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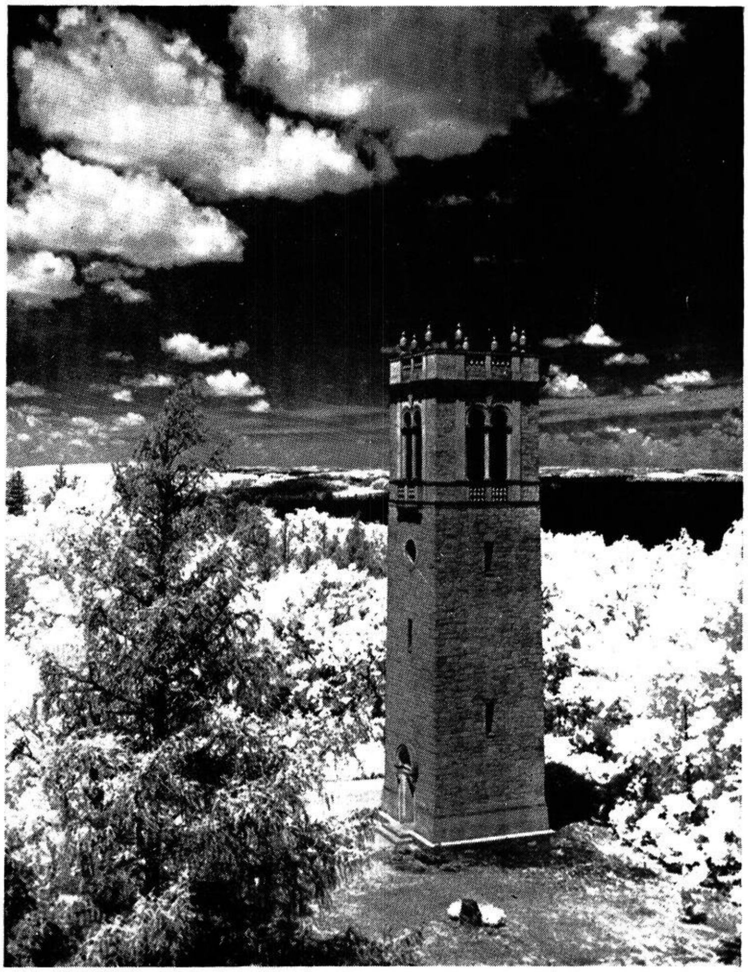
THE WISCONSIN ENGINEER

IN THIS ISSUE . .

Hydrogenation of Coal

Measuring Small Currents

Steel Surfacing



DECEMBER 1936

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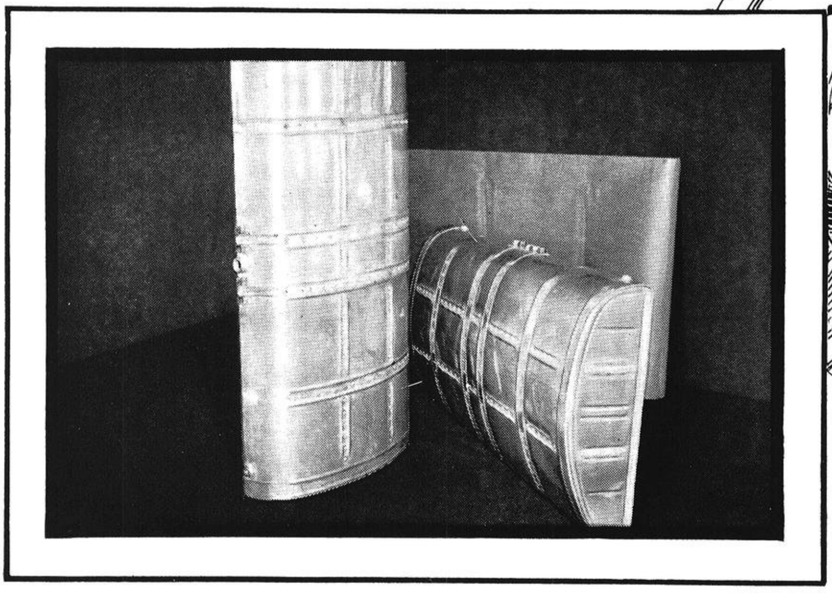

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Winter Scene

WITH THE CONTRIBUTORS . . .

- Did you ever think of using coal to replenish our dwindling oil supply? Read how it is possible on page 43.
- 10^{-14} amperes—pretty small! But it can be measured. See page 46.
- Corrosion annually costs us millions. On page 54 several means of preventing it and improving the surface of steel are described. It's interesting.
- On page 45 we bring you a new feature, short biographies of prominent engineers. Don't miss it.
- The front cover this month is a picture of the bell tower taken from Bascom Hall last June by Ira J. Kaplan. Its exceptional interest lies in the fact that it was taken on film sensitive to infra-red rays. These waves lie just below the visible spectrum and above the radio waves and ordinary camera film is not sensitive to them.

