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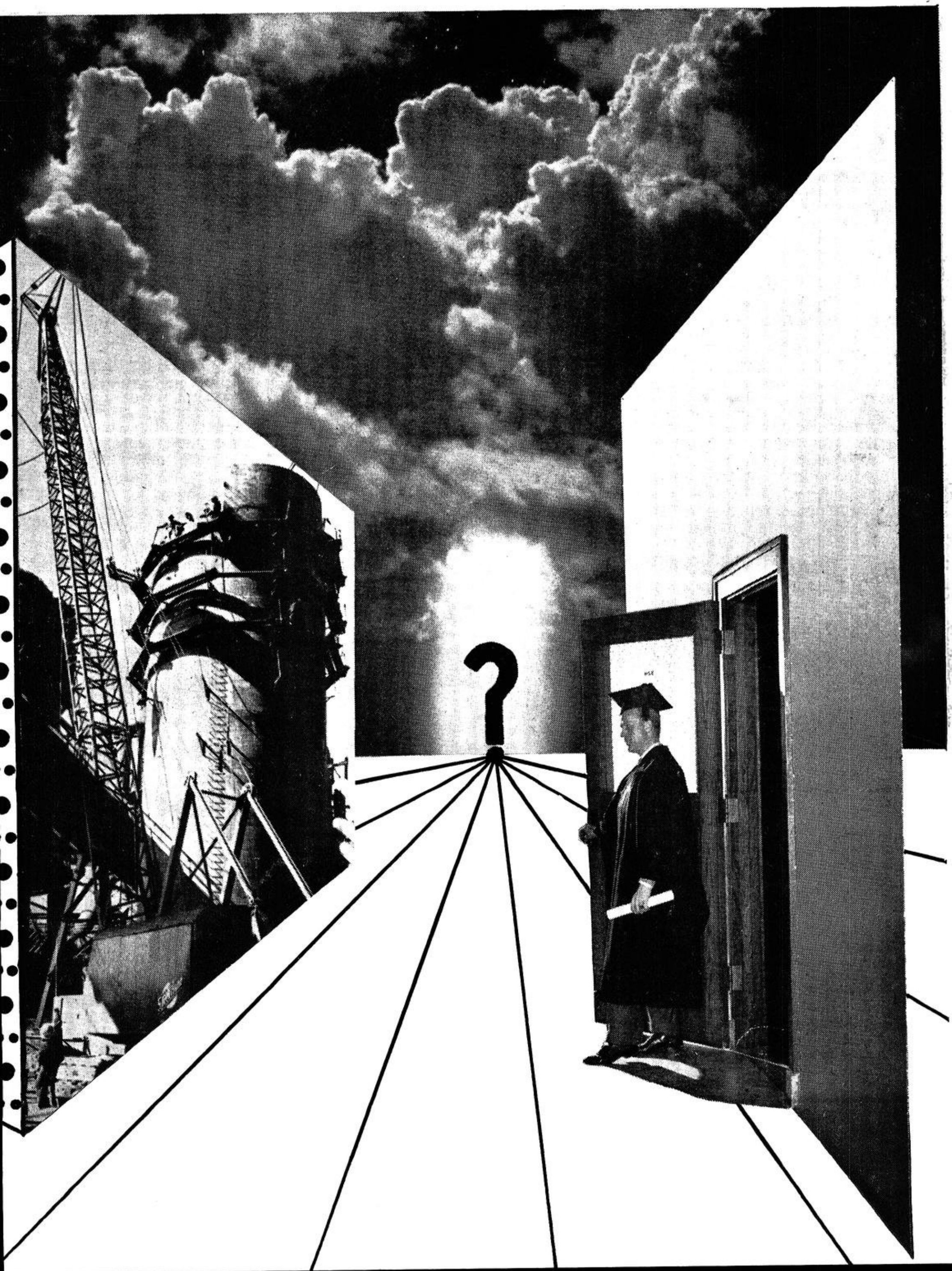

May, 1948

In This Issue:

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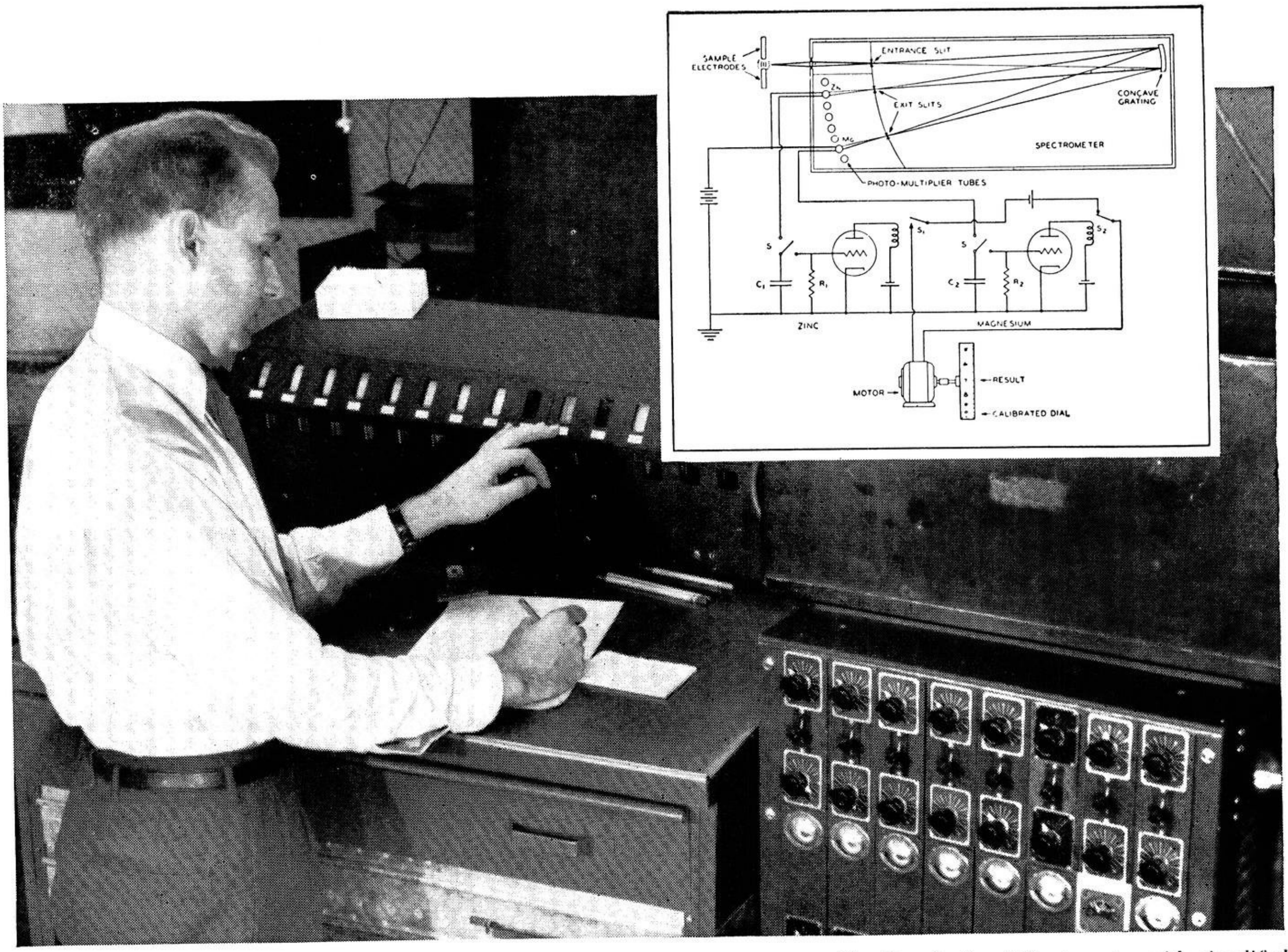

The Dow-developed Spectrometer with simplified schematic diagram showing its essential features.

An example of Dow research

This electronic and optical device, called the Direct-reading Spectrometer, is a Dow-developed instrument which—using photoelectric tubes—measures the relative amounts of different metallic constituents in a complex alloy.

A tribute to man's intelligence and industry, the Spectrometer was devised to obtain closer control and more accurate analysis of the magnesium alloys used with such spectacular success in World War II. For the past three years it has been used in the magnesium alloying plant to make many thousands of measurements and recordings of the exact concentration of the several metals in an alloy.

An outstanding feature of the Spectrometer is its speed of operation. For instance, only thirty seconds will have elapsed from the time two magnesium samples are locked into clamps and a spark passed between them to start the operation, before an analysis can be determined from direct-reading, rotating dials.

The entire operation is automatic and takes less than 10% of the time required by the Spectrographic method of analysis, which in turn is many times faster than conventional chemical methods of analysis. This enormous saving of time enables a much closer and more nearly constant control over melting, alloying and casting of magnesium.

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Here is another example of Dow research applied to production methods. Such research is typical of all divisions of The Dow Chemical Company . . . a company where intelligence and industry are held in high regard.

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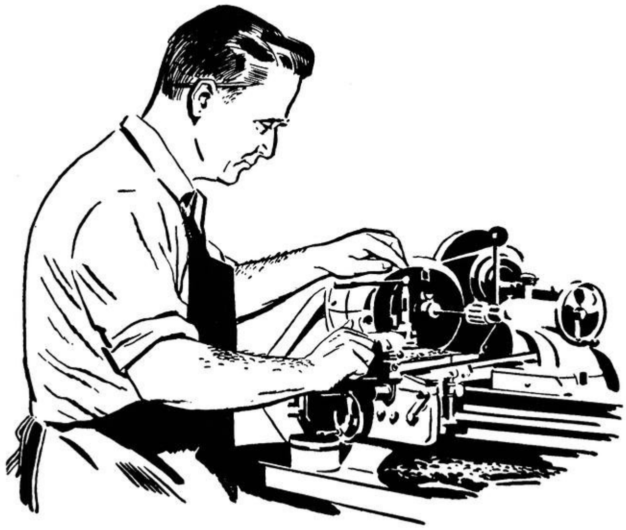
In This Issue . . .

COVER:

Ably composed by Hugh Wahlin m'49, our May cover tells the story of the graduating engineer of today. The industrial scene—courtesy of U. S. Steel. The cover man—George Piper m'48.

Another page for **YOUR BEARING NOTEBOOK**



How to make a machine tool cut out the chatter

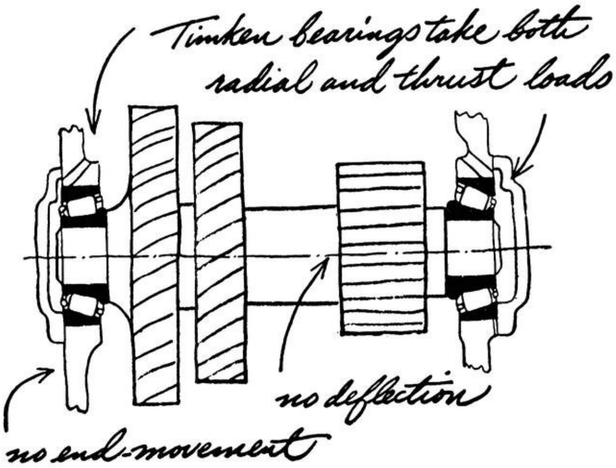
Engineers who design machine tools know that if they eliminate "chatter"—or vibration—they will be paving the way for faster, more precise machining. That's why you'll find the great majority of machine tools equipped with Timken tapered roller bearings.

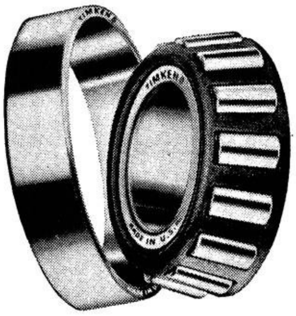
Timken bearings assure a smooth flow of power from initial drive to spindle nose. Gears are kept in precise mesh and alignment, the entire spindle assembly is rigid and free from vibration. And with Timken bearings, machine tools *retain* their precise, chatter-free performance even after many years of hard service.

There's no secret to keeping shafts in rigid alignment

Here's an engineer's rough sketch of a typical transmission countershaft equipped with Timken bearings. Due to the line contact between rolls and races, you get maximum load carrying capacity with no chance for shaft deflection or misalignment.

And because the tapered design takes thrust as well as radial loads, end-movement of the shaft is eliminated. Positive shaft alignment is another big reason why 9 out of 10 bearing applications can be handled more efficiently with Timken bearings.





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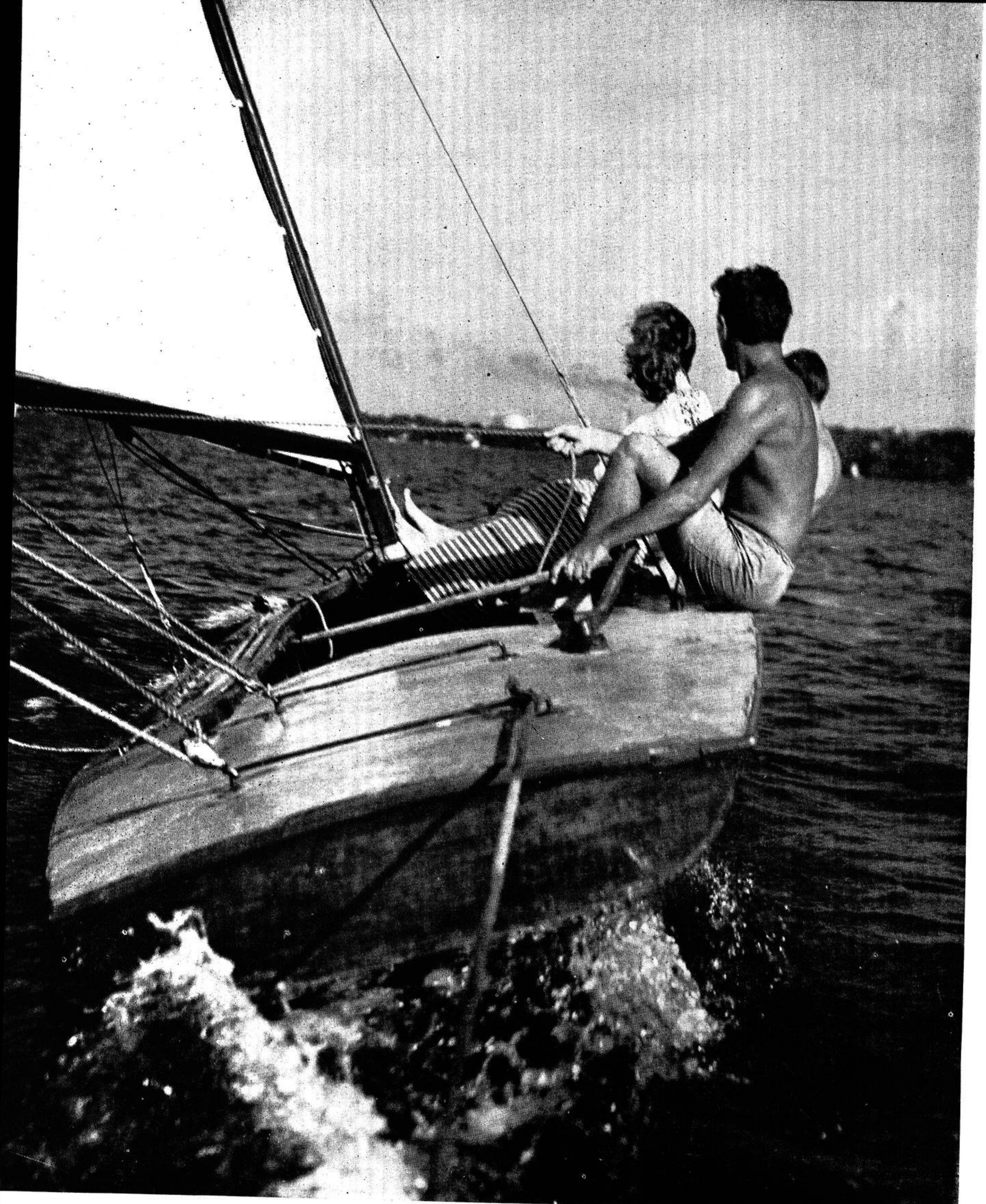

Enjoying a run on Lake Mendota, these three do not seem to be seriously considering the vector forces involved. The photographer at the end of the tow rope is probably giving much thought to the tensile strength of hemp.

Photo by Stubbe

'Sails' Engineering

by John duDomaine

FEW engineering students coming to Madison may have the opportunity to learn to sail. Many may not realize that here on the campus the Hoofer sailing club offers complete sailing instruction, including dry land training. The club maintains a fleet of Olympic cat boats through a rental charge. The university boat house rents five Marconi rigged sloops to those able to handle them. Since many graduates have found that in sailing they find an outlet for scientific interests, a way to pleasantly entertain friends, and a hobby to consume interests to make free time seem well spent, the **Wisconsin Engineer** offers this article as a review.

The diagram below shows the distinguishing characteristics of popular designs of sails—the single sail or cat rig, the Marconi rigged sloop, and the gaff rigged sloop which includes a wooden spar supporting the top of a wide main sail.

Sailing is an ancient art and one of the first means of travel man knew. Many schemes of rigging have been designed to carry sails—and many sails have been designed to fit riggings in devious ways—but only recently have the aerodynamics of sails been studied. The advent of the wind-tunnel and the perfection of more precise air-flow concepts have aided in understanding the nature of wind-power. Even today, few sailors have the training to utilize this knowledge.

The analysis by aerodynamics of the effects of air currents on the canvas carried by a sailing craft is not simple, for the conditions are constantly varying. The wind direction and intensity changes; the boat changes its position relative to the wind; and wave action alters the set of the sails to the wind. Certain analyses can be made from the wind-tunnel tests, however. The more significant among the data obtained are the pressure ratios across the sail and the air-currents on its surface.

Such an analysis of wind-action is presented herein. The information is not all-inclusive, nor is it a final analysis of the problems, but certain valuable indications can be drawn from the data. Diagrams are included to show the settings of the sails relative to the wind, the forces exerted on the sails, and air currents found on the windward side of the sail. The latter were determined by use of a telltale (a light piece of down attached to a pole by means of a length of fine thread). The telltale is being used in model testing of aircraft, but performs quite well when borrowed for the sailing enthusiast.

Referring to figure no. 2, the wind passes to the rear of the sail on most of the windward side, but flows forward near the mast to the leading edge (the mainsail luff). This current flows forward around the mast to join the current flowing between the mast and the jib. A similar current flows forward around the leading edge of the jib.

On the trailing edge of the jib (the jib leach), the air passes off the windward surface, turns about the edge, and progresses forward on the leeward side. The same is not true in the case of the mainsail. In this instance, the current simply passes off the leach in a direction paralleling the plain of the sail.

Directly below the mainsail along the boom, the air moves upward toward the canvas. The direction of flow near the mast is nearly vertical, though currents nearly parallel to the boom flow farther out. Air at the foot of the jib flows similar to that on the main.

Diagrams nos. 2 and 3 show pressures measured on both sides of the sail. It will be noted that the vacuum exceeds the direct pressure—in certain areas by as much as four times. The total effort exerted on the sail is, of course, the summation of the two.

In relating the pressures with the currents on the face of the sail, it becomes apparent that the currents on the lee side of the bottom of the sail are nearly vertical. This is due to the fact that the vacuum is constantly being filled and constantly being evacuated. The same effect can be

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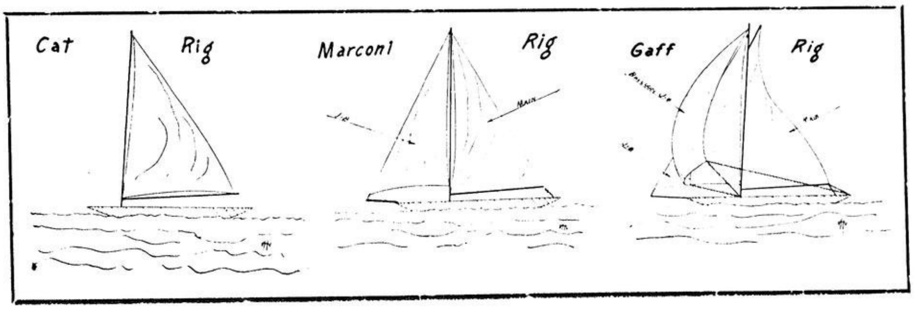

Fig. 1 At the right are the rigs most commonly found on Mendota and surrounding lakes.

PHASE EMISSIVITY

by John Harrower che'48

One reason why engineering applications have advanced so rapidly in the last two decades is the great number of new engineering materials that have been developed. This would not be possible without the knowledge about crystalline structure of metals now available. All that is known, however, is but a scratch on the surface of this field. Much more can, and must, be learned, so that even better and more suitable materials may be produced.

Many methods have been devised for determining the temperatures at which the structure of a metal changes from one crystalline form to another. These include time-temperature data, changes in heat capacity, dilatometric methods to determine the volume changes accompanying transitions, X-ray diffraction, and thermoelectric properties. Where possible, electrical resistance and magnetic effects have been investigated as functions of temperature. Until recently, however, the emissivity of a metal had not been considered as a clue to structural transformations.

Since emissivity is a fundamental property of a metal, any structural changes that affect other fundamental properties should also affect the emissivity. Following this line of reasoning, Dr. Wahlin, of the University of Wisconsin physics department, performed a few preliminary experiments to justify his hypothesis. The results were so gratifying that more elaborate experiments were performed, with considerable success. Some of these results will be taken up later.

The emissivity of a substance may be defined as the ratio between the amount of energy emitted from the surface of the substance, and the amount of energy emitted from a black body at the same temperature. This energy, in the form of light, can be measured with an optical pyrometer. To obtain these conditions, so that they could be conveniently observed, Dr. Wahlin made a miniature black body of the metal he wished to study. This took the form of a slim, thin-walled cylinder with a small hole in the wall at the center of the tube. The cylinder was heated to incandescence by passing an electric current through it. The whole arrangement was enclosed in a vacuum chamber, and an optical pyrometer sighted on the cylinder. The readings were taken in a darkened room to prevent any stray light from being reflected by the cylinder into the pyrometer. Under these conditions, the small hole acted as a black body, appearing somewhat brighter than the surface of the cylinder. Pyrometer readings of the hole and the surface, a measured distance above the hole, were taken. From this, the emissivity of the metal was calculated for the temperature used. The temperature was varied by changing the current through the cylinder wall, and a curve plotted of emissivity versus temperature.

The results of this investigation proved especially interesting in the case of pure iron. The accompanying graph shows several discontinuities; the first one occurring at 905.3°C. (1178.3°K.). From earlier determinations with some of the older methods mentioned previously, it has been found that pure iron changes from alpha iron (body centered cubic) to gamma iron (face centered cubic) at 906°C. This is a very good check. Another discontinuity in the curve appears at 1404°C. (1677°K.), which corresponds to the transformation of gamma iron to delta iron (B.C.C.), previously determined by the older methods to be in the vicinity of 1400°C. A third discontinuity may be seen between these two temperatures. None of the investigations using the earlier methods of analysis indicate any such behavior in this region. At the present time, this anomaly has not been satisfactorily explained, although several suggestions have been proposed. It is possible that this indicates the separation between the high and low heat treating regions. In any case, it does illustrate the sensitivity of the method.

Other systems have been dealt with also. These include cobalt, nickel-cobalt, and cobalt-iron alloys. In each of these systems, discontinuities in the emissivity-temperature curves appear at temperatures that have been previously identified with certain structural changes. These

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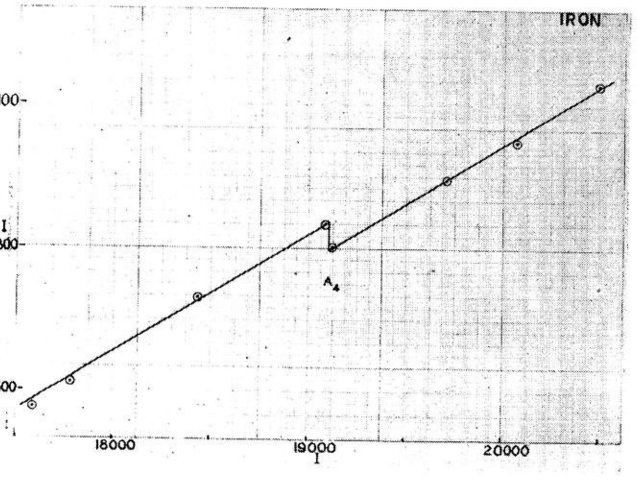
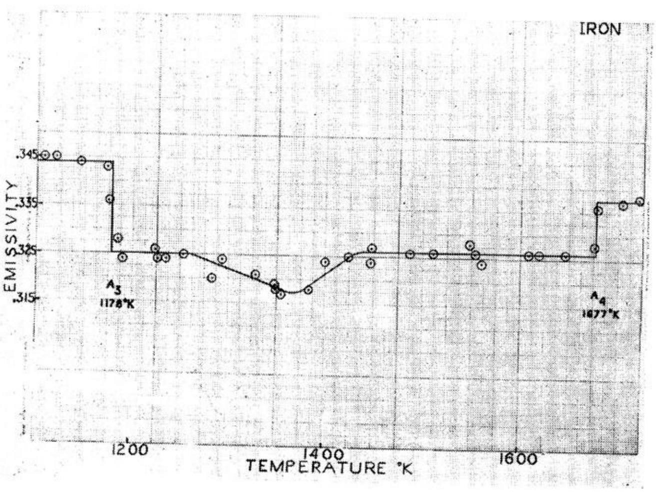




The newly applied principle of varying emissivity makes available temperature data for consise phase change-points and pyrometer calibration.

ZINC

The last in a series on WISCONSIN MINING

by W. M. Haas c'49

In the Wisconsin mining area, one cannot speak of zinc without also referring to lead, as the ores of the two metals are mined simultaneously. The early mining of lead was described in a previous issue of this magazine. Present day mining is mostly for zinc, as about eleven parts of zinc are produced for one of lead. The WISCONSIN ENGINEER wishes to acknowledge the assistance of Prof. Edwin Shorey of the Mining and Metallurgy Department, and Mr. Ernest Bean, State Geologist, in compiling the information for this series.

—W.M.H.

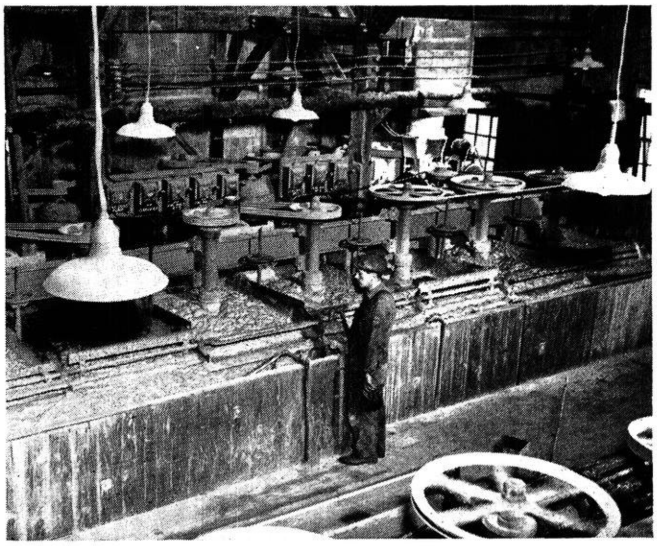
IN CONTRAST to the hand methods that characterized the mining of lead in the early days of territorial Wisconsin, present-day mining is largely mechanized. Since the turn of the century, the principal product of the mines has been zinc, rather than lead, although the latter is still produced in considerable amounts.

In the Wisconsin zinc area, the ore occurs in veins that vary in thickness from about 6 feet to 100 feet. The mining is done by sinking shafts and driving tunnels. Pillars of ore are left in place to support the roof of the mine. When a mine is to be opened, the usual procedure is for the mining company to lease the land from the owner for the mining rights. The owner realizes about 10 per cent of the yield of the mine on his property, under the terms of the lease

Zinc mining as such started about the time of the Civil War, at the end of the lead boom. However, the mining of this metal did not develop as rapidly as in the case of the earlier lead, but was to prove to be a more stable and enduring industry. The use of machinery came to be of importance at the beginning of the present century, and since then the various machines have been steadily improved and adopted to better serve the purposes of the miners.

Probably the most important tool used in the actual removal of the ore from the earth is the pneumantic drill. Previous to the invention of this device and its application to the work of mining, the miner's hardest job was to loosen the ore and rock so that it could be taken out of the ground. These miners already had blasting powder, but the difficulty lay in drilling the holes in which to place the powder charges. The introduction of drills operated by compressed air made the miners job easier, and also increased his production. The modern drilling machine is constructed in such a manner that besides hammering the drill into the rock, the drill is simultaneously turned in the hole it is making. By using hollow drill steel, water can also be used to wash the rock dust from the hole, thus freeing the bits on the drill to again batter the rock and continue the hole.

Although blasting powder was known for a long time, improvements have also been made in explosives and in the techniques used in handling them. When the miner has prepared a series of holes with the drill, he loads them with the proper powder charge. After the charge has been fired, he is ready to load the broken rock for removal to the surface. Ordinarily about one-half pound of explosive is required to produce a ton of broken rock.



—Don Every Photo

Zinc Flotation Section, Vinegar Hill Mill, Cuba City, Wisconsin

Loading the ore into small mine cars is done either by hand or by the use of mucking machines. The use of these machines is becoming more and more prevalent. When the ore has been loaded it is moved to the shaft by hand, by animal power, or by locomotives. Most of these locomotives are powered by storage batteries, but gasoline driven locomotives have been used with some success. At the shaft, the ore is hoisted to the surface where it is milled. The milling process is gravity concentration followed by flotation of the gravity concentrates. The ore is crushed in machines especially developed for handling ore.

The end result of the milling process is a zinc or a lead concentrate or both. That is, the refined metal is not produced in the mining area. The lead concentrate is about 80 per cent lead, while the zinc concentrate is at least 60 per cent zinc. These concentrates are shipped to

(please turn to page 24)

MESAB

IS IT COMIN

by John Warner m

THE discovery of iron ore in the Lake Superior region, about the middle of the last century, and the invention of the Bessemer converter in 1856 were events that gave rise to an era of industrialism which has resulted in unprecedented mass production and broad distribution of wealth from the nation's natural resources. The bulk of this ore is concentrated on a single strip of gently rolling land, the Mesabi Range, 110 miles long by 1 to 4 miles wide in northern Minnesota. From this range and neighboring lesser ranges came like milk from the earth the substances for the bridges and buildings, railroads and automobiles, ships, generating plants and agricultural equipment that characterize our nation.

The six principal productive iron ore districts of the Lake Superior region are located in the upper peninsula of Michigan, Northern Wisconsin, and Eastern Minnesota. It is by good fortune that this territory is within the United States. If it were not, the course of history and the industrial development of the United States doubtless would have left a far less impressive record than that which it has made. The fact that this district is part of this country in attributed to Benjamin Franklin, who deflected his pencil a bit to include this area within the American boundary, when he was negotiating the Treaty of Paris in 1783.

On the north, south and west shores of Lake Superior, lies rugged and rocky country. Southwest of the lake, the land flattens abruptly into plains characterized by extensive swamps, ponds, lakes and, here and there, ridges and hills of glacial debris. The first white men saw everywhere on the high land dense forests of majestic white and yellow pine, abundant birch, oak and maple. Like many other sections of North America, this region owes its earliest development to the worldwide demands for fur. It was inevitable that some of the Frenchmen should attempt to reach the country from which the Indians came with such abundant catches.

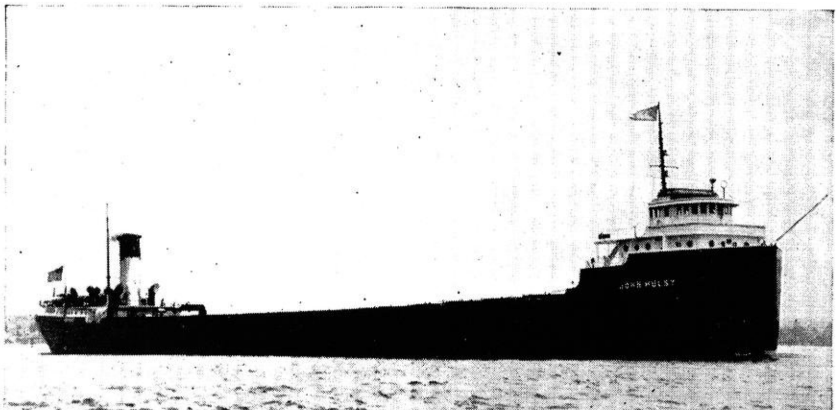
Jean Nicolet was the first white arrival in the district, arriving at Green Bay in 1635. He was followed by more Frenchmen and Jesuits, but it was nearly 150 years after the beginning of French exploration in this region before any mention was made of finding iron ore.

With the completion of the Erie Canal in New York in 1825 and the introduction of steamers onto Lake Michigan in 1826, extensive migration began to Lake Michigan's shores. Before settlement could take place, the region had to be surveyed—including federal surveys for minerals. Later the geological departments of Michigan, Wisconsin, and Minnesota studied the area previously surveyed by the federal government and made known the mineral and other resources as encouragement to settlement.

SUPERIOR DISTRICT MINES

The main deposits of iron ore in this district are the Marquette range, Gogebic range, Menominee range, Gunflint district, Vermillion range, Mesabi range and Cayuna range. The minor districts are the Mayville, Baraboo, Michipicoten and Moose Mountain districts.

The Mesabi range lies north and northwest of Duluth about 50 miles. The name is appropriate, because Mesabi means giant in Chippewa Indian language. This is indeed a giant, a great gaping maw in the surface of the earth, gouged out by man for his industry. The ore is mainly hematite and only the top soil need be removed in most cases to make the abundant ore available.



The John Hulst typifies the type of boat used to haul the ore from Mesabi to the lower lake ports.

Right: Line thickness indicates relative am of ore going to the different industrial dis

MIRACLE

O AN END?

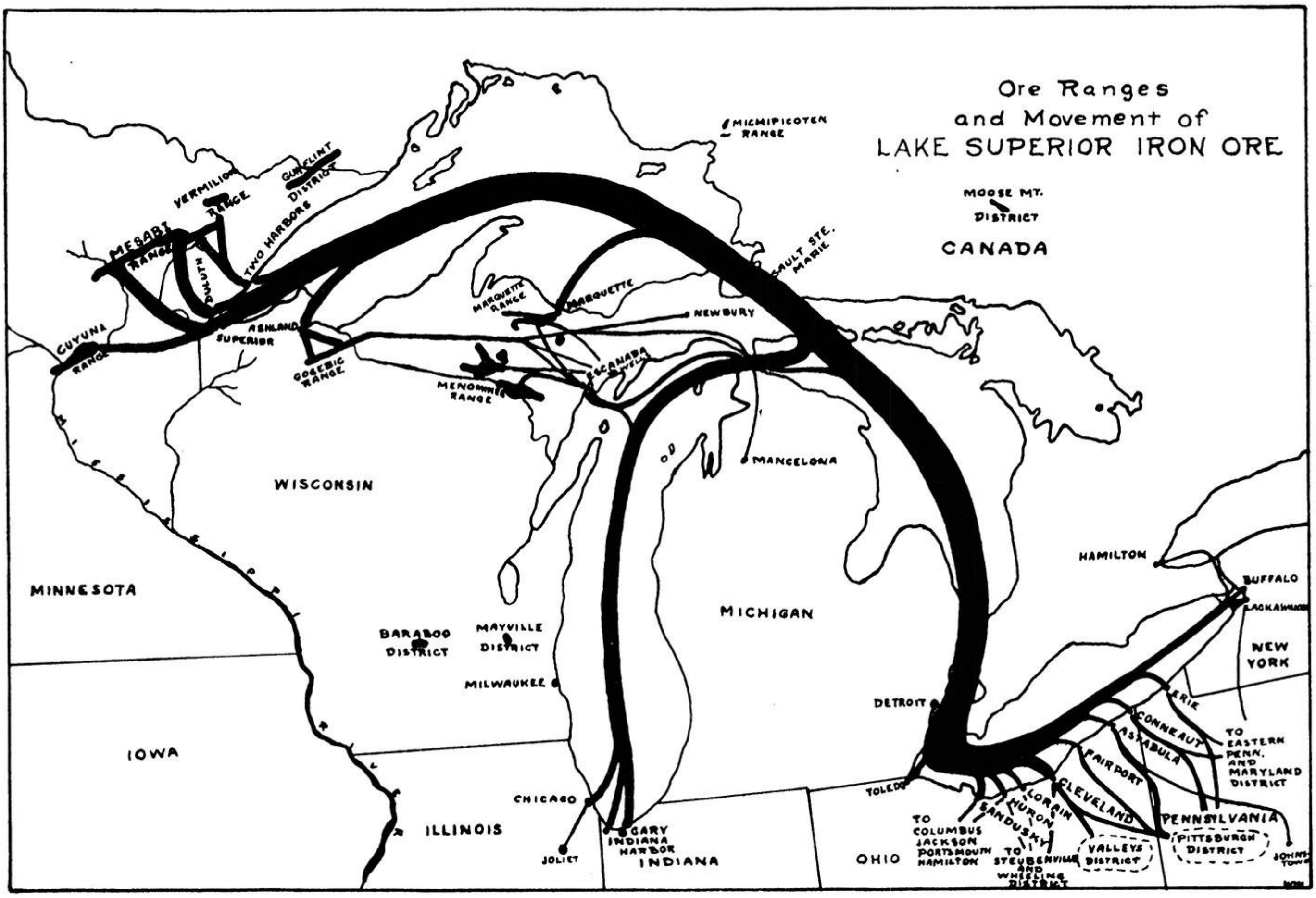
d Walter Mueller m'49

The Mountain Iron Company was the first company to ship ore and began in 1892. In 1893, 10 mines were operating and they shipped a total of 613,000 tons. Development was very rapid after that and in 1905, shipments exceeded 20 million tons.

The Vermillion range lies to the north of the Mesabi range and is also a very productive deposit. Interest was first created in this range when it was reported that gold was found there in 1860. Little gold was found, but the iron deposits were observed and investors began to take an interest in them. The difficulty of packing equipment overland discouraged the early miners and little development took place until 1882. At that time the Minnesota Iron Co. was formed to establish mining, build a railroad and erect ore docks. By the end of 1884, 62,000 tons had been shipped.

Unlike most other iron ranges, the discovery, the exploration, and the development of the Cuyuna range was not facilitated by its accessibility to a water route. Over the whole Cuyuna range is a thick, unaccentuated mantle of glacial drift and, topographically, it is not a range at all. When prospecting started, the district was already well populated and because ore was usually found in desolate areas no one really expected to find ore there. When surveying the area, abnormal magnetic variations were found in many places. That became the principal reason for prospecting.

In 1883, Henry Pajin discovered the "magnetic belts" and established the boundary of the district. Other men working for the U. S. Geological Survey proved the presence of iron ore. In the spring of 1904 the Orelands Mining Company found good ore. In 1911 the Rogers Brown Ore Company made a first shipment of 150,000 tons, the largest first shipment ever made from any mine. The peak year from the range was 1929 with a shipment of 2½ million tons.

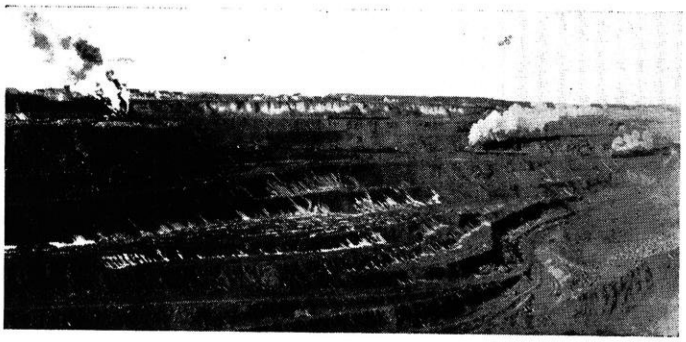


The Gunflint district located on the Canadian border has never been productive although several shafts were sunk and production attempted. The Mayville and Baraboo ranges were productive but ceased operating in 1928 and 1924 respectively. A total of about three million tons of ore have been taken from both ranges.

In 1845, search of ore on the Marquette range began in earnest and the Jackson Mining Co. acquired one square mile of land adjacent to the present city of Negaunee and this became the scene of the first iron mining in the Lake Superior region.

In 1847 the same company started a Catalon forge on the Carp river where the first metallic iron, a bloom 4x4x24 inches was made in the region, but the mine and forges were not successful and became idle in 1850.

In July of 1852, the Marquette Iron Co. shipped six barges of ore to New Castle, Pa. which was the first shipment of Lake Superior ores on the lakes. In May, a year later the company sold out to the Cleveland Iron Mining Co., which built a loading dock at Marquette and in September shipped 152 tons of ore to Sharon, Pa. The ore was hauled by wagons and loaded by wheelbarrows into boats, unloaded at St. Mary's river, hauled past the rapids by wagons, reloaded into vessels and transported to Cleveland where it was transferred to freight cars and hauled by locomotive to furnaces in Ohio and Pennsylvania. Development gradually increased and better systems of transportation along with the canal around the rapids of the St. Mary's River increased the annual output. By 1868 it was half a million tons; by 1873, over a million tons; and now, over 6 million tons annually.



—Courtesy of A. St. Vincent, Oliver Mining Co.
Looking east in the Morris open pit mine.

DISTRICT ORES AND OPERATORS

The exploration and development of the iron ranges is an interesting and romantic history. Fortunes were lost but many more were created. It took men of foresight and nerve to invest money into their development. The railroads and shipping companies grew right along with the mines. Towns sprang up on the gently rolling hills and prosperity increased in general. Today, it is one of the country's major industries and the shipping in tonnage on the Great Lakes of iron ore has a larger annual total than almost any other material that is shipped anywhere in the world.

Iron ores are essentially products of oxidation or decay, occurring in formations which originally consisted of iron carbonate and silica. These iron formations were bedded deposits laid down under water. The mineral, chemical and physical makeup of the ores varies from bed to bed within the ore bodies because of the original variations in deposition. Upon these original variants are superimposed intricate chemical and physical changes, brought about by all the different events in geological history of the deposits down to the present time. To wide variation in the ore bodies are added variations equally intricate in the inclosing rocks and in the surface overhead.

On every ton of his product nature has indelibly set the characteristic brand of a billion years of kaleidoscopic events. The open hearth operator who asks for a special grade of ore owes the fulfillment of his order to the building of long-vanished mountains in a primeval world, to their subsequent weathering and errosion to burial of the whole beneath a now-vanished ocean, and to the building up of new mountain ranges, also long-vanished, in whose mighty press the ore was squeezed into its present condition.

Ores produced in the Lake Superior district are classified as follows:

Class I ore—Direct Shipping Ore:

A substance, mostly soft and crumbly but with some hard lumps, that contain more than 50 per cent iron and can be shipped directly to blast furnaces without any processing, except, when the lumps are too big, crushing and screening.

Class II ore—Low Grade Ore:

Ore, containing 35 to 50 per cent iron, whose silica has been only partially leached away by natural water action. Man must complete the job that nature has begun, removing the silica by one or more expensive and laborious processes called "beneficiation."

Class III ore—Hardly ore:

In mining parlance, this ore does not even rate the name of ore. It is the original rock formation containing 20 to 35 per cent iron. It is called "taconite" in Minnesota but elsewhere it is simply named "iron formation" and to prepare it for steel mills, man must do all the work.

In most cases the mining is of the open pit variety, however, in the Cuyuna range and parts of the Mesabi and Vermillion ranges it is necessary to sink shafts and use underground methods. This is becoming more necessary now that rich surface deposits are running out. The open pit mining is an astounding operation because of its magnitude. If one goes to the Mesabi range he will see giant electric and steam shovels bite great hunks of ore out of the earth. He will see there one of the weirdest man made landscapes in the world—a mild countryside pocked with huge open pits that suggest the craters of the moon, dotted with strange hills and buttes of waste materials from the mines and ore processing plants. The biggest of all pits, the Hull-Rust Mahoning at Hibbing is the biggest hole ever dug by man. The pit is 3 miles long, up to one mile wide and up to 435 feet deep. It

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HOT AIR ENGINES

New Developments make them practical

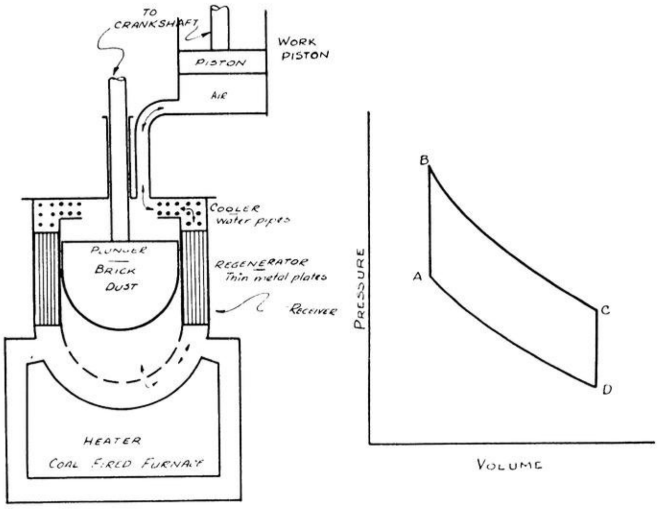
by Russell Pipkorn m'49

IN SEARCH of engines of higher efficiencies, science has again turned to a principal which was once abandoned because of its inefficiency—the hot air engine. This is an external combustion engine, since the fuel is burned outside the cylinder and the hot gases allowed to enter the cylinder and expand, producing the work. New heat resisting alloys have had the most to do with the development of this engine.

One of the earliest models used, employing this principal, was the furnace gas engine which had a fire burning below the cylinder to produce the hot gases which entered through a valve to the head end of the cylinder. The pressure produced on the crank-end of the cylinder was used to push the hot gases into the cylinder in addition to the expansion of the gases. The weakness of this engine, as in numerous other hot air engines, lies in the fact that the valves were exposed to extreme heat and would not stand up for any length of time. Only low pressure could be produced, making the engine very bulky for its power. Uses for the engine were limited except for pumping water in country districts where its extreme simplicity was a great consideration.

In 1816, Robert Stirling, a Scotch clergyman, devised a new type of hot air engine in which the air was used over and over again and most of the heat needed to reheat the air came from a regenerative unit. The two main parts of this engine were the working cylinder with its piston and the receiver with its piston. The receiver was composed of two cylinders one within the other. The lower part of the unit received the heat from an outside source; the lining here being pierced with many small holes. The middle section of the annular space was the regenerator and was composed of a series of thin vertical, oblong strips of metal or glass, with narrow passages between. The top part is the refrigerator, a hollow annular ring containing a copper coil through which cold water was circulated by an outside pump. The hollow plunger contained an insulating material like brick dust and fit very closely with the wall of the receiver, but without packing to reduce friction loss.

The alternate motion of the plunger transfers a certain mass of the working air alternately to the upper and lower end of the receiver by making it pass up and down through the regenerator. As the air received heat at the lower end, it expanded and moved up through the perforated lining causing the piston and the plunger to move upward giving the power. As the air moves up it passes through the regenerator where it gives up much of its heat. Since the crank for the plunger is set ahead of that of the piston, it begins to move downward causing the air to be transferred without change in volume, to the cold cylinder, continuing to give up its heat to the regenerator. The crankshaft having reached the proper point, both pistons move downward compressing the air mostly in the cold cylinder; then as the working piston continues to move downward, the plunger begins to move upward transferring the air, without change in volume, back to the receiver. In so doing the air passes through the regenerator where it picks up much of the heat needed for the next cycle.



Diagrammatic sketch showing the original heat engine, first designed by Robert Stirling and later improved by James Stirling. The pressure-volume diagram indicates the Carnot cycle, used in this engine.

The Carnot cycle is the one in which the processes occur in the following steps:

(1) A volume of air at A passes through the regenerator and is further heated by contact with the heat transfer plate, raising the pressure and also the temperature, the volume remaining constant (A to B).

(2) The expanding air causes the piston and plunger to move upward. The expansion is isothermal, since heat is still supplied to the air. Consequently the pressure falls and the volume increases (B to C).

(3) The plunger descends causing the air to pass through the regenerator and cooler so it gives up its heat; the temperature falls and the pressure falls to D, the

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From the chron

The Sea-Leve

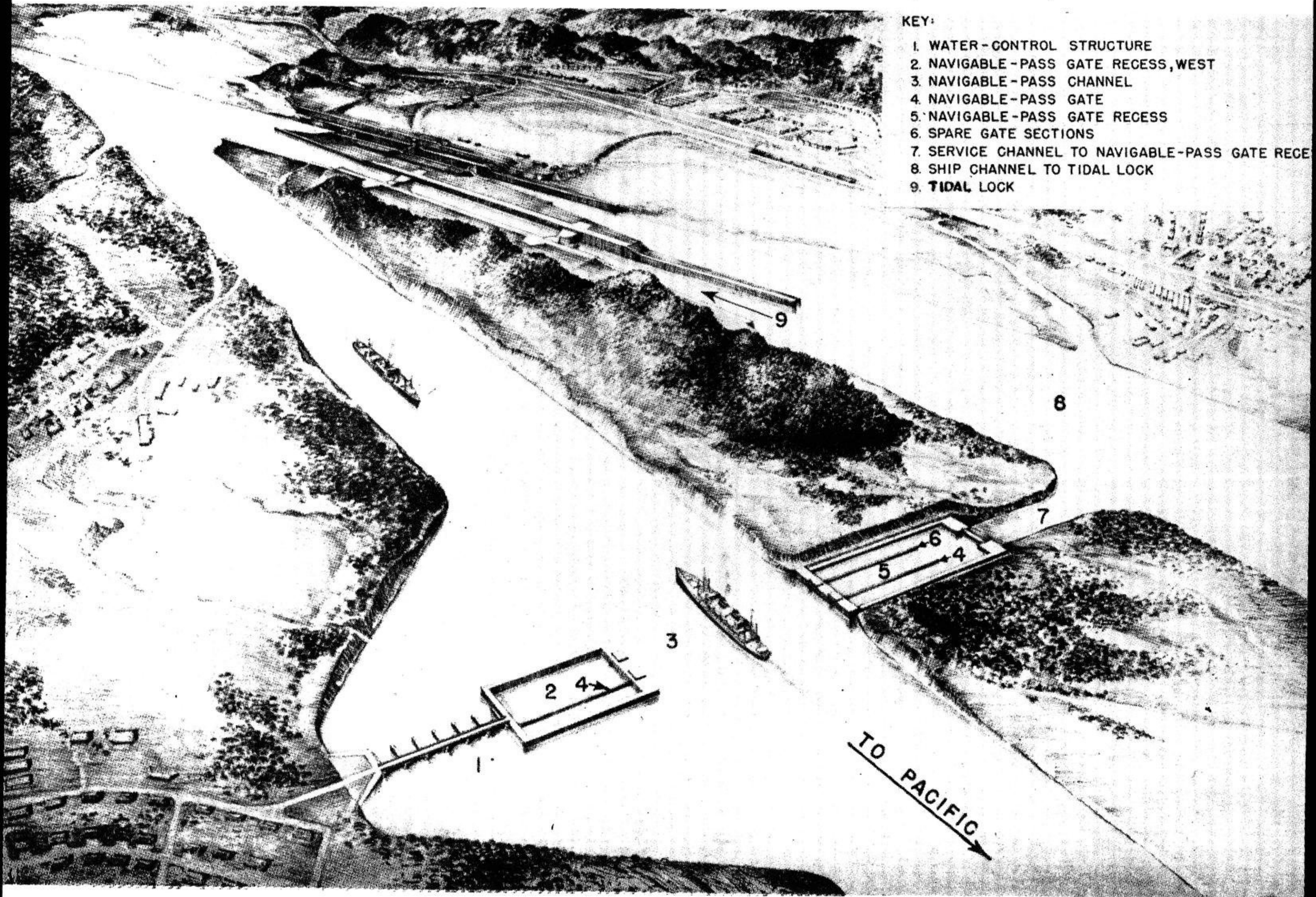
A sea-level canal across the Isthmus of Panama was given considerable discussion at the annual meeting of the American Society of Civil Engineers in New York City. Several of the papers presented at this meeting were reviewed in the February 1948 issue of CIVIL ENGINEERING magazine. The text of this article was taken from these papers.

Ever since Balboa discovered that a sea lay beyond the New World, men have either attempted to find the natural strait through the Americas that they supposed to be in existence, or have thought of making one. Proposals may be traced as far back as 1523, when Charles V of Spain initiated the movement to build a canal through the Isthmus of Panama.

For several centuries after this, proposals were made, debated, discussed and argued. From 1825 (when the "Republic of the Centre" as Central America was then known, made "overtures" to the United States Government for aid in constructing a canal) until actual construction was started by the United States in 1904, the question was debated at nearly every session of Congress—much as the St. Lawrence Seaway Project is being debated today.

In 1875, the Navy conducted a series of surveys, examining various routes through the Isthmus. The only lines by which a tunnel could be avoided were the Panama and the Nicaragua lines. The Nicaragua route was recommended at this time because, "Although the distance was greater, (156 miles as compared to some 43 miles through the Panama route), one third of the distance is covered by Lake Nicaragua, a fresh water lake having a depth itself of over 200 feet. Only a lock canal would be feasible for the Nicaragua passage; however, at Panama, a sea-level canal is a possibility." So concluded the report of the Navy engineers.

Sketch (below) shows proposed tidal locks for largest single construction project in history. —*Courtesy CIVIL ENGINEERING*



uestion department, Panama Canal

by E. H. Brykczynski c'49

A HISTORY OF EFFORT

Construction on a sea-level canal was started in 1883 by the First Panama Canal Company, headed by the engineer, Ferdinand de Lesseps, noted as the builder of the Suez Canal. As a result of financial difficulty, the plan was changed to one including locks; however, the company became bankrupt in spite of this change.

Meanwhile, the United States began the consideration of a Nicaraguan canal based on the reports of its engineers. The result of this action was the complete abandonment by the French company of their rights and equipment, and their subsequent sale to the United States. The United States began immediate negotiations with the Columbian Government for the right to construct the canal, and although the treaty was signed, the Columbian legislature refused to ratify the treaty. Fortunately, at this time a revolution occurred, the result of which was the formation of the Panamanian Government and subsequent ratification of the treaty within a month. Construction began almost immediately, and the canal was ready for use within seven years.

Practically since its completion, the Canal has been described as being inadequate to accommodate the "present day" traffic and that to be expected at some later date; remember, of course, that the Canal as we know it now was not the Canal originally planned by de Lesseps, but rather a compromise due to a lack of funds. Also, the Canal's very existence is said to be threatened by its vulnerability to attack, attracted to it by the seaway's vitalness to our national security and defense.

Various methods have been advanced and offered as a solution to this problem, to make the passage between the oceans both more secure against attack, and at the same time increase the Canal's capacity for more and larger ships. The proposals have been numerous, with the attempt several years ago to push the construction of a duplicate canal through Nicaragua as originally planned by our Government, to supplement the present canal. This proposal, however, was made in the light of techniques of warfare characteristic of an earlier date, since the Nicaraguan canal would of necessity be of the same lock-and-dam construction as is the present Panama Canal, and it is this very system of locks and dams that makes the Panama Canal vulnerable to modern warfare.

LOCK CAPACITY

The present canal consists of six pairs of locks within its limits, or a total of twelve locks. The channel is not straight, but has a total of 22 "bends" in it, the sharpest of these being 67½ degrees. The angles are constructed to allow a ship 1000 feet long to make the turn, as are the locks constructed to allow a ship 1000 feet long and 110 feet wide to pass through them. It is interesting to note that during the last war, the passage of a dry dock through the Canal was accomplished by floating it through on its side.

It has also been proposed to dredge the present canal and increase the capacity of its locks; however, this still does not minimize the inherent danger of the complete system being placed out of commission by a single atom bomb. All this has led to a revival of the interest in a sea-level canal.

In addition to helping to meet the threat of an atom bomb attack, conversion of the Canal into a sea-level route would assure adequate capacity for the rest of this century, and permit transit of any type of vessel of any size, including much larger naval vessels than now exist. The present canal is incapable of transiting some of the larger naval vessels built or remodeled during World War II. In the year 2000, the average daily traffic, it is estimated, will be 46 vessels; the peak-day traffic for which the Canal should be designed is 69 vessels. By about 1960, the capacity of the present canal, during periods of lock overhaul, would be insufficient to accommodate traffic without undesirable delays on peak days. A lock canal could be constructed with lock capacity to allow certain large naval and commercial vessels to use the canal and still handle the capacity until well beyond the year 2000. However, a lock canal designed to meet the future needs of commerce and having the maximum security feasible in a canal of this type would cost 2.308 billion dollars, and would still be deficient in resistance to modern weapons. The sea-level canal would permit not only transit of vessels of any size likely to be built during the remainder of this century, but would permit two-way passage of vessels. Such passage would be possible in fog, which has been a severe handicap in the present canal.

Atomic bombing, rockets and guided missles, for which no effective resistance has been developed, present such dangers as to dictate conversion of the lock-and-dam

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RETIRING PROFESSORS

by John duDomaine

PROF. KINNE

"A life devoted to improved teaching"

FIFTY YEARS AGO a young man decided that if he were to make any advancement as an employee of the North Western Railroad he must have a college education. He decided that he would get a degree in civil engineering no matter what the personal cost in hardship or drudgery.

The young fellow's inspiration to go to college had come from his superior on the North Western Railroad. He suggested that he go to Wisconsin which was then the best school in structures in the country, having the well known Dean J. B. Johnson and Professor Turneare, later Dean, on the staff.

Young William had been called to service in the Spanish-American war before he had graduated from high school, and spent some time encamped at Chicamauga Park in Georgia. As a result of this service, he could have enrolled at the University of Minnesota tuition free, for it was his home state. In those days this was the only offering to returning war veterans for service rendered.

Tau Beta Pi, Sigma Xi, and Chi Epsilon have given him special merit and during college he was a member of all three. He remembers well the experience of being a pledge to Tau Beta Pi and still has the letter from the society in his desk which brought him his bid on February 11, 1903. Phi Gamma Delta includes him in its ranks of college faculty alumni.

If there had been no depression in 1904, the year he graduated, the University probably would not have Professor William Kinne on its faculty, for it had kept him from the job for which he had been preparing himself. But he had made an excellent record in college and the drawing department of the University was glad to have him fill a vacancy with them.

With the drawing department only a year, he joined the staff of the structures department and has been with this group ever since. He became chairman of the department in 1910 and remained as such until 1938 when it was combined with the civil engineering department.

Ethyl Schroeder had lived right across the street from the Kinnes in William's home town of Winona. She went to normal school and became a teacher in the Winona schools before she became Mrs. Kinne in 1912.

William Spaulding, Junior, his son, has chosen a related field in his choice of architecture. He is chief architect for

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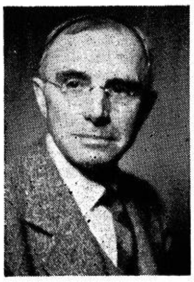
PROF. KOWALKE

"Behind a frowning countenance he hides a shining face"



WHEN this school year is over, one of the best known members of the chemical engineering department will join the emeritus staff after forty-one years of activity. During this period, the departmnt, which was one of the first in the nation, has continued to grow and always remained one of the first few in the list of accredited schools by the American Institute of Chemical Engineers.

When he came to the University of Wisconsin as a freshman in 1902, he enrolled in the course of Applied Electrochemistry from which he graduated. He was among those initiated to Tau Beta Pi and was active in many student activities including the Badger Board and the Junior Prom committee.

The course in Chemical Engineering, which was organized in 1905, had no graduates for a few years, but among those who obtained one of the first advanced degrees in Chemical Engineering was Otto L. Kowalke. He became professor in 1917 and held chairmanship of the department for 27 years.

On graduating from the university, he became a research assistant under a grant of the Carnegie Institution of Washington, D.C., and had the opportunity to work with C. F. Burgess to investigate alloys of iron.

In his career to date, he has been author and co-author of approximately 60 papers on technical subjects. Most prominent in these interests have been those papers dealing with the manufacture, calorimetry, combustion, distribution, and purification of illuminating gas. And he has been a consultant to this industry for a number of years. But he has not limited his interests to so narrow a field, and has had papers published on the alloys of iron, base metal thermocouples, refractory materials, the absorption of gases, and fluid flow through orifices. And to indicate a still further spread of interest, he investigated the geological character of abandoned beach ridges of Lake Michigan in northern Door County and published a paper on the subject.

One of his stories chemical engineering students might remember is—how the Racine gas plant was having trouble disposing of hydrogen sulfide fumes, which with the right wind, were darkening the silverware in many homes of city residents. He is famous to students for bringing into class such situations in his own experience where he was called in to decide what to do. "What would you

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ON *the Campus*

by John Ashenbrucker e'49 & Don Dowling e'49

BADGERS HAVE TOP PRIORITY

Wisconsin residents will continue to have top priority for enrollment in the University of Wisconsin in 1948-49 under the enrollment policy adopted by the university's Board of Regents recently. However, there will be some relaxation of the ban on out-of-state students which has been in effect the past two years.

Since January 15, 1946, the university has admitted very few non-resident students to its undergraduate courses. The revised policy for next fall will permit a larger number of non-resident students to be admitted, if it is found on July 15 that applicants from Wisconsin will not use all available university facilities.

ENGINEERING LECTURES

Eleven o'clock classes for junior and senior engineering students were dismissed on Thursday, April 15, in order that they could hear Mr. Alex Van Praag, Jr., speak on "A Review and a Preview of the Engineering Profession."

After graduating from the University of Illinois, Mr. Van Praag served with the United States Army during World War I. Since that time he has held several important engineering positions in Illinois, and for the past 25 years he has been a member of the firm of Warren & Van Praag, Inc., Consulting Engineers. Mr. Van Praag has been very active in the affairs of the National Society of Professional Engineers. At the present time he is the national president of that organization.

MINING CLUB

Mr. William G. Mixer, General Superintendent of the Buick Foundry, Buick Motor Division, General Motors Corporation, spoke to the AIM&ME on Wednesday evening, April 7, on "Aluminum Foundry Practice for Aircraft Engine Castings."

In the afternoon Mr. Mixer toured facilities of the Dept. of M&ME including the newly completed castings laboratory. The University of Wisconsin is one of the six schools receiving scholarships from the Foundry Education Foundation which is providing means of educating engineers in a manner to qualify them as candidates for engineering management in the foundry industry.

SAE

Mr. G. Haislmaier of the Young Radiator Company spoke to the Society of Automotive Engineers on the "Developments in Engine Cooling Systems," on Wednesday, April 14. Plans were discussed for a tentative field trip to Waukesha Motors.

TRIANGLE

Triangle Fraternity initiated nine men on Sunday, April 11, at the Chapter House. Neophytes in the organization are: Chauncey Fahey, Russell Hackbarth, Robert Heidel, Robert Hill, Richard McKeon, Walter Mueller, Robert Safford, Jack Waidelich, and Robert Wilson. Professor Ben G. Elliott delivered the address to the fraternity at the banquet in the Colonial Room of the Loraine Hotel.

TRI-TECH FORMAL

Seventy-five couples danced to the strains of Benny Ehr in the Crystal Ballroom of the Loraine Hotel on Friday evening, May 7, when the three engineering fraternities, Kappa Eta Kappa, Theta Tau, and Triangle combined for their annual Spring Formal. Chaperons for the evening were Professor and Mrs. R. R. Benedict, Professor and Mrs. G. A. Rohlich, and Professor and Mrs. R. J. Harker. Social chairmen planning the affair were Dick Wilson, Art Bukovich, Buddy Polzar, and Jim Evans.

TAU BETA PI

Tau Beta Pi, honorary engineering fraternity, announced the initiation of the following men on April 8:

G. E. Adams, E. D. Baugh, E. D. Debbink, R. J. Gerlach, H. R. Wahlin, R. Hyink, D. L. Jarosh, E. O. Schonike, H. A. Schopler, J. J. Andres, A. D. Arnaut, C. R. Barker, R. P. Benzinger, E. S. Bergo, T. Bernstein, E. D. Bonow, E. H. Brykczynski, J. P. Brzezinski, H. E. Bullis, W. K. Chipman, W. O. Collins, W. K. Creelman, J. M. Evans, R. H. Fillnow, W. E. Finken, H. Grabowski, J. L. Hagen, J. R. Humphry, M. F. Katzer, W. P. Koppenall, R. C. Lathrop, F. G. Lindeman, A. O. Melby, J. G. Minor, R. A. Mohr, G. F. Osterhaus, R. L. Pleski, E. R. Reichman, D. H. Rice, R. T. Sagen, R. J. Stamp, N. Stein, H. F. Traeder, J. C. Verweil, F. J. Wendt, I. L. Wilson, T. R. Schmidt, W. H. Zamzow.

AIEE

At a special meeting on Wednesday, March 24, student papers on "Brightness Meter" by R. Garber, and "Punch Card Machines and Routh's Criterion on Stability" by L. Saline were presented to members of AIEE. These papers represented special work on the part of these men.

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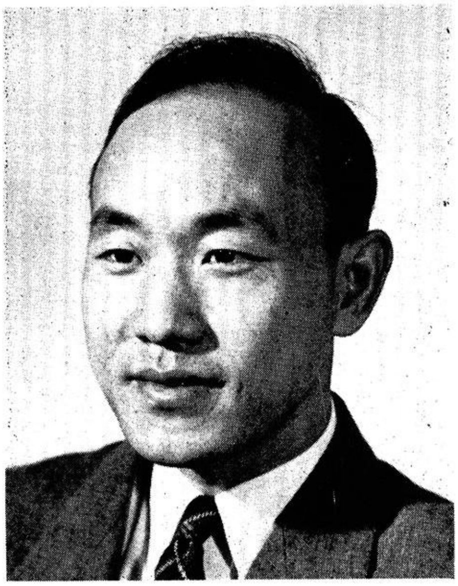
Badger FOREIGN STUDENTS

by R. Hacker e'49



PRAKASH NIGAM

Prakash Nigam, a senior in the Electrical Engineering department, has come from India to study here at the University of Wisconsin. Born in Bhainsdehi, India in 1923, Prakash claims as his home town Lucknow, one of the finest cities in India from the standpoint of culture, education, industry, and sanitation. He already has one degree. This is a B.S. in Physics and Mathematics received from the Nagpur University. Here, because all of the text books are written in English, he got good training in the language that he is now using completely. Within the next four or five years it is the intention of Nagpur University to change all of their text books into the native language. This much-needed step will help simplify the teaching problem.

Asked what he thought about Wisconsin, Prakash Nigam replied, "Wisconsin is a state of snow and lakes. The campus is very beautiful and campus life is very nice." Because he heard that 'Wisconsin is a nice school', Prakash is using the scholarship that he earned from the J. N. Tata Endowment to study electrical power. At the present time India has only 1.3 million kilowatts of installed capacity. Forty percent of this power is used in only two cities, Bombay and Calcutta. Very few Indians enjoy the conveniences of electric life. Within the next 8 years it is the intention of the government to increase the installed capacity by twenty-fold. It is Nigam's chief aim to help develop India industrially, and he hopes to work toward that end when he returns home. Before he does leave this country, however, he would like to get some practical train-

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LIAN-WEI YEU

One of the newest arrivals on the campus of the University of Wisconsin is Lian-Wei Yeu, a Chinese student who has only been in this country three months. He was born in Chengtu, Szechwan, China on April 15, 1921. After his preliminary education he entered the Wu-Han University at Hankow. From this institution Yeu received a degree in Civil Engineering in 1944.

These few simple words 'he received a degree' do not tell of the hardships that Lian-Wei and his fellow students went through to get theirs. In 1939 while he was enrolled at Wu-Han, the Japanese were closing in on the city of Hankow. In order to keep the material from the hands of the Japanese and to continue with the education of the youth of China, the university was laboriously moved by boat up the Yangtze River over 1000 kilometers to Hosan. The library, the textbooks, and the light machinery were all moved with the students. Even though much of the heavy equipment was lost to the invader, teaching continued; and Lian-Wei received his degree in 1944. This was a year before the school was returned to its original home.

Following this he spent several years working at his profession. One year was in the Bureau of Water Works and two years were spent as an assistant Engineer in the Bureau of Highways in Szechwan.

Realizing the inadequacy of much of the equipment and many of the methods used in highway construction in China, Lian-Wei Yeu decided to come to the United States to study these subjects. An example of the methods

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Science Highlights

by Robert Johnson e'50

EDUCATIONAL GAS TURBINE

Student engineers at Rensselaer Polytechnic Institute now have for first hand study an educational model gas turbine of the type that is being used in powering jet planes. It is the first of its kind to be acquired by any engineering school; with it students are provided with a means of studying the performance and characteristics of the gas-turbine cycle.

The equipment now installed at the school is built around a G.E. design of a turbosupercharger, which has been equipped with a combustion chamber, compressor inlet flow nozzle, compressor discharge, control, and accessory equipment. The turbosupercharger is of the type used in the B-29 Superfortress to provide high pressure air for the engines at high altitudes.

In addition to the gas turbine performance cycle, Dr. Bailey said, the equipment can be used in the study of centrifugal compressor performance and air flow measurement.

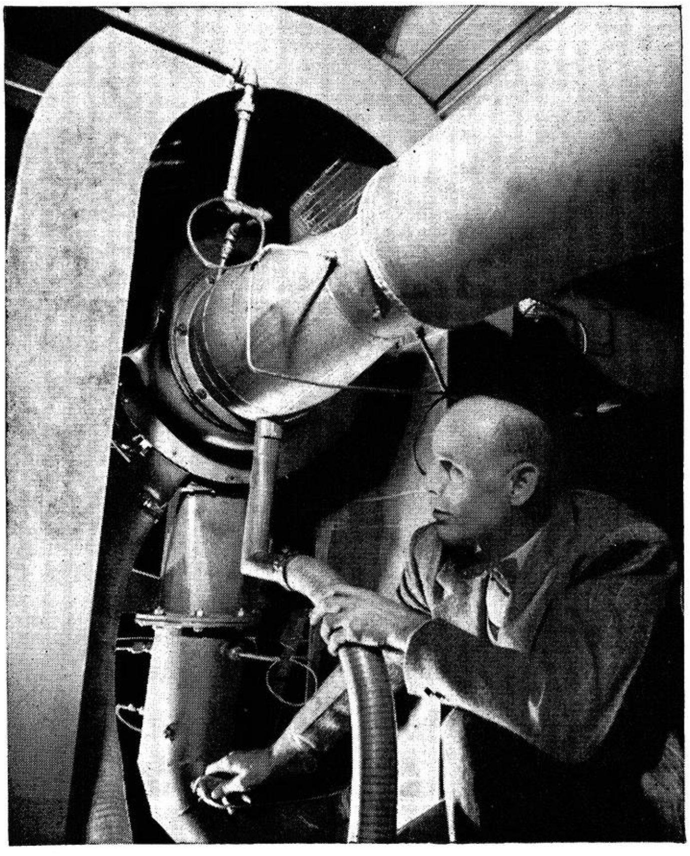
* * *

ELECTROLYTIC WATER MAIN REHABILITATION

A process for relining water mains in place, after mechanically cleaning, by electrolytic deposition of bitumen has recently been brought to the United States from England. By means of this process a thin asphalt coating is applied to internal pipe surfaces. The lining process is based on the fact that asphalt, when suitably emulsified, can be electrolyzed and deposited on the anode of an electrochemical system. The pipe itself serves as the anode, a traveling copper tube centered inside the pipe acts as a cathode, and the bituminous emulsion is the electrolyte. Known as the Eric Process, this system of lining mains is said to have a successful record of performance in England where some 2,500,000 linear feet of pipe have been treated.

As employed by the Pittsburgh Pipe Cleaner Co. at Long Beach, N. Y., and Highlands, N. J., the reconditioning process consists of five steps: 1. location of the pipes; 2. isolation of the section to be lined (a 300-1,000 foot length); excavation of extremities and extraction of short lengths of pipe at each end; 3. mechanical cleaning of the selected sections; 4. squeegeeing internal pipe surfaces prior to coating; and 5. lining of section with electrically deposited bitumen. The treatment is reported to provide indefinite protection, restore carrying capacity, and cost considerably less than an equivalent installation of new pipe.

* * *



The new gas turbine at Rensselaer Polytechnic Institute being inspected by Prof. N. P. Bailey, head of the Department of Mechanical Engineering.

Cut courtesy of General Electric

LIQUID SURFACES MEASURED

Experiments shedding new light on the behavior of matter have resulted from the development of a new instrument, without a name as yet, which measures the minute distortion of polarized light reflected off liquid surfaces. Scientists at the Stanford Research Institute have developed the instrument to measure the depth of the fine film which forms a liquid surface. This depth, about one millionth of an inch, is not only a matter of purely scientific interest; it has a practical value in the fields of lubrication, oil exploration and biology, in fact wherever the reaction of liquid surfaces in contact with other materials is a factor.

Classical mathematical theory assumed liquid surfaces had no depth. General scientific opinion for the past several decades thought the depth to be a billionth of an inch rather than the millionth now claimed. This belief was based on the assumption that attraction between molecules in the liquid was effective only over this short range. Dr. J. W. McBain, research con-

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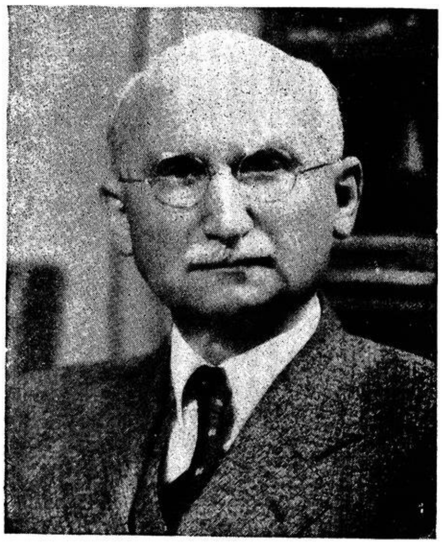
Alumni Notes

by J. J. Kunes e'48

IN MEMORIAM

EMERITUS
PROFESSOR
MAURER

Feb. 18, 1869
May 1, 1948



Cut courtesy
WISCONSIN ALUMNUS

In the passing of Emeritus Professor Edward Rose Maurer the University of Wisconsin and the College of Engineering lost one of its most faithful, devoted and inspiring teachers. A graduate of the University in 1890, after a short period of practical experience, Edward Maurer joined the College of Engineering as an instructor. For nearly 47 years he taught most effectively classes in Mechanics. For over 30 years he set an outstanding example of meticulous and thorough administration as chairman of the Department of Mechanics. During this long period of service he made outstanding contributions to the teaching of this subject, which has been recognized as an essential in all engineering curricula. He pioneered the offering of courses in Aerodynamics and Vibrations in the College. In 1934 his contributions to engineering teaching were recognized by the Society for the Promotion of Engineering Education by the presentation of the Lamme Award, of which he was the seventh recipient.

His major written contributions were a text on **Technical Mechanics,** widely used since 1903, co-author of **Principles of Reinforced Concrete Construction** and co-author of **Strength of Materials.** In addition, he wrote numerous technical papers related to teaching of Mechanics and others related to applications of his subject in engineering practice.

As an administrator he was revered and admired by his colleagues. His numerous committee assignments were always handled promptly, carefully, and with the considered application of good judgment. A thorough teacher and a strict disciplinarian, he was respected and loved by his students. His colleagues remember him particularly for the encouragement that he gave to the younger men on his staff, looking toward their professional development. His highly developed sense of honesty, justice and fairness will always be remembered by his friends and pupils.

February Grads

Here are some more February graduates who have left these halls of learning and stepped forth into industry. For the latest inside reports on conditions back at the Old Alma Mater, see these new alumni.

Two Badgers have left sunny Wisconsin to seek their fortunes in sunny California. They are **Gilbert E. Stewart** (ChE), with Standard Oil of California, and **James G. Carroll** (ME), of the California Research Corp., Richmond.

John O'Neil (ChE) is in the Foreign Department of Union Carbide & Carbon; **William R. Erickson** (ChE) is with the Phillips Petroleum Co.; and **L. K. Hanson** (ChE) is working for the North Western Railroad. Two other ChE's are **O. C. Fox** at E. I. DuPont, Wilmington, and **James B. Kaye** at the Monsanto Chemical Co., St. Louis.

Robert J. Keeler (EE) is with the Curtiss - Wright Corp., Columbus. **Rexford K. Roe** (EE) is working for Kaiser-Frazer, and **David O. Marten** (EE) is working on the railroad—the Illinois Central. Electricals who didn't go far away are **Carl Geisler,** serving with the Wisconsin Public Service Commission, and **Robert J. Trettin,** who is in the Marquette Medical School.

Robert E. Nuckles (ME) is now with Oscar Mayer of Madison; **J. G. McGuire** (ME) is at the Beloit Iron Works; and **Carl E. Wittig** (ME) is working for the Thomsen Abbott Construction Company of Marshfield.

Still in Wisconsin are **Jerome J. Luebke** (ME), at Northern Paper,

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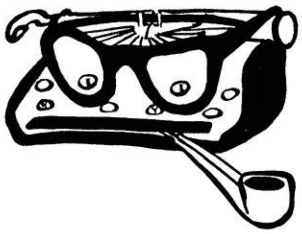


The Way We See It

. . . AND A MIGHTY BUTCHER WAS HE

Once upon a time, there was a butcher. He was a very good butcher, and his beefs were known far and wide. There were a few things wrong with this butcher, though, as was proved by a very tragic incident which occurred.

It seems that this very good butcher had a beef on the chopping block (or whatever they call those thick, overgrown poker chips). He was deftly wielding his cleaver, dividing the beef into steaks, to the delight of his numerous observers. Most butchers used a knife and saw to get the same results, but not this butcher. It was faster, and why not use the method best suited to himself? At any rate, this very good butcher was suddenly confronted with a problem. His hand was in the way.

It is a sad story, this story of the very good butcher. You see, he chose to remove the hand with the cleaver. Then he discovered that the beef would not stay steady. All the things that he had used the hand for suddenly came back to him. But it was too late then. He could no longer use his hand for all those little things, and suddenly he found that he was not a very good butcher any more. Yes, a very sad story.

But the tragic part of it is that the same role, the role of the sterling butcher, was played by our government during the last war. The role of the steadying and helping hand was played by the students enrolled in scientific courses of study in leading institutions throughout this country. The meat cleaver? Why, that was the draft.

I hope that the light manner of presenting the situation has not detracted from its gravity. The gap in the ranks of trained scientific personnel which was created by the indiscriminate use of the draft, and the misplacement of those who had recently graduated, strongly affected the advance of science and industry both in the war years and in the present critical times.

I am sure that your respective congressmen could use some direct comment from each of you on the similar legislation which is now being prepared.

R. J. M.

TO BE OR NOT TO BE, ETC.

Since medieval times, the apprenticeship system has existed in one form or another. This system was developed so that a worker of little or no experience could learn the trade under the guidance of a skilled craftsman.

Contemporary industry, too, has had training programs of one sort or another for its engineers for some time now. These programs were open to men who had just graduated from an engineering college; men who knew the theory of the class room, but didn't always know how to apply that theory to the technical problems of industry.

During the past decade, radical changes have been made in these programs. Due to two major causes, industrial upswing and the war-born gap in the ranks of engineers, industry has had to revise its training methods. This revision accomplished the same end in a more desirable manner, and with a greater rate of speed. The engineer was given the opportunity to survey a wider range of jobs. This helped to avoid the tragic misplacement of some engineers which was caused by their ignorance of the full possibilities of their training. The happy situation was reached in which the engineer was enthusiastically engaged in the work of his choice. Thus this practice proves desirable and beneficial to both employer and employee.

Although the advantages to both seem apparent, this system is still on the proving ground. If the advantages to the employer are sufficiently accentuated, then we may expect the system to endure. If, on the other hand, it becomes taken for granted, and its effectiveness decreases, it is only logical to expect the employers to return to the old system as soon as the shortage of technical employees is overcome.

It is mandatory that the trainee entering such a program take his responsibility to succeeding graduates seriously. This will insure that those following may also have the opportunity to rapidly increase their worth, and perpetuate the system.

R. J. M. and W. M. H.

S-T-A-T-I-C

by Chuck Strasse e'49

To clarify any misunderstanding that this is a joke page, we quote Webster's dictionary, "Static;—disturbing effects . . . .". Therefore the following are disturbing effects not jokes.

* * *

Customer: "Gee twin beds are high aren't they?"

Salesman: "Yes, madam, you know two can not sleep as cheaply as one."

* * *

A true music lover is a man who, upon hearing a soprano voice in the bath room, puts his ear to the keyhole.

* * *

Prof: "Will you men in the back of the room please stop exchanging notes?"

Voice: "They aren't notes, sir, they're cards. We're playing bridge."

Prof: "Well, let's suspend the bridge for a span of 50 feet—which should put you well into the hall-way."

* * *

Observing her grandmother to be reading the Bible most of the day, the little girl inquired: "What're you doing Granny,—cramming for your finals?"

* * *

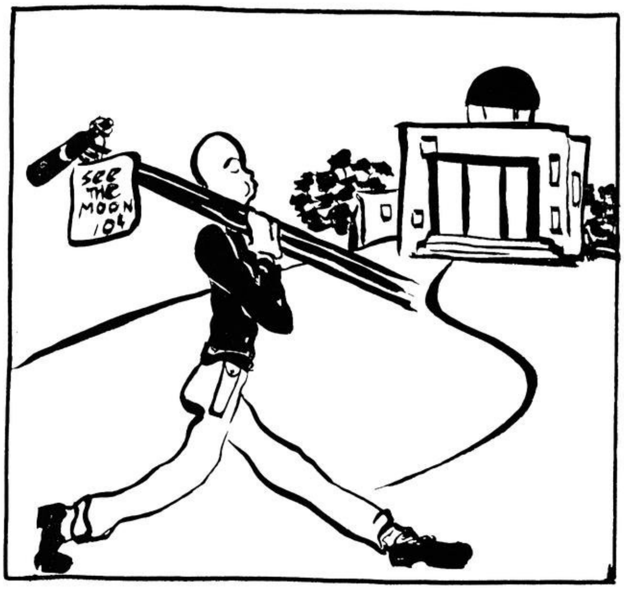
"I caught my boyfriend flirting."

"I caught mine that way too!"

* * *

"Who was that lady I saw you out with last night?"

"I wasn't out, I was just dozing."



Every time someone criticizes this column they always seem to quote some "daughter" joke which they think is funny as h--l. The following are therefore printed to put a stop to daughter jokes forever.

* * *

She was only a railroadman's daughter but she didn't give a hoot.

* * *

She was a lumberman's daughter, but don't axe her.

* * *

She was only a policeman's daughter, but she could not be beat.

* * *

Did you hear about the nude model who did her posing by mirrors because she was bashful.

* * *

"Doctor," said the patient, "my trouble is dreams. I always dream the same dream—it's about a Girls' Dormitory and the girls run lightly clad from room to room."

"Ah, yes—and you want me to make you stop dreaming about the girls?"

"No—No—all I want you to do is make them stop slamming the doors."

* * *

He: "Do you believe in free love?"

She: "Well have I sent you a bill yet?"

* * *

Yo Yo says:—

The reason some girls never get married is because they're too biased. All their boy friends hear is, "Bias this," and "Bias that."

* * *

Did you hear about the goof that applied for a job at the post office? He saw a sign: "Man Wanted for Robbery in Chicago."

* * *

You can never tell about women—and even if you can, you shouldn't.

* * *

Nothing robs a man of his good looks more then a drawn shade.

* * *

If you give a woman an inch she thinks she's a ruler.

* * *

Did you hear of the sad tale of Aloysius J. Price, a young engineer whose wife had quadruplets. It seems she was a Republican and didn't believe in Price Control.

* * *

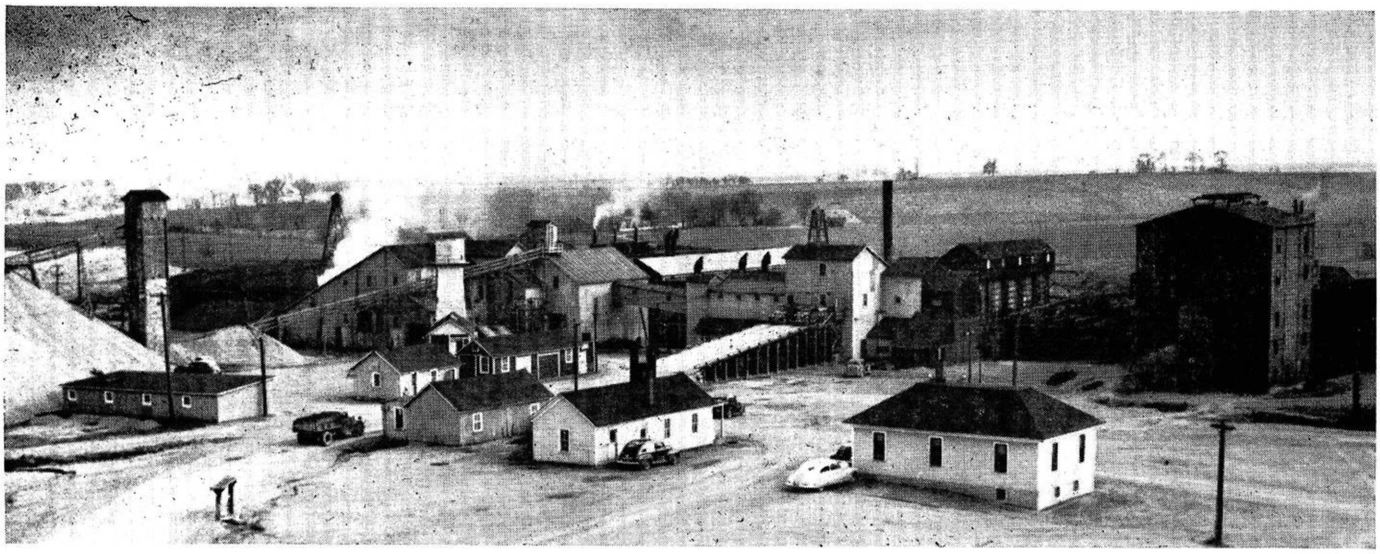
Pooch: "Hear from your beau lately?"

Patch: "Yes, got a litter from him the other day."

(please turn to page 39)

ZINC . . . .

(continued from page 9)



Central Mill and Acid Plant, Vinegar H ill Zinc Company, Cuba City, Wisconsin —Don Every Photo

central Illinois, East St. Louis, and Pennsylvania where the lead and zinc metals are produced. The reason for this procedure is that smelting requires so much fuel that it is cheaper to ship the concentrate to the fuel than to bring the fuel to the area in which the ore is produced. Some plants in the Wisconsin mining area do go one step further in the processing of the ore. They recover iron sulfide for the production of sulfuric acid.

The war had a marked effect upon the production of zinc and lead in this district, as it did to some extent in all the zinc mining regions in the United States. National production fell off from 749,000 tons in 1941 to 614,000 tons in 1945. Of the 48 zinc mining districts in the country, only 16 increased their production during this period. In 1941, the Wisconsin-Iowa-Illinois district was the 15th largest with a production of 7,956 tons of recoverable zinc metal. It was in 12th place in 1944 with 17,242 tons. The production of 19,318 tons in 1945 put this district up to 7th place in the nation for that year. In this district, 80 per cent of the production was from the Wisconsin portion.

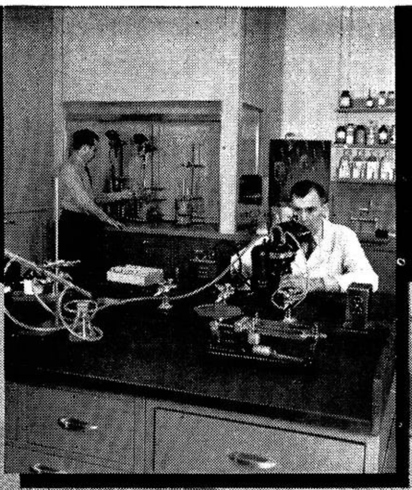
Much of this stimulation was due to the government subsidies that were offered during the war. These payments were made to increase production of lead and zinc for wartime needs. One factor that fixed the amount of the subsidy was the cost of mining in any given mine. Thus a smaller subsidy was paid to the mine where the ore was more easily obtained, and a larger subsidy went to the mine where the mining costs were high. This made it possible for these "expensive" mines to stay in business, and resulted in the large production necessary for the war effort.

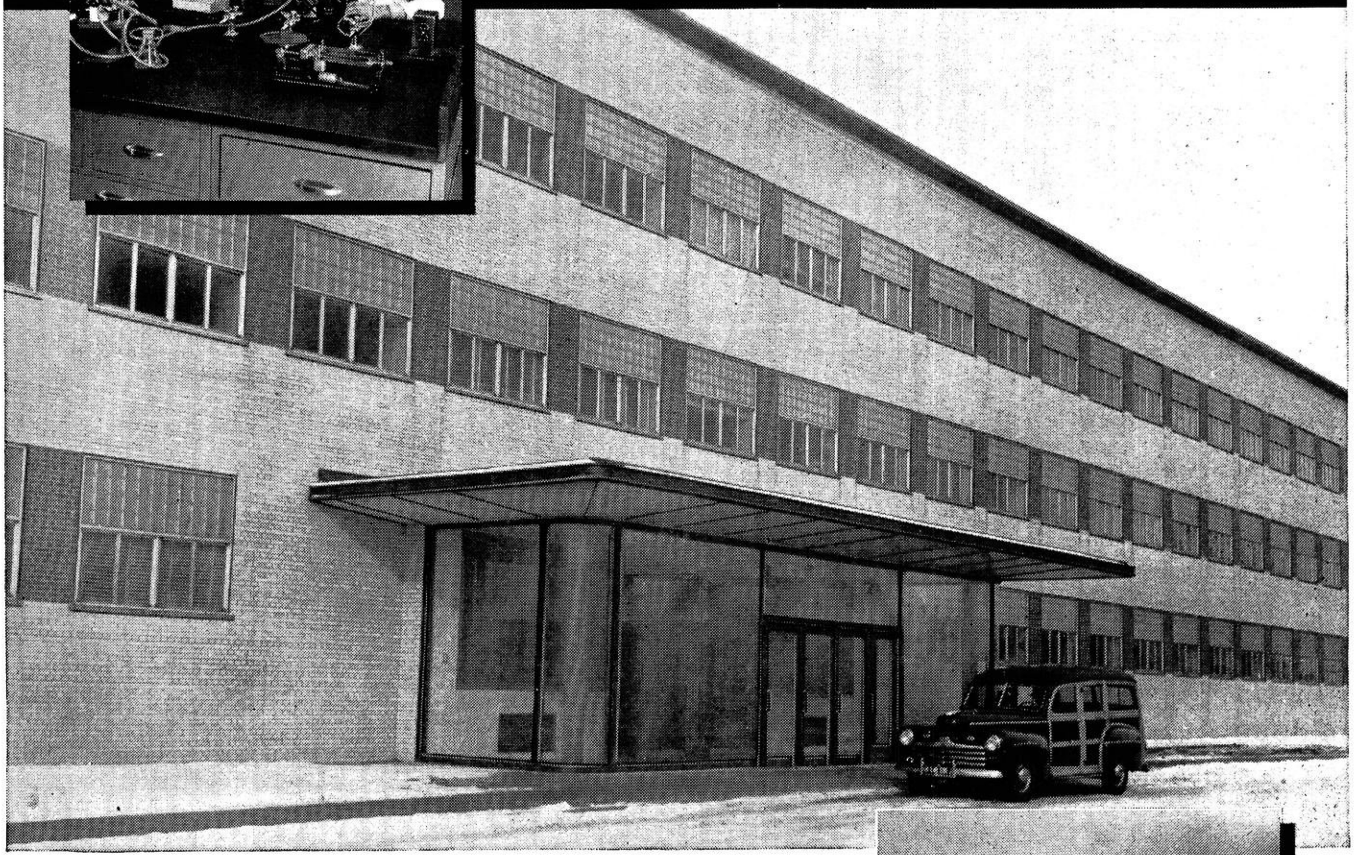
In dollars and cents, the 1945 value of the lead produced in the Wisconsin-Iowa-Illinois district was 4.832 million dollars, before subsidy. The corresponding bonus added another 1.5 million dollars to this value. Most of the mines closed when the Premium Price Plan expired June 30, 1947. In 1945 there were 51 operating units in the district. Now there are less than 6 mines being worked.

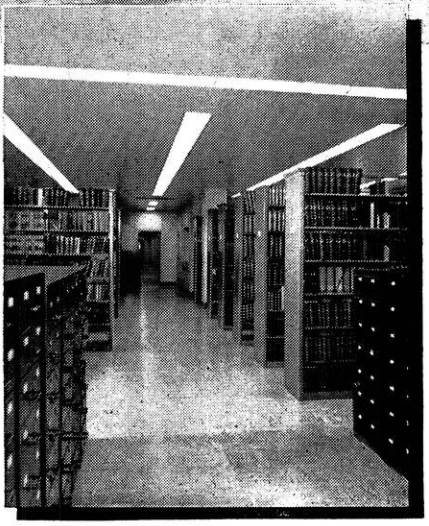
The continued production of lead and zinc became critical during the war, as many important fields were showing signs of depletion. As premium prices would do no good if there were no ore to mine, the Bureau of Mines did some prospecting during the war to try to find more deposits in the Wisconsin area that could be worked. At the present time, the United States Geological Survey, in cooperation with the Wisconsin Geological Survey, is mapping the zinc region. This mapping consists of locating the faults and folds in the earth's strata. The faults are of importance because the veins of ore occur along these breaks in the layers of rock that form the earth's crust.

Private companies have also been active in exploration. Their method is to sink a series of drill holes along the line of a fault where they suspect the presence of ore. These drills are either core or churn drills that bring up samples of the material that they are boring through. An experienced driller can tell when the drill has reached zinc ore by the color of the cores or chips brought up. By keeping an accurate log of the cores or samples of each hole, and the position of the drill hole in the series, it is possible to plot the exact location and depth of an ore vein when it is encountered. By obtaining this information, the mining companies can decide first whether it would be profitable to open a mine at that location, and if they do decide to sink a shaft, the survey information will indicate the layout of shaft and tunnels that will allow the mining of the most ore at the least cost. Apparently the results of this exploration are quite encouraging, as there are now about 60 drills operating in the area. It is likely that the miners will take zinc ore out of the earth for quite some time yet in the Wisconsin mining counties of Grant, Lafayette, and Iowa.

A new doorway to Petroleum Progress







No illustrations can do more than suggest the wealth of facilities at Standard Oil's new research laboratory at Whiting, Indiana. Here, in one of the largest projects of its kind in the world, there are provided the many types of equipment needed and desired for up-to-the minute petroleum research.

The caliber of the men who work here is high. For many years, Standard Oil has looked for and has found researchers and engineers of high professional competence. Further, the company has created for these men an intellectual climate which stimulates them to do their finest work.

And there is nothing new about the idea that motivates Standard Oil research. It is simply that our responsibility to the public and to ourselves makes it imperative to keep moving steadily forward. Standard Oil has always been a leader in the field of industrial research; the new Whiting laboratory is proof of our intention to remain in the front rank.

STANDARD

STANDARD SERVICE

Standard Oil Company

(INDIANA)

910 S. Michigan Avenue, Chicago, Illinois

Campus . . .

(continued from page 17)

SIMPLIFIED CHEMICAL PROCESS

A rapid method for manufacturing substances used in the artificial or synthetic production of chemicals for medical and industrial purposes has been made possible by the development of a new catalyst—a kind of chemical middleman—by Homer Adkins, professor of chemistry at the University of Wisconsin, and George Krsek, a research associate. The catalyst simplifies the manufacture of certain drugs, tropinone for example, used in medicine, and of chemicals of industrial importance such as alcohols. Used in this process is a high pressure reactor in which the conversion of simple into more complex chemicals is completed. Pressures in the reactor sometimes reach 4,000 pounds per square inch. The new process makes the production of certain chemicals simpler and more efficient than present industrial methods.

ASME CONVENTION

The Regional ASME Student Branches of the "Northern Tier" will hold their annual convention at Wisconsin this year. Approximately 10 schools or universities will be represented. The meeting will be highlighted by the presentation of student papers on various topics as prepared by the students themselves. The events will include a conducted tour of the Forest Products Laboratory and the concluding ceremonies will be held at the banquet.

The papers presented will be the final contenders from eliminations held at the branches of each school. The Wisconsin branch met on Tuesday evening, March 30, to hear papers by:

R. L. Smith on "The Mechanical Engineer and the Foundry."

M. Gillette on "Electrolytic Loading Device."

R. Evenson on "Plant Layout."

R. Mitchell on "Operational and Performance Characteristics of the Jumo 004" (winner).

"ENGINEER" BANQUET

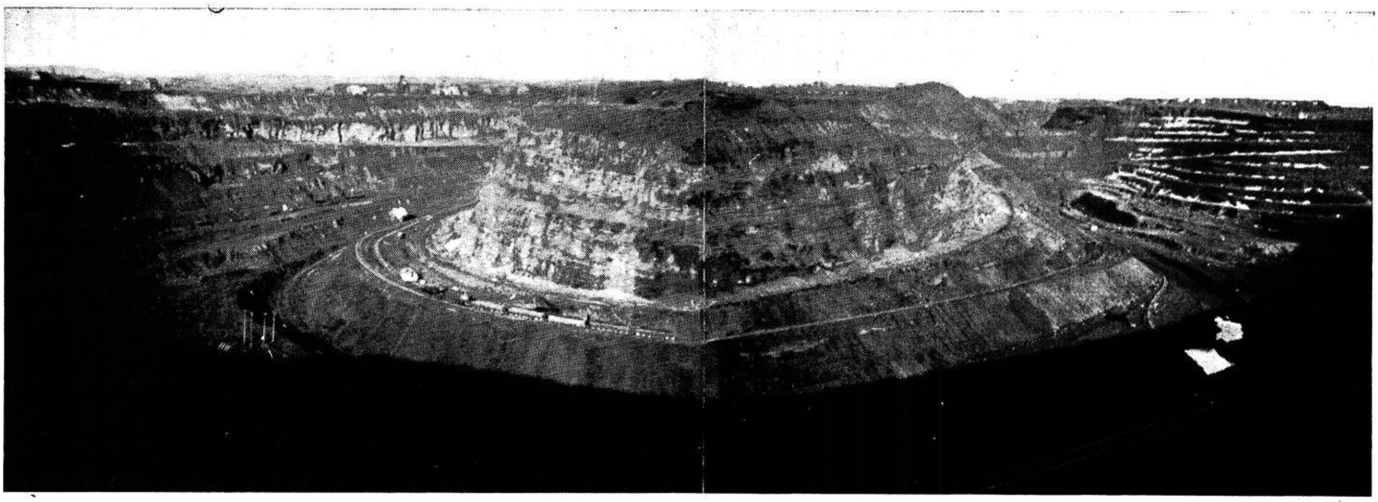
The WISCONSIN ENGINEER annual banquet was held on Friday evening, May 7, at the Italian Village Restaurant. Assistant Dean Henry G. Goehring gave the after-dinner talk on the general topic of "Employment Prospects for the Engineer." Keys were awarded for service on the ENGINEER staff to Charles Mitasik, Carl Leyse, Wilbur Haas, James Kunes, Bob St. Clair, and Bob Mitchell.

GRADUATE REGISTRATION

Assistant Dean Henry G. Goehring has announced that the regular College of Engineering Alumni Directory is in the process of being compiled. This is done every five years. In order to be placed in this issue, graduates are urged to fill out and return the cards which will be circulated near the end of May. These will contain information pertaining to place of employment, type of job, and prospective residence—if this is available. Since the directory is very instrumental in contacting classmates after graduation, the little extra time required to fill out the form-card will be very well spent.

MESABI MIRACLE . . .

(continued from page 12)



Panoramic view of one of the open pit developments in the Mesabi Range.

contains 55 miles of railroad track for hauling out the ore. The biggest of its electric shovels can take sixteen tons of ore in a single bite. The pit has produced over 400 million tons of ore. More material has been dug from it than was moved to build the Panama Canal.

From the mines the ore is beneficiated to the extent needed and graded. Then it is loaded into railroad cars and hauled to the lake ports. The trains are much longer than the usual freight train. This is possible because fortunately the way is downhill and gravity supplies a good portion of the force necessary. At the lake ports the ore in dumped in bins that facilitate loading into ore boats. These bins are about as weird, because of their size, as the pits themselves. From the lake ports the ore boats carry a steady stream of ore during the shipping season through Sault St. Marie to Toledo, Gary, Cleveland, Ashtabula, Conneaut, Buffalo, Lackawanna and other lake ports where the ore is again put in railroad cars and hauled to the blast furnaces.

The operators of the early mines were usually speculators but now the mining companies fall into three groups: (1) Steel companies that mine directly or through wholly owned subsidiaries (Republic, Jones and Laughlin, Inland, U. S. Steel's Oliver Iron Mining Co.). (2) Operating companies directly affiliated with steel companies (Pickand, Mather & Co., Oglebey Norton & Co., M. A. Hanna Co.). These two groups produce 90 per cent of the ore delivered at lower lake ports. (3) Independent mining companies, of which Butler Bros. is by far the largest, produce 10 per cent sold on the open market.

Beneficiation, the mining men's $2 word for the various ways of treating ore to remove surplus silica and otherwise prepare it for the steel mills, is not new. It has been practiced in the district for forty years. In recent years some 22 per cent of Minnesota's ore has been beneficiated in one way or another. But only as the supply of direct-shipping ores began to give out did beneficiation become a desperate necessity for the independent steel and mining companies. Nearly all beneficiation processes are based on the fact that iron, being heavier than silica may be separated from it by gravity. The important fact for laymen to understand about these complex and extremely noisy operations is that various processes required to beneficiate successively lower grade ores becomes successively more elaborate and expensive.

THE CHALLENGE TO THE MESABI

The Mesabi and Neighboring ranges have nourished the U. S. economy for a half century, through 2 world wars. Even on these seemingly unlimited resources the drain has been immense. It is not surprising that some farsighted men are saying that the Superior District's day is done. Recent estimates based on wartime consumption have placed the present supply of better ore at 1950 to 1955. Still others have ventured twenty years more at best. Loyal defenders of the district have faith enough to contend that it will supply U. S. ore for another century.

One reassuring observation can be made at once: iron is the earth's fourth most abundant element trailing oxygen, silicon, and aluminum. It is mined in twenty states and there exist abundant quantities on every continent. Minnesota alone has enough known ore to last the U. S. for centuries.

Why, then, the present concern over the ore situation? The abundance of iron makes its economics dependent not on mere supply, but on two other factors: (1) How cheaply it can be mined and prepared for the steel mills; (2) How cheaply the ore can then be transported to the mills. The easily mined Mesabi ore might never have been tapped had not the Great Lakes offered cheap transportation to the coal-rich lower lakes regions. Alabama's ore is of a lower grade, but their industry exists because the other two ingredients of blast furnaces, coal and limestone, were rich and readily available.

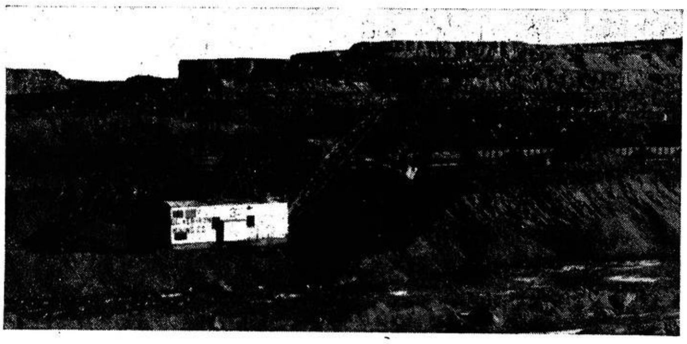
Therefore, the real issue that exists is not how long the ore will last, but how long it can continue to compete economically with ores from the eastern seaboard and foreign countries.

The iron men are justifiably calm about the situation. While they differ in their estimates of the area's productivity, they unanimously agree that if they are to successfully maintain the district's position, they will need every break they can get. The two biggest breaks would be reduction in taxes and transportation costs.

There exists an interesting taxation setup in Minnesota, with which the iron men find much disfavor. Of the three separate taxes levied, the least liked is the ad valorem or property tax. This is about 2c per ton a year depending on locality of ore in the ground and in stockpiles. Minnesota officials make their case sound reasonable by asserting that the ore is a vanishing asset and that they had better get what they can while they can.

The other two state levies are a 10½ per cent tax on profit on each ton, and a 10½ per cent royalty on fees paid to the mine's owners.

While taxes account for approximately 13 per cent of the price of a ton of Minnesota ore, transportation costs add up to 40 per cent of the total cost delivered to lower lake ports. By rail from the pits to one of the shipping points costs 92c per ton. The boat haul to the low lakes area costs another 94c.



—Courtesy of A. St. Vincent, Oliver Mining Co.

Eight-cubic-yard shovel loading ore for removal.

It is conceivable that there will be a tax reduction as the supply dwindles, in order to keep the pits working. This may be necessary to compete with forseeable competition from other sources. The ad valorem tax in part accounts for the difference of opinion as to the district's potentialities, for it discourages the search for new deposits. These new deposits would be taxed from the time of discovery until shipped.

In recognition of this, the state of Minnesota has already given tax encouragement to progressive mine operators. As has been mentioned, there exist bountiful supplies of lesser grade ores. The mine operators themselves are actively engaged in research on beneficiation processes, for it is upon the success of this research that the future of the Superior District depends.

TACONITE PROSPECTS

While it is evident that the present generation will see the end of the Class I ore, one need not be alarmed. There exists some 60 billion tons of taconite on the Mesabi range alone, enough to last the U. S. for centuries at its present rate of consumption, of 199 million tons annually.

Methods of production of merchantable ore from taconite are well advanced though far from perfected. Research, however, continues briskly. The leader in taconite experimentation is Minnesota's own Mines Experiment Station, ably directed by E. W. Davis, a taconite crusader. The station, which receives an annual grant of $100,000 from the legislature, works for Minnesota mining companies free of charge; analyzing ore, working out processing flowsheets and experimenting in beneficiation methods. It does similar work for a fee for operators in other states and foreign countries.

The great obstacle, of course, to taconite mining is cost: the first cost of plant investment plus high cost of mining (three tons of taconite to produce one ton of merchantable ore) and beneficiation. The extra cost is estimated at 40 per cent more per ton than the present cost delivered to lower lake ports.

In the opinion of competent observers, iron men clearly lack the knowledge to process taconite on a large scale. Much industrial experience must yet be obtained. To produce a ton of taconite concentrate would require seven times the number of workers needed to produce a ton of open pit direct-shipping ore. Immense quantities of electric power are required, too, in the beneficiation process, and perhaps more water than even Minnesota's many lakes could supply. Along with these requirements, are tremendous amounts of fuel for the magnetic roasting and sintering. Minnesota has no good natural fuel.

Despite its disadvantages, taconite has some good factors in its favor. Because it can be mined by open pit methods, its cost would be only ¼ that of underground mining of higher grade ores. And, beneficiated taconite is efficient. Mixed with ordinary ores, in varying quantities taconite's high iron content, porosity, and other technical advantages make it worth $1.50 to $2.00 more per ton in the blast furnace.

In order to further promote development of taconite, the Minnesota legislature exempted the ad valorem tax. In its place was substituted a tax on the finished concentrate of 5 cents per ton to be collected at the time of shipment. Along with this was another law cutting the royalty fee paid on state owned lands by almost one half.

These are the pros and cons of taconite production. Upon the pros rests the future of the Mesabi range. Already other areas are getting considerable attention.

MESABI COMPETITION

Probably one of Mesabi's leading potential competitors is the newly discovered billion ton deposit in Labrador. It is high grade and readily available for mining by open pit methods. It has a disadvantage in that its severe winters would limit mining operations. The M. A. Hanna Co. of Cleveland however is betting money on its success. Located three hundred miles north on the mouth of the St. Lawrence River, considerable development will be

(*please turn to page* 42)

Alumni . . .

(continued from page 20)

Green Bay; **William J. Abnett** (ME) with the Carnation Co. of Oconomowoc; and **Paul Timmermann** (ME) of the Automatic Products Co., Whitefish Bay.

Donald Gmeiner (CE) and **Don Reinke** (ME) have accepted positions with the Sundstrand Machine Tool Co. of Rockford, Ill. **Lee L. Lemke** (ME) is working for International-Harvester Co. in Chicago. **John Walden** (ME) has joined the Superheater Co. and **Marvin A. Port** (ME) is with General Electric.

The following are not yet alumni, but they will receive that sheepskin this June. It has been reported by reliable sources that accepting a position congeals future plans. Where formerly there was only a large question mark now appear a definite locality and type of work. Budding alumni with congealed plans are listed below.

John A. Weaver (ME) has decided to stay in Madison with the Ohio Chemical Co. **Henry Grabowski** (ChE) will work for the Falls Paper & Power Co. of Oconto Falls, Wis. **Fred O. Meurer** (ME) has accepted a position with the Fire Insurance Rating Bureau in Milwaukee. **William R. Erickson** (ChE) and **T. J. Tracy** (EE) are going to work for Goodyear; Erickson in Los Angeles and Tracy at Akron, Ohio.

H. Dale Palmatier (EE) will be with the Wisconsin Public Service Corp. in Green Bay. **Bruce F. Campbell** (ChE) will be with General Electric in Hanford, and **Berwyn M. Knight** (EE) with RCA Victor.

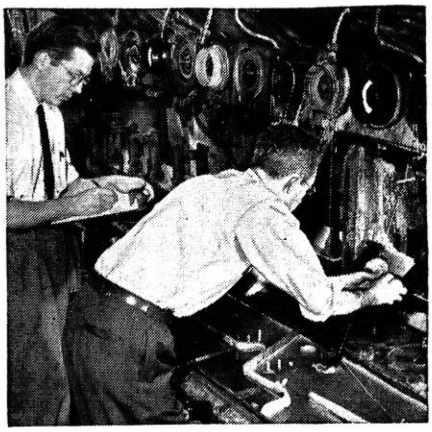
Koppers, Inc., of St. Louis, will have on their staff **A. Dorfmueller** (EE) and **William R. Corzelius** (EE). **Kensal R. Chandler** (CE) has joined Montgomery Ward & Co.

John N. Pike (MetE) likes California; he's going to work for Standard Oil Company of California. **Norbert F. Mullaney** (ME) is going to work for the A. O. Smith Corp. in Milwaukee.

DU PONT Digest

For Students of Science and Engineering

Many Theoretical and Applied Studies Behind Development of "Cordura" Rayon



Determination of spinning tension by C. S. McCandlish, Chemical Engineer, Northwestern University '44, and A. I. Whitten, Ph. D., Physical Chemistry, Duke University '35.

Stronger, lighter tires made possible by teamwork of Du Pont chemists, engineers, and physicists

On the surface, the viscose process for rayon seems fairly simple. Cellulose from cotton or wood is steeped in NaOH to give alkali cellulose, which is treated with CS_2 to form cellulose xanthate. Adding NaOH gives molasses-like "viscose," which is squirted through spinnerets into a coagulating bath of acid and salt to form from 500 to 1,000 filaments simultaneously:

$$\underset{\text{(cellulose)}}{R^{*}\text{-}OH} + NaOH \longrightarrow \underset{\text{(alkali cellulose)}}{R\text{-}ONa} + H_2O$$

$$R\text{-}ONa + CS_2 \longrightarrow \underset{\text{(cellulose xanthate)}}{R\text{-}O\text{-}\overset{\overset{S}{\|}}{C}\text{-}SNa}$$

$$R\text{-}O\text{-}\overset{\overset{S}{\|}}{C}\text{-}SNa + H_2SO_4 \longrightarrow \underset{\text{(cellulose)}}{R\text{-}OH} + CS_2 + NaHSO_4$$

$$R^{*} = C_6H_7O_2(OH)_2$$

Du Pont scientists were working to improve on the properties of rayon made by this process when, in 1928, a rubber company asked for a rayon yarn that would be stronger than cotton for tire cords. The problem was given to a team of organic, physical, and analytical chemists, chemical and mechanical engineers, and physicists.

Theoretical and Applied Studies

In developing the new improved rayon, a number of theoretical studies were carried out: for example, (1) rates of diffusion of the coagulating bath into the viscose filaments, (2) the mechanism of coagulation of viscose, (3) the relationship between fiber structure and properties by x-rays, and (4) a phase study of spinning baths.

Concurrently, applied research was necessary. This proceeded along many lines, but the main problem was to perfect the spinning technique. It was known that a short delay in the bath between the spinneret and the stretching operation allowed greater tension on the filaments. Du Pont engineers, therefore, designed a series of rollers, each revolving faster than the previous one, to increase the tension gradually. In addition, a textile finish was developed that combined just the right amount of plasticizing action and lubricating power, allowing the filaments to twist evenly in forming the cord. A new adhesive was prepared to join the yarn with rubber. New twisting techniques for cord manufacture were found, since the usual methods caused loss in rayon strength.

Engineering Problems Solved

Chemical and mechanical engineers were faced with the design and operation of equipment for more than 15 different types of unit operations. Equipment had to operate every minute of the day, yet turn out perfectly uniform yarn. It was necessary to filter the viscose so carefully that it would pass through spinning jet holes less than 4/1000th of an inch without plugging. Some of the most exacting temperature and humidity control applications in the chemical industry were required.

Out of this cooperation among scientists—ranging from studies of cellulose as a high polymer to design of enormous plants—came a new product, "Cordura" high-tenacity rayon, as strong as mild steel, yet able to stand up under repeated flexing. Today, this yarn is almost 100% stronger than 20 years ago. Tires made with it are less bulky and cooler running, yet give greater mileage under the most punishing operating conditions. In "Cordura," men of Du Pont have made one of their most important contributions to the automotive industry.

Questions College Men ask about working with Du Pont

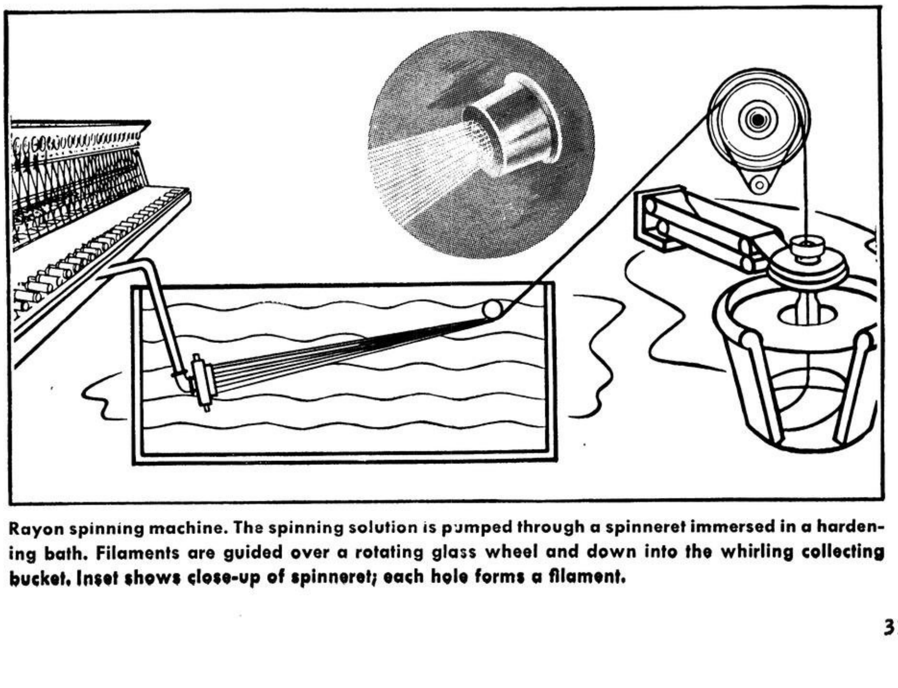
How are new men engaged?

Most college men make their first contact through Personnel Division representatives who visit many campuses periodically. Those interested may ask their college authorities when Du Pont men will next conduct interviews. Write for booklet, "The Du Pont Company and the College Graduate," 2518 Nemours Building, Wilmington 98, Del.

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

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

More facts about Du Pont — Listen to "Cavalcade of America" Monday Nights, NBC Coast to Coast



Rayon spinning machine. The spinning solution is pumped through a spinneret immersed in a hardening bath. Filaments are guided over a rotating glass wheel and down into the whirling collecting bucket. Inset shows close-up of spinneret; each hole forms a filament.

Foreign Students . . .

(continued from page 18)

PRAKASH NIGAM

(continued from col. 1)

ing in his field to better enable him to help India.

Mr. Nigam had some very interesting comments to make on the engineering profession in India. He stated that they do not have many technical personnel in India, because they do not have very much industry. However, in the next few years they hope to be manufacturing most of their own needs. He also said that tremendous schemes are being put into operation since India became free, but much of the expansion is hampered by the lack of technical personnel and heavy machinery, much of which must be imported from abroad.

Recently Prakash Nigam visited several of the leading industrial plants of Wisconsin with the senior class of the Electrical Engineering Department. Very much impressed with these industries, he said that these accomplishments were what India hoped for.

Among his many hobbies, Prakash enjoys swimming, boating, dancing, horse-back riding, and tennis. His chief extra-curricular activities have centered around the International Club and affiliate organizations. He is on the international committees of the YMCA and YWCA. On the campus he has been especially interested in the promotion of better understanding between different countries for the hope of world peace and in the understanding of problems and aspirations of these different countries.

LIAN-WEI YEU

(continued from col. 2)

and machinery often used was clearly illustrated in the construction of the landing fields for the B-29's in China. To build one landing strip as many as 100,000 people were recruited for the construction work. All of the grading was done by hand, and the huge stone rollers used to smooth the surface of the strip were moved by human power.

Upon the recommendation of a friend, Lian-Wei chose the University of Wisconsin to continue his studies. He hopes these studies will help him so that he can aid China to improve her internal communication system. For this reason he is especially interested in mechanical contracting. Hoping to get his master's degree in February 1949, he has chosen "Flexible Pavement Design" as the subject of his thesis.

Although well versed in the written English word, Lian-Wei Yeu still has some trouble with conversation. His good ability in English reading can be traced to the use of English textbooks at the Wu-Han University. However, all of the classroom conversations and lectures were carried on in Chinese.

Replying to the usual question concerning his opinion of Wisconsin and the United States he said, "Both are very nice. I like them very much. I especially like American movies."

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Science . . .

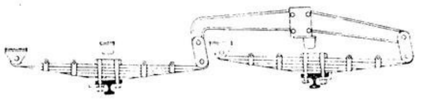
(*continued from page 19*)

sultant, explains that their work at Stanford proves that molecular attraction takes place over a wider range than ever proved before. He believes that molecules in the liquid surface polarize several neighbors and that these in turn polarize several others. (**Science News Letter**, February 14, 1948.)

HEAVY VEHICLE SUSPENSION

A novel twin front axle design with interconnected steering and weight transfer is described by Mr. J. W. Wunsch in the 1947 **Technion Year Book.** For heavy load carrying the need for two rear axles and the limitation of a single steering axle has long been recognized. Mr. Wunsch outlines an interesting design where two front axles are so arranged that the steering is inter-connected and the weight is evenly transferred.

In the conventional single - axle two wheel steering mechanism, the weight of the chassis is taken first on the chassis spring and then through the axle on the wheels. When semi-eliptic springs are used, these springs can serve not merely as suspension members but also as thrust members. In this design, one end of the spring is directly pivoted to the frame while the other end is shackled to the frame. In the new design these characteristics are retained but certain improvements result from the introduction of two equalizing beams to interconnect the two front axles. Each equalizing beam is pivotally mounted on the chassis frame and one end is shackled to the first spring, the other end to the second spring.



Twin front axle spring mounting.

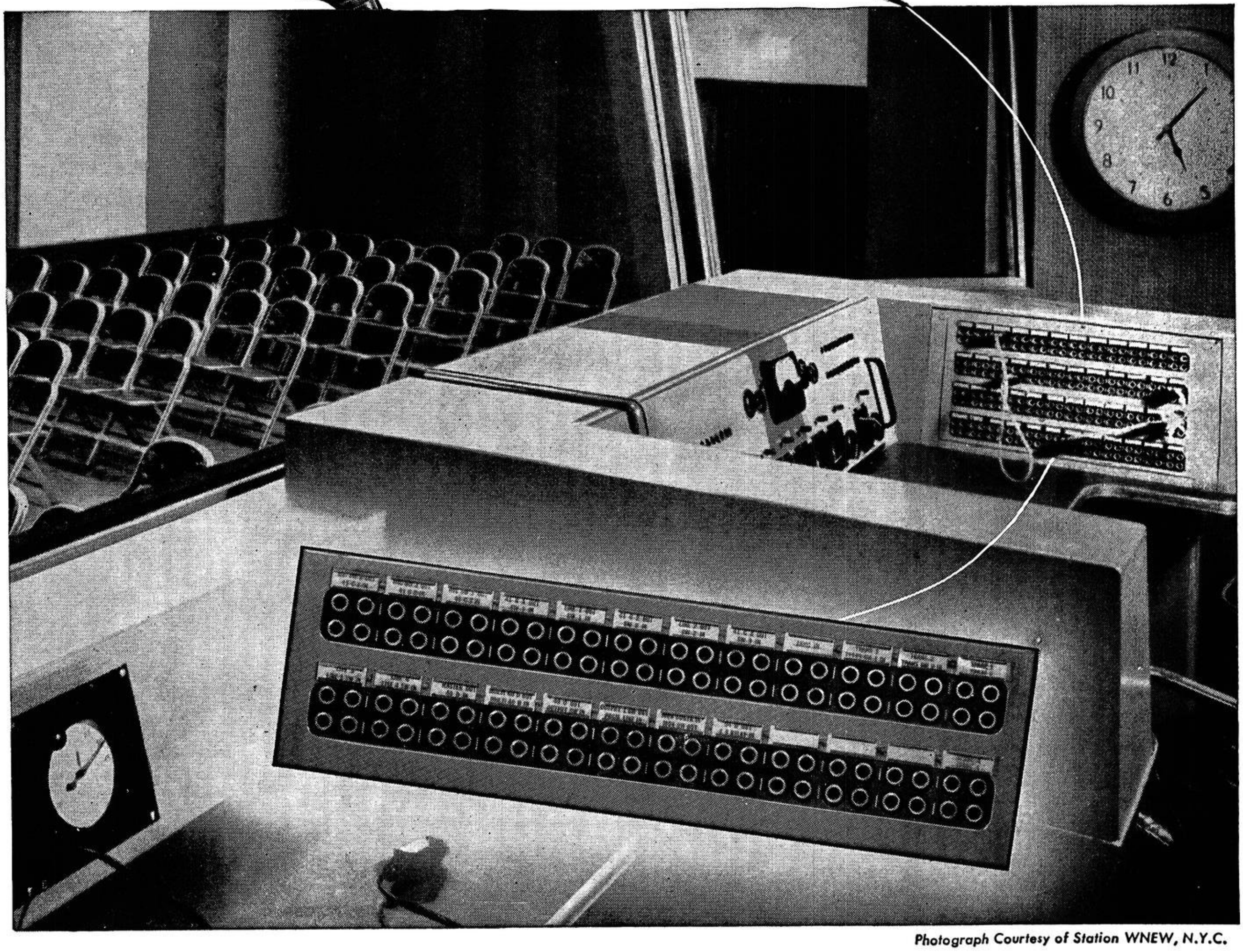
It is claimed that the four-wheel suspension provides the possibility of ideal load distribution between the front and rear axle groups. An incidental advantage is the lower unsprung weight which means less shock to axles, springs, frame, and steering elements. This low unsprung weight balanced between the front and rear axles of the front assembly by the equalizer beam eliminates many evils of two wheel steering and offers important advantages in steering stability, riding quality, and better load distribution.

An important design advantage in the use of the smaller types of the four wheel front end suspension is that in steering gear parts the bending moment at the root of the steering arm is substantially proportional to the load carried by the wheel and to the wheel diameter. Steering gear stresses are lower and lighter elements can be used. In addition, since the frame is lifted only one half the height of any obstruction encountered by the wheels, due to the equalizer beam action, there will be less pitching and tossing of the driver and load.

EXTRUSION FORGING FOR MASS PRODUCTION

Although extrusion forging in a heavy duty forging press is unique so far as mass production application goes, the Ford Motor Co. developed the principle in experimental production almost ten years ago. The first production application of the process will be in the making of Ford passenger car front spindles at the new Canton Forge plant. Later on they intend to extrude intake and exhaust valves, and once the operation is established, further study will be made on the economic possibilities of making other parts by the same process. The program visualizes a veritable revolution in forging practice, because for parts such as the front spindle in character — a combination of a relatively massive section and a long slender shaft end — the process offers not only production economy but an improvement in physical properties as well.

Plastics where plastics belong . . .
for insulation and appearance



Photograph Courtesy of Station WNEW, N.Y.C.

Synthane . . . where synthane belongs

USES for Synthane laminated plastics are almost unlimited because of their combination of chemical, electrical and mechanical properties. Synthane is corrosion and moisture resistant, light in weight, quickly and easily machined. It is also hard, dense, strong, one of the best electrical insulators known. The "set" plastic, Synthane is stable over a wide range of temperatures.

An interesting example of Synthane at work is this jack panel which enables the broadcast technician to plug in or transfer amplifiers, microphones, telephone lines or other equipment, giving the input system greater operating flexibility. This is an appropriate job for our type of plastics because Synthane is an excellent electrical insulator, and contributes to the attractiveness of the control booth. Synthane Corporation, 14 River Road, Oaks, Pa.

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S

DESIGN • MATERIALS • FABRICATION • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-MACERATED • MOLDED-LAMINATED

HOT AIR ENGINES . . .

(continued from page 13)

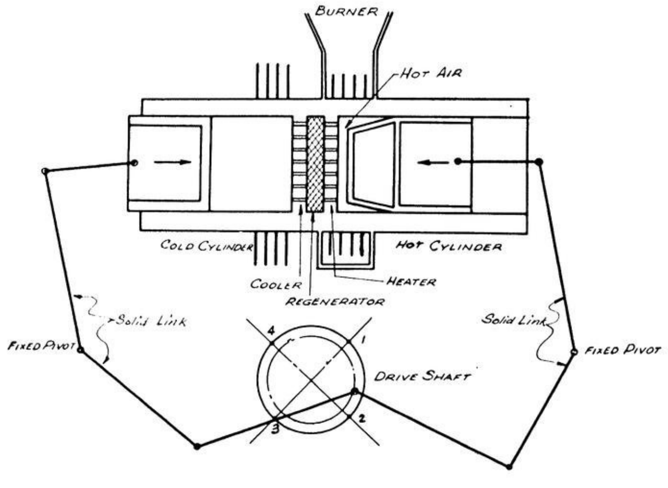
volume remaining the same (C to D).

(4) As both the plunger and the piston move downward the air is compressed isothermally, since heat is constantly being absorbed. The temperature, therefore, is constant, the volume decreased and the pressure higher, back at point A (D to A).

Because of the inherent efficiency of this engine it has again been investigated and successfully built. The Philips Physical Laboratory in Einhoven, Holland has produced hot air engines of a new design with ratings from 1/10 to several hundred horsepower.

The Philips engine combines the piston and displacer in a way which requires only one cylinder per piston. The regenerator is made of a sponge-like fabric of fine metal wire through which the air must pass between hot and cold spaces. This regenerator will give up as much as 95 per cent of the stored heat which was taken from the expanded air. The heater is made of an aluminum-bronze alloy which conducts heat well. Exterior fins expose more surface to pick up heat from the burner while the interior fins expose more air to this heat and thus allow a maximum transfer of heat. The cooler is similar to the heater except that the outside fins are cooled by air or with a water jacket so that the excess heat not removed by the regenerator is extracted.

The actual operation is divided into four cycles, the compression stroke, the transfer stroke, the power stroke, and a second transfer stroke. As the operation begins, starting at point 1 on the diagram, both pistons move toward the center, compressing the air, mostly in the cold part of the cylinder. This is the compression stroke. As the crankshaft reaches point 2, the piston in the cold cylinder continues to move toward the center while the piston in



Diagrammatic sketch of the Philips engine principle. The engine is in the compression cycle, point 1 to point 2, and both pistons are moving toward the center. Linkages are shown by the heavy black lines.

the hot cylinder begins to move toward the outside. This is the transfer stroke, since the compressed air is moved from the cold cylinder to the hot cylinder without a change in volume. In so doing the air passes through the regenerator where it picks up the greatest portion of the heat and through the heater where it receives additional heat, bringing it up to its working temperature. The power stroke is caused by the expansion of the hot air and takes place from 3 to 4, when both pistons will move toward the outside. The air expands mostly in the hot space. As the crankshaft moves from point 4 back to 1, both pistons are moving toward the left, moving the expanded air, without a change in volume, back to the cold cylinder. When this is done, the air must pass back through the regenerator, where it gives up most of its heat so it can be stored for the next cycle. Any heat that remains is removed by the cooler in the cold cylinder.

In actual operation both linkages are not necessarily connected to the same point on the crankshaft. Ordinarily there is a phase difference between the two, and actually the crank for the hot piston is set behind that of the cold piston sometimes as much as 90 degrees. This means that most, but not all of the expansion will take place in the hot cylinder and most, but not all of the compression will take place in the cold cylinder.

The useful work is done during the power stroke when more power is given up by the hot air, due to the energy added from the burner, than is used up again in compressing and transferring the air. This net gain due to the added energy is the useful power delivered. No heat is lost in exhaust since the same air is used over and over again. Heat is lost, however, due to convection and radiation losses from the engine itself; heat lost in the regenerator because all of the heat is not extracted from the air but must be removed by the cooler and is thus lost; heat lost, which cannot be given up again by the regenerator to the air. The first of these losses has been overcome by using a good insulation material. The latter two are being improved by the use of improved substances, but perfect regeneration is very difficult to obtain since this heat must be extracted and again delivered in a very small fraction of a second. The working temperatures for the cold cylinder is approximately 100 degrees C. while for the hot cylinder about 600 degrees C. Pressures as high as 50 atmospheres have been used.

One of the small units that has been built is a single cylinder engine which develops 15 HP at 3000 rpm. Multiple cylinder units have also been built which actually make the design of the engine simpler than the single cylinder. The cylinders can be arranged radially, in V's, or in a square. Each piston is used as a double acting unit, so that the lower part of one cylinder is connected to the upper part of the next one, with the hot part of the cyl-

(please turn to page 38)

PHASE EMISSIVITY . . .

(*continued from page* 8)

confirmations serve to strengthen confidence in this new method. Discontinuities in some of these curves, like the dip in the iron curve, have not yet been explained conclusively. This is due to the lack of any prior knowledge about these metals. Investigation of many of the more complicated or obscure alloy systems are very sketchy and incomplete.

There are two major applications for this equipment that are immediately suggested. One of these, of course, is the study of alloy systems heretofore unexplored. Because of its sensitivity, there is good reason to feel that profitable and extensive investigation of ternary and higher order alloy systems might be accomplished with the emissivity method of determining transformation temperatures. The apparatus is simple to operate, once set up, and is fairly rapid. There is one notable limitation, however, on the range over which it may be employed. Since the emissivity is obtained from optical pyrometer data, it is only applicable in temperature ranges where the metal will radiate visible energy.

The second application may prove equally as valuable as the first. The transformation temperatures of pure iron are well established, and they happen to lie in the most common operating range of the usual pyrometer. Therefore, a pure iron element, sealed in a vacuum tube, could be used as a calibration standard for optical pyrometers. The accompanying figure will help to illustrate how this may be carried out. Let $\triangle I$ be equal to Ih-Is, where Ih is the pyrometer current when it is sighted on the hole, and Is is the current through the pyrometer when it is sighted on the surface of the cylinder. Plotting $\triangle I$ against Ih results in the curve shown above. The break in the curve represents the A^4 point of pure iron, which occurs at 1404°C. The temperature difference equivalent to the current difference between the points at the break is only 1.5°C., or 0.107% of the temperature at which the break occurs.

Since the present standard, against which pyrometers are calibrated, is a rather complicated and delicate piece of apparatus, the emissivity equipment possesses several distinct advantages over it. It is much easier to use, and once set up, it becomes a semi-permanent instrument subject to occasional checks. Furthermore, it provides calibration points in the range over which the pyrometer will ordinarily be used. The gold point, now used, furnishes only one point for calibration, and this is on the low side of the range: 1063°C. With a set of emissivity standards, calibrations may be obtained over a greater portion of the operating range of the pyrometer.

The sensitivity and possible applications of this equipment promise to make it a very valuable tool in subsequent metallurgical research.

The author wishes to thank Dr. Wahlin for his cooperation in supplying information about his method, and copies of the graphs used in this article.

POLYGON FINANCIAL REPORT

Balance, February 27, 1948			$ 780.00
Dance Income	$892.62		
Dance Expenses	636.17		
Dance Profit		$256.45	
St. Pat Buttons Income	$635.75		
St. Pat Buttons Expense	315.64		
		$320.11	
Total Profit		$576.56	$ 576.56
			$1,356.56
Division of Profits:			
The Mining Club	$ 72.36		
AICE	66.60		
AIChE	60.12		
ASME & SAE	40.92		
AIEE	120.00		
		$360.00	
Miscellaneous Expense		7.00	
		$367.00	$ 367.00
Cash on Hand, April 12, 1948			$ 989.56

Adviser—Kenneth G. Shiels *Treasurer—Arnold D. Arnaut*

CORRECTION

In the article "Miniature Ball Bearings" in the March 1948 issue of the Wisconsin Engineer some additional information is necessary to avoid misinterpretation of the text.

It should have been pointed out that Miniature Precision Bearings, Inc., were the originators of miniature ball bearings over twenty years ago and that the manufacturing processes described in the article were developed by this firm. New Hampshire Ball Bearings, Inc., did not enter the field until two years ago and hence could not have participated in the war program, as inferred in the article. The smallest bearing, 2 MM o.d., is made by Miniature Precision Bearings while the smallest offered by New Hampshire Ball Bearings is 5/32" o.d.

R. J. M.

Hot Air Engines . . .

(*continued from page* 36)

inders at the top and cold parts at the bottom. Cylinders are connected with the cooler, regenerator, and heater joined between them in that order when going from the bottom of one to the top of the next.

The pistons again act with a 90-degree phase difference, therefore on a four cylinder engine, when piston 1 is at top dead center, piston 2 is descending and delivering power, piston 3 is at bottom dead center, and piston 4 is rising and compressing air. In reversing the rotation of such an engine auxiliary connections would be made, reversing the order of units so that now the top parts of the cylinders would be the cold parts and the lower parts the hot parts. An experimental engine has been built with the four pistons set in a square, that is the centerlines parallel to each other equidistant from each other. Instead of using the conventional crank and connecting rod the pistons drive plungers which act against an inclined plate mounted on the shaft, called a swash plate, that drives the shaft. This, however, is not a new idea, but has been employed before on internal combustion engines.

Advantages for the hot air engine should have already been realized from the description. Valves, camshafts, and other controlling moving parts have been eliminated, giving less moving parts. Corrosion has been nearly eliminated since the fuel is burned externally and can more easily be controlled, temperatures are lower, and the working gas inside is only air. Since combustion is external it can easily be adapted to any convenient fuel, gasoline, oil, gas, wood alcohol—almost anything that will burn. The manner of obtaining power, by smooth strokes, free from explosions such as occur in the gasoline and diesel engines, has made the engine a quiet operating unit, free from a majority of the vibrations found in such engines. The noise made by a 15 HP engine has been compared to that of a sewing machine. The efficiency at present lies between that of the diesel engine and the gasoline engine, but research and experiment is expected to better that of the diesel.

What, then, is the future of the hot air engine? The research men working with this new engine see its use in automobiles in the near future. Its advantage in home electric generating plants can easily be seen in its quiet operation. Although at present successful engines are small, larger units are anticipated and consequently larger scale power production and applications may eventually be experienced. Compared to the progress made in other engines, the hot air engine has made very rapid strides although it has, no doubt, benefited from the research done in other fields. This engine, employing a principle long set aside, will compete with those already in the field, providing initial costs and service costs can be met.

S-T-A-T-I-C . . . *(continued from page 22)*

Dope: "We're going to give the bride a shower."
Dopey: "Count me in, I'll bring the soap."

* * *

Get out of the barn Grandma you're too old to be horsing around.

* * *

ODE TO MY HAIR LINE

By Slip Stick

Women are babbling all the time,
Of dates and drinks and dresses,
Which wouldn't help at all when I'm
Computing strains and stresses.
My slip-stick conquers without a doubt
Whole hosts of sines and surds,
And helps me work in peace without
An avalanche of words.

Slide-rules are always accurate,
Women never so;
And though they're not affectionate,
They never answer, "No!"
So hence with women's wanton ways,
With eyebrows, lips and curls,
My little log-log polyphase
Is worth a dozen girls.

Ed. Note: ????

'SAILS' ENGINEERING . . .

(*continued from page 7*)

observed at the leading edge of the main, as the air flows forward to enter the stream between the jib and the mast.

This flow of air is what might be expected as it is according to Bernoulli's theorem. The air mass is made to increase its velocity in passing through the opening between the jib and the mast. The increased velocity creates a negative apparent pressure on the lee side, which further increases the velocity of the air passing between the mast and the jib. The forces resolve themselves into forward motion of the boat and that old exhilarator "heel."

The fact that air moves off the trailing edge in the plane of the sail indicates that there is no vacuum present on the leeward side in this area.

A sailor can understand, then, why the jib must be set so carefully with relation to the mainsail. Should he set his jib too close to the mast, the vacuum will be destroyed with a possible positive pressure being developed on the lee side. If it is not set close enough to the mast, the acceleration given to the air to create the vacuum will not be fully utilized.

To the occupant of the boat, the apparent wind-direction will be very different from the actual. This is due to the resolution of the actual motion of the boat and the actual motion of the wind. Once the boat is in motion, it is this apparent wind that will apply force to the mast. This is depicted in the accompanying diagrams.

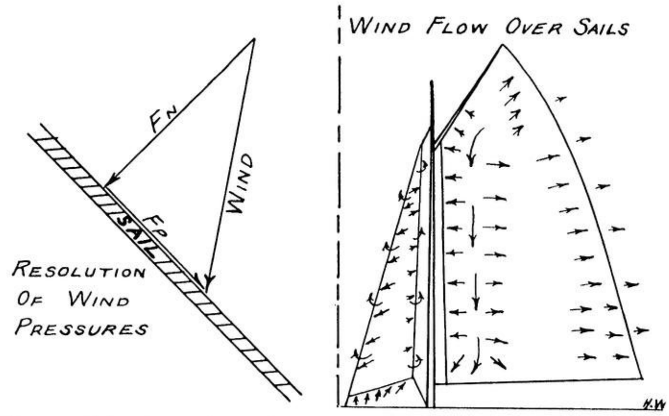


Fig. 2 Direction of air flow over sails is quite surprising. Flow data was taken with a telltale. (Originally appeared in the Cornell Engineer).

In choosing a rig for the vessel, it should be observed that the Marconi-rig is better suited to close-hauling or sailing into the wind. It is also true that the gaff-rig is more desirable if the wind is abeam. It develops more pressure, and consequently more speed.

Aerodynamical studies have been carried out on more than the sails. The most striking development to be executed as a result of these other studies is the streamlined aluminum mast. In passing between the mast and the jib, as mentioned earlier, the air is given a turbulence which decreases the pressure drop on the lee side of the sail. The sail itself is fitted into a long slot running up the trailing edge of the mast, and the halyard is run through

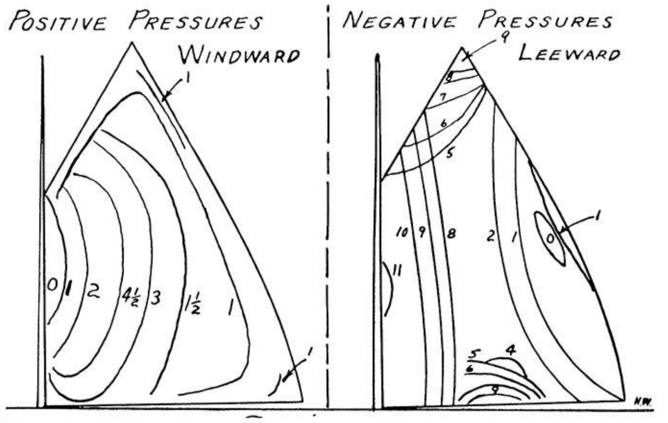
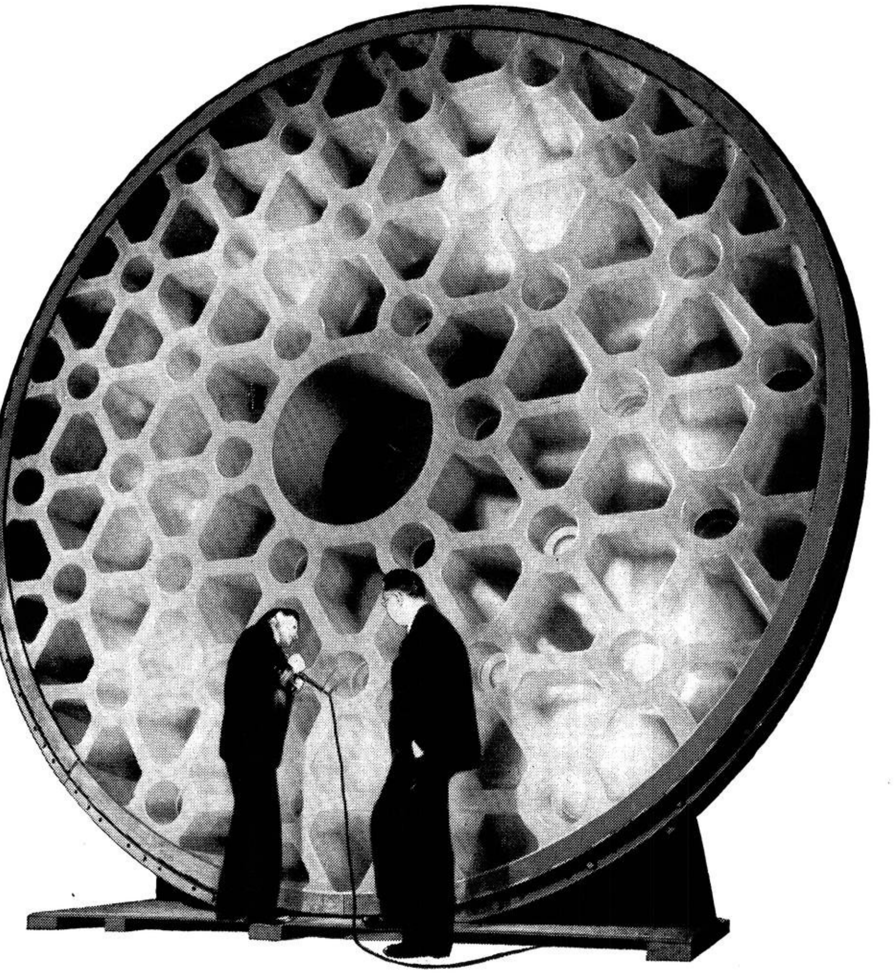


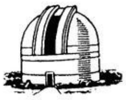
Fig. 3 Note that negative pressures or vacuum to leeward are greater than positive pressures to windward. (Originally appeared in the Cornell Engineer).

the hollow interior. A typical example of this mast is made of 61 S-T aluminum and is corrosion resistant. The only finishing operations necessary include burnishing with steel-wool and waxing. These masts are not as heavy as hollow wooden masts and are not as expensive.

It is understood that this cannot be a complete treatise on the art of sailing, but it is felt that an understanding of the basic principles set forth herein will increase the pleasure which the beginner will derive through pursuit of this old sport.

THE EYE THAT SEES
6,000,000,000,000,000,000,000 MILES





Tomorrow a new door to the secrets of the universe will begin to open. A door through which astronomers will be able to see 6,000,000,000,000,000,000,000 miles into space—twice as far as ever before. It is the giant telescope atop Mt. Palomar, so powerful that the canals of Mars, if there are any, will for the first time be photographed.

It all began 12 years ago when Corning cast the glass for the famous 200" telescope mirror—the world's largest piece of glass—after most experts said it couldn't be done.

For this big disc Corning scientists developed a special glass—the only practical material that would insure the permanence, stability and accuracy demanded by the telescope's designers. This glass is similar to that used for Pyrex ware and Pyrex industrial glass piping. Making the disc was a job Corning took in its stride, because it is accustomed to finding practical solutions to all kinds of glass problems. Its research laboratory has contributed to the development of more than 37,000 different items, ranging from simple custard cups to television bulbs, laboratory ware, optical glass, and Steuben artware.

If Corning has a specialty, it is the ability of its skilled engineers and craftsmen to translate research into glassware to solve modern problems. With labor and raw material costs constantly on the rise, glass may some day help you keep down the cost of your product.

Or glass may help you make your future product easier to sell. In either case, remember to write Corning Glass Works, Corning, New York.

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CORNING
means
Research in Glass

Prof. Kinne

(*continued from page* 16, *col.* 1)

DeLeuw Cather and Company of Chicago. His daughter is Mrs. Fred Balsey.

Professor Kinne himself is a descendant of two old American families, the Spauldings and the Kinnes, the Kinnes having come to settle in Massachusetts in 1630.

He has contributed his share to make engineering education more complete in his forty years of service as a faculty member at the University. The **Structural Engineer's Handbook** in six volumes by Hool and Kinne is internationally known. And **Modern Frame Structures** was rewritten in three volumes by Dean Turneare who was aided by Professor Kinne.

To indicate how much influence a single event might have in the life of a person, Professor Kinne tells how in his freshman year in high school he was a very mediocre student and not too happy. Immediately following a semester with a harsh teacher, he found inspiration in another whom he said showed so much faith he felt he could not disappoint her.

Her faith apparently has been a strong influence in directing his attitudes so that he has always sought to improve his teaching techniques even in this last year before retirement.

Prof. Kowalke

(*continued from page* 16, *col.* 2)

have done in such instance?" he would ask.

His textbook, **Fundamentals and Chemical Process Calculations,** is one every student remembers for its clarity and directness. Using it a student can grasp the thought easily and grow in his own ability to solve technical problems.

There has been another influence of teaching in the Kowalke household for Winifred Titus was an instructor at Milwaukee Downer before becoming Mrs. Kowalke in 1910. She also went to the University of Wisconsin and holds a master's degree.

Professor Kowalke's outside interests include reading and a hobby in photography. He plays a little handball and a little tennis although he has had to give up playing singles with the fastest of players. Some of the summer students in chemical engineering may have played him on the courts.

The cottage at Ellison Bay in Door County has been his retreat summers "off and on for a number of years."

A whimsical note is found in the Badger for 1907, the year he graduated. It says, "Behind a frowning countenance he hides a shining face." Many a student has found that he never was too sure of Professor Kowalke. But then when he needed a little help or advice, he thought, for some reason that he might go to him with the problem and he might get a thoughtful answer. Those who ventured have found him a real friend.

Mesabi Miracle . . .

(*continued from page* 28)

necessary before it will be commercially available.

Bethlehem, the leading U. S. importer of ore, has spent millions of dollars to open up and develop an unusually high grade deposit in Venezuela. It is expected to have a two million ton annual output. The development of this mine, and the problems which have arisen are typical of foreign developments:

The ore fields of El Pao, are located in almost entirely undeveloped tropical jungle, 30 miles from the Orinoco river. The ore must be transported from the mines to the river port town, and thence to river boats, or barges. It must then travel some 165 miles down the Orinoco to a tide water port, for reloading into ocean going vessels.

The development has required railroads, highways, communication systems, port facilities, and complete villages, but the richness of the deposits warrants the expense. Bethlehem also has foreign mines in Chile, Cuba, Mexico, some of which have been under operation, others yet to be developed.

In keeping with its foreign developments, is Bethlehem's new Sparrow's Point plant in Maryland. Having an annual capacity of over 4 million tons, it occupies a key position as foreign ore developments continue to expand. As the Mesabi supply dwindles other companies may be forced to follow Bethlehem's example.

Numerous other deposits of varying richness exist throughout the hemisphere. The leading disadvantage in their development, of course, is that old bugaboo of cost.

It is not unlikely that additional pressure will be put to bear on a St. Lawrence waterway, as this would enable direct unloading from ships in the Great Lakes. This would indeed make stiff competition for Mesabi, making Labrador and even high grade Swedish deposits commercially available.

Theoretically, New York, Pennsylvania, New Jersey and other commercial ore producing eastern states could replace the Superior District, as suppliers of the midland steel mills. But the investment required to increase the 5 per cent of the nation's ore they now produce by Superior's 85 per cent of the national total would obviously be enormous. Equally obviously, it will not be made. If and when the Superior supply dwindles, the midland mills will draw more and more heavily on foreign ores, chiefly the great deposits in Canada and Latin America.

But, for the reasons mentioned on the last few pages, arbitrary taxation, discriminatory laws, possible confiscation, stoppage by war—no steel company wants to risk its existence on foreign supplies. And, even if steel companies were willing, the nation could not afford to let them thus sign away the nation's independence. Especially, when that sacrifice is wholly unnecessary. For the mighty Mesabi, which has served perhaps more than any other single physical asset to make the U. S. strong, can maintain that strength for decades to come if its still rich physical resources are matched—with sufficient human resources of foresight and daring.

How ELECTROMET Serves the Steel Industry

IN addition to providing a full line of high-quality ferro-alloys and alloying metals, Electro Metallurgical Company serves steelmakers in other important ways:

Field Metallurgists — You can obtain the help of our trained metallurgists who render on-the-job assistance in the use of ferro-alloys. These men are qualified to suggest the grades and sizes of alloys best suited for your particular steel and practice.

Laboratory Research— You can benefit by the new alloys developed by our continuous laboratory research. Developments from this research include the low-carbon ferro-alloys, silicomanganese, SILCAZ alloy, calcium metal, calcium-silicon, and ferrocolumbium.

Experience—Our store of information about ferro-alloys and their use, based on over 40 years' experience in producing them, is available to the steel industry.

Technical Booklets—You will find helpful information about ferro-alloys and metals in ELECTROMET'S free technical booklets and reprints. Among these are "ELECTROMET Products and Service" and "ELECTROMET Ferro-Alloys and Metals." Write to our Technical Service Department to obtain copies of these booklets.

Convenient Stocks — You can count on prompt deliveries of ferro-alloys from ELECTROMET, since our offices, plants, and warehouses are conveniently located to insure efficient service.

ELECTROMET Ferro-Alloys and Metals

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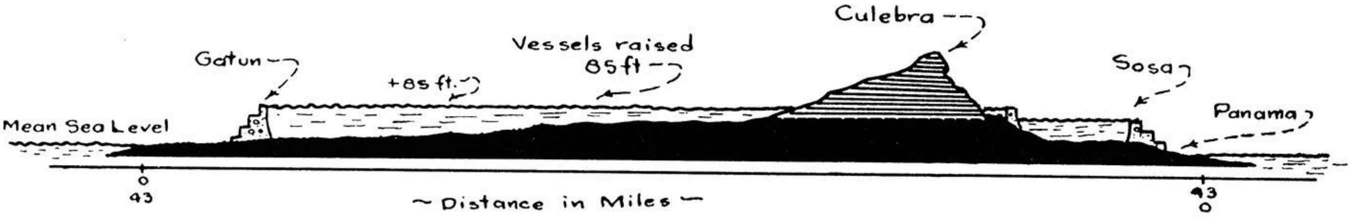
. . Sea-Level Panama Canal

(continued from page 15)



PANAMA CANAL - SEA-LEVEL PROJECT

Completed Excavation ▤ Proposed Excavation ■

Panama Canal into a sea-level waterway whose chief value would lie in the near-indestructibility of the virtually structureless project. No other site offers advantages comparable with those of the Canal Zone for either a lock or a sea-level canal. Colonel Stratton, of the Corps of Engineers, reading a paper at the annual ASCE meeting, asserted that "A sea-level canal at Panama constructed by the conversion of the existing lock canal could not be destroyed by the enemy. Only the atomic bomb could cause significant interruption in service, and then for not more than a few weeks. Navigation would be practicable in the sea-level canal even though tidal currents were not regulated. Tidal regulation would be provided for greater safety to shipping, by means of a tidal lock and a navigable pass, (See illustration), the latter allowing the utilization of the Canal as an open waterway as a matter of routine daily operation. In the event of damage to the tidal-regulating structures, the gates of the pass could be quickly removed and the canal operated as an open waterway."

He also asserted that, **"It is clear, now, that the lock structure could not have withstood Japanese bombing had an attack been made and the defenses penetrated. A single attack would suffice to destroy the lock gates and drain Gatun Lake to the sea."** He also warned that by 1960, the capacity of the Canal will be inadequate to accommodate traffic without undesirable delays on peak days unless additional capacity is provided. **The Canal has actually operated to restrict the design of Navy ships.** Breaching of the modernized locks could be effected by a determined enemy and the canal knocked out of use for periods up to four years. The extent of damage and the length of the period of traffic interruption would depend on the nature of the weapon employed and the intensity of the attack. Radioactive contamination would make repairs to the locks difficult if not impossible in the event of an atom bomb attack. The lock type of canal, no matter how strongly constructed, would not increase security to meet the needs of national defense.

A hydraulic model of the sea-level canal has been studied, and it has been estimated that a current of about 4.5 knots at the Atlantic end of the canal is the maximum that would be caused in an open sea-level canal by a tidal range of 20 feet in the Pacific Ocean, as against 2 feet in the Atlantic. Tributary areas to the waterway would have 87% of their water diverted to the Atlantic Ocean, with the reduction in danger of peak floods discharging their flow directly into the channel, and the resultant creation of cross-currents. Danger from slides, which have occurred as late as 1931, closing the Canal to traffic, can be minimized by modern engineering methods in the proposed conversion of the present canal. Although more than one billion cubic yards of excavation will be required . . . about three times the volume of material removed in construction of the existing canal . . . slopes can be designed that would be secure from major slides when exposed to the dynamic effects of a bomb explosion.

COST OF MODIFICATION

The project would cost an estimated 2.483 billion dollars. Details in the accompanying sketch illustrate the proposed additional cuts necessary. The present canal was constructed with one gigantic cut through the "Culebra" portion of the Isthmus, and various smaller cuts. The proposed canal would involve removal of all the earth represented by the bottom shaded portion of the cross-section. It is estimated that the canal conversion project would require removal of over 1.070 billion cubic yards of material, with approximately 750 million cubic yards removed dry, and the remainder dredged. The conversion in a single stage by deep dredging has been recommended because it would be cheaper, requiring a shorter construction period, and would interfere less with the canal traffic. Large shovels or draglines of 25 cubic yard capacity would be used. Wet excavation would be performed by conventional dredges supplemented by special hydraulic bucket-ladder dredges capable of dredging to a depth of 145 feet below water surface, deeper than any ever known to have been operated. Net savings of the deep-dredging plan over stage dredging are estimated at over 130 million dollars.

It is of interest to note that the ten year project, as it was outlined in a series of papers given at the annual ASCE meeting, was the original one suggested in 1906, and adopted by the majority of the engineers on the commission which studied the project.