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The Wisconsin engineer

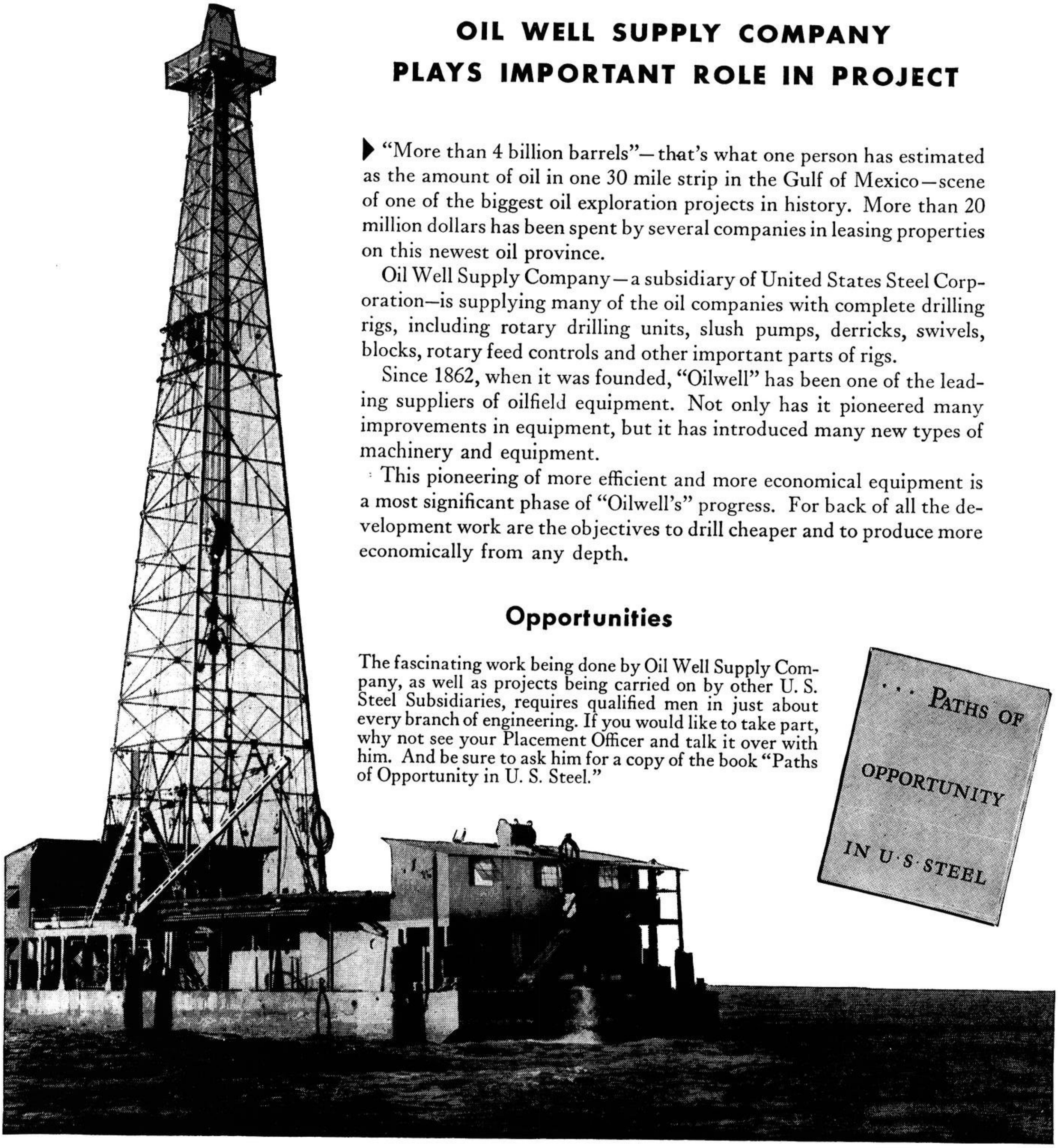
May, 1949

In This Issue:

Foundations for Tomorrow

15¢

Gulf of Mexico is site of newest oil "boom"



OIL WELL SUPPLY COMPANY PLAYS IMPORTANT ROLE IN PROJECT

▶ "More than 4 billion barrels"—that's what one person has estimated as the amount of oil in one 30 mile strip in the Gulf of Mexico—scene of one of the biggest oil exploration projects in history. More than 20 million dollars has been spent by several companies in leasing properties on this newest oil province.

Oil Well Supply Company—a subsidiary of United States Steel Corporation—is supplying many of the oil companies with complete drilling rigs, including rotary drilling units, slush pumps, derricks, swivels, blocks, rotary feed controls and other important parts of rigs.

Since 1862, when it was founded, "Oilwell" has been one of the leading suppliers of oilfield equipment. Not only has it pioneered many improvements in equipment, but it has introduced many new types of machinery and equipment.

This pioneering of more efficient and more economical equipment is a most significant phase of "Oilwell's" progress. For back of all the development work are the objectives to drill cheaper and to produce more economically from any depth.

Opportunities

The fascinating work being done by Oil Well Supply Company, as well as projects being carried on by other U. S. Steel Subsidiaries, requires qualified men in just about every branch of engineering. If you would like to take part, why not see your Placement Officer and talk it over with him. And be sure to ask him for a copy of the book "Paths of Opportunity in U. S. Steel."

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UNITED STATES STEEL

DU PONT *Digest*

For Students of Science and Engineering

TEN UNIVERSITIES TO BENEFIT BY GRANTS FOR UNRESTRICTED FUNDAMENTAL RESEARCH

With a view to stock-piling basic knowledge, the Du Pont Company has announced a program of grants-in-aid for the college year 1949-50 to 10 universities for unrestricted use in the field of fundamental research in chemistry.

The grants-in-aid of $10,000 each are to be used for research that has no immediate commercial goal. The universities themselves are to select the projects in which the grants will be employed, and results of the research are to be freely available for publication.

Du Pont's purpose in offering the grants is to help insure the flow of fundamental knowledge in science upon which the future industrial development of our country is so dependent. It is intended that the funds be utilized for such expenses as employing additional research personnel or lightening the teaching load of a professor who is eminently capable of research of a high order. They may also be expended for the purpose of obtaining supplies, apparatus or equipment.

This program of grants-in-aid is largely experimental. However, it is Du Pont's hope, should the program work out satisfactorily, to continue each grant for a period of five years.

The 10 universities to which grants-in-aid are being offered are California Institute of Technology, Cornell, Harvard, Massachusetts Institute of Technology, Ohio State, Princeton, Yale, Illinois, Minnesota and Wisconsin. Du Pont fellowships are also offered at these institutions.

Four of Many Outstanding Du Pont Fellowship Winners

STANLEY

MARVEL

WALKER

FAWCETT

Dr. Wendell M. Stanley, at University of California, is Chairman of the Department of Biochemistry in Berkeley and in the Medical School at San Francisco; Director of the Virus Laboratory. Bachelor's degree at Earlham College, 1926; M.S. at Illinois, 1927 and Ph.D. in Organic Chemistry, 1929. Honorary Doctor's degrees from five prominent American universities and the University of Paris. Has received more than 10 medals and awards for distinguished work in chemistry and biochemistry; co-recipient of the Nobel Prize in Chemistry in 1946. Du Pont fellow at Illinois in 1928-29.

Dr. Carl S. Marvel, Professor of Organic Chemistry at the University of Illinois since 1930, received his A.B. at Illinois Wesleyan University in 1915; A.M. at Illinois, 1916 and Ph.D. in Organic Chemistry, 1920; Sc.D. (honorary) at Illinois Wesleyan, 1946. President American Chemical Society, 1945; Director 1944-46. Has received numerous honors such as the Nichols Medal and memorial lectureships at outstanding universities. Du Pont fellow at Illinois in 1919-20. Consultant on Organic Chemistry to the Du Pont Company at present.

J. Frederic Walker is a Research Supervisor on formaldehyde products in the Electrochemicals Department. Trained at Massachusetts Institute of Technology. Awarded Bachelor's degree in Chemistry, 1925; Master's degree 1928, Ph.D. in Organic Chemistry, 1929. Author: "Formaldehyde Chemistry," "Organic Chemistry of Sodium," "History of Chemistry." Du Pont fellow in 1926-27.

Frank S. Fawcett is now doing synthetic organic research with Du Pont's Chemical Department. Received Bachelor's degree in Chemistry, Furman University, 1940; Master's degree Pennsylvania, 1944; Ph.D. in Organic Chemistry, Massachusetts Institute of Technology, 1948. Du Pont fellow at M.I.T. in academic year 1947-48.

77 DU PONT FELLOWSHIPS MADE AVAILABLE TO GRADUATE STUDENTS

Again in the academic year 1949-50, the Du Pont Company is awarding post-graduate and post-doctorate fellowships to universities throughout the country.

This is a continuation of the company's 30-year-old plan to encourage advanced studies in the fields of chemistry, physics, metallurgy, and engineering.

It is hoped that the plan will continue to help maintain the flow of technically trained men and women who will go into teaching and research work at the universities and into technical positions in industry. Some of them, as in past years, may come to work for Du Pont when they finish their studies, but there is no obligation to do so; fellowship holders are free to enter any field of activity they choose.

The students and their research subjects will be selected by authorities of the 47 universities participating. In this year's program, 45 of the post-graduate fellowships are in chemistry, 4 in physics, 15 in chemical engineering, 5 in mechanical engineering and 2 in metallurgy. There will be 6 post-doctoral fellowships as an incentive to those who would prefer to remain in academic work in order to obtain additional advanced training in chemistry.

What Fellowships Provide

Each post-graduate fellowship provides $1,200 for a single person or $1,800 for a married person, together with an award of $1,000 to the university towards tuition and fees. Each post-doctoral fellowship provides $3,000 for the recipient and $1,500 to the university.

WISCONSIN ENGINEER

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In This Issue . . .

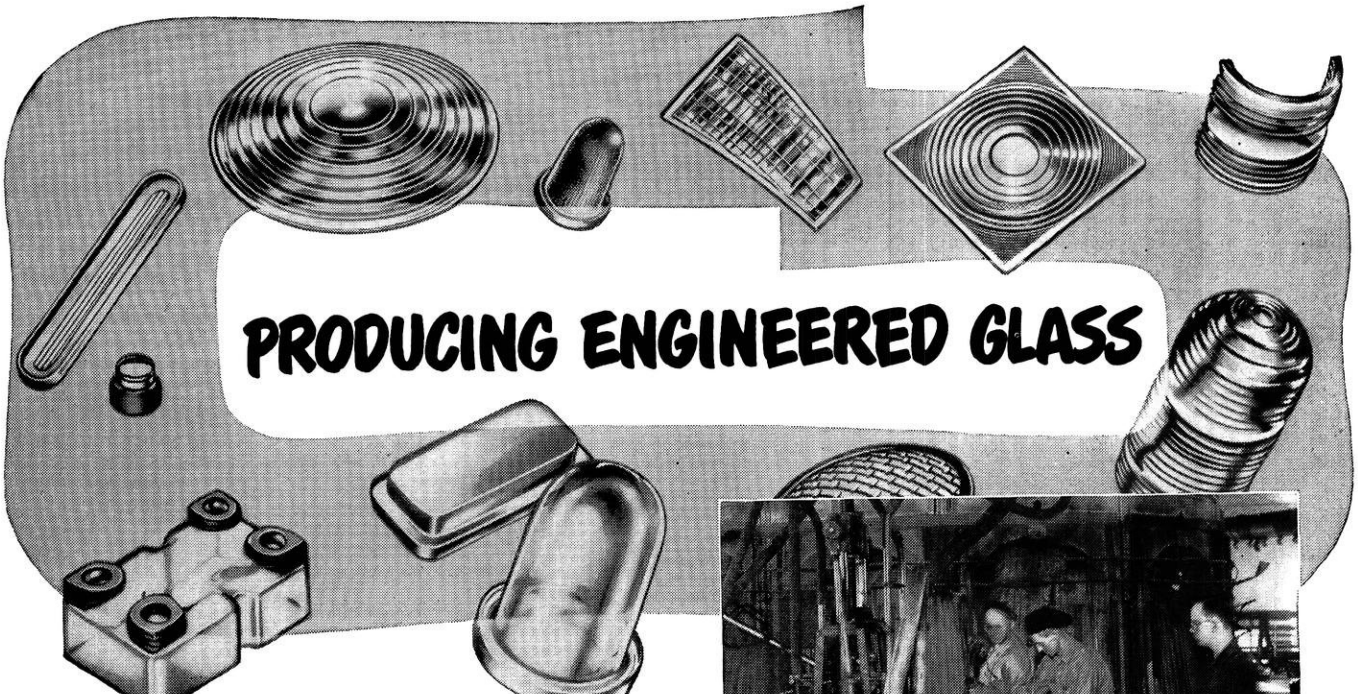
Cover:

Foundations for Tomorrow—A graduating engineer overlooks a scene with a double meaning: his education is but the foundation of the work of tomorrow.

(*Foton Photo*)

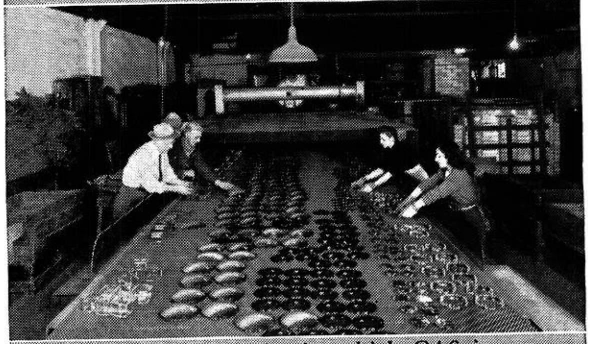
Articles:

Departments:



Modern Techniques Employed by KOPP GLASS, INC. Illustrate Effective Utilization of GAS

Molten glass from the Gas-fired regenerative furnace (rear) is placed in the mould for pressing.



Continuous Lehr in which GAS is used for annealing signal and industrial glass products.

ENGINEERED GLASS—produced for signal, technical, and industrial purposes—involves small-batch operations and specialized glass-making practices. At Kopp Glass, Inc., Swissvale, Pa. engineers have applied modern production machinery to these highly technical processes, utilizing flexible GAS for all heating requirements.

As large users of fuel, Kopp executives are concerned with the operating economies made possible by effective utilization of GAS in modern Gas-fired Equipment. But equally important is the automatic controllability of GAS for the varying temperatures used for melting, annealing, tempering, mould heating, in this specialized glass business. The importance of GAS in the Kopp plants is stressed by the wide range of equipment using this efficient fuel—

- 2 pot-type regenerative furnaces
- 2 special heat treating lehrs
- grinding and polishing plate heaters
- 4 day tank furnaces
- 3 annealing lehrs
- 1 mould oven
- 2 pot arches
- 2 ring ovens
- 1 cut-off machine
- 1 trial-pot furnace

In commenting on the use of GAS for heat-processing in the manufacture of engineered glass, supervisor of Equipment J. B. Fullen says, **"The automatic controllability and the speed of GAS are of great importance, but we can't overlook the cost of fuel in our type of operation. That's why we use every device for effective utilization of GAS."**

You'll find it worthwhile to investigate modern Gas Equipment for heat-processing in glass manufacturing.

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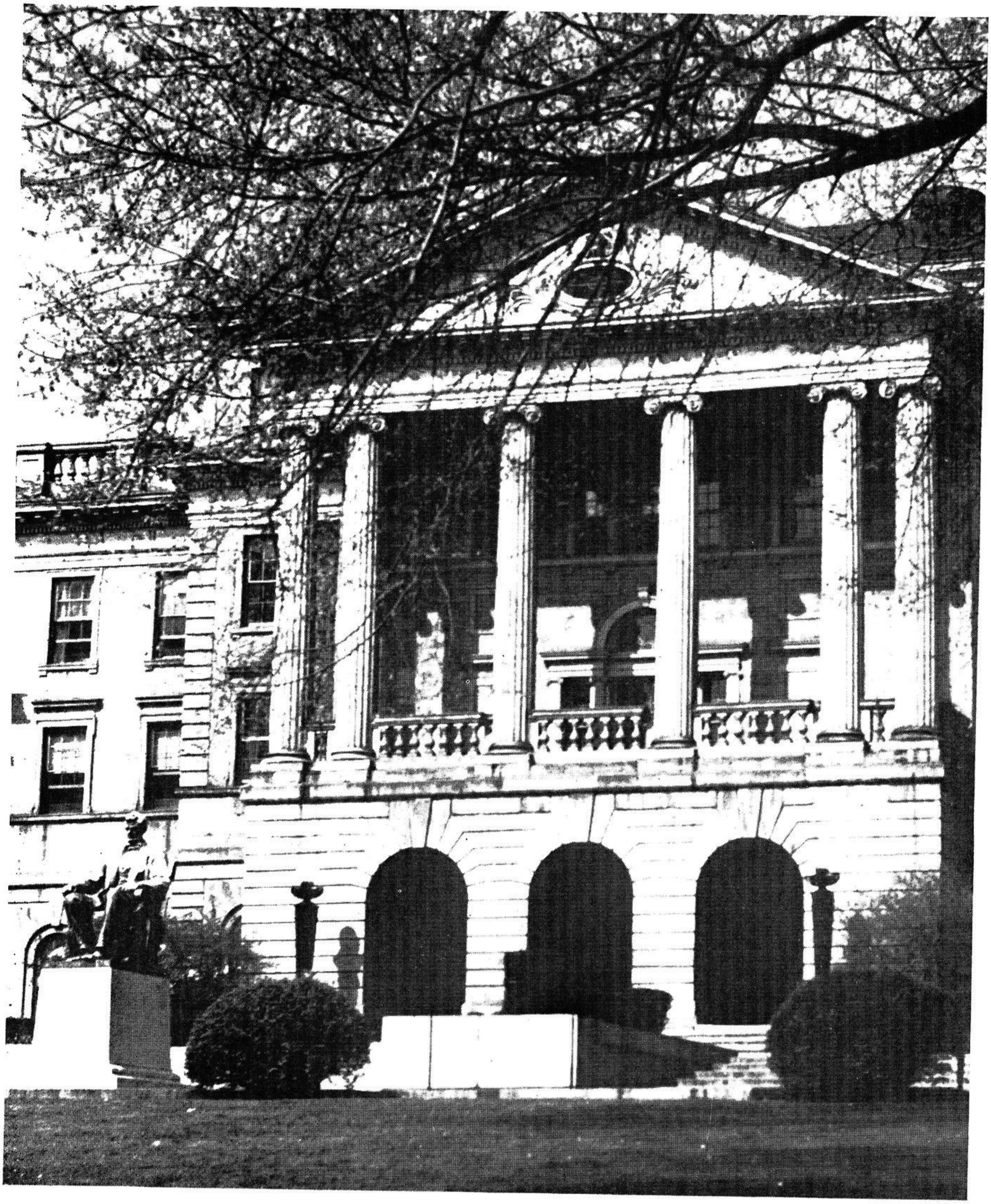


(*Foton Photo*)

To all Badgers, historic Bascom Hall remains . . .
symbolic of the years spent at Wisconsin.

MAGNETOSTRICTION

by Howard F. Traeder m'48

In 1837, at New Haven, Mr. C. G. Page observed that a horseshoe magnet hung over a conductor wound spirally in a vertical plane emitted a characteristic sound when a voltaic battery was connected to, or disconnected from, the ends of the spiral.

Mr. Page did not know it then, but the sounds were due to the sudden changes in dimensions accompanying the changes in magnetization induced in the horseshoe magnet by the application and removal of the magnetic field of the spiral.

This change in dimensions of a ferromagnetic material when it is placed in a magnetic field is known as "magnetostriction." The term applies to the inverse effect: a change in magnetization when the material is subjected to external stress.

Scientific workers made further observations of sounds similar to those observed by Page, varying the form of the magnetizing coil, the material, and the shape and mode of support for the sounding body. The various effects noted by them have come to be associated with the names of their discoverers.

The most common, and perhaps the most useful discovery is the "Joule effect." This was made about 1840, and it deals with the change in length of a ferromagnetic material along the axis of the applied magnetic field when this field is changed. For most purposes, the longitudinal change is important but it should be noted that a volume and transverse change occur.

The "Villari effect," or "inverse Joule effect," is characterized by a change in the magnetic permeability of a material in a magnetic field upon the application of external stress.

When a wire, placed in a longitudinal magnetic field is being twisted, there is a transient voltage difference between the ends of the wire. This phenomenon is termed the "Wertheim effect."

The "direct Wiedeman effect" is the twist produced in a wire, placed in a longitudinal magnetic field, when a current flows through the wire. This is due to the helical resultant of the impressed longitudinal field and the circular field of the wire. The magnetic material expands (or contracts) parallel to the helical lines of force and hence the twist.

The "inverse Wiedeman effect" is the axial magnetization of a current carrying wire when twisted.

The magnetostrictive effect is exhibited by the ferromagnetic metals (iron, nickel, and cobalt) and their alloys. The lesser known "Heusler alloys" (originally containing copper, manganese, and tin) and gadolinium also are magnetostrictive.

A theoretical explanation of magnetostriction requires an understanding of the "Domain Theory of Magnetization." The fundamental magnetic particle is the spinning electron, but in most cases the magnetic effects of all the electrons in an atom nearly neutralize each other, causing the atom to be slightly more magnetic (paramagnetic) or less magnetic (diamagnetic) than a vacuum.

Even if an atom has a strong resultant magnetic moment because one or more electron spins are not neutralized, it may not be ferromagnetic. Because of the random orientation of the atoms in a solid, the magnetic moments in groups of atoms are generally cancelled out. Further, the Kinetic Theory of Matter shows that the forces of thermal agitation are too great to be overcome by any magnetic field available today, if the atoms acted independently.

Fortunately, however, there are exceptions, which are the ferromagnetic materials. Nickel, iron, and cobalt are the best known and most widely used elements in this category.

In a ferromagnetic element an "exchange force" exists which causes the magnetic fields of atoms within a volume of 10^{-8} or 10^{-9} cubic centimeters to lie parallel. These small volumes are called "domains" and make it possible for an external field to align all the atomic moments. Each small domain is always magnetized to saturation, but the magnetic field of each domain, in a cubic crystal, may take any one of six directions within the crystal.

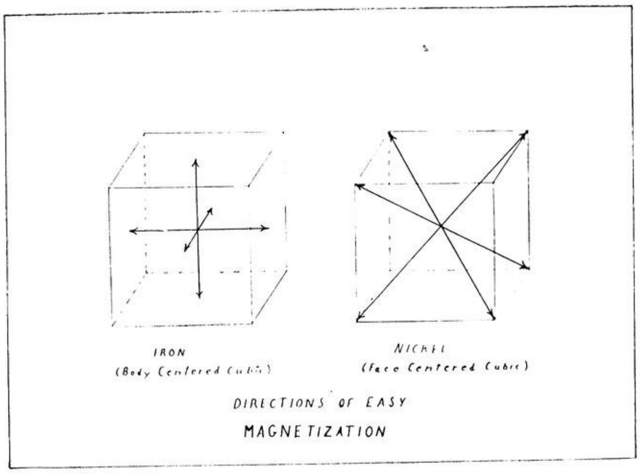


FIG. 1

Crystalline Structures

These six directions are known as the "easy directions of magnetization" and are illustrated in Fig. 1 for iron and nickel. If there is no external field present the 100,000 domains in a crystal of average size will be oriented in such a way that the net magnetic field of the crystal is zero. In addition, the crystal axes in polycrystalline materials are often randomly oriented.

If a weak external magnetic field is applied to a piece of ferromagnetic metal, some of the favorably oriented domains (those originally magnetized in the general direction of the applied field) grow slightly and smoothly in size, at the expense of others.

As the field is further increased, these domains grow, but now do so in jerks, taking over the less favorably oriented domains until each crystal becomes one large domain, magnetized along the "easy direction" of magnetization that most nearly coincides with the field. On further increase to a large applied field, the domain in each crystal rotates until it is parallel to the field.

It is principally during this process that the material expands or contracts its dimensions, thus exhibiting magnetostriction. When all the domains are parallel to the field, the material is said to be saturated; and further increase in the applied field causes no increase in induced magnetism.

At this point, it might be well to dispel two popular misconceptions about magnetostriction. The first is that large changes in length take place. Actually, the change in length for nickel, which exhibits the strongest effect, is about 30 parts in one million. For a nickel rod one foot long, this would amount to 3.6 ten thousandths of an inch. At resonance this change may be as high as one part in a thousand (limited by fatigue properties) or a rod one foot long changes about one hundredth of an inch.

The other popular misconception is that a rod, constrained at each end and subjected to a magnetic field, will exert an infinite force in attempting to contract. Actually, the static force is determined by the change in length and the modulus of elasticity for the metal. For nickel, the maximum static force is about 1000 psi, while the force for iron or cobalt is lower.

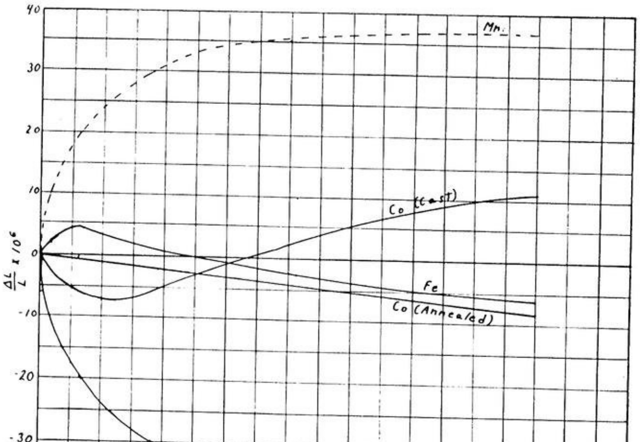


FIG. 2

Curves of the magnetostrictive effect the ferromagnetic materials are shown in Figure 2. It is a fair speculation that the ferromagnetic constituent of the Heusler alloys is manganese, which was once reported ferromagnetic, and that the sign of its magnetostriction is opposite to that of nickel.

The four consecutive elements of the Periodic Table Manganese (25), Iron (26), Cobalt (27), and Nickel (28), would then exhibit the symmetrical set of curves shown, with the magnetostrictive effects ranging from simple expansion to simple contraction, with both signs of change, in the two possible sequences, in the intervening members of the series.

As recently as 1926, it was said that no use had been made of magnetostriction or closely related effects. Since then it has grown from a laboratory curiosity to an item of commercial importance. Some of its main uses are listed below.

"Sonar" and related devices for detecting submarines and ships.
The "Fathometer" used to determine the depth of uncharted waters. A postwar use of this device has been to locate schools of fish.
Electrical filters: in particular, a band pass filter for use in commercial receiving sets.
Homogenization and sterilization of milk.
Acceleration of chemical reactions and cavitation effects.
Strain gages.
Vibration and engine detonation pickups.
Phonograph pickups.
Frequency control of oscillators operating below 100 kilocycles per second. Sharp resonance peaks are useful as frequency standards.
Dust precipitation.
New type compass.

It is interesting to note in passing that recently much of the hum in transformers has been attributed to magnetostrictive effects.

Magnetostriction oscillators have been used to control frequencies from 1000 to 100,000 cycles per second. Higher frequencies have not been feasible because the rods or tubes used become short and eddy current losses prohibitive.

The principle of operation is similar to that of any standard feedback oscillator, except here the frequency selective feedback path is through electromechanical coupling of the nickel rod. The frequency of oscillation is determined by the natural resonant frequency of the tube since its vibrations are strongest here and the system operates most efficiently.

The natural resonant frequency is given by the velocity of sound in the magnetostrictive element divided by twice the length of the rod. Application of an alternating sinusoidal voltage to the magnetizing coil of the magnetostrictive rod will cause the rod to vibrate at twice the frequency of the applied voltage, since the rod will contract or expand with both the positive and negative loops of the cycle. To avoid this, it is necessary to bias the rod or tube magnetically so that the induced magnetic field never exceeds the bias field.

(*please turn to page 38*)

MATERALS HANDLING

by Russell Pipkorn m'49

The handling of materials, from bringing in raw materials to a manufacturing process, carrying them through the process and handling the finished product, has assumed a very important place in our economy of mass production through specialization. Its importance is stressed by the fact that many companies are now employing engineers who are specialists in materials handling problems.

The type of operation classified as materials handling is difficult to separate distinctly from transportation—actually moving materials from one geographical area to another. The distinction might be made that materials handling will include those movements made other than by truck and public roads, by boat, by railroads, or by airplaines, although the operations of loading and unloading such conveyances definitely fall into the class of materials handling.

Conveyors are important in handling operations. The power driven type consist of a continuous belt of composition rubber and fabric, a chain and buckets, or chains of wide flat links which form a carrying surface, electrically or mechanically driven at one or more places and supported at numerous points to give the required elevations.

Proposed Scale of Operations

The transporation of certain types of materials, particularly raw materials on such conveyors has reached gigantic proportions. The latest proposed use of a belt conveyor for a distant transportation was made last February, when a newly formed company announced plans for a conveyor belt line of 103 miles in length extending from Lorain, Ohio on the shore of Lake Erie to East Liverpool, Ohio located on the edge of the steel manufacturing area. The conveyor would operate in both directions, carrying coal from East Liverpool to boats on the lake and iron ore from lake boats to East Liverpool. The conveyor, carrying 3400 tons of coal or 5400 tons of ore per hour would be entirely enclosed in an elevated tube which would follow the terrain. Short spur sections would connect to Cleveland and Youngstown.

A few facts on the proposed unit might help to picture the size of the undertaking. The total cost of the main line would be about 210 million dollars. The total length of the main line and spurs would be 130 miles and would require 151,000 tons of structural steel; 267 miles of rubber belting varying in width from 72 inches between East Liverpool and the Youngstown spur, 60 inches from there north to the lake, and 42 inches for the connecting spurs to Cleveland and Youngstown; 400,000 idlers carrying the belts; and 217 terminal power units. The total horsepower required would amount to 250,000 horsepower, and would require 338 men to operate the entire unit.

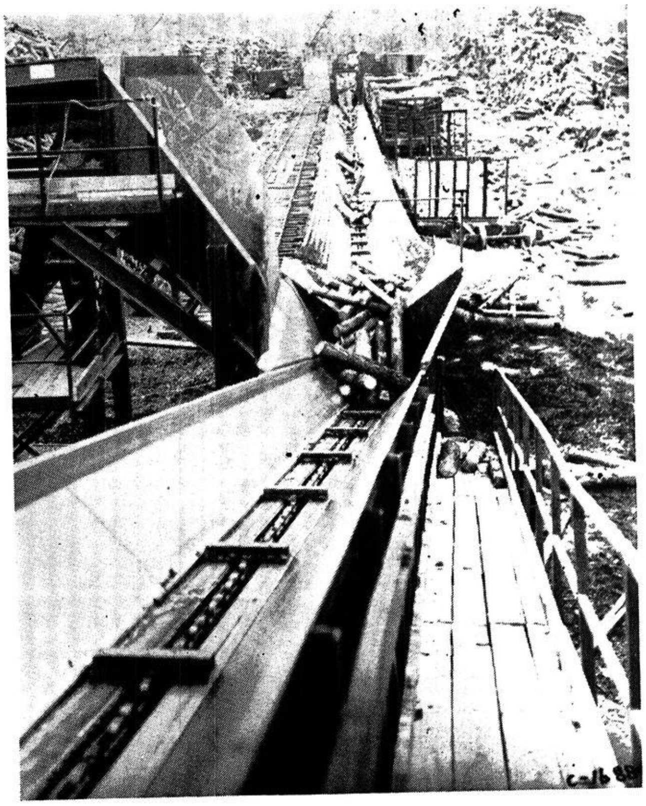
Streams Were the First Conveyors

The first conveyors used by man were natural ones. Loggers who logged all winter long would stock pile their logs until the spring thaw would open the streams. The logs would be floated with the current down to the mill to become boards. Streams might therefore be considered the first conveyors.

Today conveyors of the mechanical variety are used throughout the logging industry, from the cutting of the logs to the preparation of the finished product. Small portable conveyors driven by gasoline engines load the logs on trucks or railroad cars. At the mill the logs are dumped on a conveyor which carrys them into the mill to be debarked, then to the saws and even through the saws. Other conveyors carry away the refuse and sawdust to be dumped or processed. Logs which eventually become pulp for paper are also handled almost entirely by conveyors of one sort or another.

Use of the Conveyor in Manufacturing

Some foundries have employed conveyors throughout their operation to make the production of castings easier and more economical and the handling of sand more rapid. Besides their use in moving molds from the molder's

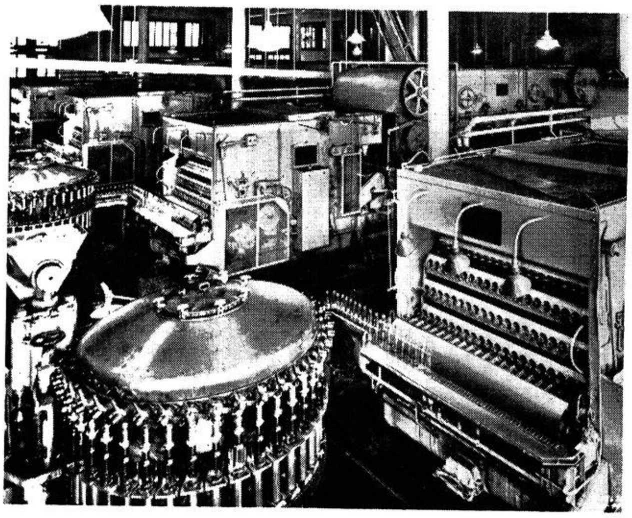


(Photo courtesy Chain Belt Co.)

Conveyors have become extremely important in the logging industry. Here the logs are being carried from the receiving station up into the mill.

bench to the pouring floor, and then while cooling, to the shakeout floor, they are also used to carry the finished castings to the cleaning room. Other conveyors move the molding sand from the shakeout floor to the reconditioners, from there to the storage bins, and even distribute it to the individual molders' benches.

Conveyors are also used extensively in the manufacturing industries, one example of which is the automobile industry. The assembly of an automobile is done on a very slow moving conveyor with the job beginning at one end with just a frame, continually moving through all of the assembly operations until a finished car is driven off the line at the other end. The frames themselves are similarly made on a special conveyor. Some concerns will use them to move parts from operation to operation on various machines. In such situations the part continues to come around until all of the operations have been done and the part can be removed. These conveyors are often mounted overhead and have convenient hooks hanging from the chain to carry the parts.



(Photo courtesy Chain Belt Co.)

Material handling equipment of various types have become important in special machinery. Here conveyors are put to use in bottle machinery.

Conveyors in the Food Industries

Special machines use conveyors in handling the products and containers. Typical examples are found in the food industry where cans or bottles are carried through a machine, automatically filled and capped or sealed. They may also be automatically packed into cases. The beer industry is an example of such a condition.

Some of the food industries which require grading or sorting of the product will use conveyors to carry the product before operators who are trained to grade the product. Citrus fruits are often examined in this manner.

The designs of machinery today, such as farm equipment, have incorporated materials handling equipment in them, although it is not often considered as such. Take for the example a harvester, where the grain is cut, picked up, carried into the machine automatically where the grain kernels are removed and the straw is bundled and tied and thrown out. All of the material handling is done by the machine.

Conveyors in Large Scale Movements

Although this is probably the most radical proposal in the use of conveyors, several examples of large undertakings are available. The building of the Shasta Dam saw the use of a 9.6 miles belt conveyor for the transportation of materials to and from the dam site. This conveyor was not covered and was only constructed for the building of the dam. Other conveyors also were employed in this construction. Since the dam required such large amounts of concrete, a cement plant was erected not too far from the site. Here a 6000 foot conveyor carried stone from a pit up and into the cement plant.

Coal and Ash Handling Equipment

The handling of coal in large power plants by conveyor has, first of all, made possible plants of the size that are common today, and, secondly, has done away with the back-breaking job of stoking the fires by hand. Coal that has been unloaded from railroad cars or boats into hoppers is carried, by bucket conveyors, up to the coal bunkers to be fed by gravity to the automatic stokers. Very often the return section of the conveyor is used to remove the ash from the furnace below.

A good example of the use of conveyors in smaller and simpler situations is the short gasoline-engine driven conveyor used in the unloading of commercial coal trucks. The coal is gravity fed from the truck to the moving belt which carries the coal to the chute in the basement window and then to the boal bin.

Gravity or Roller Conveyors

All of the conveyors so far discussed were of the power driven type. In plants where the production is smaller or where the movement is erratic, that is, in various direction, the gravity roller conveyors have been used. This type consists of a sturdy framework with a number of parallel mounted freely rolling rollers. Their spacing depends on the size of the parts being transported. When setup the conveyor is set at a slight grade. The parts are set on at the higher end, started off, and are carried by their gravitational force to the other end.

Truck Type Handling Equipment

For the transporation of parts along irregular routes or of large and bulky and heavy parts several types of trucks are in use. Four classifications are commonly made: hand trucks, tractor-trucks, power lift trucks, and stackers.

Hand trucks are many and varied. Delivery men use small two-wheeled types in handling cases. Manufacturing plants and others use a type which has three or four wheels and can be rolled under skids or pallets and can be raised by a special mechanism controlled by the handle. The skid can easily be moved where needed and again lowered into position. Their use is extensive in plants which do not operate on the line principal, but where parts must often be back-tracked.

Tractor-trucks are typified by three or four wheels, gasoline-engine driven tractors which are coupled to a number of small castered trucks to be pulled about. Their

(please turn to page 30)

SHALE OIL

by Eugene Haupt m'49 *(Photos courtesy of the Bureau of Mines)*

What have been the recent developments in the petroleum field that have alleviated the critical oil shortage, while our consumption of petroleum products has continued to rise rather than decrease? By far the largest factor has been the Bureau of Mines very favorable reports of investigations of "Synthetic Liquid Fuels." These reports cover the three main fields, namely: "Oil from Coal," "Liquid Fuels from Agricultural Residues," and "Oil from Oil Shale."

Oil from coals seems to be a logical step, but why use our coal resources to fulfill the needs of both coal and oil? Undoubtedly the cost of oil from coal would be considerably above the present cost of oil, as two new steps are added to the manufacturing process; the distillation of the coal and then the refining of the oil.

Producing liquid fuels from agricultural residues seems to be a better approach to the problem, as here we have a new source of material. But this too, has its drawbacks because of the discontinuous nature of the growing season.

Obtaining oil from oil shale does not present any of these difficulties and also means a more complete utilization of our natural resources.

Shale oil is not something new. It has been used in France for over 100 years. Scotland has been annually

This handy rig swings men into position to remove loose rock from walls and roof.

mining 3,000,000 tons of oil shale that yields from 18 to 25 gallons of shale oil per ton. Estonia mines over 1,000,000 tons a year of 50 gallon per ton oil shale, half of which is used directly as a fuel, substituting for coal. These foreign deposits are in seams only 4 to 12 feet thick. Manchurian shale oil deposits are overburden for open-pit coal mines. Before World War II, Manchuria was producing over 2,000,000 barrels of shale oil annually.

In the U. S. shale oil was available before the first well was drilled for oil in Pennsylvania in 1859. The 50 companies then in shale oil work were forced out of a business, which until recently has been hindered by an abundance of natural petroleum. Six or seven years ago with a shortage of petroleum facing the U. S., Congress started the Synthetic Liquids Fuels program. This program was to construct and operate demonstration plants to produce synthetic liquid fuels.

The oil shale reserves in the U. S. are enormous, occurring in 20 states of the Union, as well as Alaska. The principal field is in the Rocky Mountains at the juncture of Utah, Idaho, Wyoming, and Colorado. The vein of ore in this field runs from 500 to 1000 feet thick, and western Colorado alone is estimated to contain over 200 billion barrels of shale oil. (1946 production of petroleum in the U. S. was 1.7 billion barrels).

The Green River section near Rifle, Colorado was chosen by the Bureau of Mines for its test mine. This field, known as the Naval Reserve No. 1, contains ore that varies from 15 to 75 gallons of oil per ton of oil shale.

Oil shale is not actually shale and does not contain liquid oil, but is rather a light-gray to dark brown marlstone that contains an organic material called "kerogen." Kerogen is composed largely of remains of macerated plant life deposited on the lake beds of the geological past. Kerogen is only slighty affected by the action of solvents at normal temperatures, but upon destructive distillation it yields oil, gas, and fixed carbon.

This structure of oil shale requires that it be mined before it can be distilled. Early in the program it was realized that the cost of mining would be a definite factor in the production of shale oil. To this end the Bureau of Mines investigated all possible means, and has had great success by departing from the more common methods of underground mining.

The marlstone containing shale oil, though so soft that it can be carved with a knife, is strong and tenacious. Unsupported openings 60 feet wide will stand safely. A 50 by 100 foot test room was developed underground to check the theoretical conclusions made in the Barodynamics laboratory at Columbia University and in the Applied Physics laboratory at the College Park, Maryland station of the Bureau of Mines. This test room has since been widened to 80 feet in 10 foot increments and total sag recorded was only 0.3 inches, well within the roof's elastic limit. Geophones, which record rock stresses by hearing rock noises caused by shifting the crystal arrangement, have not indicated any undue stresses. Original plans were to widen the test room in 10 foot increments until failure.

The test mine is located in the richest part of the vein known as the mahogony ridge which is 70 feet thick. This part of the vein averages 30 gallons of oil per ton of shale although portions exceed 75 gallons per ton.

The use of heavy equipment keeps mining costs down.

The plan is to mine the upper third of this thickness by ordinary mining methods; that is, with horizontal drilling and blasting. After this upper level or bench has been advanced the lower levels or benches can be mined by quarrying methods; that is, by vertical drilling and blasting.

The procedure has been to have 60 foot openings between pillars, leaving 60 foot pillars to support the roof. This large span between pillars allows the use of large scale equipment, but has made necessary the design of new equipment for drilling, loading the holes for blasting, and scaling the walls and roof after a blast.

Not all the work has been in the design of new equipment. Some has consisted of altering machinery to better fit the job. As an example, early experience showed that ordinary detachable rock bits would only last for 3 to 5 feet of drilling before dulling and losing gage, thus requiring replacement. Diamond bits were tried without very good success. So a special hard-surfaced bit was developed for the job that will drill 50 feet per bit. Average drilling speed is 90 feet of 2 inch hole per man-hour. An efficient multiple drill carriage mounting four drills and requiring only 2 men, drills the holes 10 feet at a setting. A new carriage being developed will allow 15 foot holes to be drilled at a considerable saving.

Studies of special drilling patterns and methods of packing the explosive are still being carried on to determine the optimum methods.

Because oil shale is combustible and will burn if ignited, fire prevention must be exercised. The fact that no roof supports are required helps to keep inflammable material in the mine at a minimum.

The possibility of dust explosions is recognized although a sample collected in the test room could not be ignited with blow torches or electric arcs when in suspension in a cabinet. Relatively little dust is present except during the blasting operations when all personnel are out of the mine. All broken shale is wetted down before handling, therefore very little dust has been observed.

With these unique and somewhat radical (though completely safe) methods direct mining costs were only 49.7 cents per ton on a 20 day test. During this period 10 men and 2 foremen mined 16,800 tons of shale or 81 tons per man-day under actual commercial operating conditions. Compare this to 5.4 tons per man-day average for deep coal mines.

The fact that the top level bench is 27 feet high and that there is 60 feet between pillars allows ample operating room for a 3 yard electric shovel. The shovel picks up the loose shale that has been previously blasted loose and loads it directly into 15 ton diesel trucks. The trucks then haul the shale to the crushing house.

The trucks are able to drive directly into the mine because the mine is located on the face of a very steep cliff. The distance between the mine and the crushers is only 6000 feet along a straight line, but the road is 5½ miles long because of the rugged country.

The shale, as mined, is in rather large chunks, too large for efficient conveyor operation. As the retorts operate much more efficiently on uniformly sized shale, the rock is crushed to finer and more uniform size. Preliminary crushing is carried on in open jawed crushers and the final crushing is carried on in fixed roller crushers.

The particle size ranges from ¾ to 3 inches depending on the type of retort to be used. The cost of crushing varies upward from about 15 cents a ton, depending on quantity, closeness to size, type of crushers and other factors.

Since oil shale kerogen must be heated to temperatures in excess of 750°F to carry out the conversion to oil, oil shale retorting is essentially a matter of transferring heat to solid materials.

The equipment developed for heating crushed shale to form shale-oil vapors is known collectively as oil-shale retorts. Many types and varieties of retorts have been developed during the oil-shale's 100 year history. The Bureau of Mines has compiled indexes of patents on oil-shale and shale oil and the patents on retorting devices alone number well into the hundreds.

The Bureau of Mines demonstration plant at Rifle, Colorado has tried various methods of retorting the shale. N-T-U retorts were the first methods tried to develop better methods and to retort sufficient liquid shale oil for experimental processes of distilling and cracking. These N-T-U retorts are of the batch type using hot gasses for heat transfer with a 40 ton capacity.

(please turn to page 40)

THE SLIDE RULE

by Russell Henke m'49

Last month we took a look at the historical background of the slide rule and how it developed into the instrument we know today. This month we will spend our time going over a few of the lesser known slide rule techniques which can be utilized to advantage in easing the calculating process.

Basically the slide rule is a device for carrying out mechanically, the multiplying, dividing, raising to power, and root extracting processes by means of logrithmic scales marked off on the rule.

Simply, to multiply two numbers, you add the logrithms of the numbers and determine the anti-log. i.e.

$$A \times B = X, \quad \log A + \log B = \log x, \quad x = \text{anti-log } (\log x)$$

The slide rule does this mechanically.

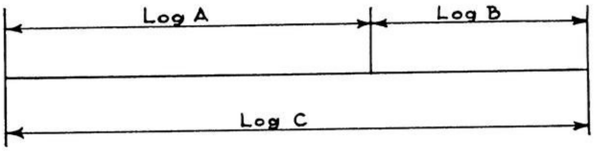


Fig. 1

It should be noted that while the lengths on the scales are laid out proportional to the logrithms of the numbers, the numbers printed on the scales are the numbers themselves. This is evident when we note that the left hand index or the first number of the D scale is 1, rather than zero, and that

$$\log 1 = 0$$

By a similar analysis, when we want to divide two numbers we subtract their logrithms and look up the anti-log, thus

$$x = \frac{A}{B}, \quad \log x = \log A - \log B$$

Graphically this can be shown as —

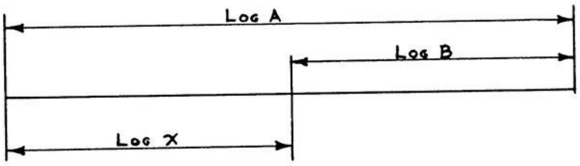


Fig. 2

It is an accepted fact among engineers that to raise a number to a power, we can multiply the log of the number by that power, i.e. $x = A^2$, $\log x = 2 \log A$. Graphically:

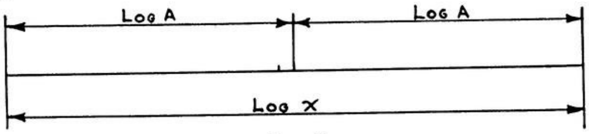


Fig. 3

Finally, to extract a root of a number, divide the log of the number by the root you wish to extract, i.e.

$$x = \sqrt{A}, \quad \log x = \tfrac{1}{2} \log A$$

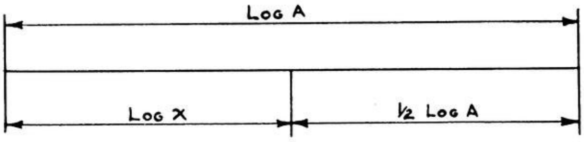


Fig. 4

These representations have been made to point up the basic theory of the slide rule in a very simple manner. These processes are, in effect, what occur when numbers are manipulated by means of the slide rule.

It should be pointed out that the above processes for multiplying and dividing are quite satisfactory, but when it comes to taking roots or powers they are a bit clumsy. It is too awkward to have to determine exactly 2 log A or 3 log A for square or cube powers, or ½ log A for square root as illustrated. However, if two scales were set opposite each other, one of which was exactly twice the length of the other, a length representing a log, or the double size slide, projected over to the shorter scale would represent the square of the number; set on the short scale and projected on the double length scale, it would represent square root numbers. This is essentially the set-up for the D and A scales on the slide rule.

The first technique we shall look at is the use of reciprocals in dividing. To many this may seem an obvious thing, but the number of engineering students who either don't know about it or who have forgotten about it is surprising.

The underlying idea in the use of reciprocals in dividing is that to divide A by B is one and the same as multiplying A by 1/B, i.e., by the reciprocal of B. Therefore, when using this technique divide 1 on the D scale; i.e., either the left or right index, by B, then multiply by A. For example say you want to divide 2 by 9.5. Using the ordinary division procedure you would have to run the slide out to the left until the number 9.5 on the C scale was directly over the no. 2 on the D scale, and this involves an unnecessary amount of work. By reciprocals all you have to do is to divide the 1 on the right index of D scale by 9.5, effectively calculating 1/9.5, then multiply it by 2 by setting the hairline over 2 on the C scale and read the answer on the D scale. See the following illustration. Figure 5.

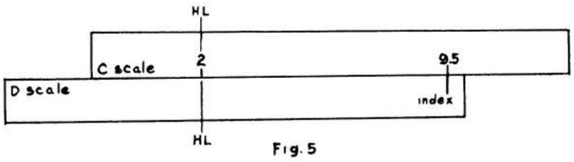


Fig. 5

Set 9.5 on the C scale over the right index of D scale; in effect dividing 1 by 9.5. Next, set the hairline over 2 on the C scale, in effect multiplying 2 by 1/9.5.

Let's take a quick look at the folded scales DF and CF, on your duplex rule. A little know-how here will save a lot of slide pushing. Nothing is quite so exasperating as to set up a problem on the rule only to find that the last multiplication falls off the rule. That's where the folded scales come in—it won't fall off if you use them.

The folded scales are the regular log scale cut in half at π and rearranged so that there is one index at the middle and π at either end of the scale. Haul out your rule and take a look. While you have that stick out, set the index on the C scale over any number on the D scale. Then note that the index on the CF scale is over the same number on the DF scale. That should be the tip-off. You can multiply back and forth between the D and the CF scales and read your answers on the DF scale. For example, say you ran off a brake horse power determination, $BHP = \frac{2\pi LWN}{33{,}000}$, and you had everything plugged into your slide rule except one last number. You go to set it up with your hairline and it is over the end of the scale. You merely set that last off-scale number on the CF scale and read on the DF.

To illustrate, supposing you want to multiply 122.7 by 8.7, that is, the last step of your problem comes out with the left index of the C scale over 122.7 on the D scale. Ordinarily you'd have to run the slide over and reset it, but utilizing the folded scales you merely have to set the hairline to 8.7 on the CF scale and read the answer, 1068, on the DF scale above. The following illustration, Figure 6, demonstrates the process.

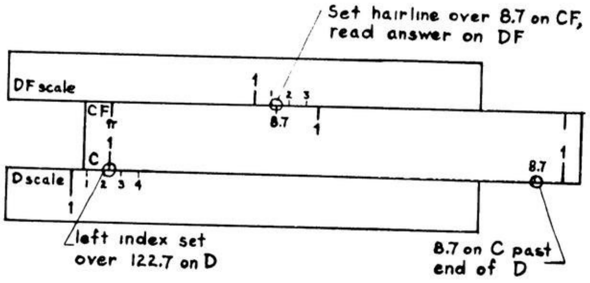


Fig. 6

The next set of scales we'll look at is the inverted scales, i.e., CI, DI and CIF scales.

These scales are more generally known as the reciprocal scales. Although the CI and DI scales are identical to the C and D scales, and the CIF matches the CF scale, they run in the opposite direction to them on the rule. That is, where the left index is 1 and the right 10 on the C and D scales, the right index is 1 and the left 10 on the CI and DI scales.

This makes it simple to read reciprocals right off the scale just by setting the hairline over the number on the C scale and reading the reciprocal on the CI scale. Similarly for the CF and CIF scales.

For example, the hairline set over 4 on the C scale lies over "25" on the CI scale, .25 being the reciprocal of 4, $\frac{1}{4} = .25$.

This use of the inverted scales is convenient, but the real utility of these "I" scales lies in that they can be used in connection with the other C and D scales in multiplication involving minimum movement of the slide. For example, to multiply 3 x 6 x 25 would involve quite a bit of lost motion if done "conventionally", but by combining the C, D, DIF, and CF scales it can be done simply.

1—set the hairline over 3 on the D scale
2—move the slide until 6 on the CIF scale lies under the hairline
3—move the hairline to 25 on the CF scale
4—read the answer on the D scale below the hairline, 450

What has really occurred in the process is the adding of the logrithm of 3 to the logrithm of 6, which, if this is done, carries you to the index of the CIF scale. But since this is directly in line with the index of the CF scale, the log of 25 can be directly added to the rest merely by moving the hairline over 25. The sum of all the additions is recorded below the hairline on the D scale. Since these aren't really logs, but distances, and since these distances are labeled with the numbers corresponding to that log, the answer is given on the D scale directly. See Figure 7.

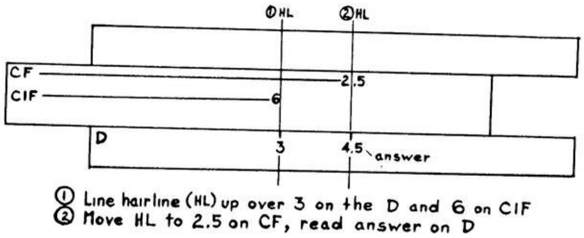


Fig. 7

Now it stands to reason that if we can add log distances like this and come up with an answer we ought to be able to subtract them and divide. Let's use the same numbers as before, only divide by 25 this time: $\frac{3 \times 6}{25}$ Start as before by setting the hairline over the first number on the D scale, better use 6 first this time or we'll run off the CIF scale before we're finished. Move the slide until the 3 on the CIF falls under the line. Now here's where the difference comes in: instead of moving the hairline to the 25 on the CF scale as we did in multiplying, we move it to the 25 on the CIF scale, thereby effectively subtracting the log

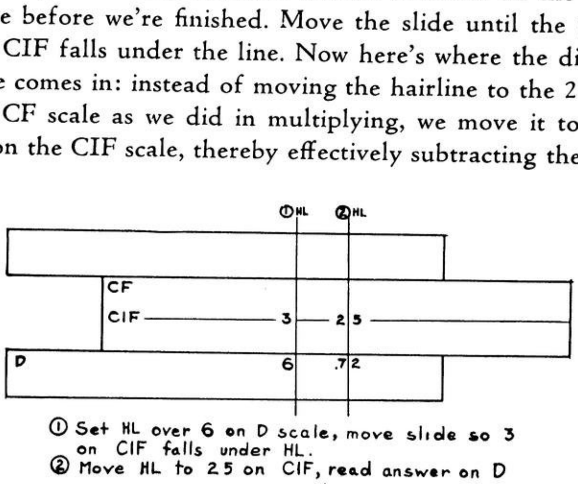


Fig. 8

(*please turn to page* 42)

THE "*Atomic*" CLOCK

by John J. Misey e'49
(Photographs courtesy National Bureau of Standards)

The Problem

Ever since the beginning of time man has been seeking a means to accurately determine time. At first the measurements were rather crude but effective for his needs. He was wont to measure time by the periodicity of natural phenomena about him: the rising and setting of the sun, the movement of the stars through the skies at night, the changing expressions of the moon, and the regularity of the seasons.

As man progressed through the ages he devised water clocks and hour glasses, mechanical clocks, and finally electric clocks. To provide a standard time clock he depended on very accurate observations of the movement of celestial bodies.

The Approach

In recent years, vibrations of atoms in molecules, or what are more specifically termed spectrum lines originating between energy levels of these atomic systems, have been found in the microwave region of the radio spectrum. It has been possible to make very precise measurements of these lines by using electronic equipment of unprecedented sensitivity and resolution.

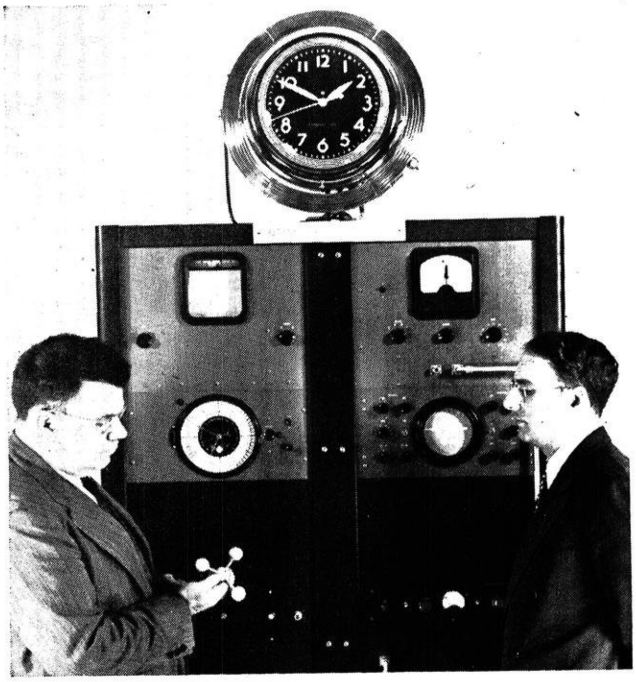
When it became evident that such spectrum lines might eventually provide new primary frequency standards, scientists at the National Bureau of Standards began seeking a means of utilizing one of these lines to control an oscillator which in turn could be used to drive a clock. Others have also been doing research on this problem but it was Doctor Harold Lyons of the Bureau who designed and constructed a clock embodying these principles.