The parts of the picture which appear snow white are caused by the reflection of the infra-red rays by the chlorophyll in the leaves of the trees.

Notice Picnic Point in the background which is visible in spite of the cloud bank shading it.

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Volume 41 **DECEMBER, 1936** **Number 3**

CONTENTS

READY!

Hydrogenation of Coal

by LEO A. HERNING, ch'38

Illustrations Courtesy Chemical and Metallurgical Engineering

TODAY in a complex world a nation's wealth is almost as dependent on its coal supply as its gold reserve. In an age of chemistry and chemical progress coal becomes the base of an increasing number of important products. Dyes, perfumes, sugar, as well as sources of power and heat put coal at the top of a nation's needs. At the present time, through a recent discovery, this is more true than ever before. A new process by which coal can be converted into liquid gasoline and oil was conceived of in the minds of chemists early in the 20th century. This dream became an actuality and now makes coal rank first in the needs of any nation that is to survive. Luckily, coal is one of the substances bountifully distributed throughout the world so that every nation has access to a supply of it.

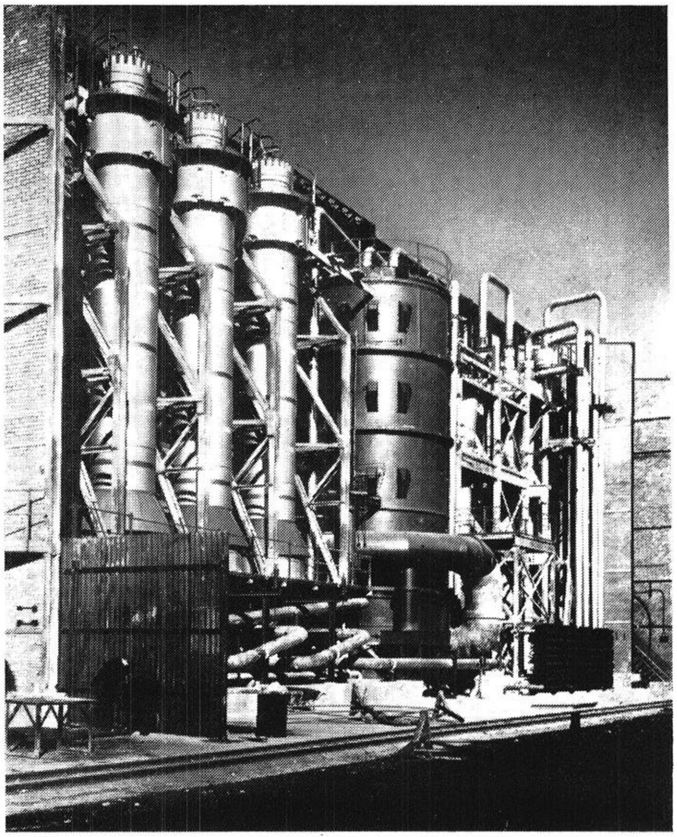
Oil has recently become a rival of coal for heating and steam raising and has opened up new fields through the internal combustion engine. Thus the possibility of converting coal into oil has become of supreme importance to the countries which have no natural petroleum. While all nations have supplies of coal, oil is an entirely different matter. Almost all European countries import oil from the United States and other sources. Great nations like England, France, Germany, and Italy have no natural petroleum from which oil and gasoline can be derived. Therefore it is obvious that these nations would strive to find some means to make themselves independent of a hostile world.

Germany, England, France, Russia, Hungary, and the United States have hydrogenation plants in operation today while plants are under consideration in Switzerland, South America, Australia, and Japan. The greatest commercial output of gasoline and oil from coal is in England and Germany. When plants now being constructed are completed Germany will be able to produce 750,000 tons of high grade gasoline a year from their native brown coal. England can produce 150,000 tons a year at their Billingham plant from bituminous coal.

The essential feature of a hydrogenation process is that gaseous hydrogen is supplied from some external source to make good deficiencies in feed stock. Thus production of coke is avoided and high yields of light spirits can be obtained. Petrol or gasoline so obtained is free from a tendency toward gum formation and its volatility, antiknock, etc., can be controlled within wide limits. Hydrogenation may be thought of as an ally rather than a rival of the cracking process in countries which have supplies of natural petroleum. Hydrogenation provides an effective means of converting creosote, low temperature tar, etc., into standard fuel oil or gasoline. In countries which have natural petroleum, like the United States and Russia, hydrogenation is used only in this capacity and not with solid coal to any extent at all.

Gasoline contains 85% carbon and 15% hydrogen, while coal has 85 parts carbon to approximately five parts of associated hydrogen. Detailed scientific investigation on the formation of coal resulted in a conception of its chemical structure. It was therefore conceivable that under certain conditions one could transform coal by the addition of hydrogen into compounds of lower molecular weight and a relatively high hydrogen content. Such substances would be closely related to the hydrocarbons contained in crude oil. The invention of the hydrogenation of coal was purely the result of scientific research and not the result of any planned idea on a national scale.

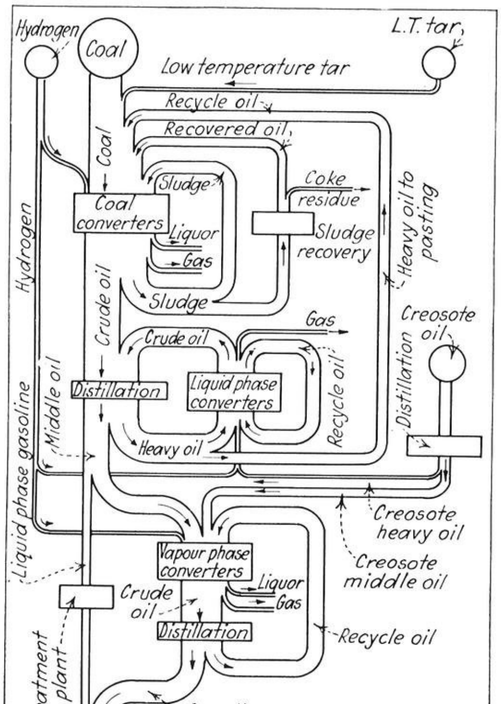
Dr. Bergius was one of the first workers in the field of coal liquefaction. He was the first to actually show that coal could be liquified at temperatures between 400-500°C. under high pressure. Soon after the World war Germany became interested in what was known as the Bergius process. They commenced work on the problem of turning out the laboratory work on a commercial scale. They erected a large plant in 1927 for which they had developed successful catalysts to make the reaction proceed commercially. They found that an increase in temperature accelerates hydrogenation, but too high a tempera-



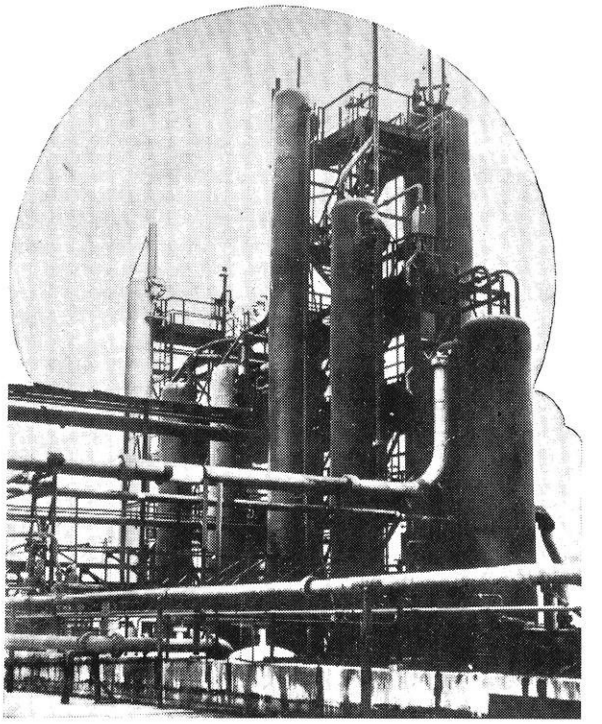
Hydrogenation unit with three converters at the left and, at the right, catch pot and heat exchangers ture results in a reduction of the maximum degree of hydrogenation. An increase of pressure results in increased conversion of coal to liquid products and a decrease in the rate of deterioration of the catalyst. Therefore as high a pressure as is commercially feasible to use was used. Among various catalysts used were molybidic oxide and a mixture of iron and chromium oxides. Tetrahydronaphthalene was quite an effective catalyst because of its action as a hydrogen carrier.

Perhaps a description of the building and operation of one of the most modern plants in the world will give a true perspective of the process of hydrogenation. The Billingham plant in England was the first in the world to actually commercially hydrogenate bituminous coal:

Raw coal is cleaned to less than 2½% ash. It is then ground into a powder and mixed with heavy oil and a small amount of the desired catalyst to make a 50% coal in oil paste. The heavy oil was previously made in the process. This mixture is injected against working pressures of 250 atmospheres (3700 pounds per square inch) and mixed with hydrogen. The mixture is heated to a reaction temperature and liquefaction of coal takes place at 450° C. (850° F.) and 250 atmospheres pressure. A small heavy oil fraction containing unconverted coal and ash (about 5% by weight) is treated for oil recovery, and the unconverted residue used as a fuel. A major part of the coal is transformed into lighter oils which are vaporized and are recovered on cooling the gaseous products which leave the converters. The crude oil so obtained is distilled into heavy oil, middle oil, and petrol (gasoline). The heavy oil is further hydrogenated to give middle oil and gasoline. The middle oil is then further hydrogenated in vapor phase converters in which the vaporized light oil and hydrogen are passed over a solid catalyst. The crude vapor phase product is distilled, the residual middle oil being separated from petrol and treated again. Thus the original coal is transformed into a small solid consumable residue, gas, and petrol. Once started, the system can be run continuously using only water and coal as materials.



Flow diagram of three-stage hydrogenation process



Distillation equipment for fractionating hydrogenated products

Hydrogen for use in the coal hydrogenation is made by the action of hot steam on coal.

$$C + H_2O \longrightarrow CO + H_2$$

The gas so formed is treated by what is known as the bog iron ore process. This process removes sulphur in form of H_2S. Twenty boxes, each made of electrically welded mild steel, 35x35x23 feet, are filled with iron ore by means of an overhead crane of seven ton capacity. From the sulphur removal plant the gases pass to the hydrogen plant where they undergo a high temperature catalytic process for the conversion of the CO to hydrogen at the expense of steam.

$$CO + H_2O \xrightarrow{\text{CATALYST}} CO + H_2$$

The gas is compressed in stages to a pressure of 825 pounds per square inch. Water is then injected against the gas pressure by turbo-driven pumps each of 1000 h.p. capacity. The water is finally reduced to atmospheric pressure by Pelton wheels which recover a large portion of available energy in the form of electric power. This washing removes most of the CO_2. The gas is then compressed to 3,750 pounds per square inch. After compression the last traces of CO and CO_2 are removed by scrubbing the gases with a special solution of cuprous ammonium salts. The gas is now passed into the mains ready for use.

Again the dream of an engineer who had the courage to carry through his convictions has become of world importance. Today the world needs more engineers who will do what they believe in the face of odds to make the world a better place to live in.

ENGINEERS In the News—

Athlete:

EDWARD G. CHRISTIANSON

When Ed graduates from the university this spring he plans to try his hand at gold mining. He will head for Dillon, Montana, to seek adventure in a newly discovered gold field. A self-styled adventurer, gold bug, mining engineer is this man Christianson who leaves behind a colorful career. A six letter man, having played three years of varsity football and this spring will be his third season of intercollegiate track. Ed heaves the shotput and hung up a second place for himself during the Big Ten meet when he was only a sophomore. However, his greatest laurels have been won on the gridiron. Declared the most valuable tackle to the team, Ed has offered the stiffest opposition to all of his opponents. It was during the Illinois game of the 1934 season that he had the most fun playing.

CHRISTIANSON

Ed was born twenty years ago in Chicago. He attended Wisconsin high school, where he was constantly in contact with athletics. He has lived to realize an ambition that was formulated when he was in the seventh grade—an ambition to make the varsity squad.

He is affiliated with the student mining club. His record as a student is one of the best. He likes the engineering school because "things are put across to you." Ed would like to see the engineering courses broadened to include more cultural subjects. He claims good engineers don't have time to think about the lawyers.

Active in all walks of life, Ed has not neglected the social world. He is an active member of Sigma Chi and has done much to hold up their traditions.

Flyer:

FELIX WAITKUS

First-Lieut. Felix Waitkus—U. S. Army Air Corps—made the sixth successful solo flight of the Atlantic . . . two thousand flying hours to his credit. First year of preparatory work in the mechanical engineering school . . . M.I.T. or New York University will graduate Felix as a designing engineer . . . has received highest award the Lithuanian government can bestow . . . comparable to the Distinguished Service medal of the United States government . . . stamps of that country have commemorated his epic flight . . . turned down offer of assistant chief of the air corps for two European nations . . . has conferred with more dignitaries in one month than most government officials meet in a lifetime.

WAITKUS

Born in Chicago, twenty-six years ago . . . spent his early days dreaming . . . not of model airplanes or of an engineering career, but of athletics . . . spent three years at the University of Chicago in the commerce school . . . then the flying bug bit . . . Felix packed his bags and entrained for Kelly field in Texas . . . after twelve hours of flying instruction he soloed . . . against government regulations. Transferred to Selfridge field in Detroit and two eventful years in aircraft training before fate planted him in Kohler, Wisconsin, the first step in his trans-Atlantic flight.

First conceived the idea in the spring of 1933 . . . began preparation in June, 1934 . . . Lockheed Vega plane with a Wasp 560 h.p. motor was chosen . . . special fuel tanks to carry 760 gallons of fuel were installed . . . all the instruments necessary for blind flying were installed . . . luckily, too, for Felix flew across the "pond" without having once caught sight of it . . . Customary raft and all life-saving equipment were stored . . . navigation accomplished by radio directional finder and dead reckoning . . . only a compass and a straight line map of the Great Circle route were necessary to plot the course.

Then four months of tedious waiting for favorable weather conditions . . . the start—4:00 a.m.—September 6, 1935 . . . the 8,000-pound Lithuania II rose from Floyd Bennett airport, New York . . . followed the trail blazed by Lindbergh, eight years earlier . . . saw the American continent for the last time at Kings, Nova Scotia . . . ran into bad weather just before leaving the coast . . . twice forced down from 15,000 feet by ice formation . . . engulfed in storm during the entire crossing . . . Altonole, Ireland, commercial station acted as the directional sender . . . perfect communication was maintained at all times . . . finally beaten by fog and failing fuel supply . . . forced down in a field at Balleinrobe, County Mayo, in Ireland . . . proceeded to the Lithuanian capital, Kaunas, by train . . . cordially received by the president . . . national holiday was declared . . . two and one-half months spent in Europe . . . then home to a welcome in New York City.

Seeing the futility of attempting commercial flying, Felix decided on aircraft designing. Carrying a full schedule in the engineering school he finds time to engage in a host of other activities. His correspondence course in the commerce school will bestow a Ph.B. on him before he receives his B.S. in aeronautical engineering.

Measuring Small Currents

by **FREDERICK A. MAXFIELD,**

Instructor in Electrical Engineering

IT OFTEN happens that an engineer or physicist in seeking the solution of a particular problem by experimental means is hindered by an inability to measure with ordinary apparatus some very small electric current or quantity of electric charge. This problem arises when one tries to evaluate very large resistances or very small electric condensers, or when one tries to measure very small photoelectric currents or the charge liberated by the passage through a gas of a single particle produced by the spontaneous disintegration of such substances as uranium or radium (alpha particles).

Up to a few years ago, the apparatus available for such measurements was very inadequate. It is true that there were several pieces of apparatus that were considered ultra sensitive, but there was none that could be called satisfactory for comparing the intensity of light from distant or faint stars, or determining the charge liberated by the passage of a single alpha particle through air. In the first case, the star intensities could be compared by using a photoelectric tube, if the small current produced in the tube by the star light could be measured. And in the second, the charge could be collected by having the ray pass between a pair of plates maintained at a difference of potential. But in neither case could the small charge or current be measured satisfactorily with existing equipment.

It was natural that physicists and engineers should turn to radio technique to furnish better measuring devices. Not only are electronic tubes extremely sensitive to small effects, but through them it is possible to amplify these small effects to any degree whatever and broadcast them to the nation if it is desirable.

In picking the proper type of electronic tubes to use for these measurements, one must bear in mind that the very small amount of power available to actuate an amplifier may appear at a moderate current and a very small voltage, or it my appear at a moderate voltage and a very small current. To meet this situation, there are now two general types of amplifier tube available. One satisfying the first condition is a voltage amplifier; the other is a current amplifier. Quite different conditions must be fulfilled in the proper design of these tubes. In the design of the "low noise" voltage amplifiers, such as the PJ 11 or RJ 544, the grid current is relatively unimportant, but uncontrolled fluctuations in grid potential are important. Consequently relatively low grid resistances are used, and fluctuations in electron emission from the cathode are reduced to a minimum. In a proper circuit, it is possible to use these tubes to amplify potentials of less than 10^{-5} volts, the grid fluctuations being kept to less than 1×10^{-6} volts.

On the other hand, if it is desired to measure a photoelectric current of 10^{-14} amperes, the only way that this small current could be made to produce an appreciable change in grid potential in a circuit such as shown in Fig. 2 or Fig. 3 is by using a very large grid resistance, R_2, of the order of 10^{12} ohms. This would produce a voltage drop of .010 volts. For this purpose, then, one would like an amplifier with a very small grid current, otherwise the available charge will be simply side-tracked from the high external grid resistance through which it ought to flow. Besides this the grid current must be small so that small fluctuations in it will not mask the small currents that are to be measured. Slight variations in grid potential caused by irregularities in filament emmision are of little importance since the potentials applied to the grid are relatively large.

These two classes of application lead to tubes of quite different design. Only the low grid current tube or electrometer tube will be considered in detail. Let us first discuss the unavoidable sources of grid current, since they are the most important factors in determining the design of these tubes.[1] Later the means that various manufacturers used to meet the specifications imposed will be dis-

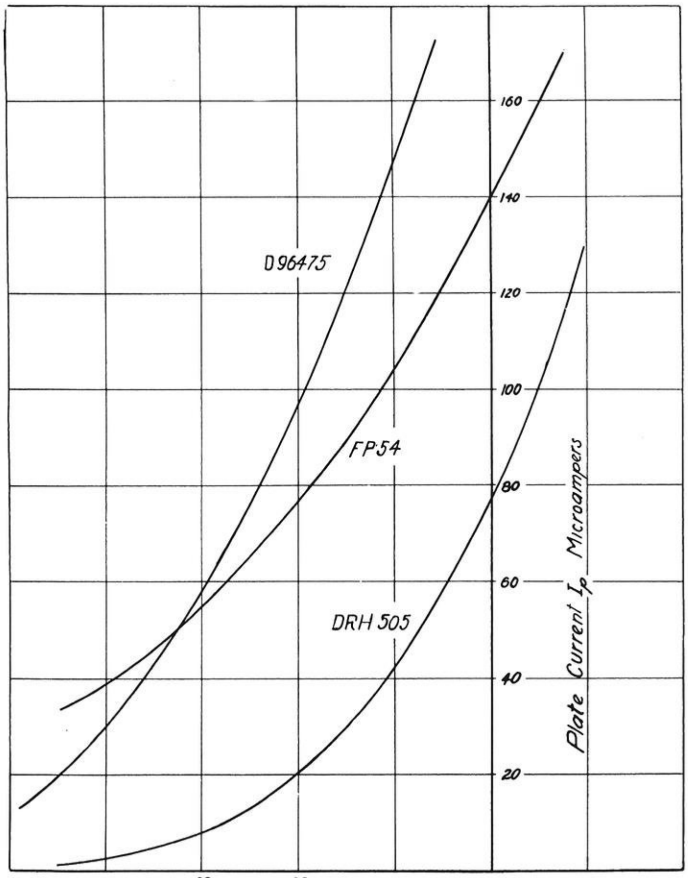


FIG. 1

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[1] G. F. Metcalf and B. J. Thompson, Phy. Rev., vol. 36, p. 1489, 1930.

cussed, as well as typical circuits employing electrometer tubes.

The sources of grid current even when the grid is sufficiently negative to repel all electrons coming up to it can be conveniently divided into six classes.

1. Insulation leakage, or leakage of current over the glass of the tube. This may be approximately 10^{-16} or 10^{-17} amperes under usual operating conditions.

2. Positive ions formed in the residual gas of the tube. Free electrons in the tube may acquire enough energy to ionize anv gas in the tube. (A perfect vacuum is impossible.) The positive ions so formed are attracted to the negative grid by their electric charge, and constitute the greatest part of the current to the grid.

3. Thermionic emission from the grid if it gets hot. This represents a loss of negative charge from the grid and constitutes a current.

4. Positive ions from the filament. A thermionic cathode may emit positive ions as well as electrons. In a practical case this may be as large as 10^{-11} amperes. The positive ions are attracted to the grid and produce a current in the same way as positive ions formed in the residual gas.

5. Photoelectrons emitted from the control grid, caused by light from the filament. Just as in the case of thermionic emission, photoelectric emission from the grid constitutes a current. In the case of the light from a pure tungsten filament, this may reach 10^{-12} amperes. The light from a thoriated filament may produce no more than 10^{-15} amperes and the light from an oxide coated filament even less. This follows since the latter two filaments need not be operated at as high temperatures as pure tungsten.

6. Photoelectrons from the control grid produced by soft X-rays from the anode and space charge grid if any. This produces the same effect as the preceding item, but the source of the rays is now no longer the cathode. These rays are produced by the bombardment of the anode or grid by the normal tube current of electrons. Changes in cathode temperature will, of course, through change in plate current, affect the production of these soft X-rays.

At present there are three tubes on the market which are satisfactory for amplifying small currents. These are the Westinghouse RH 507, a three-element tube; the General Electric FP 54, a four element (screen-grid) tube; and the Western Electric D-96475, also a four element tube. All of the tubes have the control grid connection coming out of the top of the tube, since that is one of the easiest ways to increase the resistance to leakage current. It is interesting to compare the three and see how they satisfy the criteria of a good tube as set forth above. Such a comparison is given in the following table.

TROUBLE	WESTINGHOUSE RH 507	GENERAL ELECTRIC FP 54	WESTERN ELECTRIC D 96475
1. *Leakage over glass.*	High resistance glass. Non-hygroscopic wax on top of tube around control grid connection. Grounded conducting coating outside tube; guard ring inside.	High resistance glass. Two quartz insulators inside to support grid but no provision for stopping leakage over outside glass surface.	High resistance glass. One quartz insulator inside to support grid. Control grid brought out through a long thin glass neck. No provision for stopping leakage over outside glass surface.
2. *Positive ions from the gas.*	Plate potential held at approximately six volts which potential is lower than the ionization potential of all gases and vapors likely to be present.	Plate potential held to approximately six volts.	Plate potential held to approximately four volts.
3. *Thermionic emission from the grid.*	Low filament temperature and hence less heat radiated to grid, possible by use of oxide coated filament.	Low filament temperature. Thoriated tungsten filament.	Low filament temperature. Oxide coated filament.
4. *Ions from filament.*	Oxide coated filament. Ions prevented from reaching grid by having grid outside plate.	Thoriated tungsten filament. Space charge grid at positive potential prevents ions from reaching control grid.	Oxide coated filament. Space charge grid at same potential as plate prevents ions from reaching control grid.
5. *Photoelectrons produced by light from filament.*	Low temperature oxide coated filament.	Low temperature thoriated tungsten filament.	Low temperature oxide filament.
6. *Photoelectrons produced by soft X-rays.*	Low plate voltage (6 volts).	Low plate voltage (6 volts).	Low plate voltage (4 volts).

As was mentioned before, these tubes are current amplifiers and not voltage amplifiers. That is, the voltage amplification factor, mu, is one or even less. However, the current amplification factor may be several million. For example, a current of 10^{-14} amperes flowing through a grid resistance of 10^{12} ohms will produce a change in the plate current of .25 microamperes ($.25 \times 10^{-6}$ amperes) to .40 microamperes, depending on the test conditions. This represents a current amplification of at least $\frac{.25 \times 10^{-6}}{10^{-14}} = 25{,}000{,}000$. As another illustration, consider the problem of measuring the number of ions produced by the passage of a single slow alpha particle through air. Such a particle will produce about 100,000 ions or about $100{,}000 \times 1.59 \times 10^{-19} = 1.59 \times 10^{-14}$ coulombs of charge. If this small charge is transferred to the grid of one of these tubes, since its capacity with auxiliary ionization chambers is about 10.5×10^{-6} mfd, the charge will produce a change in plate current of from $.03 \times 10^{-6}$ to $.06 \times 10^{-6}$ amperes, depending on the tube used. Fig. 1 shows typical grid voltage-plate current characteristics for the three kinds of tubes. It will be seen that the characteristics are remarkably straight over a wide range of grid voltage. The curve marked DRH 505 refers to an experimental Westinghouse tube which has been superseded by the RH 507.

The simplest possible one-tube circuit is shown in Fig. 2. With this circuit the steady part of the plate current is compensated in the galvanometer by sending a current through it in a direction opposite to the plate current. The resistance R_1 is adjusted so that the galvanometer

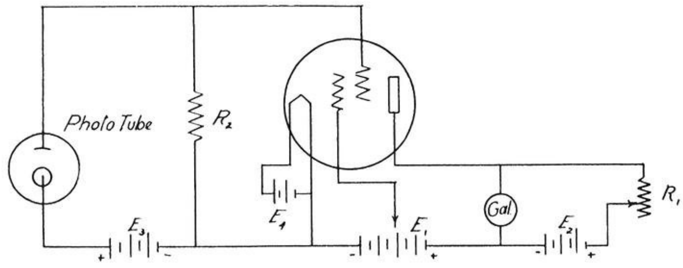

FIG. 2

stands at zero until the potential of the grid is disturbed. The galvanometer is of course provided with a variable shunt so that it may be used at reduced sensitivity until the current is nearly in balance. With this type of circuit there is always a certain galvanometer drift or continuous change in plate current, due to the running down of the batteries. By properly choosing the batteries E_1 and E_2 the drift due to change in battery voltage can be practically eliminated, but the running down of the filament battery and the aging of the filament cause a change in filament emission for which it is practically impossible to compensate completely. Periodically the circuit must be rebalanced. Hafstad[2] was able to measure currents of the order of 10^{-17} amperes with a circuit of this type using a grid resistance of 10^{12} ohms and a galvanometer sensitivity of 10^{-10} amperes per millimeter of the scale. Under these circumstances he had a galvanometer deflection of about 2.5 mm. and a galvanometer drift of 10 to 50 mm. per hour (1 to 5×10^{-9} amperes per hour), but to attain this sensitivity he took considerable pains to obtain proper compensation and employed several large storage batteries in parallel to supply his filament, which was rated at only .090 amperes.

Other circuits have been much used, however, which eliminate most of the trouble of drift. They are essentially bridge circuits which make use of the fact that all of the voltage necessary for operation can be supplied by one or two batteries.[3] Stability is obtained in these circuits by an adjustment of the elements of the network to fit the characteristics of the tube to be used. In this way it is possible to make the effect of variations in battery voltage very small. A typical circuit of this kind due to Du Bridge and Brown[4] is shown in Fig. 3. Here the four arms of the bridge are represented by R^p, R^n, the resistance of the tube between plate and filament, and R^d plus the resistance of the tube between screen grid and filament. This circuit depends on balancing the plate current against the screen grid current, the filament being supplied from the same battery as the plate. In the balanced condition, small variations in the battery voltage should affect the current through R^p and R^n in the same way and should not appreciably affect the current through the galvanometer. Although this circuit has the advantage of greater stability, it is not capable of the sensitivity of the circuit shown in Fig. 2. This is characteristic of bridge type amplifier circuits, because any increase in plate current does not all pass through the galvanometer; only part of the increase goes through the galvanometer, the other part going through R^p. The magnitude of R^p and R^n and the resistance of the galvanometer determines what proportion of the increase will pass through the galvanometer. As a matter of fact, with this circuit an increase of control grid potential causes not only an increase of plate current but also a decrease in screen grid current, thus producing a slightly greater unbalance than would ordinarily be obtained with a simple bridge circuit.

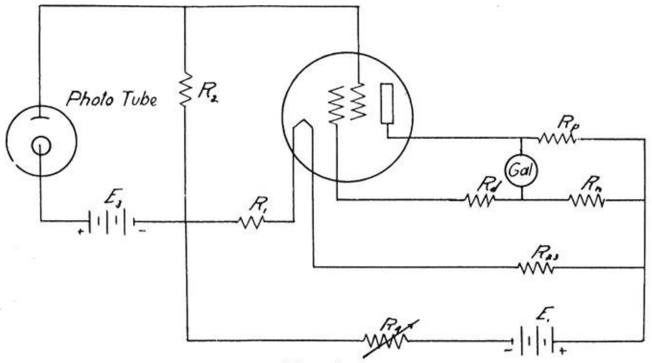

FIG. 3

One might think that using, in place of the galvanometer, a second tube connected to a similar circuit or perhaps several such circuits connected in series, that there would be no limit to the smallness of a current that could be measured and that one might indeed measure the current produced by a single electron. As a matter of fact, this is quite impossible. A single tube produces sufficient amplification to measure the smallest current that one will ever be able to measure experimentally. Natural fluctuations produce currents which are large compared with that due to the passage of one electron per second.[5]

These fluctuations are caused by a number of factors Certain of these can easily be eliminated. For instance, effects due to electrostatic or electromagnetic disturbances in the region of the circuit can be overcome by properly shielding all the parts of the circuit, and effects due to the variation of resistance values with room temperature may be minimized by thermally shielding the circuit. Likewise stray ions in the air about the tube may produce a non-

(continued on page 58)

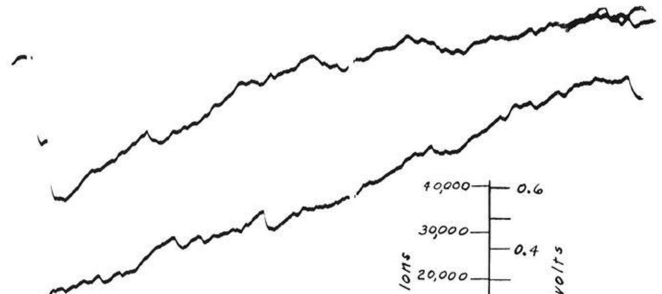

FIG. 4

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[2] L. R. Hafstad. Phy Rev. vol. 44, p. 201, 1933.

[3] For a discussion of bridge type circuits see D. B. Penick, Rev. Sci. Inst., vol. 6, p. 115, (1935).

[4] Du Bridge and Brown. Rev. Sci. Inst. vol. 4, p. 532 (1933).

[5] A drift of one electron per second past a point is equivalent to a current of 1.59×10^{-19} amperes.

WITH THE SOCIETIES

A.S.A.E.

It was through a regrettable misunderstanding that we did not introduce to this page sooner our newest organization. The ag engineers had their first meeting of the year on the second Thursday of November. At that session, Donald Wiggins, '37, was elected president; Fred Hoppart, '38, vice-president; and Richard Witz, '39, secretary-treasurer.

The first presentation on the evening's program was a resume of a seminar paper by Jim Elliot entitled, "The Relation of Machinery Cost to Farm Income." Two significant facts brought out were that the average net income of typical farms in Wisconsin and Nebraska was $1,000 a year and the ratio of machinery cost to net income was 1 to 4.7.

The main speaker of the evening was Mr. E. C. Meyers, instructor in ag engineering, who described his last summer's trip through the Mediterranean and Black Seas. As illustrations of the various ports discussed, he passed around mounted photographs. At the end of Mr. Meyers' talk, the meeting was officially adjourned. The chairman of the next meeting, December 17, will be Gordon Meyers.

CHI EPSILON

Tuesday evening, December 1, Russell Langteau, Charles Miller, Russell Newbury, Spaulding Norris, Ray Voelker, Robert Zwettler, and Louis Sheerar were initiated into Chi Epsilon, honorary civil engineering fraternity. Prof. Ray S. Owen acted as toastmaster at the banquet which followed the formal initiation.

Chi Epsilon is planning to hold a Christmas party the week before recess.

A.S.M.E.

On November 24 the mechanicals attended a meeting at which the speaker of the evening was Mr. Roscoe G. Walters, m'06, from the Wisconsin Power and Light Company. Eugene Kirtland, president of the society, conducted the proceedings and passed out copies of Mechanical Engineering for this month to members of the national society as well as membership cards for those wishing to join.

Mr. Walters discussed the increase in power and electric service to rural communities and also showed charts which graphically illustrated the increase from 1913 to 1930. In addition he described the features of the steam and hydroelectric plants operated by his company. In connection with the hydroelectric plants he showed how water is stored for use during dry seasons.

The finale of the evenings' program was a moving picture on the development of the steam engine and steam locomotive. At the end of this picture frankfurters and coffee were served in the heating and ventilating lab.

TAU BETA PI

Pointing out the importance of engineers and engineering in astronomy, Prof. Joel Stebbins, director of Washburn Observatory, addressed the members of Tau Beta Pi, national honorary engineering fraternity, at the fall initiation banquet held at the Memorial Union, Thursday evening, December 3.

Gerard A. Rohlich, c'36, president of Tau Beta Pi, welcomed the initiates. The response was given by Robert F. Zwettler, c'37.

One of the high spots of the evening was the presence at the meeting of Mr. Walter S. