.

The unit brings much nearer to realization the long-dreamed of truly all-electric home. There can be no question that it is currently the most exciting advance toward fuller enjoyment of the great potentialities of electrical living. Unlike high temperature resistance type heating and the newer low temperature radiant panel electric heating which contribute nothing to comfort when cooling is required, the Weathertron inherently provides for summer cooling as well as heating and operates at an efficiency—three times as great as resistance heating—which promises to bring electric space heating within the means of literally millions of people.



One of the reasons for the seemingly slow development of the heat-pump since 1932 is that it had to wait for the development of residential air conditioning. The Weathertron is not, in general, a direct competitor to conventional automatic heating. Except for conditions such as extremely mild climate, or high fuel cost as compared to electric power, there is little if any economic advantage to a Weathertron for heating alone. However, when the Weathertron is not considered as a heating machine but as a machine for providing year-round air conditioning, that is, both cooling and heating, its real economic usefulness begins to emerge, and the recent rapidly rising trend toward complete year-round air conditioning of residences has focused new attention on the Heat Pump.

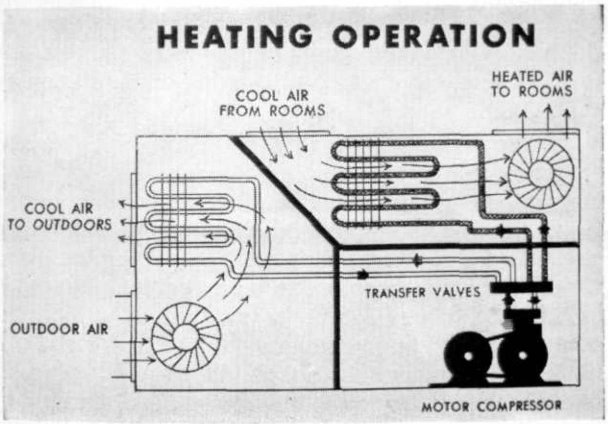
Year-round air conditioning includes heating in winter, cooling and drying in summer, air filtering, circulation and ventilation. These functions are accomplished electrically, under automatic control, without combustion and without fuel in the ordinary sense.

To better understand the operation of the Heat Pump, one must keep in mind four basic laws of nature, namely:

1. Heat exists in the air at all temperatures—below freezing as well as above—all the way down to absolute zero (−459° F.).
2. Heat always tends to flow from a higher temperature to a lower one.
3. All gases cool on expansion and become warmer when compressed.
4. Heat is absorved when a liquid changes to vapor and heat is given off when vapor condenses to a liquid.

Your ordinary household refrigerator utilizes these laws of nature in its operation every day and the basic principle of the Weathertron is the same as that of an electrically operated refrigerator.

DIAGRAMS COURTESY OF GENERAL ELECTRIC



In a refrigerator heat is drawn from the food stored inside by evaporating a liquid refrigerant passing through a coil inside the box. The heat-bearing refrigerant gas is then compressed and pumped to another coil on the outside of the box where the gas condenses to a liquid and the heat is given up to the room (place your hand behind the refrigerator when it is running and you will notice that it is warmer than the rest of the room). The cooled refrigerant then returns to the inside coil to pick up more heat and repeat the cycle.

The Weathertron works the same. In winter it expands a refrigerant and sends it through a coil where it extracts heat from the outdoor air. The heat laden refrigerant gas is then compressed and pumped through another coil and the heat is released into the house. Air from the house is blown through the refrigerant coils at this point. The air absorbs the heat from the tubes in the coil and warms the rooms as it is gently circulated.

The main difference between the refrigerator and the heat pump, other than the difference in their capacities, is that the heat pump is built to automatically reverse its cycle of operation so that in summer, heat is picked up from inside the house and dumped outdoors.

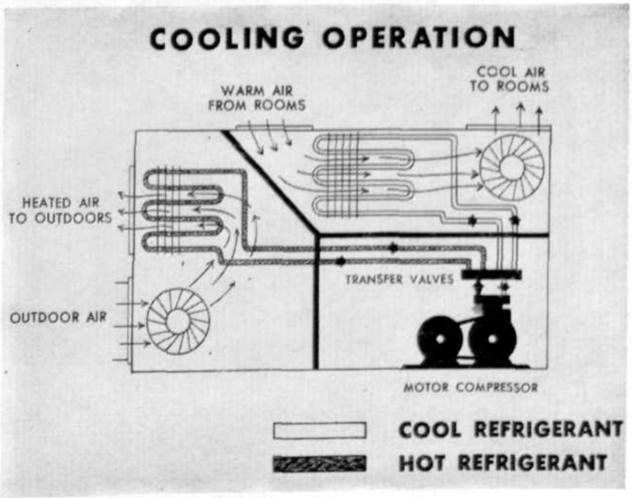
The addition of equipment such as blowers, filters, controls, etc., completes the system. Ordinary duct-work delivers the warmed or cooled air throughout the house. An ideal system for distribution of air within the space served delivers heated or cooled air upward in a fan-like pattern low along the walls of the rooms that are exposed to the outdoors. Return air is taken from grills in interior partition walls.

The principle of the heat pump is not limited to the use of air for heating or cooling. It is also possible to take heat from the ground, deep wells, or ground water.

The use of ground coils as a heat source has practical limitations for use with Heat Pumps. In addition to the expense of installing a ground coil, there are so many variables (such as soil composition and moisture content) involved that each ground coil has to be individually engineered and even then you may not be sure of the results.

Well water is a good heat source since its temperature is fairly constant throughout the year. However, in many sections of the country ground water is not readily available and the cost of providing a well of sufficient capacity may be prohibitive. Also in the event a deep well is used considerable power may be consumed in pumping water.

So from an over-all standpoint, weighing the advantages and disadvantages, it was decided that an air-to-air unit be made. The prime advantages are that air is universally available, is easy to move in sufficient quantities and results are relatively predictable. In addition it permitted development of a truly packaged unit, sort of a large domestic appliance machine, which is ideally suited for the mass market.



The Weathertron is compact in size and can pass through a 28-inch door. It can be placed in almost any location, garage, basement, alcove; any place that is convenient to the home owner. Since it does not burn any combustible fuel, its location is not dependent on a chimney, and in fact, the house does not need a chimney. The flexibility and function of the unit may have a profound influence on future home design.

The development of the Heat Pump fits that historical pattern of "Electricity for Better Living."

New Developments

Edited by: Harlow Nelson, M. E. '54

On the Ground Air Conditioning for Airliners

Passengers who have sat in airplanes waiting to take off and either sweltered or shivered, according too the weather, will find relief at the new Greater Pittsburgh Airport at Pittsburgh, Pa.

It's the only airport in the world to provide a central air-conditioning and heating system that connects by hose to standing aircraft.

Trap doors on the apron where airplanes park contain hoses for fresh air as well as gasoline and oil. The hose for the air-conditioning and heating system is connected to the bottom of a plane and fresh air is pumped through the airliner's ventilation ducts as long as the craft remains in the parking area.

Ramp Hose Connection

Simple Method for Keeping Reciprocating Machines Out of Step

Westinghouse has a solution for keeping compressors driven by synchronous motors out of step that is both novel and simple. This old problem of keeping a battery of reciprocating machines out of step to avoid shaking the place apart has had many solutions—often very complex.

This new scheme, already applied to an installation of ten machines, equips each motor with an extra slip ring which has a contact segment built into a small arc on its periphery. This slip ring, turning under a pair of brushes, closes a circuit each motor revolution. A master reference, common to the ten motors, consists of a brush which is rotated at synchronous motor speed around a stationary commutator having ten evenly spaced contact segments, one for each motor. One side of a circuit, common to the ten units, enters through the brush and in one revolution makes contacts with each of the stationary contacts.

An idle motor is started, brought up to speed, and synchronized by leaving the compressor unloaded and the motor field weak. A set of relays then begins to reverse the motor field excitation and, with each reversal, the motor slips a pole. This process continues until the motor slip ring contact closes at exactly the same instant as that motor's indexing contact on the master reference. At that instant, a high speed relay closes to terminate the field reversing process and to increase the motor field current to normal; the relay also operates a signal to the operator that the compressor may be loaded.

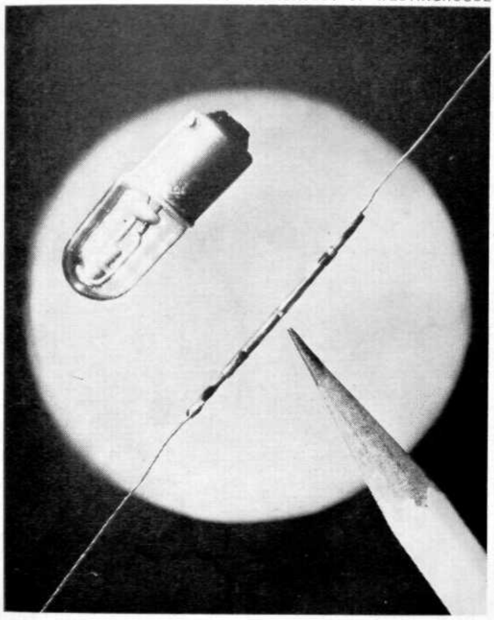
The whole secret, of course, is that all ten motors are adjusted so that their slip ring contacts close at approximately the same angular positions of the compressor crank for each machine. However, since each motor's indexing contact on the master reference is different from that of every other motor, the ten compressor cranks are out of step with each other and station vibration is held to a minimum.

Lamps the Size of a Pencil Lead

A new light source is smaller than the head of a pin. It is a sub-miniature, neon-argon glow lamp and has a special job to do. Fifty of them are laid out side by side in front of a moving strip of 35-mm film for recording events in laboratory experiments where space is scant. This "lamp" is a slender glass tube 0.05 inch in outside diameter and 1¼ inches long. When a 110-volt, d-c potential is impressed across the lamp, a glow is formed in a gap 1-mm (1/25 inch) long between 0.03-inch diameter Kovar electrodes in the glass cylinder. This lamp is a contender for, if not the holder of the title of the "world's tiniest lamp."

The lamp and a tiny series resistor to limit the current—½ milliampere—draw only 1/20 of a watt. The current in the glow is but 1/30 of a watt. One of the problems in making such a tiny glow lamp is that the volume of gas is so small that any slight contaminant has a large effect. Even the seemingly inconsequential volume of gas contained in the bit of glass pinched off the end when the tube is sealed must be taken into account.

PICTURE COURTESY OF WESTINGHOUSE



Control of Tension in Steel Strip

A new tensiometer regulator that has a total movement of only 100 mils—less than one eighth inch—controls tension in steel strip moving two thirds of a mile per minute over a range of 20 to one. Its predecessor had a travel of two to three inches. The shorter travel makes for faster response. Chart records show that the operator of a temper-pass mill can effect a change in strip tension from 8000-pounds down to 6000-pounds in one-half second. Consequently if the operator sees a bad edge or other defect in the strip, he has a better chance of reducing the tension before a tear occurs.

The tensiometer gets its signal from a reluctance-type pickup, similar in principle to that used in phonograph record players. The signal is amplified by Magamps. A special circuit takes the tensiometer out of operation when tension falls to less than 800 pounds thus preventing the tensiometer from trying vainly to maintain tension during start up, shut down, or when the strip breaks.

The tensiometer is all electric. In contrast to systems that are part mechanical this requires no dampening, thereby eliminating the need to readjust when operating tension is changed over a wide range. Although the previous type of tensiometer is widely used and will continue to be preferred for some tension-regulation applications, the small-travel tensiometer is better suited where the range in tension is wide and also where rapid adjustment of tension is required.

In addition to controlling tension it gives a continuous indication to the operator. The ability to contorl tension closely during acceleration and deceleration reduces the amount of off-temper material produced.

Noiseless Exhaust for Trucks

After two years of intensive engineering research, an exhaust system has been developed that renders exhaust noises inoffensive to the human ear.

Truck models with the newly-designed mufflers and exhaust pipes will be in production next month. A special name, "Silent Power," was originated for the system to indicate not only that it has eliminated objectionable exhaust noises but has not had to decrease its engine power to achieve it.

Although "Silent Power" system costs more to manufacture, it will be standard equipment at no extra cost to the user.

"When we started work on this two years ago in response to demands by truck operators, we had no formulas or a base line from which to begin," an official explained.

"Engineers by trial and error method, and in cooperation with muffler manufacturers, finally worked out a system that will absorb those noises so offensive to the ear."

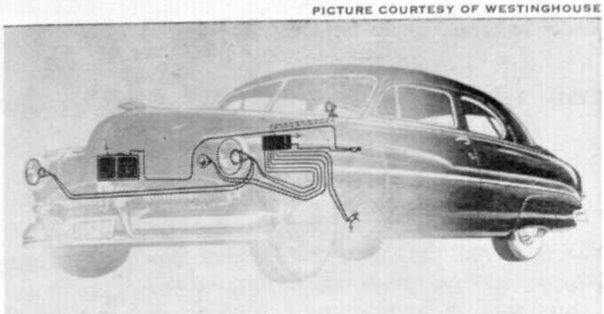
The mufflers are a reverse-flow type, larger than previous units and made more rigid by the use of heavier gauges of metal. New exhaust manifolding and larger exhaust pipes are incorporated in the system. A different system had to be developed for gasoline and diesel engines because of the different volumes of noise to be stifled.

Lights Dimmed Automatically

The "Techtronic Eye," causing much excitement in the automotive and safety fields, is being readied for national distribution.

Designed to reduce accidents caused during night driving trips, the "Techtronic Eye" relieves the driver of the tedious task of dimming and brightening headlights. It functions whenever, and only when, the car's "open-road lighting" equipment is sent into action. The driver is completely relieved of the task of manually switching light beams. Accidents caused by temporary blindness due to headlight glare become minimized.

PICTURE COURTESY OF WESTINGHOUSE

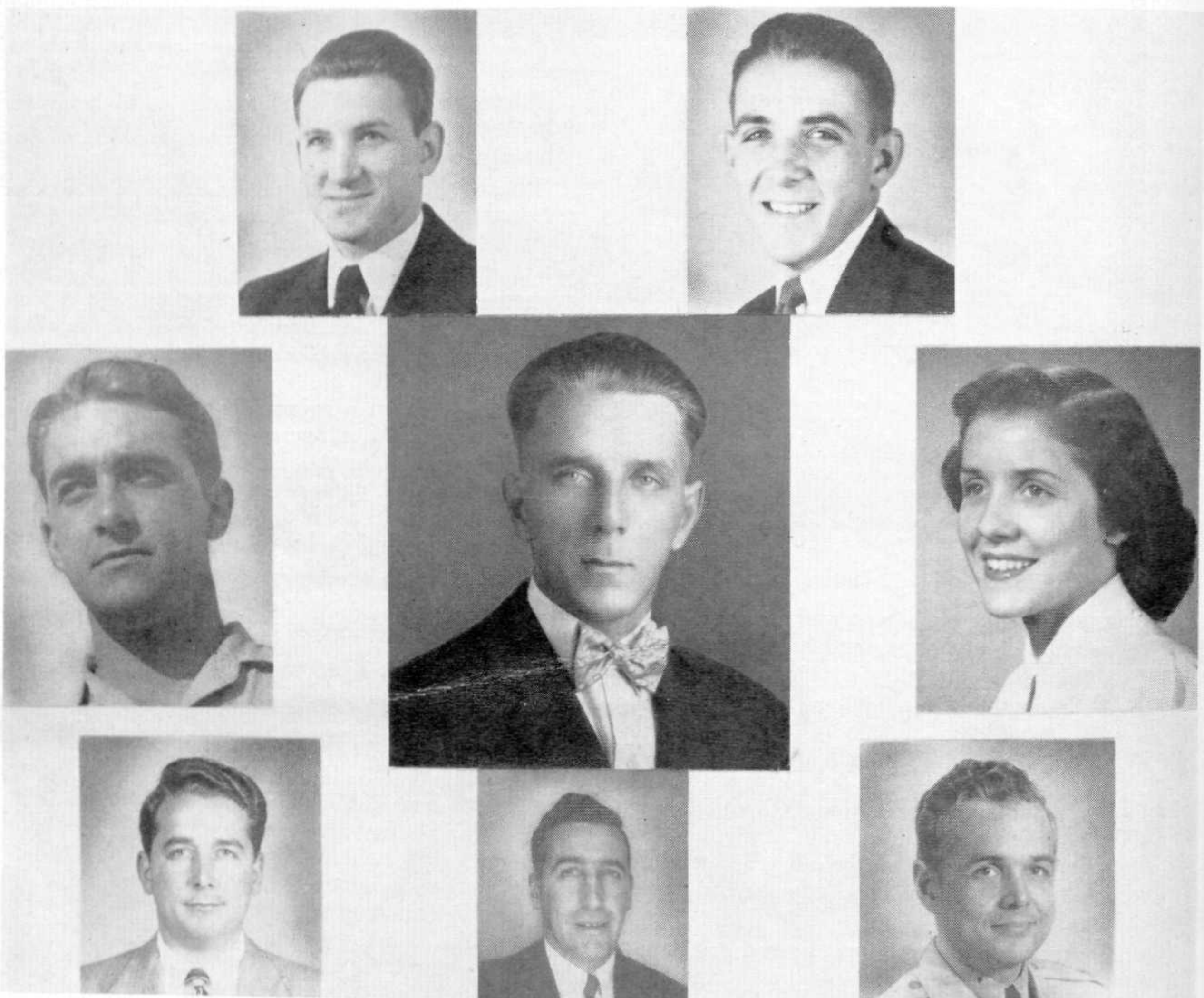


In its regular pattern of functioning, an oncoming car moving with its "brights" engaged, would cause the device to undergo a switching-action as soon as it appears on the device's horizon." Your headlights automatically go from bright to dim—stay that way until all oncoming traffic passes. When the opposite lane is clear they automatically return to bright.

(Continued on page 32)

The Therouxs

by: Bruce Harding, M. E. '54



Clockwise, from upper left: Charles, James, Frances, Robert, Louis, Frank, and Paul. In the center, Prof. Theroux.

The Therouxs

In Room 108 of Olds Hall there is a man with an unusual distinction. He is Frank R. Theroux, a professor of civil engineering, who hails from New Haven, Connecticut. Professor Theroux was in the first graduating class, the class of 1909, at Technical High School in Springfield, Massachusetts, and went on from there to receive his bachelor's degree in civil engineering in 1915 at Valparaiso College in Valparaiso, Indiana. After considerable field experience throughout the country, Prof. Theroux went back to college and received his master's degree in 1924 at Cornell University. Twenty-five years ago, after a few more years as a consultant, he joined the staff here at Michigan State College, and has remained here ever since.

The most unusual distinction about Prof, Theroux, however, he must share with Mrs. Theroux, for they are the parents of seven children, all of whom have graduated from Michigan State! This, they believe, is a record. The seven children are, in order of their ages: Louis–34, Robert–32, Paul–30, Frank–28, Charles–26, Frances–23, and James–22.

Louis, who graduated in 1939, received a B.S. in electrical engineering, spent some time in the Air Force, and now holds an executive position in communications at Wright Field in Dayton, Ohio.

Robert, class of '41, has his B.S. in sanitary engineering. After serving in the Air Force, both during World War II and on a tour of duty checking sanitary installations of European Air Force bases, he is now

(Continued on page 42)

THEY STARTED OUT EVEN AT GRADUATION:

Why is one doing better now?

You may not see it in their outward appearances — but there's a big difference between these young men. One has held three jobs in the five years since graduation. He's still looking for a job that offers him a lifetime career. The other has been with a Bell Telephone Company during that time. He's on his way up!

Seventy-five per cent of college men hired by the Bell Telephone Companies since World War II are still with these telephone companies after *five years!* Here's why:

Telephone Work Is Interesting—As an engineer, you'll be planning telephone facilities or supervising construction, installation and maintenance. You'll work with the newest developments in electronics and communications as you help expand and improve the world's best telephone service.

There Are Places to Go—Each year the number of college people hired is related to estimates of the number of future management positions expected to be available. We are looking to the future—yours and ours.

You Grow with a Growing Business—The Bell System is one of the fastest growing businesses in the world. Since the end of World War II, it has spent about nine billion dollars for new construction. The past five years have seen the introduction of network TV transmission, dialing of Long Distance calls and the development of the remarkable transistor.

You'll Be Happy—Not only because of the interesting and rewarding work, but for many other reasons. For instance, Bell Telephone Companies are located in all parts of the country. So you may be able to start where you want to live. And what about salaries? It is the basic policy of the telephone companies to pay salaries that compare favorably with those positions of similar responsibility in other fields.

No matter what your military status, it's worth inquiring about Bell System employment opportunities. Your Placement Officer has the details. And be sure to talk to our employment representatives when they visit the campus. The time to plan your future is now!

BELL TELEPHONE SYSTEM

New Developments

(Continued from page 29)

Television Camera Attachment

New Small Television Camera for Use in Home, Schools, and Business Establishments Extends the Services of TV — Camera Over the Door Can Check Callers, While Camera in Nursery or Yard Will Enable Parents "to Keep an Eye" on the Children Through the Standard Television Set — Many Other Uses for Such a Closed-Circuit Television System are Foreseen.

A simple television camera attachment that can be combined with any standard TV receiver to extend human sight in businesses, schools and homes was demonstrated by scientists and research men at the National Convention of the Institute of Radio Engineers at the Waldorf-Astoria.

This attachment, consisting of a small television camera and an electronic control device, can transform any of America's 23,000,000 TV sets into a closed-circuit viewing apparatus supplementing the field of entertainment, according to Dr. V. K. Zworykin.

"Uses in the home," said Dr. Zworykin, "might include watching the children, asleep in the nursery or playing in the yard, checking callers at the door, and observing activities in the kitchen. This system would make the receiver in the living room, not merely a means of entertainment, but the real nerve center of the home."

He also pointed out that up to the present broadcast television has far overshadowed all other television applications, but reported that closed-circuit, or industrial-TV, is finding increasing use in industry, research and education. He continued:

"We shall describe a device which is aimed at the fullest realization of potential uses of television pickup equipment. This device is a camera adapter which makes every existing television receiver a potential closed-circuit television system. It takes the form of the simple Vidicon camera which transmits video signals over a cable to the receiver. Its use does not impair the normal operation of the receiver in any way.

"The camera attachment is so simple and easy to adapt to the receiver that applications in schools, businesses and homes, as well as other fields, become feasible.

"The school presents a fertile field for inexpensive closed-circuit television. In an increasing number of schools, the television receiver is coming to be looked upon as a standard piece of classroom equipment. The addition of even one camera attachment, linked by cable to several receivers, can enhance their usefulness.

"With the aid of the attachment, the school principal can address all classes simultaneously, introduce distinguished visitors, and present visual demonstrations at close range to the students. All this can be accomplished with a minimum expenditure of time and without disruption of classroom schedules."

The paper reported that if, in addition, camera units were placed in each classroom, this would enable the principal to obtain an instantaneous check on classroom conditions from his office. Furthermore, teachers in training and visitors would be able to study classroom procedures and student reactions without personal intrusion.

Through the use of two cameras and receivers tuned to complementary channels and linked by cable, it would be possible to set up a two-way television communication system for the transmission of visual information, the paper stated.

The camera, it was explained, contains a Vidicon pickup tube and a three-tube signal amplifier. The camera is about the size and weight of a 16-mm motion picture camera. All power requirements and the signal pulses which control the scanning action of the camera are taken from the receiver through adapters placed between the tubes and their sockets.

A standard receiver so used for closed-circuit purposes, it was emphasized, may be returned to regular TV broadcast reception in a moment. The quality of the observed picture, the paper stated, is limited only by the normal picture reproducing quality of the receiver itself.

The simplicity and economy of the system is a result of maximum utilization of receiver circuits and components. Its potential uses go far beyond those of the usual industrial television system. It brings us a step nearer to the fullest utilization of television in its broadest sense as an extension of vision.

Providing Answers with Electronic Computer

Have you a battleship that has acquired the quivvers? Or a chemical formula that needs exact control? Or perhaps you're curious about the life expectancy of that new oil well of yours.

A west coast airplane company, it would seem, can provide a lot of help with its electronic analog computer, a fantastic assembly of vacuum tubes and circuits which, if given all the facts and figures, can provide the answers.

Engineers and mathematicians make haste to point out, however, that their computer is not an electronic "brain." It cannot create. But if given the differential equations of a problem through its dials and wiring hookups, it can provide the answer with alacrity. It does this within its electronic circuits, regulating voltages so that they simulate the variables inherent in the problem.

In short, it is a great mimic, and can imitate an airplane in flight, a hockey puck skidding down the ice, or an incinerator burning trash. It can simulate anything that does not have a mind of its own, provided the effects of an outside will can be determined.

It was in 1949 that the electronic analog computer became an identifiable unit, although its pieces had been operating for several months. It was not an invention so much as it was a collection of existing inventions rooting back to small, special-purpose electronic sets which were built for use in the development of automatic pilots for guided missiles.

The units were expendable and junked after each use, but as the scrap pile grew, engineers decided a flexible set-up that could be re-used for different problems was indicated. That led to today's computer. Physically, it resembles an up-ended telephone switchboard.

The computer has been used to solve numerous problems in industrial and college research, and has brought about considerable savings in material, man-hours and dollars.

A case in point was provided during the reconditioning of an escort-type aircraft carrier. Two electric generators had been replaced with a single higher-capacity generator, but when started the new unit was found to have vibrations, severe enough when the ship was docked, but more objectionable when the carrier put to sea and increasingly so when the ship accelerated.

Engineers at the shipyard came up with several structural-change ideas, one of which called for altering the dimensions and rigidities of the existing structure supporting the generator and then observing the effects. Instead of actually cutting into the ship's steel, however, the situation was simulated on a computer, and 16 modifications were tried out in five hours without touching a torch to the floor plates. One was found to reduce the vibration by 47 per cent and was selected as the answer.

The computer can also be used for process control of the rate of flow of chemicals going into the making, for instance, of wood pulp. Hooked up between a signal indicator and a valve-activating device, the computer can control the chemical composition at much closer tolerance than can be done manually or by a relay mechanism. The slightest detected change of composition would be corrected by the computer, assuring a constant quality of pulp. The valve would be opened or closed only enough to correct the slightest defection from the formula.

The petroleum industry offers another example, with the factors affecting the flow of oil in wells having been computed and the life expectancy of the wells determined.

It is in the area of simulating dynamic situations (motion problems) involving inertias, angles, forces, springs, displacement, frictions and temperatures, together with their electrical, chemical and fluid equivalents that analog computers are most applicable.

Of course, in areas where the computer's answer is affected by the preconceptions of the operator, its accuracy is equal to the accuracy of the preconception. For predicting the winner of a horse race or a prize fight, the computer is not superior to the gambler who bets with the odds, but it would be glad to discuss the inertia at the starting gate or the force behind a knockout punch.

New Paint Stops Fire from Spreading

Engineers are studying with a great deal of interest the recent development of a new fire retardant paint that is easily applied by brush or spray and actually stops fire from spreading. Everyone realizes the loss of life and property that results from rapidly spreading flame, so this may well prove to be one of the greatest advancements yet made to help prevent these disasters.

Because every drop of this paint is claimed to contain a mass of minute "built in" fire extinguishers; when exposed to flame it pours out carbon dioxide and calcium chloride which smothers fire and retards the spread of flame right on the surface.

Industrial Television Solves a Mystery

Industrial television turned detective during the past summer and solved a case by giving police an eye-witness view of thieves at work.

The locale was a stockroom of a television service in Holywood. Inventories had disclosed that television equipment was being stolen on a substantial scale—some $38,000 worth (covered by insurance) was missing on the initial check.

Officials on the spot, recalling the success of industrial television equipment in functioning as an "eye" in locations too dangerous or inconvenient for human observers, decided to try the device as an electronic witness to the crime. Summoning the police, they concealed the camera unit among the rafters of the stockroom with the lens focused on the loading platform. The rest of the unit—the TV receiver and viewing screen—was placed in a second-floor room some distance away.

Every day for two weeks, the TV "eye" was trained on the loading platform as police watched at the receiver. The camera recorded the routine activities at the platform—but it also recorded the suspicious actions of one clerk, who casually placed a number of boxes of TV tubes on the loading platform during the lunch hour ono Tuesdays and Thursdays when four other people were around. At apparently pre-arranged intervals a pick-up truck would back into the driveway, the boxes would be put aboard with the help of the suspect, and the truck would pull away—all before the gaze of the camera and the interested watchers at the TV screen.

One of the facts had been made clear by the TV unit, the trap was set. The police at the reeciver waited until the truck took off with another load of tubes. As they moved in to arrest the clerk, a police car trailed the truck to its destination and seized the driver and two alleged confederates.

The hero of the story is an industrial TV unit which already has been put to scores of uses—patrolling, guarding, transmitting fingerprints and signatures, checking numbers of freight cars, supervising operations of machinery at a distance, riding rockets, and generally fitting itself handily into locations where

(Continued on page 38)

Clubs & societies

Edited by: Emory Geisz, M. E. '56

Triangle

(Editor's Note: This is the story of the beginning of a fraternity and their beliefs of what this new organization will accomplish for them.)

Good scholarship is not intended to be, nor is it often interpreted, as an accurate gauge of probable success in the business world. It is possible and often happens that a man has developed personal qualities through contacts with others which go a long way in making him successful in the daily walk of life. Fraternity means brotherhood, involving association with individuals of similar background and understanding. With this in mind, a group of enthusiastic engineering students visualized a fraternity which would achieve closer relations with other engineering students and increase their scope of scholastic advancement through brotherly help and assistance.

photo by E. Geisz.

Front Row (left to right):
Dan Robbins, Prof. Apple, Homi Kapadia.
Back Row:
Lloyd Reynolds, Dick Consiglio, Joe Piacenti.

Michigan State College was the only Big Ten college lacking a fraternity of this type. Forming a nucleus in the winter of 1952, these prospective engineers contacted the national headquarters of the Triangle Fraternity, a national professional-social fraternity of engineers and architects, and asked for their help and assistance in organizing a chapter on this campus. In the following spring term, the intentions of the group were revealed to the Engineering School and a meeting of all interested was called. Election of temporary officers and a committee to draft a constitution to be presented to the Student Government constituted the rewards of this initial meeting. Activities of other meetings that term included visits of representatives from the national organization and the University of Michigan Triangle Fraternity Chapter.

Election of the officers for the year of 1953-1954 was carried out soon after the college reopened for the Fall term. At this time official recognition from the Student Government was also obtained. Not having finished a year's probationary period, this organization operates under the name of **The Triangle Club** until official recognition is granted from the national headquarters next spring.

Owing to the constant efforts of all the members and their personal contacts with other engineering students, coupled with frequent open meetings and smokers, Triangle now boasts of over a thirty man membership. Also, a very promising group is undergoing the pledge program.

The aims of Triangle are those of the college—the development of well-rounded, educated gentlemen who will be prepared to go out and take a fitting place in society. Fraternities offer all students better living accommodations, superior food, organized home life, friendship, and valuable experience in human relations. In addition to the advantages of joining any other good fraternity, Triangle aims at outstanding scholarship and emphasizes the advantages of living with a group of engineers, the men with whom the engineering student will be associated all his life.

° ° ° °

Tau Beta Pi

The annual Fall initiation and banquet of Michigan Alpha chapter of Tau Beta Pi was held on Wednesday, November 4, 1953. The members initiated at this time were seniors William Bartley, John Cheney, Fred Copple, John Kuly, Don Koppelman, Roger Miller, Richard Pfeil, James Reif, Robert Somerville, and juniors Jerry Griffith, Bruce MacDonald and John Rood.

Mr. George Foster, chief deputy commissioner of the State Highway Department, spoke on the "Proposed Strait of Mackinac Bridge." Prof. A. H. Leigh was toastmaster.

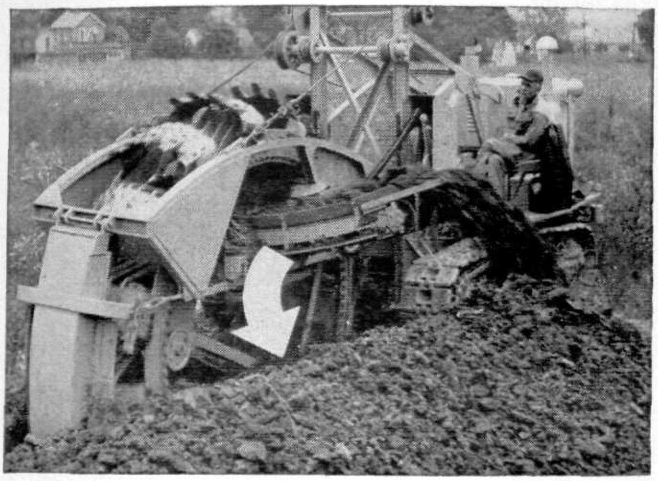
° ° ° °

Eta Kappa Nu

The Gamma Zeta chapter of Eta Kappa Nu initiated six new members on November 7, 1953. The formal

(Continued on page 36)

Another page for YOUR BEARING NOTEBOOK

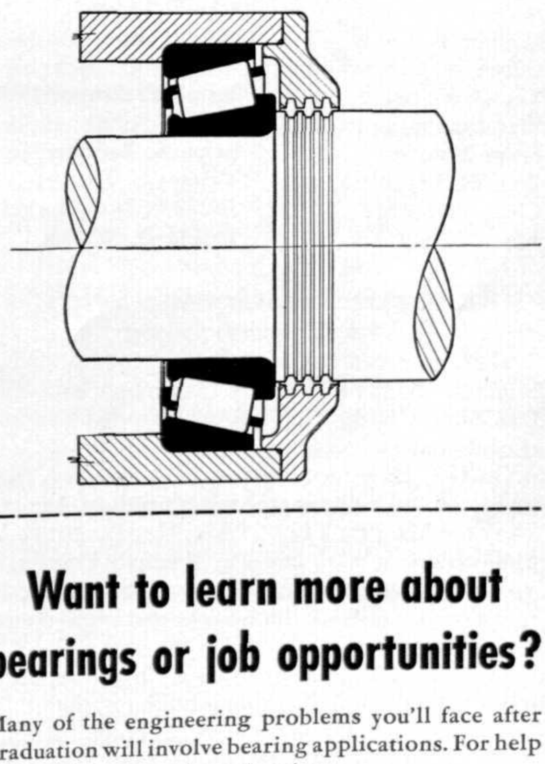


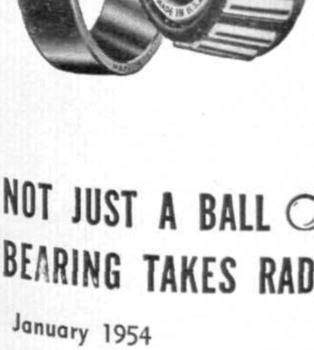
How to keep buried wheels turning smoothly

Hidden under the pile of dirt (see arrow) is a 4-wheel truck that backs up this ditch digger's whirling buckets. To prevent breakdowns, the wheel bearings had to be able to absorb the shocks of boulders and the digging action itself. And they had to be protected from the dirt. The engineers who designed this application licked both problems by mounting the truck's wheels on Timken® tapered roller bearings. Timken bearings absorb the shocks because they have tough, shock-resistant cores under hard, wear-resistant surfaces. And Timken bearings make closures more effective.

How TIMKEN® bearings help keep dirt out—lubricant in

Timken bearings make closures more effective because they hold the housings and shafts concentric. As a result, dirt can't get in—lubricant can't get out. Maintenance is minimized. Continuous, trouble-free operation is assured.





TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Want to learn more about bearings or job opportunities?

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

Clubs & Societies

(Continued from page 34)

initiation and banquet were held at Kellogg Center. The men initiated were William Bartley, Jacquith Butler, Stuart P. Byam, Delbert Elliott, William Kannawin and Richard Pfeil.

The history and growth of Eta Kappa Nu was told by Mr. Frank Sanford. The toastmaster was Dr. J. A. Strelzoff.

° ° ° °

Pi Tau Sigma

Mechanical Engineering Honorary

The Fall term initiation this year began on Monday, Nov. 16, and continued through Friday, Nov. 20. As work projects the initiates painted several air compressors for the Engineering Exposition, and nearly completed the new display windows in the Olds Hall reading room. The week ended with the all-night problems on Thursday night and the formal initiation and banquet on Friday night, with Dr. A. C. Posz of the Communication Skills department as the guest speaker.

The following men were initiated:

William J. Brand	John L. Larson
William R. Carey	Fred J. Locke
Calvin N. DeBruin	Kenneth L. Lyons
George M. Fox	Joseph C. Piacenti
Fred Herzberg	Jack D. Puffer
Homi Kapadia	Ralph A. Redman
Don W. Koppelman	Thomas G. Thomas
Cleon R. Kortge	James P. Throgmorton
John P. Kuly	Jerrold D. Widing

° ° ° °

American Foundrymen's Society

MSC Student Chapter

Many members of the student chapter attended the Michigan Regional Foundry Conference held at Michigan State College Oct. 8-9, which proved to be very educational.

On Oct. 28 a meeting was held at which the new industrial advisors were introduced to the group. They are Mr. Frank Rote, Chief Metallurgist at Albion Malleable Iron Co., and Mr. Kenneth Priestly, Chief Metallurgist of Vassar Electroloy Products. Mr. Priestly showed slides of high-alloy cast iron operations at his foundry.

On Nov. 5 the group took a "triple-decker" field trip—first to Vassar Electroloy Products, then to Eaton Manufacturing Co. in Vassar (permanent molding grey iron), followed by dinner with the Saginaw Valley Chapter AFS at their monthly meeting in Frankenmuth, where they heard a talk on nodular iron.

Members of the student chapter constructed the Cast Metals Industry's booth at the Career Carnival and manned the booth part time.

Plans for Winter term include foundry open-houses, an educational show on WKAR-TV, and, of course, field trips and regular meetings.

° ° ° °

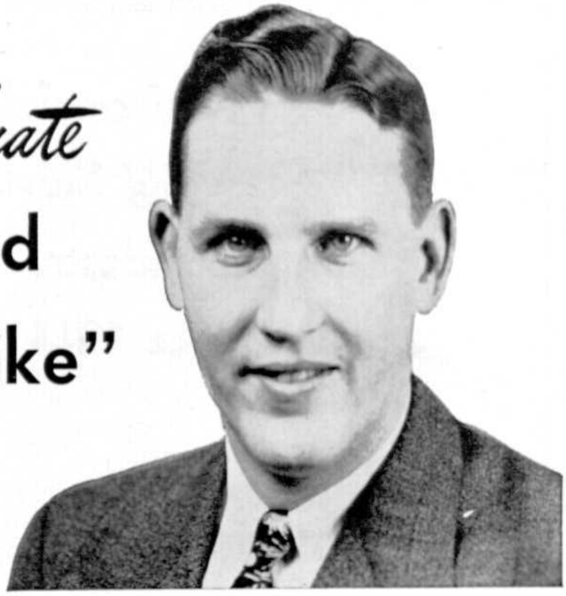
An Invitation

From the Goldmine . . .

In the November issue of the *Spartan Engineer* an

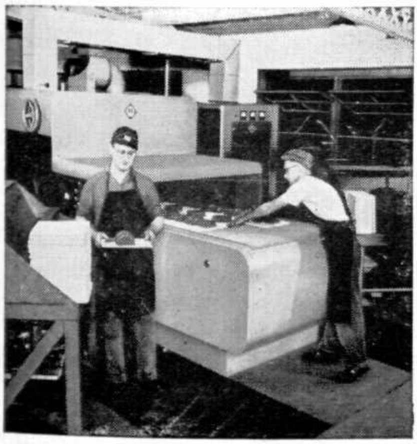
(Continued on page 44)

"Allis-Chalmers Graduate Training Course Helped Me Find the Work I Like"



says HUGH C. SELLS,
Syracuse University, BS—1942
and now Manager, Knoxville District Office

"I guess I was like many graduating engineers. I didn't really know what I wanted to do. When the Allis-Chalmers representative visited the campus, and described their Graduate Training Course, it sounded like the type of postgraduate training I really needed.



ELECTRONICS—Modern way to dry sand cores is with Allis-Chalmers *Foundromatic* Sand Core dryer. Revolutionary new process dries cores in minutes instead of hours.

POWER—Neat, compact and safe switchgear installation is big improvement over open framework and knife switches in older installations.

"What appealed to me then—and still does—is the broadness of the program. Here is a company filling a unique spot in industry. It makes important, specialized equipment for almost any industry you can name."

Wide Choice of Activity

"It's like a big department store for industry. But that isn't all! In addition, it offers a wide choice of activity within each of these many product groups . . . whether it be sales, design, research or production.

"After getting the broad look at industry the program offers, my interest began centering on Service and Erection of large equipment. This led me into many departments of the company, and I learned about everything from steam turbines to sifters for flour mills."

Valuable Background

"The transition from service to sales was natural. The background of service and erection work proved very valuable.

"So you see, whether you think you know what you want to do or not, the Allis-Chalmers Graduate Training Course is so flexible, so broad in its scope, you have a real chance to find yourself. Best of all, you don't have to waste time doing it."

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbo-generators, circuit breakers, unit substations, transformers, motors, control pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

C-5677

Foundromatic is an Allis-Chalmers trademark.

New Developments

(Continued from page 33)

direct view is required and the human eye cannot go.

Its efficiency in these operations, and in its newly-acquired detective role, stems from the compactness of the camera and the fidelity with which it transmits what it sees. The Vidicon tube, heart of the system, is only six inches long and an inch in diameter. The camera that is built around the tube is no larger than a 16-mm movie camera and is easy to handle.

The unit is completed by a connecting cable and a compact control monitor with a ten-inch viewing screen. Other receivers can be attached to the monitor if required, and the controls allow the camera focus to be controlled from the receiving end.

Although TV in this compact form has been available to idnustry for less than ten years and has been developed by engineers into its present state within the past two years, it has already carved a vital role for itself in a wide variety of jobs. Its recent performance in Hollywood was a new departure, however, and its success as a witness to the crime promises to open a broad field for TV as an electronic arm of the law.

Small but Mighty Expendable Motor for Navy Torpedoes

An expendable electric motor that packs 25-horsepower into its 10 pounds helps our Navy's submarine crews to guide their deadly torpedoes on a true course. The useful working life of the motor is but a fraction of a second—then it is blasted apart.

Development of the small but powerful motor, little larger than a rolled-up newspaper, was just announced recently. Volume production in undisclosed numbers is under way for the Navy now.

While engineering details of the motor are restricted for security reasons, it was revealed that its sole "life work" is to serve as a starter for the torpedo's gyroscope—the guiding mechanism which keeps a torpedo on its predetermined course. A small prong at one end of the motor shaft meshes with the gyro's flywheel as the torpedo is shot from its tube. In about one-fifth of a second, the flywheel is spinning at upwards of 13,000 revolutions per minute and the job of this little motor is completed.

When the desired speed of the flywheel has been attained, the motor automatically uncouples from the gyro, and its job is done. Seconds, or minutes later, depending on the distance from the submarine to its objective, the torpedo strikes its mark and blasts the target apart.

Engineers report that a standard 25-horsepower motor for industrial use is some 16 inches in diameter, 22 inches long and weighs 415 pounds. The expendable motor is 3½ inches in diameter, 10 inches long, and weighs 10 pounds.

Fireflies Compared with Electric Bulbs—Lightning bugs are efficient producers of light, but it would take 1000 to 2000 of them to illumine a room to the same intensity as the light from one candle.

Using intricate laboratory apparatus, including a photometer and an oscilloscope, it was determined that the average light output of all fireflies in Cleveland measured was only 6-thousandths of a lumen, and that the brightest produced 9-thousandths of a lumen.

The lumen, it is pointed out, is a standard measure of light. The 60-watt inside-frosted bulb produces 835 lumens, and it would take more than 137,000 average lightning bugs, all flashing simultaneously, to give out as much light.

The study also revealed the nearest electric lamp from a light-output aspect to be the somewhat brighter glow lamp, used on electric appliances, wall switch plates, radios, and elsewhere, to indicate that the current is "on" or "off."

Unofficially renamed the "firefly lamp" as a result of the tests, the tiny light source presently is being recommended for use on portable table and floor lamps. Since most modern living rooms lack ceiling lighting fixtures, glowing switches on portable lamps will serve to enable persons walking into a dark room to find the lamps easily and quickly, it is pointed out.

IT'S FUN
IT'S PRIZES
IT'S . . . . . .

The engineering exposition

January may seem remote from April and spring vacation, even more remote from May 6th, 7th and 8th and the Engineering Exposition, but now is the time to work out a theme, plan student exhibits, contact industrial exhibitors, plan programs, schedule shows and buildings, and just plain plan for the sixth annual Engineering Exposition. All these jobs require people, interested, intelligent, industrious, inspired people. They require you, for regardless of what you're interested in, you'll find it at the exposition.

Inspired seniors might construct their own individual exhibits. So go ahead and build a miniature diesel; or better yet, why not build a scale model of that dry ice freezing plant with which you've been toying. And this year for added inspiration a first prize of a fifty dollar savings bond and a second prize of a twenty-five dollar savings bond are being offered for the best student-constructed exhibits. Imagine the thrill you'd get cashing the bond ten years from now, and discovering that it put you in another income bracket.

If you happen to be an intelligent junior, the electrical engineering department needs you to collaborate with a new, ingenious, scientific electronic detection machine. So if you're capable of distinguishing between a leaky fountain pen and a battered golf ball, and you fit nicely under a table, please volunteer your services to the electrical engineering student exhibit chairman.

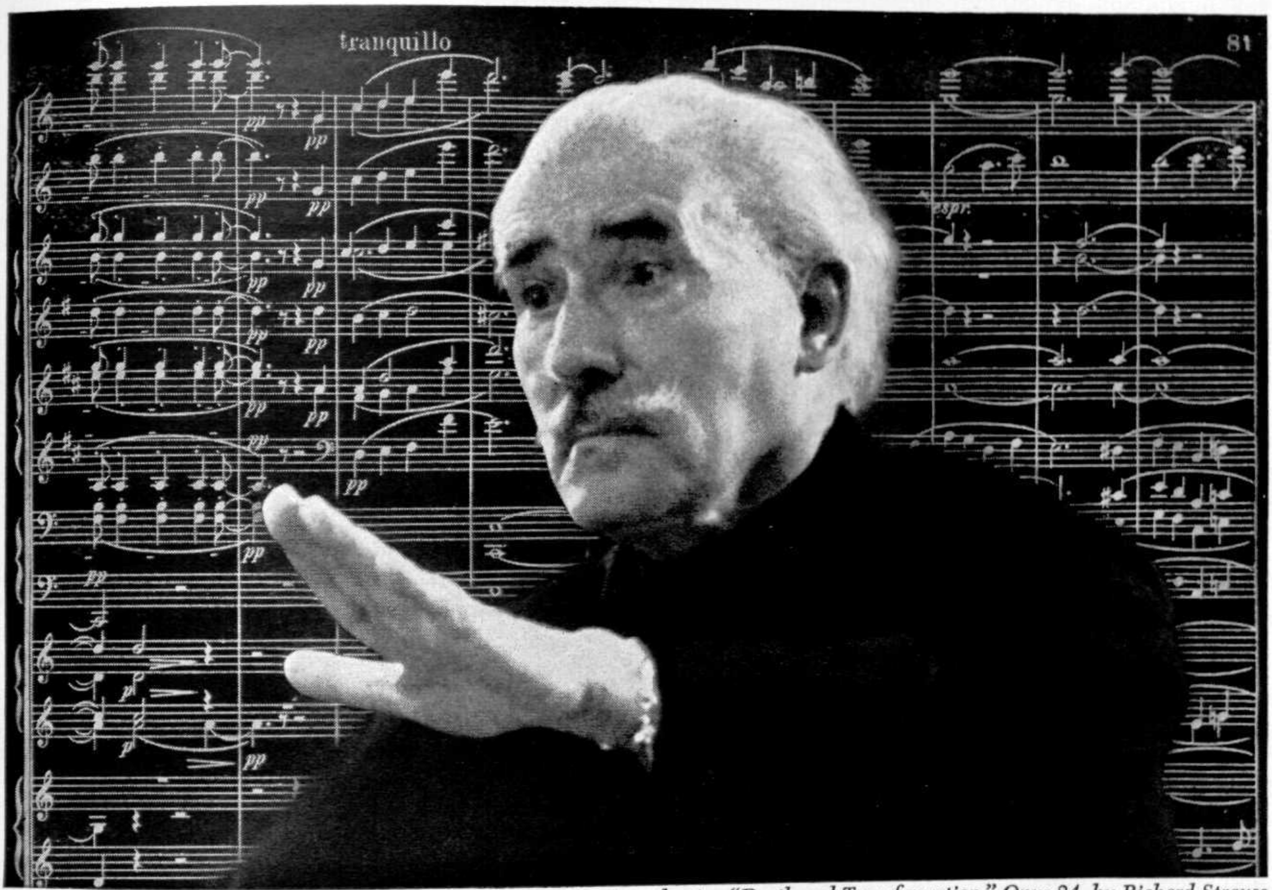
Industrious sophomores are needed to help set up exhibits, explain them to the visitors, and also to answer their questions. To be successful in this line of endeavor you must be able to make up scientific answers on a moment's notice – not necessarily right, but reasonable answers.

Interested freshmen who have detective minds are needed to conduct tours through the exposition. To facilitate transportation about the campus a jolly trolley has been constructed and it seems no one can find it at the right time.

(Continued on page 42)

MELVIN

BY MADELYN



Arturo Toscanini conducting "Death and Transfiguration," Opus 24, by Richard Strauss

RCA High Fidelity brings you every musical note!

RCA Victor High Fidelity is the result of 50 years of leadership in recorded music, phonograph research and development of radio and motion picture sound. It is a new dimension in sound created by the perfect union of recorded music and the phonograph.

A genuine high fidelity instrument re-creates the full range of tones and overtones of the original composition—exactly as the composer intended. The precise balance of sounds from the highest to the lowest must be maintained if perfection is to be achieved.

"Victrola"® phonographs, Victor records, and "intermatched" high fidelity equipments for those who want to assemble their own units—all are designed to work together to bring the brilliance of the original performance into the home. Now, with RCA High Fidelity instruments, you can hear the full gamut of the orchestra—from the shimmer of the cymbals to the beat of the tom-tom. Your favorite music sounds just as if you were in the presence of the recording orchestra and artists.

True Hi-Fi—as in RCA Victor instruments and components—embraces the entire scale of tones from the rich lows to the colorful highs. Nothing is missing . . . the sounds reach the ear in their proper proportion and relation.

The nation-wide interest in high fidelity reflects a growing taste for the highest quality music. Developments by RCA scientists and engineers now let you enjoy this new musical experience. Visit your RCA Victor dealer and hear the new Hi-Fi models of "Victrola" phonographs, Victor records and "intermatched" components.

CONTINUE YOUR EDUCATION WITH PAY—AT RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short-wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to College Relations Division, RCA Victor, Camden, New Jersey.

Also many opportunities for Mechanical and Chemical Engineers and Physicists.

RCA

Radio Corporation of America

World leader in radio—first in television

Engineering Exposition

(Continued from page 40)

There are many reasons for working on the exposition besides the fact that your help is needed. It is a good way to become better acquainted with your instructors and fellow students. It's also a good way to meet and make new friends. And you'll be surprised how much you'll learn in the process because it's true we learn best by doing. So why not do something in connection with the planned color television demonstration, or the possible atomic energy exhibit, or any one of the individual department displays? If this appeals to you, contact the presidents of the various societies who are in charge of their respective department exhibits.

Everyone who is interested in working on an individual exhibit should get in touch with George Fox, whole those interested in routing and conducting tours are invited to see Dick Sedlack.

So get in touch with the proper representative of the Exposition Manpower Commission and have fun working on the 1954 edition of the Engineering Exposition.

The Therouxs

(Continued from page 30)

a consultant with a sanitary engineering firm in Los Angeles.

Paul, class of '47, also served in the Air Force, and is now working with the Boston Mutual Factory Insurance Co. in New York, inspecting and selling factory insurance. He has a degree in chemical engineering.

Frank, class of '48, has a B.S. in civil engineering and served his duty in the Navy. He is now working in the Los Angeles area with the Colorado River Board of California, which handles projects of diversion and utilization of the Colorado River in California.

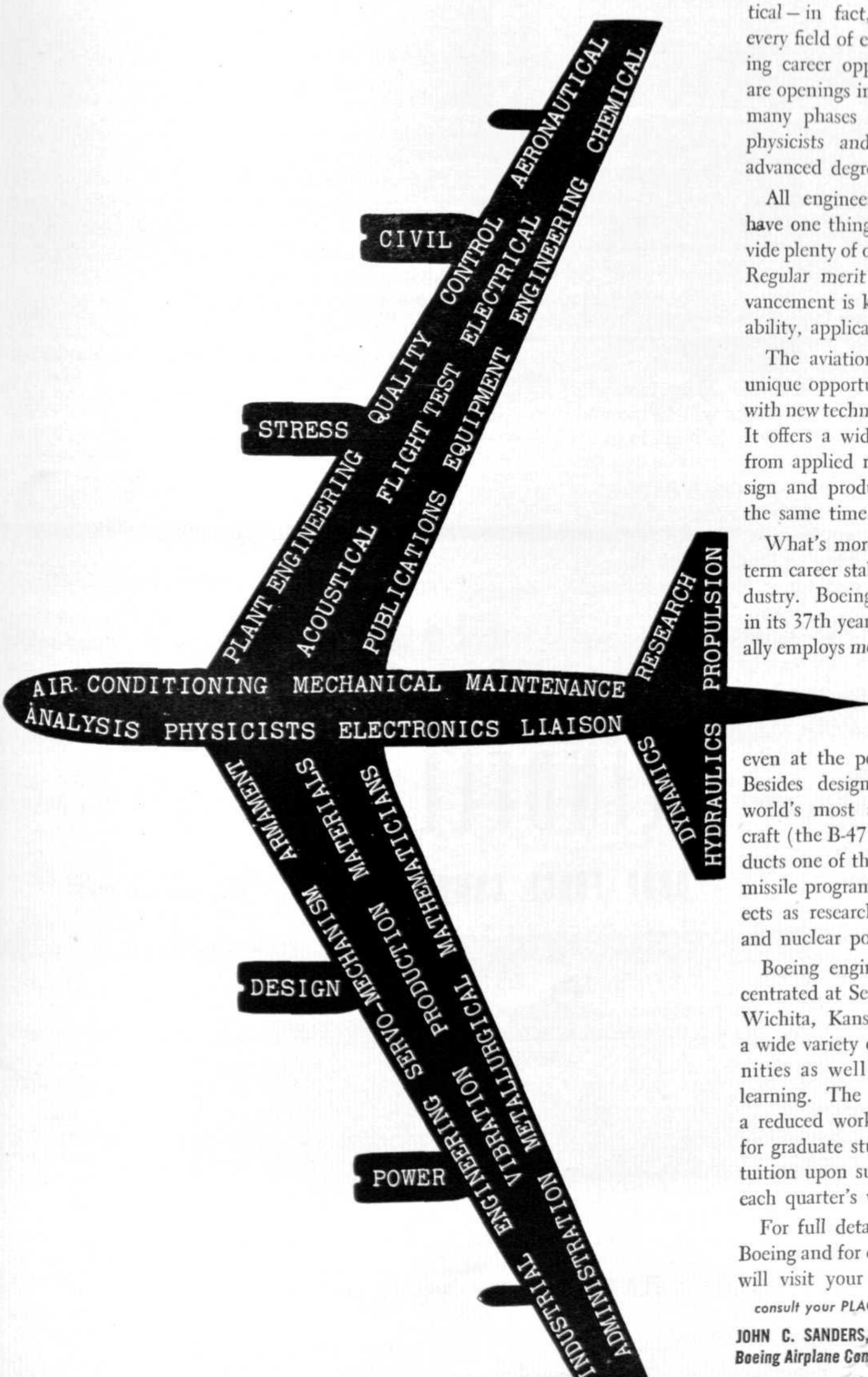
Charles, deviating from the engineering pattern preceding him, graduated from the School of Business Administration in 1951, and is now in sales work in St. Petersburg, Florida.

Frances, the only girl, received her degree in education in 1953, and is now playing the role of Mrs. Frank Kush in Columbus, Georgia, while Frank is at Fort Benning with the Army.

Last in line, James graduated this past term with a degree in hotel administration, but will soon be with the Army at Fort Dix.

Certainly this is an unusual family, and though the standard they have set is high, we hope that there will be many more families like the Therouxs here in future years, for Michigan State College, and especially the School of Engineering, is proud of Professor Theroux and his wonderful family.

Engineers of virtually EVERY type are needed on the Boeing team



Mechanical, electrical, civil, aeronautical – in fact, graduates in virtually every field of engineering–find rewarding career opportunities here. There are openings in design, research, in the many phases of production, and for physicists and mathematicians with advanced degrees.

All engineering careers at Boeing have one thing in common: they provide plenty of opportunity to get ahead. Regular merit reviews are held. Advancement is keyed to your individual ability, application and initiative.

The aviation industry offers you a unique opportunity to gain experience with new techniques and new materials. It offers a wide range of application, from applied research, to product design and production, all going on at the same time.

What's more, you can expect long-term career stability in the aviation industry. Boeing, for instance, is now in its 37th year of operation, and actually employs more engineers today than even at the peak of World War II. Besides designing and building the world's most advanced multi-jet aircraft (the B-47 and B-52), Boeing conducts one of the nation's major guided missile programs, and such other projects as research on supersonic flight, and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas – communities with a wide variety of recreational opportunities as well as schools of higher learning. The Company will arrange a reduced work week to permit time for graduate study and will reimburse tuition upon successful completion of each quarter's work.

For full details on opportunities at Boeing and for dates when interviewers will visit your campus,

consult your PLACEMENT OFFICE, or write:

JOHN C. SANDERS, Staff Engineer – Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING

Clubs & Societies

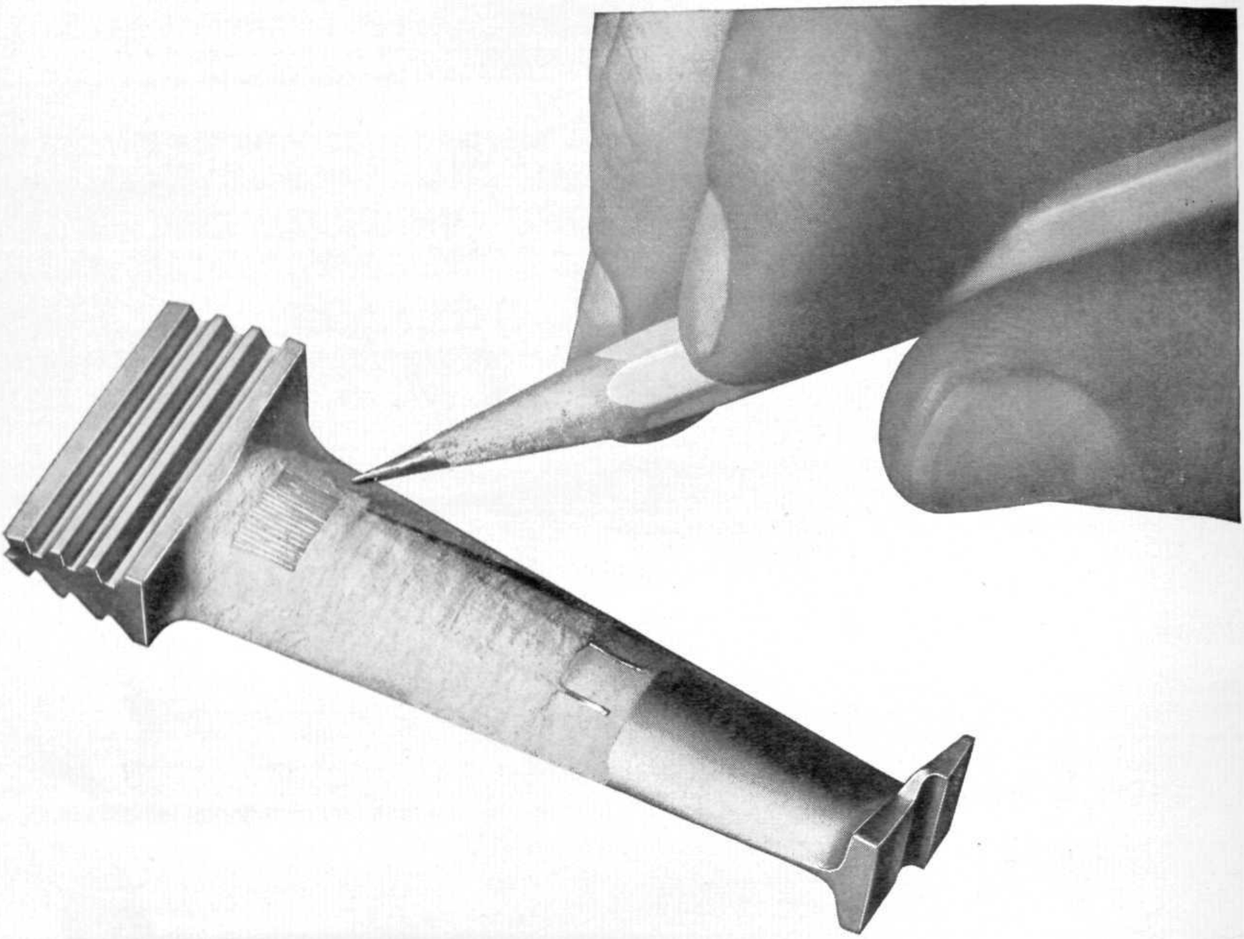
(Continued from page 36)

invitation was extended to take advantage of the opportunities which the MSC foundry offers in the line of gaining experience in the nation's fifth largest industry, cast metals. Here, then, is a further and more definite invitation.

During this Winter term the foundry will be open from 9 AM to 5 PM on several Saturdays (see engineering activities schedule in Olds Hall stairwell) for the purpose of letting students make whatever castings they want to (within reason); AFS members and a staff member will be present to assist in any way they can. Students may supply their own patterns or may use those in stock at the foundry, which include ashtrays, book-ends, souvenirs, andirons, bench anvils, vises, etc. Participators will be expected to pay only for the metal which is taken away, unless they choose to provide their own. Aluminum will be available as needed, while brass will be poured only when there are enough projects in brass to make melting it worthwhile. Molds for grey iron can be made and allowed to stand until the next class pouring.

Practicing engineers commonly come in contact with castings, so it would be a wise move for engineering students to become as familiar with them as soon as possible, for a man cannot do good work with tools he does not know how to use. The WELCOME mat is out, so come on over—we'll be looking for you!

MSC Student Chapter AFS.



Author's Page

"A Challenge To Leaders," Page 12

The author of *"A Challenge to Leaders,"* **John Rood** is a 19 year old native of East Lansing. While attending East Lansing High School, John was a member of the Band and Chorus, and played basketball for three years. As a student at Michigan State College, he has played and coached basketball for intramural and church teams. In addition to Tau Beta Pi, John is a member of Pi Mu Epsilon and Green Helmet honoraries, Assistant Business Manager for the *Spartan Engineer,* and Secretary-Treasurer of the Peoples Church Choir.

"Creep In Metals," Page 13

Zigurds J. Levensteins – *Senior mechanical engineer* – Ziggy was born in Riga, Latvia, coming to the United States in 1949 under the Displaced Persons Act.

Before entering Michigan State in the fall of 1950, Ziggy worked eight months at Oldsmobile in Lansing. Now firmly rooted in East Lansing – he says with thanks to Professor Sigerfoos of State and Mr. Hover of Oldsmcbile – Ziggy adds membership in Pi Mu Epsilon, Pi Tau Sigma, and Phi Lambda Tau to his writing activities for the *Engineer.*

"An Interview: Dr. R. A. Smith," Page 18

Albert Summers was born in Clearwater, Florida, and attended Eastern High School in Lansing, Michigan. He entered Michigan State in the fall of 1948 and received his B.A. from the Foreign Language Department. In the fall of 1952 he re-entered Michigan State College to study geology. His keen interest in geology is reflected in the report of his interview with Dr. R. A. Smith, former State Geologist and Chief of the Geological Survey Service.

Power Transmission

(Continued from page 23)

tor. Using this figure as basic capital cost, annual charges have been calculated. Interest, depreciation maintenance, and taxes were evaluated at ten per cent and both corona and copper losses were evaluated at $100 per kilowatt. Table IV gives the results of a calculation for one condition. These figures emphasize the fact that corona loss, determined on present information and design practice, is a small factor in the over-all operating cost of a high-voltage line. If sufficient data are available on corona loss under all conditions, a closer design would be permissible with a possible large saving in the high-voltage system.

TABLE IV.
Annual Charges for 100 Miles of 345-Kv Line Having 20 Insulators and 1.75-inch Diameter Conductor.

	Load in Megawatts		
	100	200	400
Capital	$450,000	$450,000	$ 450,000
Copper loss	67,000	259,000	1,033,000
Corona loss	13,000	13,000	13,000
Total	$530,000	$722,000	$1,496,000
Annual cost per kw.	$5.30	$3.61	$3.74

Rough estimates show about ten per cent increase in capital cost for building a line with increased spacing from 33 feet to 42 feet and about 25 per cent increase in cost for increase in conductor size from 1.558 inches to 1.901 inches for a given spacing. Thus, if better data will allow a smaller conductor diameter or smaller spacing, or both, capital cost can be decreased by a sizeable factor.

Table V shows the effect of increased spacing on corona loss for a given conductor and also decreased corona loss for increased conductor size for a given spacing and line insulation. These comparisons are based on present fair-weather corona loss data and indicate a real need for better data on corona loss and associated radio influence for the many varying conditions, so that the maximum capabilities of all equipment may be utilized to secure the most economical system.

TABLE V. **Corona Loss Data.**

	Estimated Effective Corona Loss, Kw Per Mile*		
Size, In. Conductor	20 Insulators, 33-Ft. Spacing	24 Insulators, 37-Ft. Spacing	30 Insulators, 42-Ft. Spacing
1.558	1.60	1.38	1.12
1.610	1.46	1.28	1.06
1.750	1.28	1.10	0.92
1.901	1.14	0.98	0.80

*Assuming average annual loss is twice the fair-weather loss.

Conclusions

The indicated need for developing higher voltage transmission and the fact that costs increase very rapidly with increased voltage make it increasingly important to evaluate carefully and precisely all engineering factors entering into the design of higher voltage transmission systems. This necessitates having precise and reliable data on the characteristics and performance of materials and equipment constituting transmission systems.

The two factors that influence design, and, therefore, costs of extra-high-voltage transmission lines and systems, are corona and basic impulse level, and the two are interrelated. There is good engineering reason for the belief that materially lower insulation levels than any heretofore attempted on extra-high-voltage transmission can be used successfully in the future, if all the unknown engineering questions that this raises can be answered. A specific series of such levels is presented in the paper.

Of the questions that need to be answered, fairly good engineering data are now available on lightning and switching surges, insulation co-ordination, and the effects of line spacing on reactance and capacitance. But line spacing also affects corona. Some data are available on corona and radio influence, particularly on fair-weather corona losses for horizontal configuration on single conductor per phase and on how the surface affects these losses. There is need for corona loss and radio influence data showing the effect of ground wires on various combinations with single conductors and the effect of rain, fog, clouds, and other natural elements that make up the yearly weather conditions in a given location. Also, bundle conductors offer some advantages that need be investigated carefully to make possible proper weighing of advantages versus disadvantages. Such data would allow a closer estimate of corona losses so that they could be considered on an average loading basis, the same as other variable losses. All of this should lead to more precise design and the development of transmission systems operating at extra high voltages that would yield the maximum economies possible by higher voltage use.

The investigation and test program now in progress at the Tidd plant of the Ohio Power Company is planned to obtain the necessary data to answer these and other pertinent questions that need be answered to make possible the economic design of extra-high voltage transmission systems.

Measure WASHO

(Continued from page 25)

test section were provided, one set every 60 ft. The entire operation, including the taking of the profile, moving to the next location, and setting up the equipment to take the next profile, requires about 3 min. for a three-man crew.

To determine where the deformations occur—that is, whether in the subgrade, subbase, or surface—an auxiliary system was devised, made up of devices called settlement assemblies. A settlement assembly consists of a perforated steel plate about 5 in. square; a rod about 1½ in. shorter than the thickness of the pavement structure, with a self-tapping screw welded to one end; a riser rod; and miscellaneous collars, etc. The perforated plate is placed during construction on the surface of the subgrade (or subbase).

After construction is completed, a ½-in. hole is made thrugh the pavement to the plate, and the rod

(Continued on page 50)

THE DU PONT DIGEST

Robert Thomson (*left*), B.S. in Ch.E., Univ. of Va. '50, **David S. Rumsey** (*center*), M.S. in Ch., Univ. of Mich. '48, and **Rene M. LeClair** (*right*), M.S. in Ch. E., M.I.T. '51, test samples on an experimental batch unit.

Plant Development

Offers Training and Opportunity

John Purdom, M.S. in Ch.E., Ohio State '48 (*right*), confers with other engineers on the progress of a new plant.

A young chemical engineer recently had his first assignment in a *Plant Development* group at Du Pont. He was part of a team assigned to improve recovery of adipic acid, a nylon intermediate, from plant-waste streams.

First, he made a literature survey for possible leads. Three recovery methods came under consideration: *solvent extraction*, *crystallization*, and a combination *distillation-crystallization* process. He helped to set up a laboratory program to compare and evaluate them.

Preliminary results were somewhat inconclusive. It was decided to go ahead with semi-works tests, while an organic chemist completed the laboratory work.

Next, the young chemical engineer joined forces with a mechanical engineer to design a semi-works plant to evaluate each method. In this plant, all vital points were checked and rechecked: materials of construction, steam and water requirements, heat-transfer coefficients, yields, product quality, and pollution problems.

The semi-works data revealed that the *distillation-crystallization* process was the most economical, and also gave the best product quality. Usually, the next step would be construction and operation of a pilot plant. But this time, engineers from the *Production Division* arranged for a limited-scale plant test, using a spare batch still and a crystallizer on a part-time basis. Two months of testing confirmed the previous data—the new *distillation-crystallization* process recovered adipic acid efficiently, and would reduce costs considerably. The plant is now using this process successfully.

That's how one young chemical engineer started his career in a typical Du Pont *Plant Development* group. The job of such groups is to make processes and equipment more efficient, to adapt products to new uses, and to improve product quality.

Plant Development work not only offers opportunity in itself but valuable training for other fields.

ASK FOR "Chemical Engineers at DuPont." This new illustrated booklet describes initial assignments, training, and paths of promotion. Just send a post card to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware. Also available: "Du Pont Company and the College Graduate" and "Mechanical Engineers at Du Pont."

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
... *THROUGH CHEMISTRY*

Watch "Cavalcade of America," on Television

Measure WASHO

(Continued from page 48)

is screwed into one of the holes in the plate. The hole around the rod is then filled with sand to within a few inches of the surface, and a short steel tube of ½-in. diameter is inserted to prevent the top of the hole from collapsing. A rubber stopper is pressed into the steel tube when the installation is not in use. When readings are to be made, the cork is removed and a riser rod inserted. Readings are taken by rolling the profilometer wheel over the top of the riser rod. The high point of the oscillograph tape is then an indication of the elevation of the subgrade (or subbase) with respect to the profilometer truss.

Some of the early work on the Board's flexible-pavement research project in cooperation with the Asphalt Institute and the Bureau of Public Roads, carried out at Hybla Valley, Va., and elsewhere, indicated that the elastic deflection under load of a flexible pavement structure, or of its subgrade, is of significance, and that information about it may be useful in predicting pavement failures. In the WASHO test, it was decided to measure elastic deflections both within the pavement structure and at the surface of the pavement. Differences betwen surface and structure deflections are deflections of the subgrade itself.

The basic element or transducer used to convert deflection into changes in electrical potential for recording, is the LVDT, as used in the profilometer. The greatest problem here was to find a satisfactory means of anchoring the transformer body to one element in the pavement, and the core to another. Perforated plates on the subgrade were placed during construction, long steel reference pins were driven into the subgrade, and surface disks were rolled into the asphaltic concrete when the top was laid. The remainder of the installation was completed after construction was finished. When not in use, a dummy top plate replaces the plate containing the transformer holder. When readings are to be taken, the dummy plate is removed and the transformer holder, complete with LVDT, is inserted in its place. In each test section provision is made for one total-deflection and one structure-deflection installation in each wheel path, and for one total-deflection installation midway between wheel paths.

Another device developed and used on the test for measuring deflection is known as the Benkelman lever-arm deflection indicater. This is an extremely valuable instrument in that it may be used to measure the total pavement deflection at creep speed at any point—that is, it is not restricted to use at the location of elaborate instrument installations.

In operating the Benkelman indicator, a probe beam is inserted between the rear dual tires of a loaded truck or trailer. A foot on the front end of the probe rests on the pavement surface well ahead of the infiuence of the truck wheel. This beam is pivoted at the end of a reference beam which rests on three points on the pavement well back of the influence of the load. The truck is then moved ahead so that the loaded wheel passes the probe foot. An Ames dial measures the movement of the probe (and thus of the pavement surface) with respect to the referenc beam.

Normal operation of truck traffic follows a known and reasonably constant pattren of transverse placements, depending on the width of the lane among other things. To simulate normal operation, it is necessary to instruct the test drivers to follow some definite sequence of transverse positions on the road. Lines were painted in color longitudinally along the pavement for use by the drivers as guides in keeping the wheels of their trucks at certain distances from the edge of the pavement. Since the job of driving these vehicels is monotonous, drivers may not remember which line to follow for each trip. It was therefore necessary to provide a means of reminding them. Mounted in the cab of each truck is a box with colored lights which change each time the driver is to change the transverse position of his wheels. Thus, the color of the light in the box coincides with the color of the line on the pavement which the driver is to follow in positioning his wheels. The proper sequence for these code lights is established by a radio-activated, automatic stepping switch which moves up one position each time the truck completes a trip around the loop.

Cooperative Agencies

The WASHO Road Test is sponsored by the Highway Departments of California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming. The right-of-way was furnished, without charge by the State of Idaho, and after completion of the test the facility will revert to the state. Other cooperating agencies include the Bureau of Public Roads, which is contributing certain supplies, equipment, and personnel; truck manufacturers of the Automobile Manufacturers' Association, who furnished the tractors; trailer manufacturers of the Truck Trailer Manufacturers' Association, who furnished the trailers; and certain companies in the petroleum industry who are furnishing the gasoline, diesel fuel, oil, and grease consumed in the test. The total cost of the project is estimated as approximately $650,000.

As is its custom in operating a test of this nature, the Highway Research Board established an Advisory Committee made up of representatives of the above cooperating agencies, of the Department of Defense, of the National Highway Users Conference, of the American Trucking Association, and of certain pertinent departments of the Board. The committee also includes certain officials of the Board. The chairman is Earle V. Miller, M. ASCE, State Highway Engineer for the Idaho Department of Highways. This committee is considered by the Board as the final authority in all matters concerning construction and maintenance of the road and operation of the test.

° ° ° °

"Goodness, George, this is not our baby. This is the wrong carriage."

"Shut up! This is a better carriage."

Creep *Continued from page 15*

reduce the effective stress bearing area. However, there is also evidence that stress intensification alone cannot explain the accelerating stage of creep. First, often times the very small creep strains are not nearly sufficient to cause stress intensification that would produce a rapid acceleration of creep rate and second, in compressive creep tests where there is actually a reduction of stress in the last stage of creep, the creep rate is also accelerated. This is shown in Figure 6.

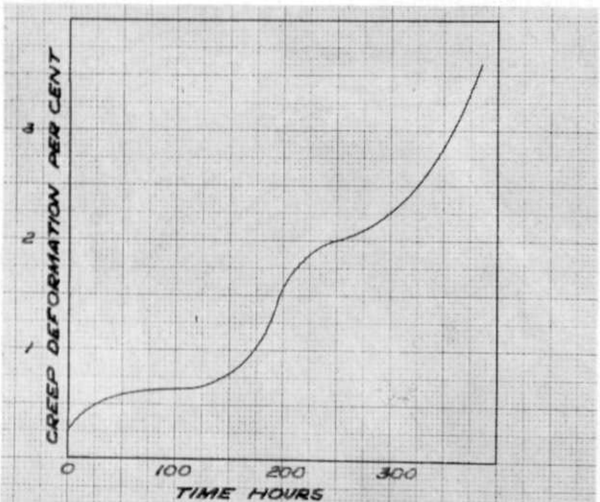


FIG. 6 COMPRESSIVE CREEP TEST CURVE

Another reason given for the tertiary creep stage is the metallurgical changes like overaging, recrystallization and phase changes in the specimen. Metallurgical transformations affect the creep characteristics very much, but in many tests no metallographic changes are seen, while the accelerated creep rate still occurs. Thus the precise mechanism of this last stage of creep is very obscure and much investigation is needed to explain it.

Types of Fracture

Generally three types of fracture following the tertiary stage of creep can be distinguished.

(1.) Fracture accompanied by necking of the specimen and considerable elongation during the test. This type of fracture is transcrystalline and occurs in polycrystalline metals at relatively low temperatures and high rates of strain and metallic crystals at all temperatures and all rates of strain.

(2.) Fracture accompanied by no necking of the specimen, the fracture being entirely intercrystalline. This type occurs at relatively high temperatures and low rates of strain.

(3.) A fracture intermediate between types one and two, the fracture being partly transcrystalline, partly intercrystalline. The portion near the surface of the specimen is mostly intercrystalline. Usually this type of fracture is not accompanied by necking of the specimen.

The different types of fracture have led to a definition of equicohesive temperature, or better, temperature range above which the crystals are stronger than the boundaries and below it the boundaries are stronger than the crystals.

Creep Testing

The usual creep test is conducted with an applied tensile stress. In obtaining creep test data for precise engineering work, there are four quantities that must be measurable: the applied load, the temperature, extension and time. In order to do that special creep testing machines have been devised. The equipment necessary for obtaining accurate results is expensive.

The essential conditions in creep tests are: the load must be applied exactly axially and maintained constant, the temperature of the specimen must be uniform and maintained constant within very close limits, because a variation of only 20° F. may double the creep rate, and it must be possible to measure the extension accurately at short intervals of time.

Because of the cost involved in the standard creep test for accurate results, simpler tests not requiring elaborate equipment are used where data of less accuracy and dependability are adequate. For instance, most academic work, research in new creep resistant alloys, etc., would be occasions to use simplified creep tests.

Interpretation of Creep Test Data

There are two types of methods for interpretation of creep test data. One attempts to find an empirical equation to fit the creep curve at a particular stress and temperature and the other includes several methods that attempt to relate the creep rate and stress for a particular temperature and material. In order to know whether a part will perform satisfactorily in service and not exceed an allowable deformation, the relationship between creep rate, stress and time is very important to the designer. If the relation is found, knowing the operating conditions, expected life and allowable deformation, an allowable stress can be selected to which the part may be subjected without failure.

The method considered first has been found to be in good agreement with the test results of many engineering materials. This method is designated as the Modified Log-Log Method and gives good approximation to the actual creep strain values.

In this method the creep strain E at a time t is considered to consist of two parts: E — the elastic strain plus the initial creep strain and E — the time dependent strain.

$$\epsilon_t = \epsilon_o + \epsilon$$

Figure 7 shows the common curve obtained by plotting creep strain against time from tests conducted

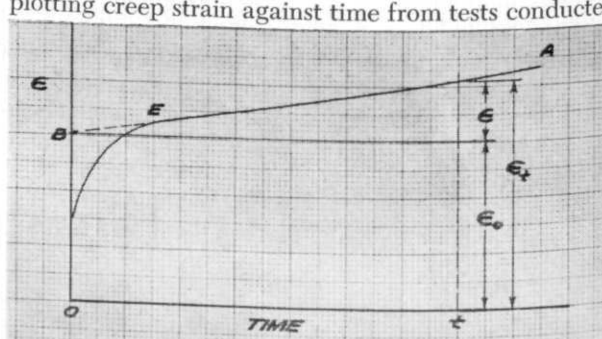
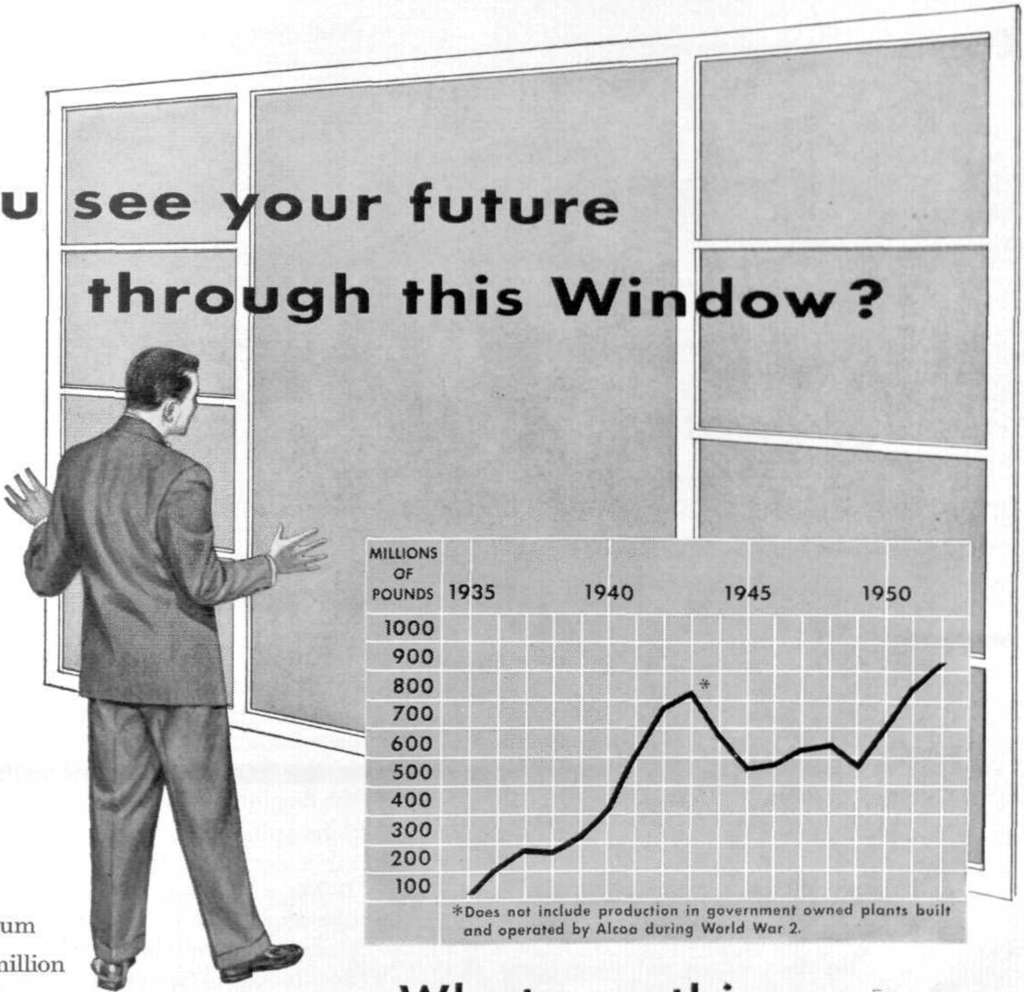


FIG. 7 CREEP STRAIN — TIME AT CONSTANT TEMPERATURE AND STRESS

Continued on page 54

Can you see your future through this Window?



This is an aluminum window, one of four million that will go into buildings in 1953. Twenty years ago, it was just an idea in the mina of an Alcoa development engineer. Ten years ago, only a few thousand were made annually. Now, production *is increasing* at the rate of over half a million a year. This is just one of a torrent of new uses for aluminum which means that Alcoa must continue to expand. Consider the opportunities for you if you choose to grow with us.

What can this mean as a career for you?

This is a production chart . . . shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1952. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve—is still rising, we're still expanding, and opportunities for young men *joining us now are almost limitless.*

Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places", get in touch with us. Benefits are many, stability is a matter of proud record, *opportunities are unlimited.*

For more facts, consult your Placement Director. Aluminum Company of America, Pittsburgh, Penna.

Alcoa Aluminum

ALCOA ALUMINUM ®

ALUMINUM COMPANY OF AMERICA

Sidetracked

The Thing

Verily I say unto you, marry not an engineer, for the engineer is a strange being and possessed of many devils.

Yea, he speaketh eternally in parables which he calleth "Formulae."

And he wieldeth a big stick which he calleth a slide rule, and he hath one Bible—a Hand Book.

He talketh always of stresses and strains and without end of Thermodynamics.

He showeth always a serious aspect and seemeth not to know how to smile.

And he picketh his seat in the car by the springs thereof and not by the damsel beside him.

Neither does he know a waterfall except by its power, nor a damsel except for her specific heat.

Always he carrieth his books with him and he entertaineth his maiden with "Steam Tables."

Verily though she expecteth chocolates when he calleth, she opens the package to disclose samples of iron ore.

Yea, though he holdeth his damsel's hand but only to measure the friction, and he kisses only to test the viscosity.

For in his eyes shineth a faraway look which is neither love nor longing, but a vain attempt to recall a formula.

There is one key dear to his heart, and that is a Tau Beta Pi key, and one love letter for which he yearneth, a "B."

And when to his damsel he writeth of love and signeth with x's mistake not these symbols for kisses, but for unknown quantities.

When a boy, he pulleth a girl's hair to test the elasticity, but as a man he discovers different devices.

For he would count the vibrations of her heart beat and he reckoneth her strength of materials.

For he seeketh ever to pursue the scientific investigation, even his heart flutterings he counteth as a vision of beauty, and inscribeth his passion in a formula.

And his marriage is a simultaneous equation, involving two unknowns and yielding diverse answers.

Penn State Engineer.

° ° ° °

The little old grey woman bent over the cherub in the cradle.

"O-o-o, you look sweet; I could eat you."

Baby: "The heck you could; you haven't any teeth."

° ° ° °

Professor ———: "Why aren't you taking notes?"

Student: "I don't have to. I've got my grandfather's."

Junior says he may like the Army a little better after a while, but right now there is too much drilling and fussing around between meals.

° ° ° °

"Yes, this is a nice little apartment, but where is the bath?"

"Oh, pardon me! I thought you were one of those engineering students who wants the place just for the winter."

° ° ° °

The average husband is proof enough that a woman can take a joke.

° ° ° °

Now I lay me down to sleep.
The lecture's dry, the subject's deep;
If he should quit before I wake,
Someone kick me for goodness sake!

° ° ° °

The eager relatives gathered for the reading of the will. It contained one sentence: "Being of sound mind, I spent every darn cent I had."

° ° ° °

In defending his state the Arizona native was saying: "All we need is a better type of settler and more water."

"When you come to think of it," retorted the tourist, "that's all Hell needs."

° ° ° °

Being confined in a hospital for a complete check-up, a very shapely blonde was not surprised when a handsome chap dressed in white, came in, pulled down the sheets, and for some minutes looked her over. Shaking his head, he left. Shortly he returned, pulled down the sheet and made another examination. The third time he came in, the blonde, in desperation, inquired, "Say, what in the world am I in here for, observation or examination?"

The chap in white replied, "Darned if I know, lady, I'm just doing some painting in the hall."

° ° ° °

He: "You remind me of the ocean."

She: "You mean I'm wild, romantic and restless?"

He: "No, you make me sick."

° ° ° °

"You can't beat the system," moaned an E.E. over his last term's grades. "I decided to take basket-weaving for a snap course, but two Navajos enrolled and raised the curve and I flunked."

° ° ° °

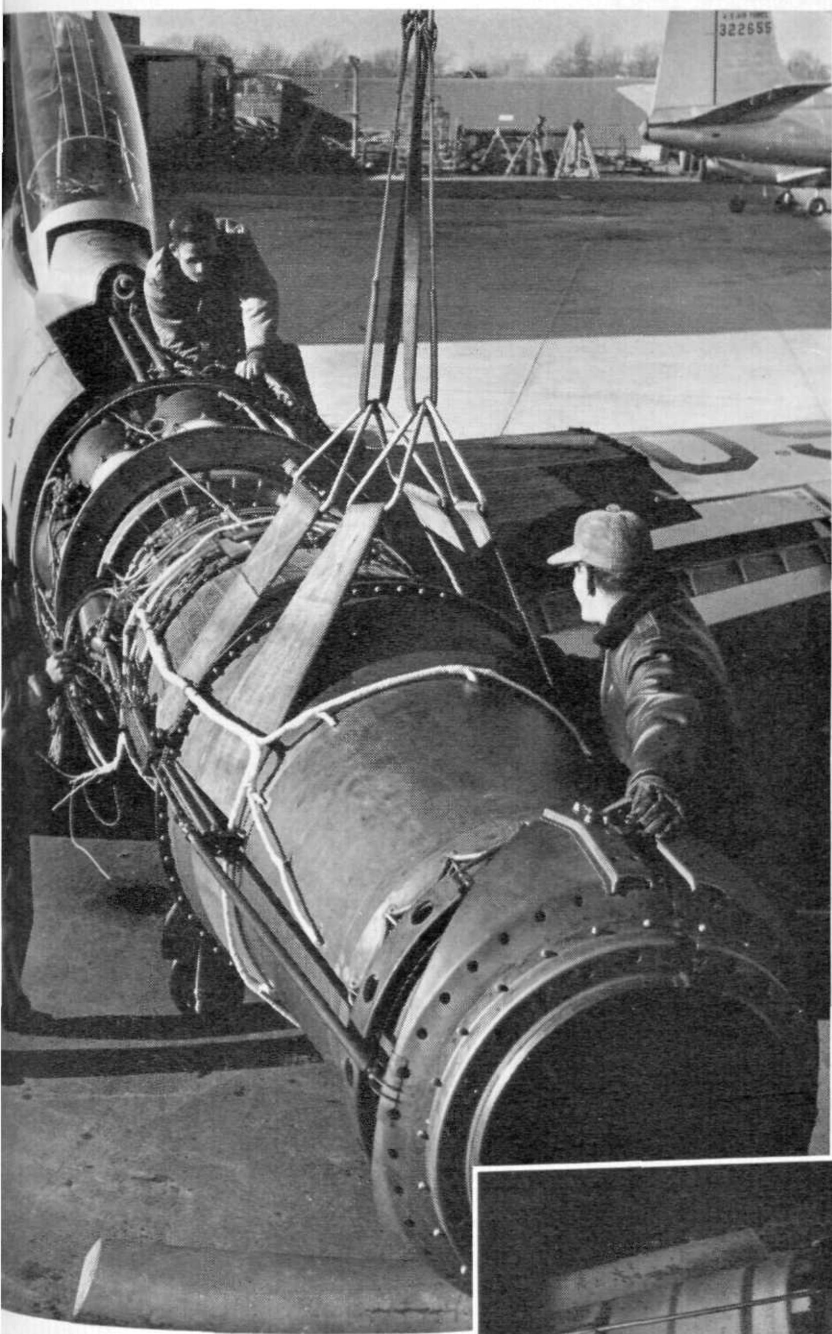
Small boy (looking at an elephant): "Gee, Ma, ain't that a hell of a big animal?"

Proud Mama: "How many times must I tell you not to say ain't?"

PHOTOGRAPHY AT WORK   No. 6 in a Kodak Series

Photography teams with research to slash industry's corrosion bill

Camera and Film work as research tools as International Nickel Company develops new alloys which prove tougher and defy corrosion.



Each year industry saves more and more millions on its corrosion bill by using Monel*, Inconel* and other corrosion-resisting alloys of the International Nickel Company.

To develop such alloys, "Inco" maintains extensive research—research that keeps photography on the job day-in and day-out.

This is because photography provides information which can be obtained and studied in no other way. Photomicrographs show metal structure. X-ray diffraction patterns reveal the arrangement of molecules. High-speed and time-lapse movies display the workings of corrosion.

Industries, large and small, find photography an important factor in their research—just as they know it improves manufacturing, cuts costs, and speeds many business operations.

"Today so many new applications of photography exist that graduates in the physical sciences and in engineering find them valuable tools in their new occupations. Other graduates—together with returning servicemen—have been led to find positions with the Eastman Kodak Company."

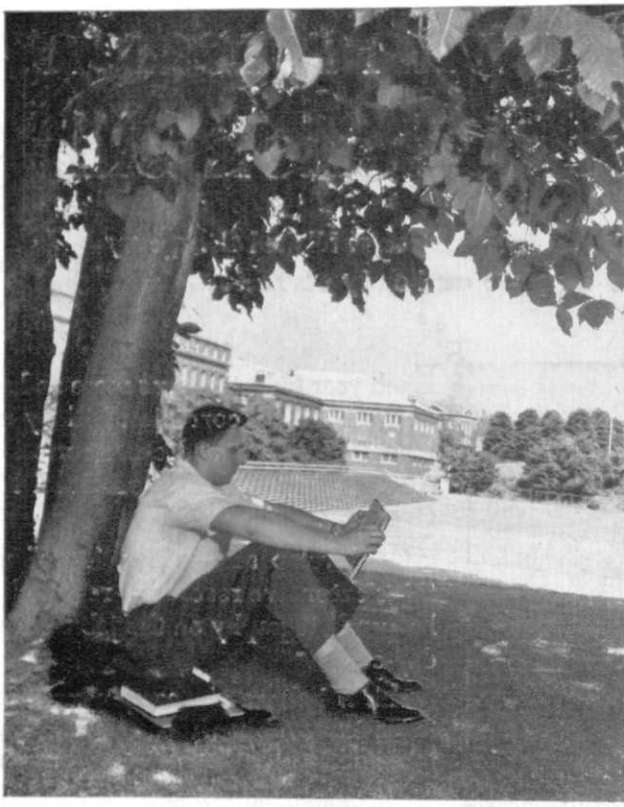
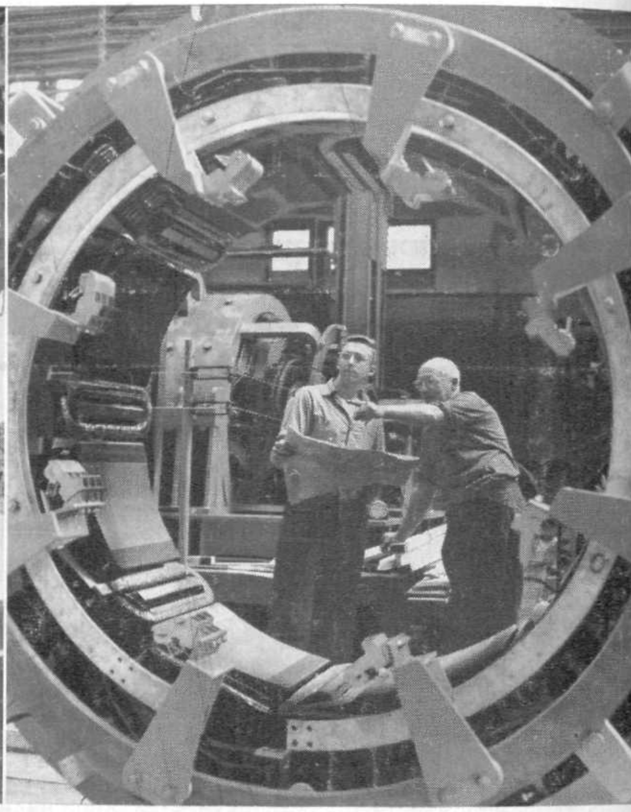
If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

*Reg. trade marks of the International Nickel Co.

Eastman Kodak Company
Rochester 4, N. Y.

To stand up against intense heat and highly corrosive gases, vital jet engine parts such as rotor blades, afterburner, and insulation bindings are made of nickel alloys. Illustration shows a Pratt & Whitney Aircraft turbojet engine with afterburner.

Kodak
TRADE-MARK

FROM CAMPUS — TO CAREER IS A BIG STEP

When the graduate leaves the college campus to begin his career he is taking an extremely important step. For he is leaving the area of directed-development in college and entering the area of self-development in industry.

Closing the gap between his campus experiences and the realities of earning a living is not easy. The complicated maze of modern industrial society has made this transition a tough task. While the craftsmen of former years grew up with the business, the college graduate of today steps into a strange organization at a relatively high level. He has had no opportunity to understand, through a long period, the methods and operations of the concern.

During his first few years, he is finding his place in the organization—learning its policies and objectives, and at the same time shaping his professional career. He needs all the assistance and guidance he can get.

Here at General Electric, hundreds of young men have found that intensive efforts are made to "bridge the gap" between college and industry—and to help young professional people realize their goals. Through extensive training programs, classroom study programs, leadership programs, and guidance in professional development, carefully selected young men are prepared for positions of responsibility and leadership in their individual fields.

Providing college graduates with the opportunity to know the Company and find the right job in it . . . giving them high-level, flexible orientation and training . . . offering continued opportunity for professional growth are most important tasks at General Electric. Nothing is more important—for our young professional people are our biggest asset.

If you are interested in building a career with General Electric, see your college placement director for the date of the next visit of the G-E representative on your campus. Meanwhile, for further information on opportunities with General Electric write to College Editor, Dept. 2-123, General Electric Company, Schenectady 5, New York.

GENERAL ELECTRIC