The Answer

In early January, 1949, the National Bureal of Standards unveiled the **"Atomic Clock"** in a new and radical departure from all conventional methods of measuring time, based on a constant natural vibration frequency of atoms in the ammonia molecule, and for the first time independent of astronomical observations.

The Heart of the Atomic Clock

The heart of the Atomic Clock is a wave guide absorption cell filled with ammonia gas under a pressure of 10 or 15 microns. The frequency of vibration of the atoms in the gas molecules is 23,870.1 megacycles (23,870--100,000 cycles). It is at this frequency and pressure that the gas molecules exhibit the property of absorbing energy. If a frequency varying signal is allowed to pass through the absorption cell, the energy at the absorption frequency of the cell is transferred into heat energy. The output energy of the cell has a noticeable drop at the absorption frequency. This drop in energy or pulse can then be used to correct any variation in the fundamental frequency generator.



The control panel of the Atomis Clock with Dr. Condon (left) holding a model of the ammonia molecule while Dr. Lyons looks on. The ammonia gas is located in the 30-foot absorption cell wound around the synchronous clock (directly above the scientists).

The Development of the Microwave Signal

The microwave signal is initiated by a 100 kilocycle (100,000 cycles) quartz-crystal oscillator or any other oscillator which is designed for a high degree of stability. The fundamental frequency is first multiplied up to 270 megacycles by a frequency-multiplying chain using standard low-frequency tubes. In the next step, the multiplying chain is continued up to 2970 megacycles by means of a frequency-multiplying klystron.

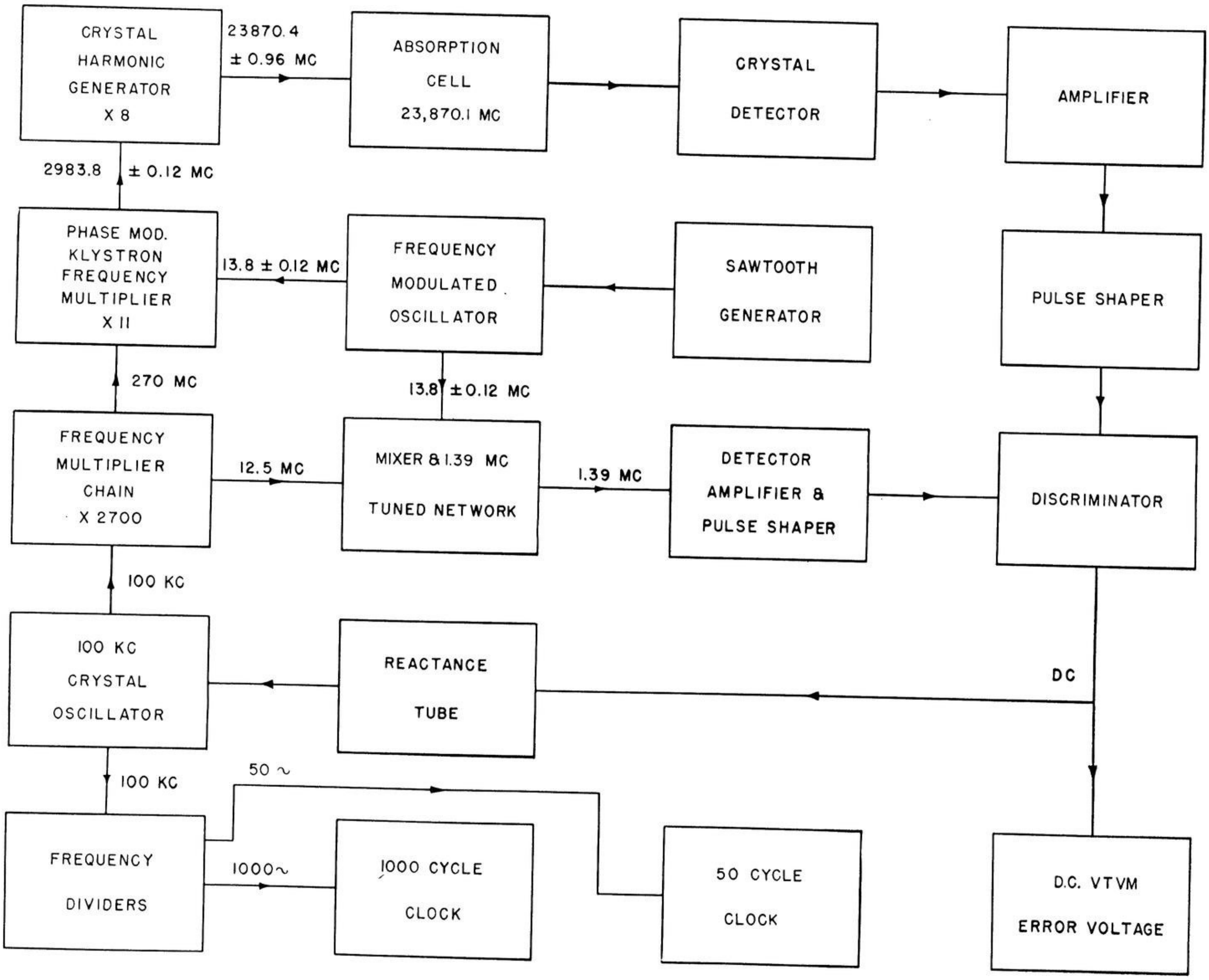
The klystron is modulated by a frequency-modulated oscillator which is generating a signal at 13.8 $\pm$ .12 megacycles. The output of the klystron is then a frequency-modulated signal at 2983.8 $\pm$ 0.12 megacycles. After further amplification the frequency-modulated signal is multiplied by a harmonic generator using a crystal silicon rectifier to 23,870.4$\pm$0.96 megacycles, and fed to the absorption cell. As the frequency of this modulated signal sweeps across the absorption line frequency of the ammonia vapor, the signal reaching the silicon crystal detector at the other end of the absorption cell dips because of the absorption in the cell, and this gives a negative output pulse. The pulse is finally amplified and shaped before it is introduced into the discriminator circuit which generates a control signal.

The Comparison Signal

A second pulse is generated when the output of the frequency-modulated oscillator at 13.8 $\pm$ 0.12 megacycles is fed to a mixer of a high frequency receiver where it is mixed with a 12.5 megacycle signal from the quartz-

square wave generator, the relative duration of the positive and negative parts of the square wave indicating the time interval between the two pulses. The square wave is fed to a positive and negative peak detector.

When the time interval is correct both the positive and negative parts of the square wave are of equal duration. They neutralize the detector and no direct current output is realized. However, when they are not of equal duration a direct current output is generated. This output is either positive or negative, depending on the change in the time interval.



COMPLETE BLOCK DIAGRAM OF NBS ATOMIC CLOCK
FIGURE 7

crystal multiplying chain. The intermediate frequency of the receiver is set at 1.39 megacycles and when the modulated signal sweeps across the frequency to which the mixer is turned (12.5 megacycles plus the intermediate frequency of the receiver, or 13.89 megacycles), an output pulse is generated. The output pulse is amplified, shaped, and introduced to the discriminator.

The Generation of a Control Voltage

The discriminator measures the time interval between the two pulses, and therefore can be made to generate a control signal when the time interval is wrong. In the discriminator the two pulses excite a trigger circuit or

The control signal thus generated is fed to a reactance tube which forces the quartz-crystal circuit to oscillate at the correct frequency to tune to, or to synchronize with the absorption frequency of the ammonia molecules. If the oscillator drifts in frequency to a higher value, the time interval increases; for frequencies which are too low, the time interval decreases. The resultant control signal opposes these frequency drifts and locks the oscillator to the ammonia line. Thus, no control voltage is generated when the quartz-crystal oscillator is on the proper frequency to agree, through the frequency-multiplying chain,

(please turn to page 32)

Science Highlights

by Howard Traeder m'48 and Donald Miller m'50

ULTRAVIOLET SENSITIVE EMULSION

An emulsion which will aid the study of radiation far into the ultraviolet has been developed by the Kodak Research Laboratories. The new photographic emulsion is called a "vacuum ultraviolet" or VU emulsion.

In the past it has been difficult to record spectra in the ultraviolet region because the gelatin of normal emulsion absorbs ultra-violet light. The new emulsion, with very little gelatin and close-packed silver grains, enables the ultra-violet light to be recorded.

The uses of the emulsion are expected to advance our knowledge of the sun through the analysis of the radiation in this part of the spectrum. The study of these rays is also important because electrical disturbances in the upper air which affect our weather and radio communications are associated with them. The emulsion will be carried aloft in rockets which will penetrate the earth's atmosphere and expose the emulsion in a vacuum spectrograph. VU emulsion is also expected to advance research in atomic spectra studies for identifying chemicals or atoms through analysis of their radiant energies.

THERMO-RADIOGRAPHY

A new method of making "heat radiation pictures" by photographing a glowing phosphor screen has been announced by Eastman Kodak Company.

In the new technique a screen is coated with the specially prepared phosphors. Through the use of a curved metal mirror, the heat radiation of an object is focused on the screen. Here the image can be examined under ultraviolet light, or can be photographed. The image is a picture of the object against its warmer or cooler background. In the laboratory a picture of a piece of ice was made successfully simply because it gave relatively little radiation compared to the warm air around it.

In a related technique, called "thermography," the sensitive phosphors are coated directly on an object to get a picture of its heat distribution. The phosphors show a 20 percent change in brightness with each Centigrade degree change in temperature. In thermography, temperatures ranging from that of liquid air to four or five hundred degrees Centigrade can be used.

If, for example, you wished to obtain the temperature distribution of an engine which was operating, you might paint the engine with the phosphor compound. Where the motor was fairly hot it would appear dark blue in color when viewed in ultra-violet light. Where cool, it would appear light blue or nearly white. In this way it would be possible to measure the temperature of many points simultaneously and to record these differences in still or motion pictures. The sensitivity of the new phosphors is expected to provide a variety of new scientific applications.

PIPE CORROSION TESTS

Continuous flow laboratory tests extending over a period of ten years have been made on the relative corrosion resistance of commercial pipe to cold flowing water. Studies of the data indicate that while there were significant differences in the corrosion of some of the materials, the more expensive pipes offer no appreciable advantage over the usual cast-iron water pipe.

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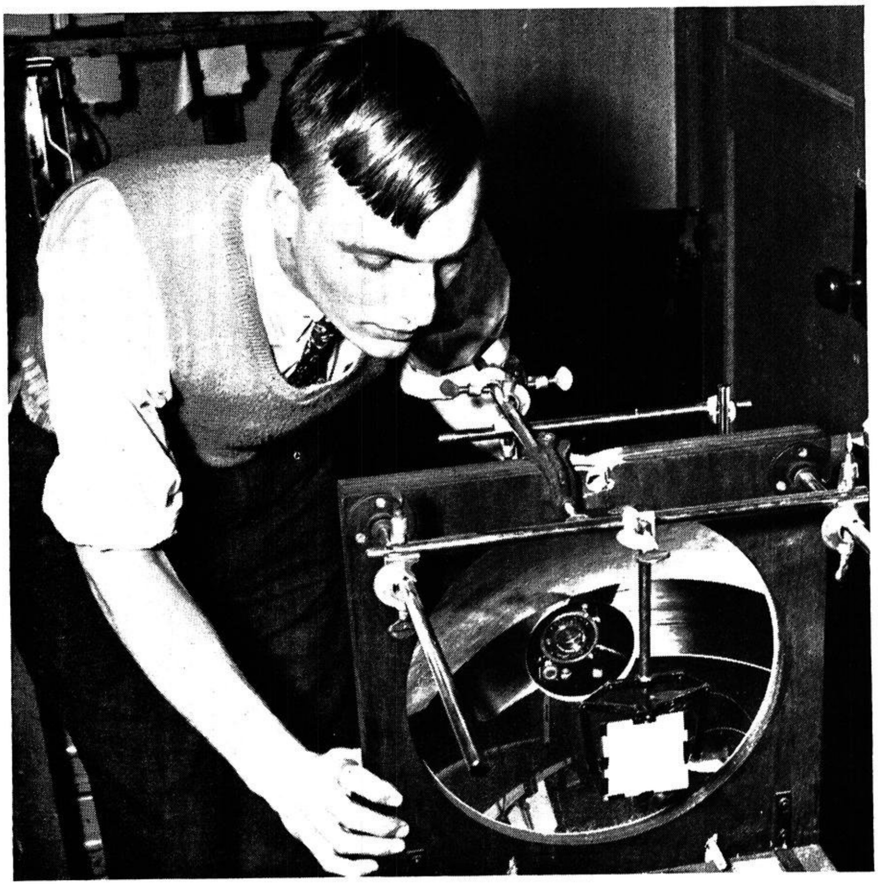


Laboratory set-up for heat radiation photography.

Alumni Notes

by Hank Williams e'50

John Lucian Savage

C. E.

John Lucian Savage, ('03), was the recipient of the "Washington Award" of the Western Society of Engineers at a meeting held on April 20 in Chicago. At this dinner, Savage, recipient of the award "for his unselfish public service devoted to the creation of monumental hydraulic structures utilizing natural resources," discussed the Yangtze river dam project in China which he designed.

Savage has received degrees from the University of Wisconsin, the University of Denver and the University of Colorado. He is consulting engineer for the Tenessee Valley Authority and the U. S. Bureau of Reclamation.

No other individual has had the direct responsibility for more dams than Savage. His projects have included work in Afghanistan, Australia, Canada, China, India, Mexico, Palestine, Spain, Switzerland and England.

Vern W. Tenney, ('41), is assistant sanitary engineer, 12th Naval District, San Francisco. He received his master's degree from the University of California in 1947.

Walter S. Sivley, ('43), is reported to have left the service of the City of Baltimore to join the staff of the Walla Walla district of the Corps of Engineers.

Kirk E. Schreiber, ('48), is engineer with the Boeing Aircraft Company at Seattle.

T. M. Halverson, ('35), is in the sales department of the Standard Oil Company.

* * *

M. E.

Frank A. Breese, ('22), is a consultant for the A. T. Kearney Company of Chicago.

W. E. Schubert, ('24), is vice-president and general manager of the Wisconsin - Michigan Power Company.

Ernst A. Longenecker, ('22), was awarded a citation of merit at the centennial day banquet. At present he is president and general manager of the LeRoi Company.

J. Frank Roberts, ('18), was awarded a citation of merit at the centennial day banquet. He is general manager of the hydraulic turbine department of Allis-Chalmers of Milwaukee.

Walter H. Pagenkopf, ('26), was at Wisconsin for two days interviewing students for jobs with the Western Electric Company. He is superintendent of plant engineering and is in charge of College Public Relations.

Ralph Kircher, ('22), attended the centennial engineering banquet. He is chief engineer of the West Bend Aluminum Company at West Bend, Wisconsin.

M. K. Drewry, ('22), is vice-president in charge of engineering at the T.M.E.R. and L. Company of Milwaukee, Wis.

Arnold Meyer is vice-president in charge of engineering at the Heil Company of Milwaukee, Wisconsin.

Fred Dorner is a sales engineer and partner of the Dorner Brothers Engineering Equipment and Machinery Company of Milwaukee, Wisconsin.

Carl John is a design engineer of the Ladisch steel forging company of Milwaukee, Wisconsin.

* * *

E. E.

Terence J. R. Tracy, ('48), is employed as an engineer for the Goodyear Aircraft Corporation of Akron, Ohio. He recently applied for admission of Associate of the American Institute of Electrical Engineers.

Philip J. Wanzek, ('46), is employed with the General Cable Corporation of West Bend, Wisconsin. He is a sales engineer working in the line of electrical wires and cables.

Boyd Guthrie is now supervising engineer, and has administrative charge of the whole Bureau of Mines, oil shale project. The site is located at Rifle, Colorado, where the experimental mine and plant are located.

The American petroleum industry is supplying the present domestic demand for liquid fuels. Known reserves of petroleum in the ground, however, are limited and the cost per barrel of finding new oil pools is increasing. Dependence upon foreign oil for part of our industrial requirements is not necessarily cause for alarm, but in time of war an adequate, dependable, domestic source of liquid fuels is vital to the defense of the country. Steps are now being taken to insure a future continuous oil supply for our economic machine.

The development and construction phases of the oil-shale program have largely been completed. The authorized program has two more years to run.

mercury

by John M. Warner m'50

In this modern day of superlatives, we should take notice of the presentation of a scientific "ultimate." The usually cautious scientist, fully aware of the possibilty of censure, is prone to couch his terms in a less grandiloquent manner than deserved. With the rare exception of the scientific "glamor boys," scientists as a whole, if anything, tend to underestimate their discovery, and play down its practical significance.

This being the case, is it not unusual then, to have a scientist state that an ultimate has been reached? The ultimate being considered here has to do with the use of a glowing isotope of mercury, which makes possible the determination of distances to the fantastic degree of one part in 100 million.

The story unfolds like this: Since early time, measurement has been more or less arbitrary. The early Dutch settlers in this country are purported to have used their staunch right legs on the opposing pan of a beam scale, when trading furs with the Indians, Likewise, an inch is supposed to be "as long as the end joint on a man's index finger." Every civilization has found in the growth process, that standardization of weights and measures has been essential to stable, equitable transactions. Each has developed its own standards.

Our present standard of length is the platinum-iridium meter bar at the International Bureau of Weights and Measures near Paris. It was designed in the 1790's to represent one ten-millionth of the earth's quadrant. Around 1889, more accurate measurements proved it was slightly too short, thus it was arbitrarily defined the standard meter. So it goes, nothing permanent and "ultimate" and indestructible.

The first clues to the eventual solution were from the active mind of Jacques Babinet, a French natural philosopher who suggested the wavelength of light. It remained for Michelson and Morley in 1887 to translate this suggestion into a practical method. They devised the interferometer, which is an instrument that makes waves of light overlap and interfere with one another. This results in bright fringes where waves reinforce each other, and dark ones where they cancel each other. As the wage length of light is constant, and reproducible, here is a means of establishing an absolute standard of length.

The next problem was to find a suitable monochromatic light source, since a complex light source produces a fuzzy fringe. Even pure elements when caused to glow, produce fuzzy lines, due to varying nuclear spin and mixtures of isotopes. Different elements were tried, among them cadmium, which produced a fair image. It lacked sharpness, however, and counting was tedious, there being over one and one-half million lines per meter.

The solution was found in the isotope Hg^{198}, which emits a sharp green line, free from complex structure. Unfortunately this isotope does not occur free in nature. By a reversal of the alchemist's age-old dream, gold (Au^{197}) is transmuted by neutron bombardment into Hg^{198}. This is done in the atomic pile at Oak Ridge Tennessee, where over 60 milligrams has been produced in a year. The ordinary lamp is the size of a cigarette and contains about five milligrams.

William F. Meggers, chief of the spectroscopy section of the National Bureau of Standards gives the following reasons as evidence that the ultimate has been found:

(1) The green line coincides almost exactly with the wave-length to which the human eye is most sensitive.

(2) High temperature radiation add fuzziness, and mercury is unique among all the elements in radiating at a low temperature and pressure.

(3) Random radiations make the lines fuzzy. Mercury's heavy weight retards these radiations.

(4) By using a pair of yellow mercury lines, interference occurs every 275 waves, thus making it unnecessary to count the fringes, as was the case with cadmium.

These reasons seem to be clear and conclusive. Light waves can be produced anywhere, anytime, by any civilization needing fineness of measurement. Thus, mercury has given us our most nearly ideal standard of length.

Mercury, or more commonly, quicksilver, has long tantalized alchemists, philosophers, and natural scientists by its unique physical properties. As early at 300 B. C. a man named Theophrastus prepared mercury from cinnabar by treatment with copper and vinegar; and another man, Dioscorides, obtained it from the same mineral with the aid of iron, by a crude distillation process. It was looked upon as a powerful medicinal agent, and correctly so, in its compound mercurochrome. It is highly poisonous however, if ever assimilated in its pure state.

Important sources in Europe are Almeda Spain, and Carniola Italy; while in the U. S. it is found in Texas and California. There are deposits in Russia, Mexico, Peru, and other places to a lesser degree.

One Pint of Memory

Ever try remembering 1000 twelve digit numbers? Don't bother practicing because a new device developed by the Eckert-Mauchly Corp. of Philadelphia can do it at the rate of five million pulses per second. The unit is based on a radar development and is designed for high-speed calculating machines. It is claimed to be ten times faster than former methods.

Here's how it works: A column of mercury is inclosed in a glass tube which has a quartz crystal at each end. The crystal at one end is the transmitter, and the one at the other end in the receiver. These crystals resonate at ten to fifteen million cycles per second. Electrical impulses excite the transmitting crystal which converts the electric impulse into sound, or sonic, vibrations. These pulses are the numbers to be remembered and travel down the length of the column to the receiving crystal, which acts like a microphone and re-converts the sonic pulses to electrical signals.

You ask, "Where does the memory come in?" Well, sound impulses travel about one one-millionth as fast in a mercury column as comparable electrical impulses travel in a wire. The first pulse transmitted is not received by the second until thousands of pulses have entered the column behind it.

Compared to the elephant, this seems insignificant, but not so fast. By merely piping the impulses electrically back into the front end of the tube, the process is repeated and this can be continued indefinitely, or until they are wanted, at which time they can be piped off. Simple!

The new improved size operates 4 times as fast, and is therefore only ¼ as long as the original tubes. A slightly longer tube than the one pictured is used in the

(Photograph courtesy Science Service, Inc.)
The memory unit held by Isaac Auerbach.

U.N.I.V.A.C. (Universal Automatic Computer) and can hold as many as one thousand 12 digit numbers.

This amazing gadget was developed by Isaac L. Auerbach, J. Presper Eckert Jr., C. Bradford Sheppard and Robert F. Shaw. It is another example of mercury's versatility. Add this to the standard length application.

Nix on Airborne Germs

Tuberculosis, smallpox, chickenpox, measles, mumps, and diptheria, not to mention the common cold, are but a few of the many diseases transmitted by air. Every breath you take might contain one or more of these undesirable agents.

There are several air disenfectants, heat, glycol vapors, ozone, and ultra-violet radiation. The last mentioned has several distinct advantages over the other agents. It adds nothing to the air which might prove harmful, is relatively inexpensive, and is one of the most effective.

The sun, of course, is the major source of ultra-violet light. Sure enough, our old friend, the low-pressure mercury-vapor arc is second best. It is especially suitable since the largest part of the ultra-violet energy produced is of a wave length very close to that most effective for killing bacteria. In some cases it is the best, since the sun does not shine at night!

It would be absurd to install a germicidal lamp in the tent of a person living alone in Arizona; on the other hand, it might be very wise to install them in an overcrowded contagious disease hospital. Between these limits are homes, theaters, schools etc.

There exists a slight "catch" to the idea. Air disinfection in some cases might prove to be undesirable, in that it reduces the natural bodily resistance to airborn disease so that as soon as the light goes off, someone starts to sniffle! These are the doctor's worrys however, the mercury vapor lamp remains available to them for any desired application.

Blue Lipstick?

The fertile, unsatisfied, scientist's mind may eventually alter our esthetic sense. The lyricist may be forced to re-rhyme his songs to incorporate blue with lips instead of sky.

The story behind this one is attributable to the use of mercury street lamps. The lamp emits a brilliant bluish-white light with a tinge of green. While it has not proved disagreeable, the color detracts from the brilliancy of colors predominantly in the red end of the spectrum, but enhances the richness and beauty of colors in the blue end.

The mercury lamp is especially adaptable to street lighting as it affords a high level of illumination. The installation cost is slightly higher since each lamp requires a ballast (transformer) to regulate its type of current. Though this ballast uses 10 percent of the power, the lamp is 2 to 2½ times as efficient as the ordinary incandescent. These lights can be used alone, or in combination with incandescent luminaires. Thus we add illumination to the growing list of mercury applications.

Bang!

In 1799, a man named E. C. Howard made the first known batch of fulminate of mercury. It is always possible that someone prior to that time may have mixed up a batch and blown himself up, but Howard is given the credit.

Fulminate of mercury is extremely sensitive to friction, percussion, or heat, and produces a violent explosion. It is generally conceded the fulminate of mercury is $(CNO)_2Hg$. The compound is retained militarily for two purposes: (1) as an igniter in so-called cap-compositions; and, (2) as a detonator in which case it may be used alone or mixed with T.N.T.

Add to these, the differential pressure gages; the mercury vapor turbine, a story in itself; myriad pathological uses; the mercury chlorine cell for the production of chlorine; silent electrical switches; black light and other applications of ultra-violet light; and lastly the most common and important use to us all, the thermometer.

This is mercury!

ON *the Campus*

by Robert Gesteland e'52
and Robert Consigny ch'52

POLYGON PICNIC

Here's the dope on the picnic sponsored by the societies represented on Polygon Board. The date is May 28 at 3 o'clock. It will be held at Burroughs Park, near the end of the Sherman Avenue bus line.

A small band will play for dancing, and, to make the afternoon complete, full 8 ounce glasses of beer will be sold for only a nickel. Soft drinks will also be availabe. Bring your own beer mugs or use the paper cups that wil be provided at the park.

ORANGE BLOSSOMS

Herewith we present our best wishes to Miss Mildred Bowar, secretary to Dean Withey. Her engagement to William Wachtl was recently announced by her parents, Mr. and Mrs. Lawrence J. Bowar of Madison.

Mr. Wachtl received his master's degree in mechanical engineering here in 1947. He was a member of Tau Beta Pi and Pi Tau Sigma and is now employed by the NACA in Cleveland.

The wedding is set for May 28 in St. James church.

TAU BETA PI

A banquet celebrating the golden anniversary of the Wisconsin Alpha Chapter of Tau Beta Pi and the initiation of fifty new members took place at the Hotel Loraine on Thursday, May 5, at 7:00. Four national officers of the all-engineering honorary fraternity were present for the ceremony. They were: M. M. Cory, president; R. H. Nagel, secretary-treasurer; L. W. Lentz, councillor; and R. C. Matthews, secretary emeritus. Lewis E. Moore and C. A. Keller, charter members of the Wisconsin Alpha chapter, were also at the banquet.

Prof. L. F. Van Hagan served as toastmaster for the evening and the main speaker was Mr. Walter Richter, consulting electrical engineer for the Allis-Chalmers Corp. Mr. Richter spoke on the history and development of high fidelity reproduction of music. Accompanying his talk were slides and a demonstration using the electronic equipment of Dr. Warren Gilson of Bradley Memorial hospital.

Chapter officers Ed Baugh, Dick Rayford, Clarence Fordham, Howard Traeder and over one hundred twenty-five guests attended the banquet following the initiation of fifty new members. The new initiates are:

G. Albert, R. Allen, R. Baun, R. Benway, R. Bertz, R. Biddick, L. Bischel, A. Broshot, R. Bull, R. Cotts, D. Dodge, J. Einarson, D. Fisher, L. Guth, R. Hauser, N. Hogue, T. Hubbard.

R. Huibregtse, H. Jones, J. Karlson, G. Kempa, F. Kohli, F. Kubiak, F. Kufrin, J. Luening, J. Maier, R. Lea, R. Manske, H. Markey, R. Mendelsohn, C. McMullen, W. Meggers, C. Navratil, H. Patneaude, E. Pepper, R. Peterson, J. Quick, L. Retzinger, B. Roberts, R. Rulseh, W. Sakowski, D. Sands, R. Schoessow, E. Sokol, J. Stark, G. Sylvester, E. Trantow, R. Voelz, F. Williams, and R. Woods.

ASCE

Prof. Ray Owen, now on leave before retiring, spoke on his trip through the southwestern part of the country at the April 26 meeting of ASCE. Prof. Owen also dispensed several clever anecdotes and some interesting information about the opening of the new Shamrock Hotel in Houston, Texas, which he attended.

After the talk, movies on the lighter side of the summer survey camp at Devil's Lake were shown.

As a parting gift, the chapter presented Prof. Owen with a pen and pencil set.

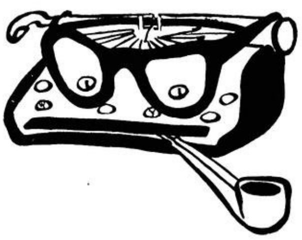
AIEE

Prof. John C. Weber, AIEE faculty advisor; John F. McCoy, Student Branch Chairman; and John F. Misey, Student Paper Contest winner, attended the Great Lakes district convention of AIEE at Ann Arbor, Michigan, on April 29 and 30.

TRIANGLE

Triangle actives were entertained by the pledge class at an informal house party on Saturday, April 9. The evening was kept alive by the procession of tricks planned and pulled on the actives by the pledges. No one knew who would bear the brunt of the next one. Guests for the evening were Mr. and Mrs. Paul J. Grogan. Mr. Grogan is an instructor in Mechanical Engineering.

After spring vacation the pledges started the tedious journey through hell week. On Saturday, April 31, the formal initiation was held with Lolay E. Wichman, Matthew M. Champion, Raymond T. Wilhelms, Gordon L. Kleinhammer, Warren E. Racine, Kenneth R. Merner, and Milton R. Adams becoming new members. After initiation the traditional "Founders Day" banquet was held. Toastmaster at the banquet was Howard H. Buer. The main speaker and guest for the evening was Arthur Schwerin, one of the sixteen founders of the Fraternity.



The Way We See It

"HONORARIES"

Tau Beta Pi—Chi Epsilon—Eta Kappa Nu—Pi Tau Sigma. Yes, an attractive list of Greek letters. For what do they stand? What do these societies accomplish?

These groups are reputed to represent the top-notch men in each branch of engineering. The men are chosen because they are scholastically outstanding, and are men of high character. The men are leaders; election into these societies is recognition of their "academic and extra-curricular achievements."

Actually, few of these groups are capable of doing an effective job. Election does not mean the end of all activity. The hands of these societies are so effectively bound by student apathy that many have been relegated to the role of supplying gold keys for watch chains. Even for a large initiation ceremony and banquet it is appallingly difficult to attract more than a mere handful of "actives".

At the recent initiation banquet of Eta Kappa Nu, for example, a total of four—4—actives appeared. The total membership was nearly 70.

One of the faculty members present even commented on the pitiful lack of student support. In former years, each society played an important role in the functions of the engineering college. In his own opinion, the groups had deteriorated badly!

Is it negligence on the part of the officers which causes this apathy? Is it the size of the organizations? Is it the fellows themselves?

In the opinion of one of our own professors, the membership in the honory societies is much too large to facilitate any type of organized program. This may be the trouble. The only remedy would be a limitation of membership, an arbitrarily set grade point.

Consider that Phi Beta Kappa requires a 2.75 or above for election. Contrast the distinction of this society with those in engineering. Most engineering honoraries require but a 2.25!

Remember the fuss that was raised about making the limit 2.3 in Tau Beta Pi?

Perhaps, to you, grades don't mean that much, but they are not that hard to get either.

With a smaller number of men in each group, a closer tie would exist between the men, election would be a greater honor, and the societies could at least begin to function properly.

R. R. J.

SECOND RATE—OR SECOND TO NONE?

"Budget Threat to UW, Claim . . . Serious Results Seen by Fred if Recommended Amount Is Granted" (headline in a recent edition of a state newspaper).

Our university officials have presented a budget request to the state of $28,606,87. They consider this the least amount they need to maintain Wisconsin in a position of leadership among state universities. This rock-bottom figure does not allow for many of the improvements we really need on our campus. It would be little more than a "subsistence diet."

The state legislature's joint finance committee has seen fit to recommend only $24,031,006, however. This is a cut of more than $4,500,000. This amount is the difference between "just another state university" and the truly leading institution that Wisconsin has been, and which it should continue to be.

President Fred has outlined three courses that would be open to the University if the reduced budget is passed. One is to increase the already high general fees, an action that would work a distinct hardship on many students, and would mean the end to ". . . educational opportunity for all."

The second would be to lower the quality of teaching and research, a move that the President rightly terms "Disastrous."

The third would mean a reduction in such services as off-campus training, short courses, adult education, and housing aids to students. Fred adds that a sharp reduction in research projects appears inevitable.

The university president says that such a curtailment would be "unfortunate". May we submit that "unfortunate" is a rather mild word when speaking of an action that would mock the concept of the campus whose boundaries are those of the state. He says that this reduction "is perhaps our only feasible course . . . ," and perhaps he is right, but this is not the Wisconsin Idea.

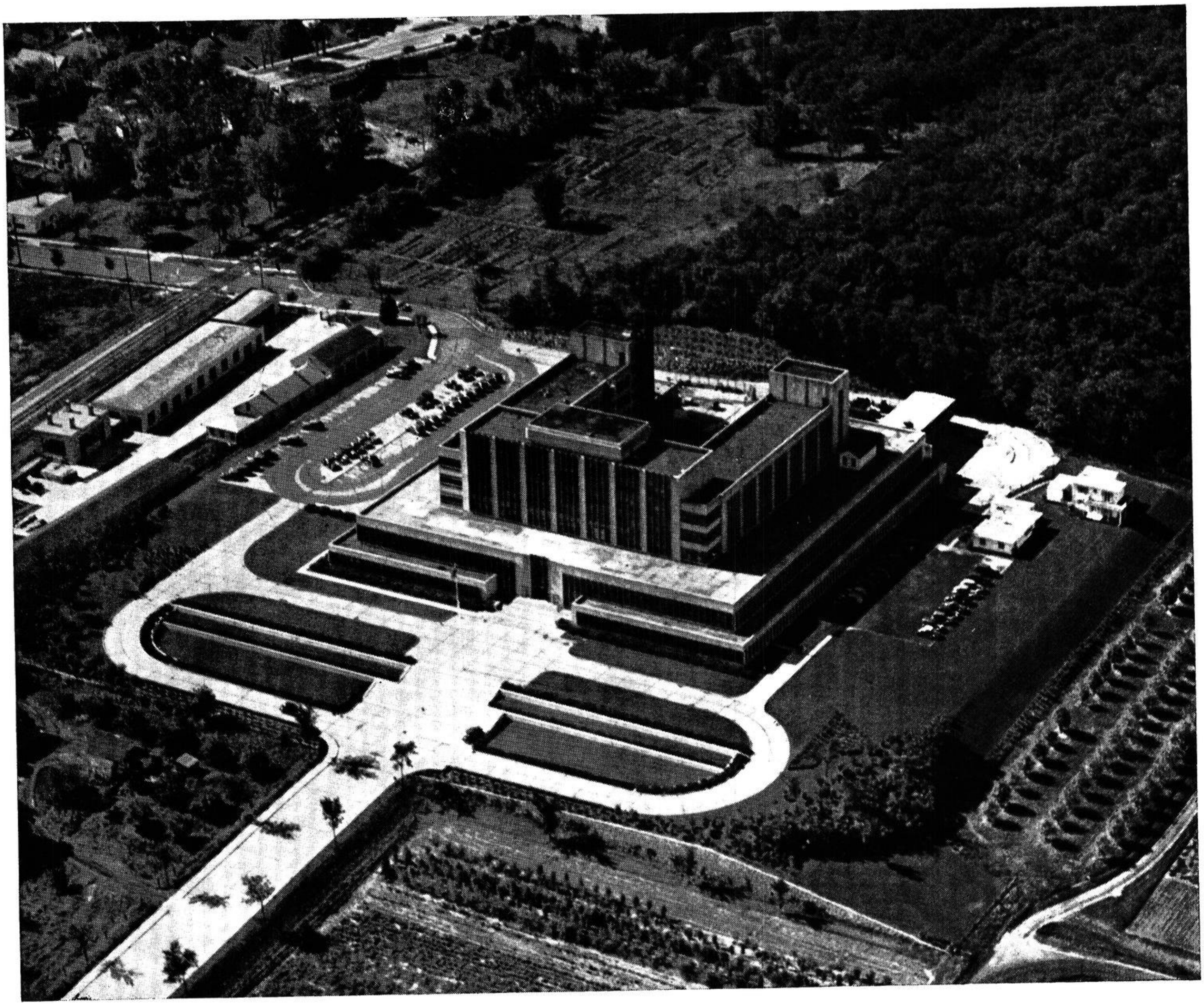
We still have time, if we act quickly. The difference, four and a half million dollars, when distributed over the population of Wisconsin, is only about $1.50 per person. We must impress the state legislature that we will not compromise the future of our university for such a trifling sum!

Second rate, or second to none?

W. M. H.

Wisconsin Engineer Index

Volume 53, October 1948 to May 1949



MEMBER ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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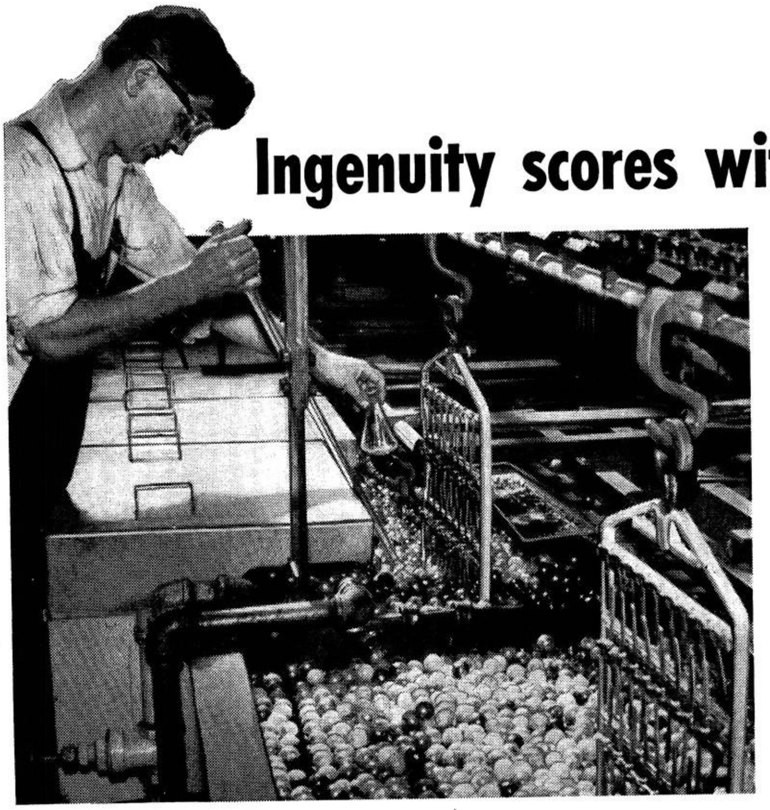
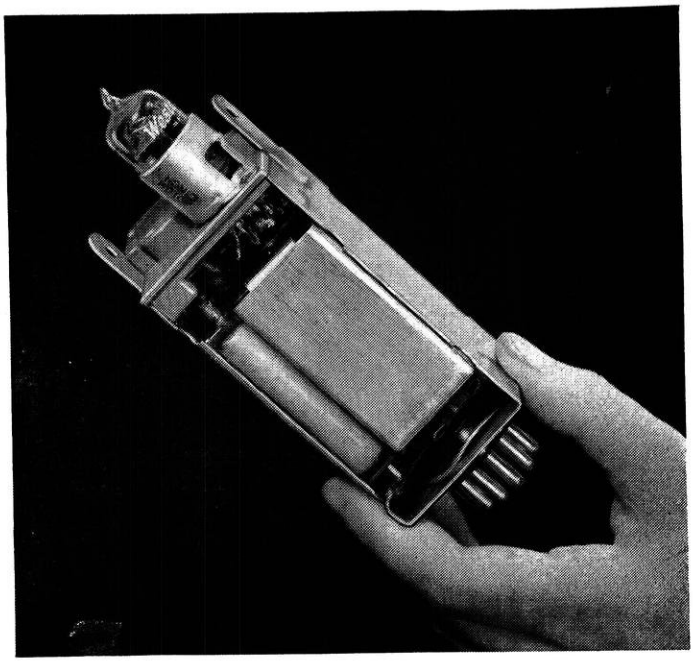
AUTHOR INDEX

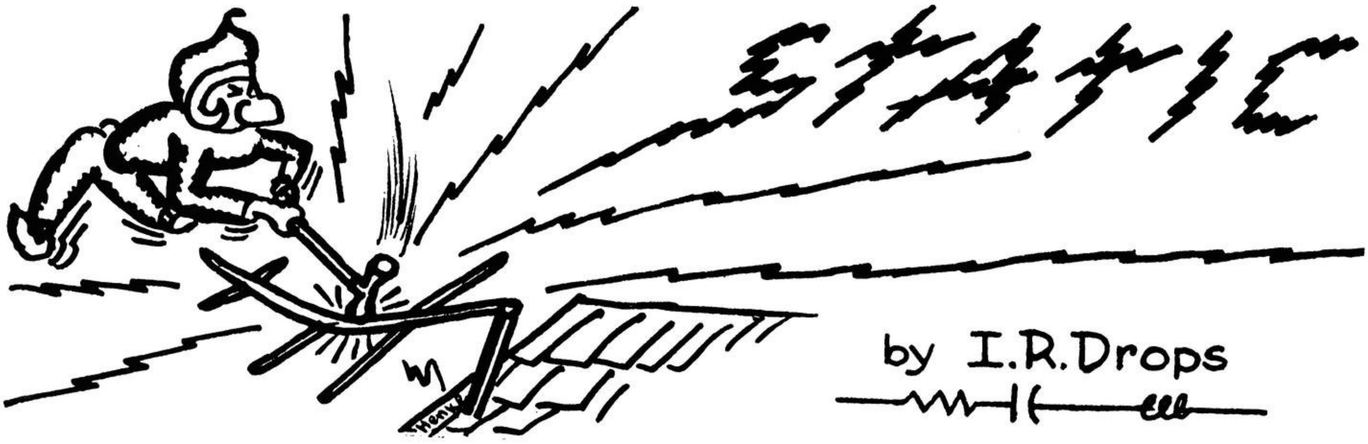
VOLUME 53

SUBJECT INDEX

VOLUME 53



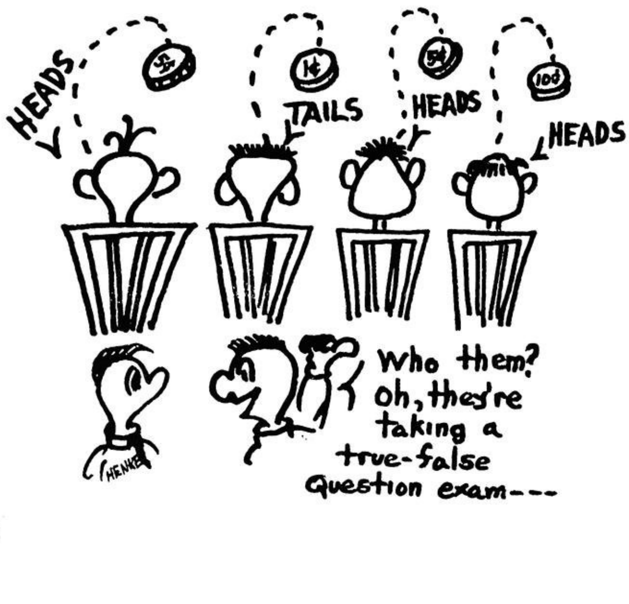




Here's a specially requested reprint dedicated to aspiring students taking Drawing I.

THE CRAFTY DRAFTSMAN

The designer sat at his drafting board
A wealth of knowledge in his head was stored
Like "what can be done on a radial drill
Or a turret-lathe or a vertical mill?"
But above all things, a knack he had
Of driving gentle machinists mad.
So he mused as he thoughtfully scratched his bean
"Just how can I make this thing hard to machine?
If I make this body perfectly straight
The job had ought to come out first-rate
But 'twould be so easy to turn out and bore
That it would never make a machinist sore.
So I'll put a compound taper there
And a couple of angles to make 'em swear
And brass would work for this little gear
But it's too darned easy to work, I fear.
So just to make the machinist squeal
I'll make him mill it from tungsten steel!
And I'll put those holes that hold the cap
Down underneath where they can't be tapped.
Now if they can make this it'll just be luck
'Cause it can't be held by a dog or a chuck
And it can't be planed and it can't be ground
So I feel my design is unusually sound!"
And he shouted in glee: "Success at last!
This #°★*&:$# !;$*& thing can't even be cast!"



A Lawyer answering the telephone:

"You must have the wrong number. Why don't you try the weather bureau?"

"Who was that?" asked his wife.

"How do I know?" he snapped. "Some dope wanted to know if the coast was clear."

* * *

A pessimist is a man who feels that all women are bad. An optimist hopes so.

* * *

A Scot was engaged in an argument with a conductor as to whether the fare was 25 or 30 cents. Finally the conductor picked up the Scot's suitcase and tossed it off the train just as it passed over a bridge.

"Mon!" screamed the Scot. "It isn't enough to try to overcharge me, but now you try to drown my little boy."

* * *

As he felt his way around the corner lamp post, the well greased M.E. senior was heard to mutter, "S' no ush, I'm walled in."

* * *

For Sale:

Beautiful, rustic farmhouse on rural route 79. Five rooms and path.

* * *

"Does you cigarette taste different lately?" asked the little dog as he left the tobacco patch.

* * *

Overheard in the lobby: "I was at a party the other night where everybody was so drunk I could hardly see 'em."

* * *

Inspired by the recent ROTC controversy:

Co-ed: "Soldier, you're getting corpulent."

Lawyer in ROTC uniform: "Oh no, I'm not. I'm a sergeant already."

* * *

Student: "May I kiss you?"

Co-ed: "Jeepers, another amateur!"

* * *

Six weeks' remorse in Math 102:

Inst.: Oscar, how far were you from the correct answer?"

Oscar: "Only three seats, sir."

She is only a chimney sweep's daughter, but she soots me fine.

* * *

King Arthur: "I hear you have been misbehaving."

Knight: "In what manor, Sir?"

* * *

Girl on bus reading statistics: "Every time I breathe a man dies." Man sitting beside her: "Why don't you try Sen-Sen?"

* * *

Dinner guest at Engineering Banquet: "Will you pass the nuts, Prof?"

Preoccupied Prof.: "I suppose so, but I really should flunk most of them."

* * *

He: "Can you see all right?"
She: "Yes."
He: "Is there a draft on you?"
She: "No."
He: "Is your seat comfortable?"
She: "Yes."
He: "Let's trade seats."

* * *

"Something is wrong with my chickens," wrote the would-be chicken farmer to the U. S. Dept. of Agriculture. "Each morning when I go out to my chicken coop, I find several of them lying on their backs with their feet stuck in the air." "Your chickens," wrote back the Dept. of Agriculture, "are dead."

A Law Student from the farm was visiting New York city. A guide pointing to the Empire State Building: "And that is a skyscraper."

Law Student: "Fine, when does it start working?"

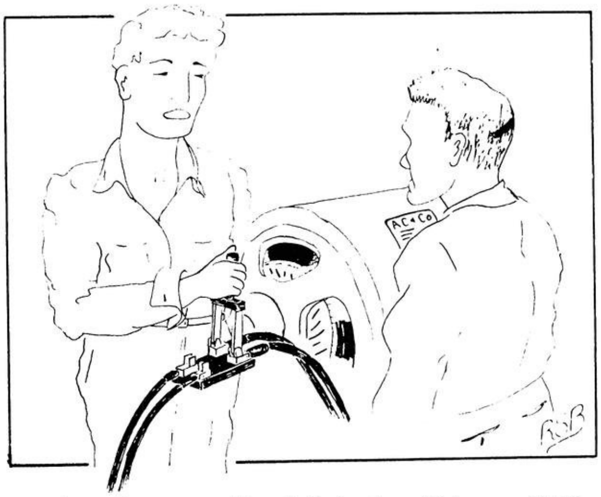
* * *

She fell upon the slippery pave.
And a man who watched her whirls,
Said, "There you'll have to lie my dear;
I never pick up girls."

* * *

"How did you like the bridge party last night?"

"Fine, until the cops looked under the bridge."



"Where do we put this switch for least Kelso trouble?"

POLYGON

Statements of Cash Receipts & Disbursements

July 1, 1948 to April 30, 1949

Cash Balance, July 1, 1948			950.56
Cash Receipts			
Share of Profit—St. Pat's Dance		210.71	
Total Cash Receipts			210.71
Total Cash Available			1,161.27
Cash Disbursements			
Smoker:			
Refreshments & Rent	52.80		
Entertainment	93.00		
Door Prizes	20.33		
Posters	6.20		
Sound System	5.00		
Cigarettes	3.48		
		180.81	
Booklet		76.00	
Film & Projector Rental		7.00	
Sign Material		11.47	
Sign for Campus Carnival		25.46	
Stationery		28.00	
Postage & Supplies		5.60	
Telegram		2.44	
Gift		5.00	
Keys		42.90	
Wisconsin Badger		35.00	
Donation — C.C.C.		20.00	
Dinner		36.00	
Photos		10.00	
Total Cash Disbursements			485.68
Cash Balance, April 30, 1949			675.59

RAY L. HILSENHOFF
Student Financial Adviser
April 30, 1949

ST. PAT'S DANCE

(Polygon)

March 19, 1949

Cash Receipts			
Ticket Sales — 786 @ $2.40	943.20		
Tax on Comps	4.00		
		947.20	
Button Sales		609.75	
Total Cash Receipts			1,556.95
Cash Disbursements			
Orchestra — Lou Rene'		250.00	
Publicity & Promotion:			
Photos	31.75		
Signs & Posters	65.45		
Engraving	1.26		
Supplies	1.86		
		100.32	
Buttons (2,500)		217.00	
Prize — Button Contest		15.00	
Rent		55.00	
Decorations		20.88	
Tickets		5.35	
Programs		108.53	
Master of Ceremonies		10.00	
Trophy		19.71	
Refreshments		2.65	
P.A. Rental		10.00	
Wisconsin Badger		35.00	
Tax on Admissions		166.40	
Share of Profit:			
A.I.E.E.	110.00		
A.S.M.E.	61.10		
Mining Club	57.10		
A.I.Ch.E.	47.60		
A.S.C.E.	54.60	330.40	
Total Cash Disbursements			1,346.24
Net Profit			210.71
Distribution of Profit			
Transferred to Polygon Board			210.71

RAY L. HILSENHOFF
Student Financial Adviser
April 30, 1949

Science . . .

(*continued from page* 17)

In the National Bureau of Standards test, tap water of known analysis was circulated at a constant velocity through a system made up of 14 different pipe specimens. The specimens consisted of two types of cast iron, three of wrought iron, two of ingot iron, and three of open hearth steel. Except for the metal specimens, the water within the apparatus came in contact only with rubber, glass, and stainless steel. Care was taken to prevent galvanic action and turbulence of flow.

It was found that corrosion of the interior surfaces of the pipes started with the formation of small localized mounds of rust, the number and size increasing with time. Rust formed during the first two years was lightly adherent and easily removed. As corrosion continued, the coating became denser, tightly adherent and developed into a tubercular form of rust. Few uncorroded areas were found after exposure of more than five years.

The results of the test showed that there was no great difference in the rates of corrosion of most wrought iron materials. A low-alloy steel had the highest corrosion rate while a copper-molybdenum ingot iron and a nickel-bearing wrought iron had the lowest rates. Medium carbon steel and other low alloy materials corroded at intermediate rates. The continuous flow caused corrosion to be twice as fast as would be encountered in ordinary practice. A rough estimate of the minimum life when subjected to a continuous flow would be about 15 years.

IMPREGNATED LEATHER

Resin treatments that promise to effectively improve the wear resistance of sole leather have recently been developed at the National Bureau of Standards. The use of resins should also reduce the amount of tanning materials now required to produce high quality leather.

Three methods of treatment have been developed. The first method is accomplished by immersing the leather in manomer and then polymerizing; the second consists of immersing leather in polymer solutions such as gutta-percha, certain types of natural rubbers, or synthetic elastomers; while the third involves immersion in a partially polymerized liquid resin which is further polymerized in the leather itself.

Abrasion tests show that the wear to be expected is increased up to 75 percent with the rubber treatment. The amount of water absorbed is decreased up to one third depending upon the type of treatment.

Service tests of shoe soles and pilot plant processing runs are being planned as the next step in the investigations.

BETATRON X-RAY

X-ray pictures may be made through a piece of steel ten inches thick with an exposure of nine minutes, using a 10,000,000 volt mobile betatron which has been developed by General Electric. The largest previous mobile industrial machine was a 2,000,000 volt device which used a resonance transformer to develop the high energies used, but the size and weight of such type machines set a practical upper limit to its use. To go still higher, therefore, another principle had to be invoked, namely that of a betatron. In this device, electrons are whirled around in a doughnut-shaped vacuum tube mounted between the poles of a large alternating current electomagnet. When the electrons reach the desired energy, they are hurled against a metal target inside the tube, and a beam of high energy X-rays are emitted.

The magnet of the new machine uses a special alloy steel containing 42 percent nickel. It is built up of sheets four thousandth of an inch thick. Oil is circulated through the magnet and through a heat exchanger to prevent overheating. The entire unit weighs 5000 pounds. The machine is housed in an X-ray room that has walls 36 inches thick, and is entered by a maze rather than a door, since the cost and time factors

(*please turn to page* 36)

"Madame X" was the code name, during research and development, for an entirely new system of recorded music . . . perfected by RCA.

The remarkable background of **"Madame X"**

Now the identity of "Madame X", the unknown in a long search for tone perfection, has been revealed. From this quest emerges a completely integrated record-playing system—the first to be entirely free of distortion to the trained musical ear . . .

The research began 11 years ago at RCA Laboratories. First, basic factors were determined—minimum diameters, at different speeds, of the groove spiral in the record—beyond which distortion would occur; size of stylus to be used; desired length of playing time. From these came the mathematical answer to the record's speed—45 turns a minute—and to the record's size, only 6⅞ inches in diameter.

The record itself is non-breakable vinyl plastic, wafer-thin. Yet it plays as long as a conventional 12-inch record. The new RCA Victor automatic record changer accommodates up to 10 of the new records—1 hour and 40 minutes of playing time—and can be attached to almost any radio, phonograph, or television combination. The record *player* ends faulty operation, noise, and cumbersome size. Records are quickly changed . . . RCA Victor will still supply 78 rpm instruments and records.

This advance is one of hundreds growing from RCA research. Such leadership adds value beyond price to any product or service of RCA and RCA Victor.

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.
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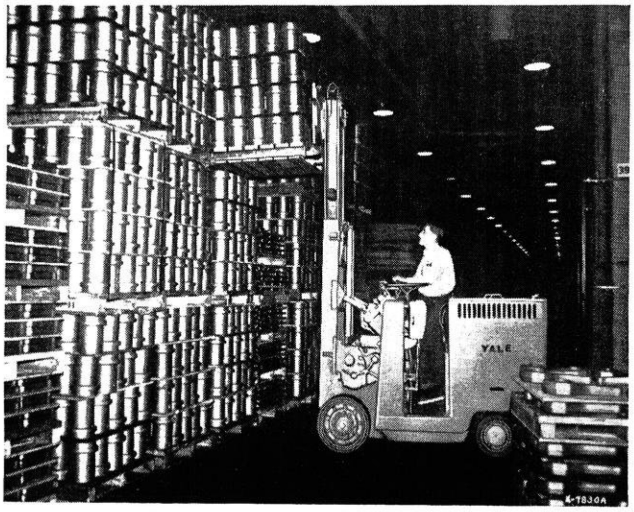
MATERIALS HANDLING

(*continued from page 10*)

general use is in large storage areas, particularly outdoor yards.

Power lift trucks are similar to the tractor-trucks except that they have a lifting ram at the front which is power operated. This unit picks up the skids or pallets, moves them about and sets them in position. For use indoors the trucks may be electrically driven through storage batteries to overcome the dangers of the engine exhaust.

Stackers are similar to the power lift trucks except that their lifting mechanisms can be raised to high levels, fifteen feet and even higher. These are particularly useful in warehouses and other storage areas where material is stacked as high as possible to make the best use of the entire area. Their lift is a great as 50,000 pounds.



Various trucks with standard or specialized attachments are used in handling and storage of materials. Here a standard forked truck is used in storing parts.

Uses of Trucks in Manufacturing

Hand trucks have wide usage. Beside all of the uses in general delivery work and similar movements, the three or four wheeled type are used in many industries to transport raw materials from storage to the operations, parts from one operation to the next, and finished parts to storage or assembly. Heavy fixtures and dies are also brought to the required places.

Power lift trucks are similarly employed for heavy loads and long moves. For all types of trucks, skids or pallets (flat wooden skids just high enough for the fork of the truck to fit below) are used when the parts are small. Special rams have been designed to handle specific materials. A large bar type has been designed to handle coils of steel in storage or in transportation. Large rolls of newsprint, jute or similar material can be handled on the standard fork.

Beside their more common uses, stackers have been employed by airlines in handling baggage. The small castered trucks carrying a large amount of luggage are picked up by the stacker, carried to the waiting plane and raised some fifteen feet or so up the baggage hatch where the luggage can be easily stowed.

Cranes and Hoists as Handling Equipment

Cranes and hoists are also materials handling equipment of importance. Cranes, useful in raising and stacking material, have been built on power trucks similar to those already mentioned. The use of crane-type shovels in digging and lifting cranes in building steel structures are again only two common examples. Other examples are almost infinite.

Tram rail hoists are those mounted, free to travel from one end to the other, on swinging beams; monorail hoists are free to move along a stationary beam as on a track.These hoists may be electrically or mechanically operated and are important where heavy material must be raised or lowered.

Large beam cranes are important in the heavy manufacturing industry. Smaller cranes of the beam type are in use in foundries, power plants, and wherever heavy equipment must be serviced.

Special Developments

Many special pieces of equipment have been developed for particular applications. It is known that canned, condensed milk must be turned over occasionally to prevent spoilage. This becomes quite a problem when hundreds of cases are stacked in a warehouse. A special unit has been developed to pick off a number of cases from the top of one pile, turn them over and restack them on another pile. The unit has the appearance of an ordinary stacker except that it has a large vertical turning unit mounted on the ram.

The Importance of Materials Handling Equipment

The types of equipment discussed are only typical of the equipment now in use. Numerous sizes and types of standard models are being built and are in common use. As was mentioned, special equipment has been designed for a great variety of jobs. All of these have in some manner made the handling problems easier, possible at all, more economical or all three.

The economies experienced through mass production are not only due to new and improved methods of production or processes, but a great deal of the saving has come through new and improved methods of handling material of all kinds. It is not difficult to find examples of how work has been made easier and faster even in everyday life if a person will associate these correctly to materials handling.

Although much has been done, particularly during the war years, much is yet to be done, both in the development of equipment and in the selling of the idea of the important role played in our economy by material handling equipment.

The importance of materials handling will be emphasized here at Wisconsin next fall, when a course will be offered to seniors and graduate students. The course will be given by Professor Daggett, and will delve into the various aspects of the subject.

THE "*Atomic*" CLOCK . . .

(*continued from page 16*)

with the absorption frequency of the ammonia cell; but an error voltage is produced to correct the oscillator when it drifts in either direction.

The Measuring Devices

The atomic clock is completed by installing special clocks and equipment for checking the accuracy of the clock. A frequency divider divides the precise 100 kilocycle signal down to 50 cycles to drive an ordinary synchronous motor clock, and also down to 1000 cycles to drive a special synchronous motor which is designed for exact adjustment and comparison with astronomical time to within 5/1000 of a second.

The accuracy of the clock is determined by comparing the frequency of the clock's quartz-crystal oscillator with primary frequency standards; a group of precision 100 kilocycle quartz-crystal oscillators calibrated in terms of the U. S. Naval Observatory time signals. These oscillators maintain constant frequency with respect to each other to an accuracy of one part in a billion for intervals up to 10 hours and better than one part in 100 million per day. They can therefore be used to measure the constancy of the atomic clock to this accuracy. This is done by beating the signals from the two sources together at 12.5 megacycles to obtain a greater measurement sensitivity. A change of one cycle per second in the frequency of the beat note, as recorded on a frequency meter or on an automatic recorder, indicates a frequency variation of one part in 12.5 million.

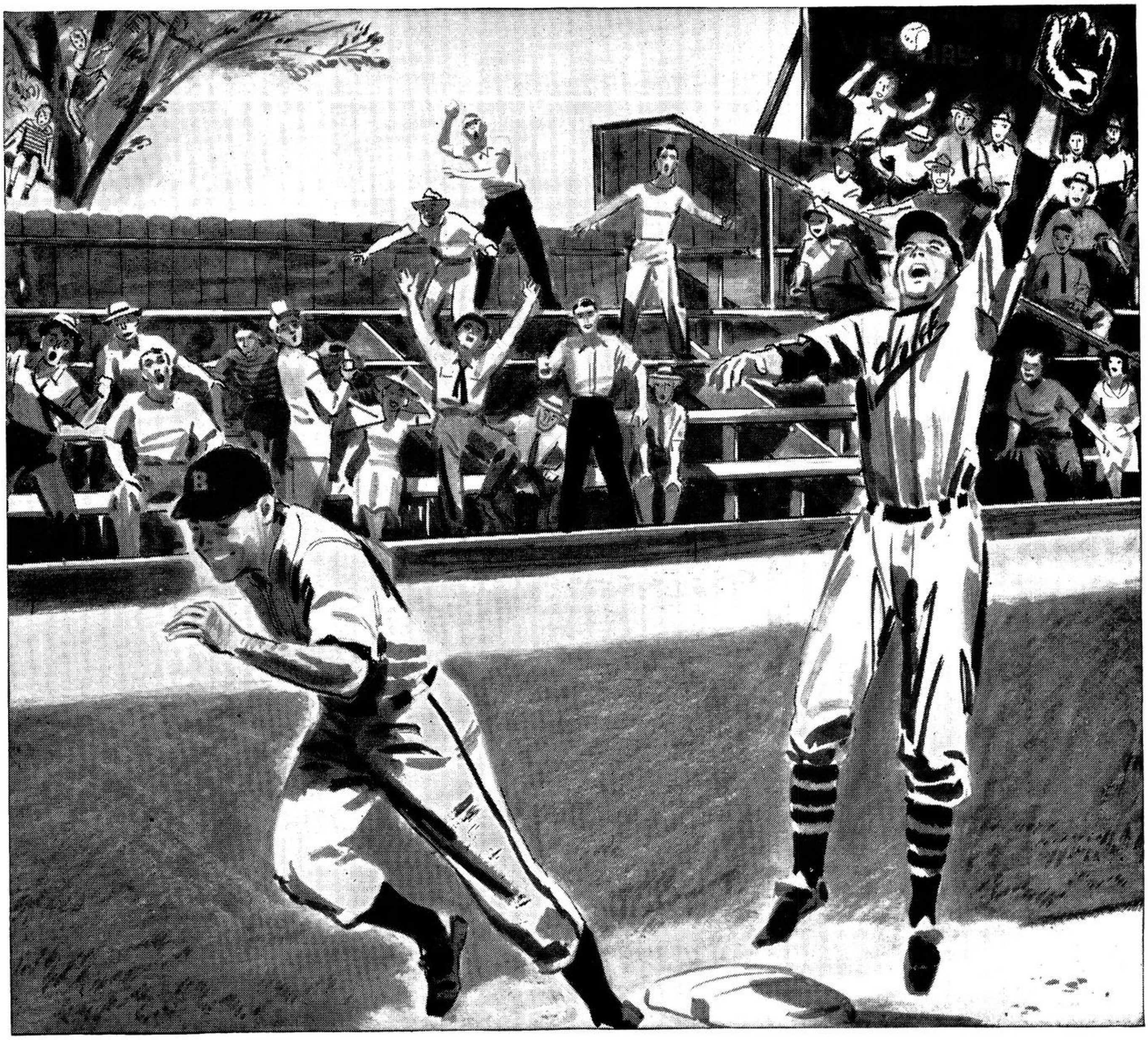
In recent tests the clock maintained a constancy of one part in ten million for several hours. These tests showed that the clock will lock accurately to the ammonia line even when a disturbance signal is applied to the reactance tube in an attempt to force the clock to change its rate.

The Conclusions

The ultimate accuracy of an atomic clock depends on many factors, of which the most important are those governing the width of the spectrum line. Spectrum lines are not infinitely narrow but have a finite width covering a considerable frequency range, since atoms or molecules do not emit or absorb radiation at only one frequency but over a narrow band of frequencies.

The ratio of a line frequency to its width at the half-power points is called the Q of the line. The Q is a measure of the sharpness of the line and therefore determines the accuracy and time standard. The natural line width of ammonia gives a Q of 10^{18} (a billion billions) which indicates that frequency and time could be theoretically determined to better than one part in a billion billions. But the Q is lowered to a value of from 50,000 to 500,000 depending on the temperature and gas pressure. When a gas molecule is approaching or receding

(*please turn to page 34*)



THE "Atomic" CLOCK . . .

(continued from page 32)

from an electromagnetic source because of its heat motion, its absorption frequency is different and gives rise to a "Doppler Broadening" of the absorption line which lowers the Q of the line. Decreasing the temperature will reduce the heat motion of the molecules and increase the Q of the line.

Molecular collisions with one another and with the walls of the cell also broaden the absorption line and is determined by the distribution of time intervals between collisions. At a pressure of 10 microns there are about 120,000 collisions per second with an experimentally measured Q of 45,000. The Q is increased by lowering the gas pressure but a limit is reached where saturation sets in at which point too few molecules are left in the proper energy level to absorb microwave radiation coming into the cell. Saturation can be eliminated by decreasing the strength of the incoming radiation but a condition will be finally met for which the signal strength will be down in the electrical noise level of the circuits used to detect the signals.

It is estimated that by reducing the pressure to about one micron a Q of 300,000 to 400,000 can be obtained and an accuracy of one part in 100 million should be possible, since a measurement of the center of the absorption line to within 1/250 of the width of the line could be made.

The Applications

There are many important applications in the field of pure and applied sciences to which the time clock could be put to use. It can be used to measure the variation in the earth's time keeping which varies as much as one part in 20 to 30 million per mean solar day. It will find useful application in broadcasting a standard frequency which is required in international transportation and communications.

The present limitation of long wave transmission of a standard frequency could be overcome by line of sight transmission by which method a whole series of standard clocks could be synchronized with a master atomic clock. This would eliminate the necessity of checking and monitoring the clocks with astronomical time signals.

It will permit improvements in astronomical time standards in a way impossible with electric pendulum or quartz-crystal clocks and thus open up the possibility of improving the precision of knowledge of the length of the year independent of the earth's rotation about its own axis.

Finally the overlapping of the fields of electronics and molecular physics may well provide a new technique for opening up the millimeter-wavelength bands above the region where ordinary microwave methods are applicable and below the region where optical methods are used.

IF HE COLLECTED SAMPLES

as he made his rounds

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Science . . .

(*continued from page 28*)

involved in opening and closing 3-foot-thick doors would be prohibitive.

BETA-RAY THICKNESS GAGE

A new instrument uses radioactivity to measure the thickness of sheet materials moving along a conveyor. The beta-rays, which are high speed electrons, are emitted by the substance "strontium-90." The instrument measures the number of electrons passing through the sheet material being checked. This measurement is translated, by means of a complex electronic circuit, into terms of how much the sheets being checked vary from the desired thickness.

The great advantage in a gage of this type is that it does not come into contact with the material being checked and can be used to monitor the thickness of rubber, plastics, textiles, and paper, as well as metal, while the material is in motion. It is capable of checking metal strips that are moving as fast as 1000 feet per minute and is accurate to within two percent.

The strontium-90 beta-ray source has a surface of about one-half inch, and is enclosed in a brass cartridge four inches long. On one side of the cartridge is an opening through which the rays pass. The cartridge wall is thick enough to stop the radiation, and the opening can be closed when the instrument is not in use, so that persons handling it are in no danger. Beta-rays have a very low penetration, compared with x-rays and hence the operators are very easily protected. The detector for the rays passing through the material is called an "ionization chamber," and works on the same principle used in a radiation detector.

Because of the low penetration of beta-rays, the gage is limited to use on thin sheets, no thicker than 1/50th of an inch of steel, and 1/13th of an inch for aluminum.

MAGNETOSTRICTION

(continued from page 8)

Sonar, used for submarine detection, sends out a pulse of sound energy through the water, using a magnetostrictive transducer. This transducer consists of several magnetostrictive elements driven in parallel to radiate a directional sound wave of great intensity.

The Villari effect is utilized to detect the returning sound waves, which are reflected by objects in the water. The detecting device, or hydrophone, usually consists of a nickel cylinder, toroidally wound and permanently magnetized. Thus any strain caused by sound vibrations in the water will cause a change in magnetization. This change induces a voltage which is amplified and detected.

The JP type hydrophones, used to listen to noises made by enemy ships, were of similar type. A highly directional transducer, using a nickel tube two inches in diameter and about three feet long, was connected to an amplifier containing a number of filters and a supersonic converter. A skilled operator could detect the size, position, and speed of an enemy ship, and also make a fair guess at the time since the engine was overhauled.

Another type of hydrophone was used in Sono-buoy equipment. Here a complete amplifier and radio transmitter in a waterproof cylinder was dropped by parachute. Upon striking the water, a trapdoor released a nickel transducer that hung from a 25 ft. cord. Sounds from any nearby submarines were picked up, amplified, and transmitted to a circling plane.

A more complicated type of Sono-buoy, later developed, had a directional device. Two or three of these would give a "fix" and guide the dropping of depth charges.

A new type of phonograph pickup uses a magnetostrictive element. A nickel wire is held between the poles of a horseshoe magnet and given an initial twist so that small torsional displacements will result in linear relations between flux density and displacement angle. A light needle is fastened to the center of the wire and a coil is wrapped around the wire on each side of the needle so that the voltages induced are in a push-pull relationship which cancels out the even harmonics and the effects due to external disturbances.

It is claimed that this pickup has substantially uniform characteristics over the frequency range of 30 to 10,000 cycles, except for the normal falling off below 400 cycles due to the transition from constant velocity to constant amplitude recording.

This range can be extended to 15,000 cycles by a suitable transformer so that it has possibilities in high quality FM work. A further advantage is the low needle point mass and subsequent low needle pressure necessary to operate the device.

A stress meter described by Smith and Luxford utilizes the change in permeability with stress. Two identical magnetostrictive rods are used as the cores of transformers. When identical voltages are applied to the primary and the rods are unstressed, the voltages induced in the secondaries are equal.

The circuit is balanced with equal voltages across the output of two bridge rectifiers, and no resultant current flows through the meter or detecting device. Stress applied to one rod will cause an unbalance and cause a deflection on the meter.

Magnetostrictive elements have been used as detonation detectors in automotive and aircraft engines. One type of pickup is connected externally to some solid metal portion of the cylinder head and depends for operation on the pressure waves traveling through the metal upon detonation. Another type has a flexible diaphragm separating the magnetostrictive rod from the combustion chamber and can be used to obtain pressure vs. time diagrams with the aid of a cathode-ray oscilloscope.

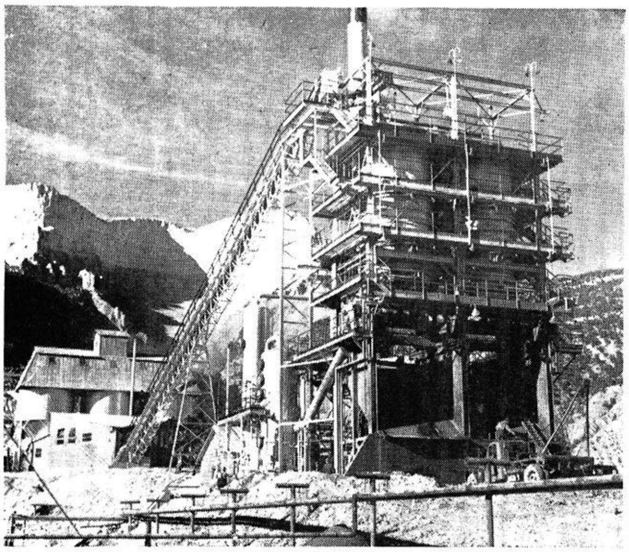
The application of magnetostriction to this type of device is somewhat hindered by the effects of temperature on ferromagnetic materials. The Curie Point, at which ferromagnetic materials lose their magnetism, is only 360 degrees C. for nickel, which also exhibits the strongest magnetostrictive effects. Cobalt has a Curie Point of 1080° C. but has a smaller and varying magnetostrictive effect. Furthermore, the behavior of cobalt depends on its past treatment since it may exist in either of two crystalline structures—face-centered cubic or hexagonal close-packed.

The above examples illustrate the application of a laboratory curiosity of 100 years ago—magnetostriction—to devices that affect the daily lives of everyone.

SHALE OIL

(continued from page 12)

In these N-T-U retorts the batch is loaded, then kindling is placed atop the charge and ignited. The heat from the kindling ignites the kerogen in the upper layer of the oil shale, while the hot gases are drawn downward and heat the shale sufficiently to release the oil. As this process is carried on, the hot gases are re-circulated and the fixed carbon left in the shale serves as fuel. By controlling circulation and oxygen content the maximum amount of oil is obtained, which is drained continuously during the run. Upon the completion of the run, the bottom drop doors are opened and the shale is shoved over the edge of a nearby cliff with a bulldozer.



A conveyor links the shale storage bins to the N-T-U retorts in the foreground.

Another method known as the "Jodavis" retort has also been tried. This method is similar to the N-T-U retort except that the gases are heated outside the retort in pebble stoves and then are circulated by a blower. More than enough heat is available in the flue gases or the fixed carbon in the shale for the process.

The N-T-U retorts give yields of slightly less than Fischer assay values, while the "Jodavis" retort gives yields of from 106 to 108% of the assay values.

Several other types of retorts are under test by other people. The Petroleum and Oil-Shale Experiment Station at Laramie, Wyoming has a bench model continuous flow process using a liquid heating medium.

The fluidized solids technique which has been developed on a large scale for the catalytic cracking of petroleum, has been applied by the Standard Oil Development Company to oil-shale retorting. This process involves the principle of solid-to-solid heat transfer. Crushed shale is fed continously into the retorting vessel, where it is mixed with hot spent shale that has been transferred from a spent-shale burner. The oil vapors and flue gases are then collected in the usual manner.

The Union Oil Company has a continuous flow underfeed retort under test. In this retort the shale is fed in at the bottom by a piston or ram and continuously forced upward. Spent shale is burned in the upper part of the retort and the hot gases flowing downward release the oil in the middle section, and the lower section of shale is being preheated while it is condensing the oil that has been released. This method has the advantage of a relatively low water consumption, which is important in the arid regions in which shale oil is found.

The efficient use and conservation of heat is important, as 500,000 Btu are required to retort a ton of average shale. Ordinarily the fixed carbon and the combustible flue gases produced in the retorting of the shale are more than sufficient to make the process self sustaining.

The Swedish Oil Shale Company of Orebro, Sweden has developed and has in use a spent shale burner that handles approximately 1500 tons of shale and coke every 24 hours and produces roughly 55 tons of steam per hour.

After the oil has been released from the shale, the next step is the distillation of the raw shale oil into products that are more usable in every-day life. The distillation of shale-oil is similar to that of petroleum, in that the basic processes are much the same.

Shale oil differs from petroleum in that a large proportion of the hydrocarbons are olefinic and sulphur, nitrogen, and oxygen compounds are present in larger amounts.

Considerable trouble has been experienced in cracking the light ends of shale oil, such as gasoline. Union Oil has found that by thermal coking followed by catalytic hydrogenation, a yield of about 85% high grade fuels can be obtained.

High pour point and high gum content are two other refining problems. The wax content is also relatively high, and of quality comparable to that of petroleum.

Though the refining problems are vexing, there are indications that they will be solved for the best interest of all concerned.

The people in their individual capacities as distinguished from organized transportation, for example, are the main users of petroleum products. The large increase in demand since the end of World War II indicates that the people want to use more petroleum products such as gasoline and heating oil. Shale oil can be used to good advantage to augment our dwindling supplies of petroleum and natural gas.

Since almost one fourth of our oil needs, such as domestic heating, are satisfied by low grade oil, shale oil at the present time could be used to satisfy these needs. The future availability of oil is a serious question in all new or expanded uses of oil.

An oil-shale plant in Colorado or any other large field could plan and schedule operations for 20 years or more in advance. They would be armed with accurate knowledge of sources of their raw materials and the costs involved.

The Union Oil Company states that when the need for supplementary sources of liquid fuels is great enough, they will be ready to make up the deficit from shale oil.

The Slide Rule

(continued from page 14)

of 25 from the log 6 + log 3 and effecting the division, the answer being read on the D scale under the hairline as before. Try again with 2.765 x 6.525/11.450.

This briefly covers the inverted scales and illustrates how they may be used to save much labor in complete operations.

The use of the A scale in conjunction with the D scale for obtaining powers and roots of numbers is fairly well known, but there are two labor saving techniques involving the A scale which I would like to point out in passing.

One is the use of the A and B scale in solving problems. Generally, when a problem involves a square the student finds the square by means of the A and D scales and then transfers it to the other side of the rule for calculation by means of the C and D scales. This is unnecessary on many occasions.

Take for example the calculation of the area of a circle: $A = \frac{\pi d^2}{4}$ The diameter, known, can be set on the D scale and its square read on the A scale. Now instead of transferring it to the other side of the rule to multiply by π and divide by 4, set the index of the B scale to the hairline and multiply by π on the B scale. Then divide by 4 on the B scale also, and read the final answer on the A scale. For example, suppose the diameter of the circle is 7"; set the hairline over 7 on D scale, read $7^2 = 49$ on A scale. Set left index of B scale under hairline at 49 on A and move hairline to π on B scale, read $49 \times \pi = 153.4$ on A scale. Slide the 4 on B scale under hairline and read

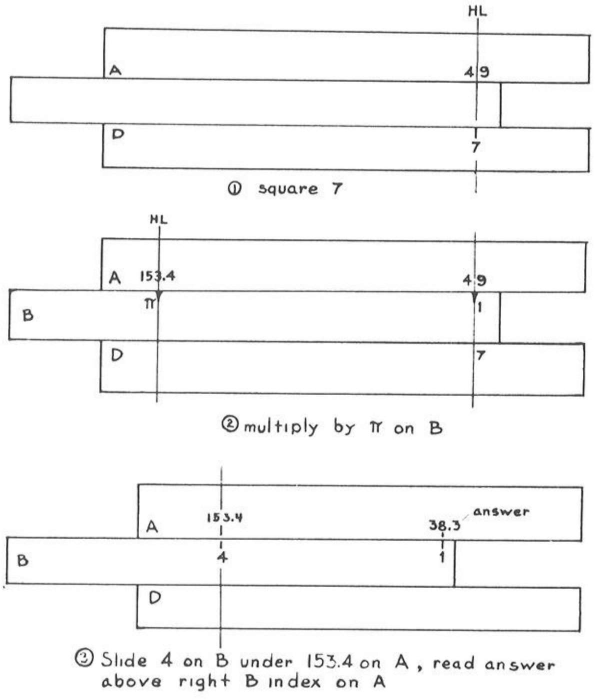


Fig. 9

$\frac{49 \times \pi}{4} = 38.3$ on A scale under right index of B scale.

The second of these two applications of the A scale involves the multiplication of a number times a square root. An example serves best to illustrate this one. Say we want to determine the product: $3.7 \times \sqrt{365}$

To do this, simply set the left index of the C scale (which corresponds to the left marking on the S scale) over 3.7 on the D scale. Then move the hairline to 365 on the B scale and read the answer 70.75 on the D scale. Figure 10 illustrates this.

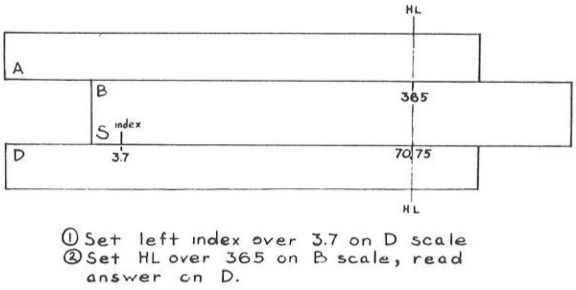


Fig.10

These are the only ideas we will discuss involving the A scale since the other operations are straight-forward and need not be taken up here.

The next topic we will cover in this article will be those problems centering around the trigometric scales and the solution of problems involving trigometric functions.

The first and simplest problem we run up against in engineering involving trig functions is the multiplication involving a function. For example, $3.75 \times \sin 9.85°$. Many times do we have problems such as these. To solve it simply and swiftly merely set the left index on the S scale over 3.75 on the D scale, move the hairline to 9.85 on the

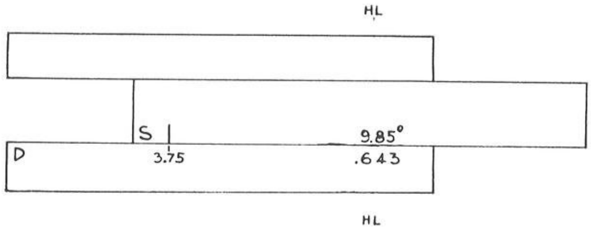


Fig. 11

S scale (black numbers) and read the answer below the hairline on the D scale, .643.

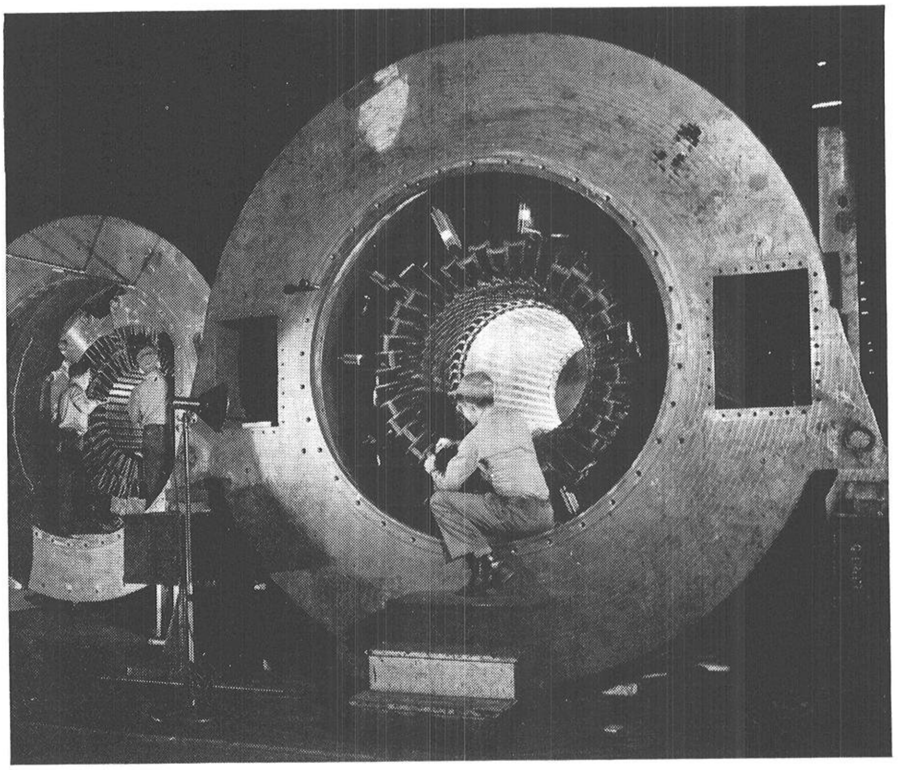
Another simple type of problem is shown by

$$\frac{21.7 \text{ sine } 33°}{\tan 13.7°}$$

To solve this problem set the hairline over 21.7 on the D scale and bring 13.7° under it on the T scale, this is the division in effect of $\frac{21.7}{\tan 13.7°}$; then move the hair-

(please turn to page 44)

Get a Close-Up OF THE BASIC INDUSTRY OF YOUR CHOICE!



Inside View of a hydrogen-cooled steam-turbine generator. A-C Graduate Training Course students may follow important electric power equipment from blueprint to installation.

by R. S. FLESHIEM
Manager Electrical Department
ALLIS-CHALMERS MANUFACTURING CO.
(Graduate Training Course—1904)

WHEN YOU GET into daily working contact with an industry, you may find it offers specialized opportunites that you hadn't known about before. That's why it's not always possible—or wise—to pick *your* final spot in industry until you've had some all around first-hand experience.

R. S. FLESHIEM

I want to suggest a good way to *get* a close-up of the industries that appeal to you.

Naturally, I can talk with most assurance about the electric power industry. But the same principles apply to others.

When I got my engineering degree from the University of Michigan, the electric power industry was a fast-growing youngster. I decided to go to Allis-Chalmers, where I joined the company's first Graduate Training Course in 1904. I was sent to Cincinnati and started in the old Bullock Electric Mfg. Co. plant that Allis-Chalmers had purchased that same year. Bullock, incidentally, started in 1884—one of the real old-timers in the electric industry. It was the start of the present Allis-Chalmers Electrical Department.

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The industry was growing fast at the turn of the century, but it's growing even faster now. Opportunities were never greater—or more varied.

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Today we have Graduate Training Course engineers applying their ability and training to the problems of machine design—research and development—manufacturing and production—sales—application engineering. Here we're working with electric power generation, control and utilization—with advanced industrial uses of electronics—with research in D. C. transmission. We're in intimate touch with the electric power industries—with transportation—with steel, metal working and other big power users. And I know that the field is just as broad in the other major industry departments here at Allis-Chalmers.

What Industry Interests You?

I firmly believe that Graduate Training Course engineers have a unique opportunity at Allis-Chalmers. They have the opportunity here to explore thoroughly not one, but many basic industries if they choose. This company produces the world's widest range of major industrial equipment, and every department is open to the graduate engineer. That includes electric power, mining and ore reduction, cement making, public works, steam turbines, pulp and wood processing. It also includes the full range of activities within each industry: design, manufacturing, sales, research, application, advertising.

Graduate students help plan their own courses at Allis-Chalmers, and they move around a good deal. It's possible for a man to come here with the idea of designing electrical equipment—later become interested in manufacturing—and finally find his greatest satisfaction and success in sales work. Men move from department to department, getting a practical working knowledge of each. And—the departments get to know the men. Opportunities present themselves according to ability.

At the completion of the Graduate Training Course, you've had a close-up of many industries. You're ready to take your place in the work of your choice.

Write for details of the Allis-Chalmers Graduate Training Course—requirements, salary, advantages. Representatives may visit your school. Watch for date.

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The Slide Rule

(continued from page 42)

line to 33° on the S scale, thus multiplying by sine 33°, and read the answer below the hairline on the D scale, 48.4. See Figure 12.

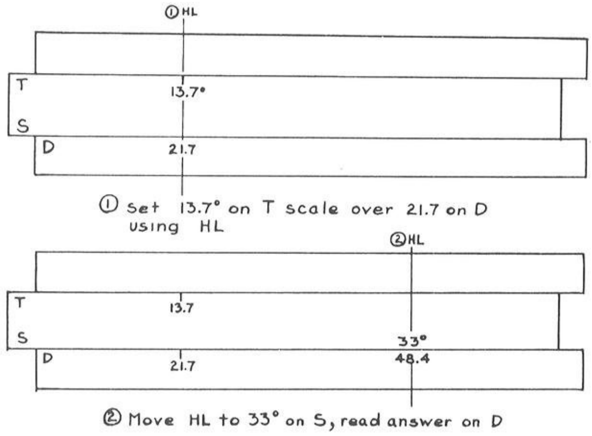

Fig. 12

As the final topic in this article I'd like to present the procedure for rectangular-polar form conversion and its converse, the polar-rectangular conversion. These conversions come up frequently in electrical problems where the vector numbers are used extensively in solving circuit problems.

The polar form of a vector number is generally $C\angle\theta$, and the rectangular form a + jb. Graphically these can be represented as:

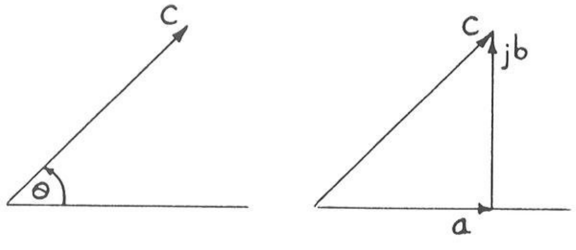

Fig. 13

In some problems it is more convenient to have the vector number expressed in the polar form and in others in the rectangular. The ability to convert from one to the other on the slide rule is of considerable value in handling these problems.

First, let's consider the rectangular-polar conversion. We have the complete number in the form a+jb. The procedure is; (these problems are done on the trig scale side of the runner.)

1—set the index of the runner on slide over the larger number (a or b) of the complex number on the D scale.

2—set the hairline to the smaller number (a or b) on the D scale and read θ on the T scale. If b is larger than a, read the red figures on the T scale; if a is larger than b, read the black figures.

3—Leaving the hairline as set in determining θ, move the slide until θ on the S scale comes under the hairline, reading the same color figures on the S scale as was read on the T scale.

4—the number, C, will be read on the D scale under the index of the S scale. See Figure 14 for illustration.

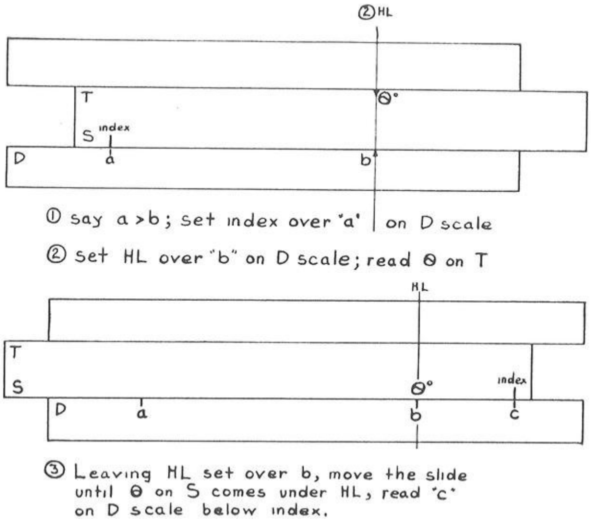

Fig. 14

The reverse process can be worked to convert the polar form $C\angle\theta$ to the rectangular form a + jb. The procedure is:

1—set the index of the S scale over C on the D scale.

2—for angles between 5.74° and 84.26° i. e. the readable limits on the S scale, set the hairline to the angle θ on the **red** scale, i. e. red numbers.

3—read **a** under the hairline on the D scale.

4—set the hairline to the black S scale, and read **b** below the hairline on the D scale. Figure 15 shows the process graphically.

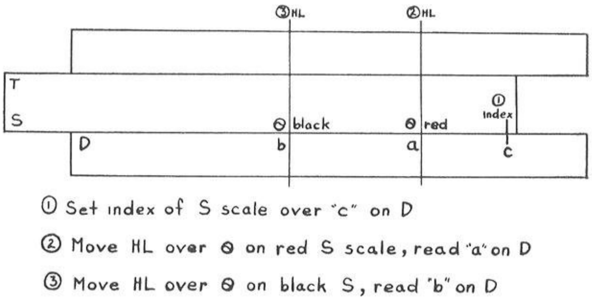

Fig. 15

For angles below 5.74° the ST scale is used to determine b, and the S scale used for a, as above outlined.

For angles over 84.26° the ST scale is used in determining a and the S scale for b, as previously shown.

While the preceding brief sketch of the techniques which can be used to speed up calculations with the slide rule is not held to be complete, a thorough treatment of the subject would fill a book let alone an article in a magazine. It is hoped that you have been able to pick up a few new ideas, or refresh your memory, by which the handling of your slide rule will be a little more efficient and more pleasant than it had been before reading this article.

Photography can make this page

this  small

IT'S DONE WITH MICROFILM MAGIC

TINY AS IT IS, the little rectangle above is this page in black and white—as it appears on microfilm. Everything there, condensed to a mere spot, but ready to be brought back full size with all its features intact. For photography can reduce tremendously without losing a detail.

As a business or professional man, you can utilize photography's reducing ability in any of many important ways.

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Only a suggestion . . . this . . . of what photography can do because it is able to condense. And because it has many other unique characteristics as well, photography is becoming an increasingly important tool all through science, business, and manufacturing.

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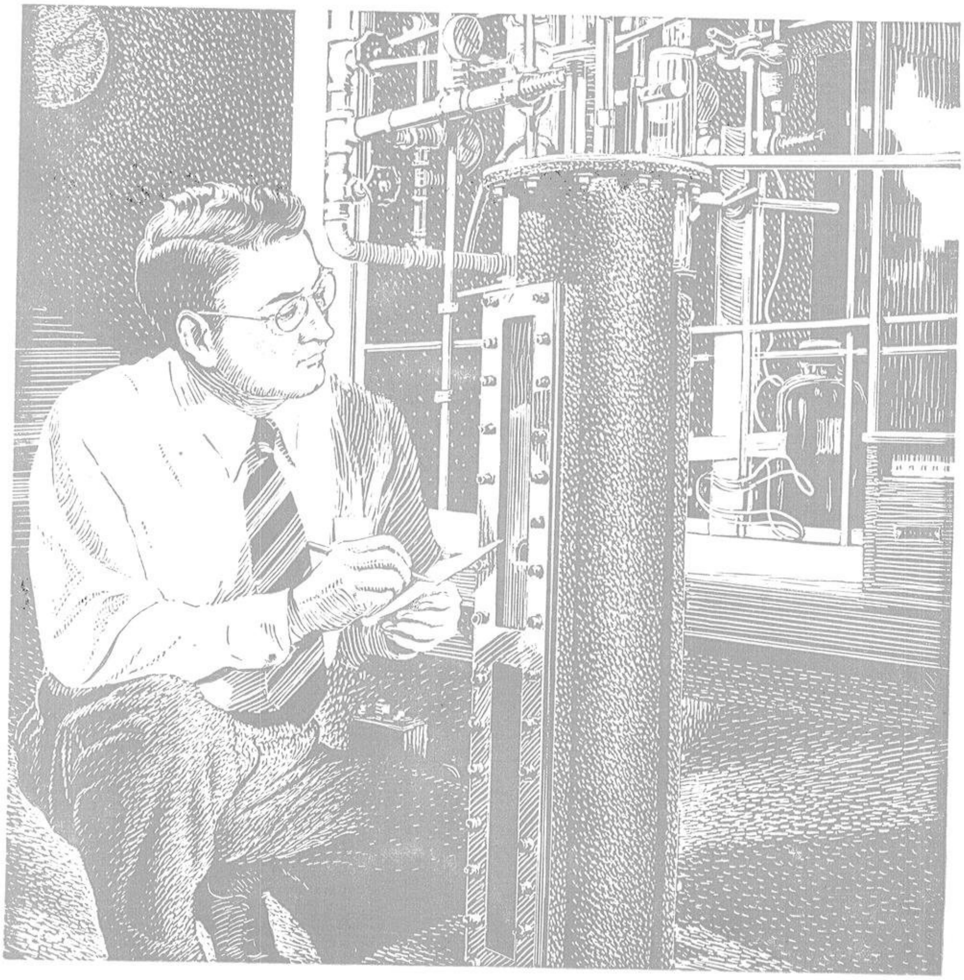
NEW LABORATORY UNIT, *part of G-E Research Laboratory, is the center of General Electric research into such low-temperature phenomena as . . .*

SUPER-FLUIDITY *of helium—meaning that at near-absolute zero it loses its viscosity, can spin forever . . . and*

SUPER-CONDUCTIVITY—*the loss of all electrical resistance by some materials below about 15° absolute.*



Near absolute zero, matter does strange things . . .

At 455 degrees below zero Fahrenheit, liquid helium becomes a "superfluid." That is, it loses its viscosity; if it were to be set in motion like stirred coffee spinning in a cup, part of it would theoretically continue to spin forever.

It also becomes a "super-wetting" agent, meaning that it will creep up the sides of a container and flow over the edge.

Other types of matter develop the property of "super-conductivity." Columbium-nitride, for example, loses all electrical resistance below 15 degrees absolute. If an electric current were set in motion in a closed loop of this substance, it would in theory flow indefinitely.

These are some of the facts of cryogenics—the study of low-temperature phenomena—into which a group of young General Electric scientists are directing their investigations.

So far their studies are in only the earliest stages. But already the facts of this nether world of temperature have aroused enough interest that with the building of a new Research Laboratory near Schenectady, a $250,000 laboratory unit has been especially constructed to aid and amplify their work.

Through its emphasis on research and creative thinking, through encouraging fertile minds to follow their own imaginative bent and by implementing their work with the best available facilities, General Electric remains "a place where interesting things are happening," and stays in the forefront of scientific and engineering development.

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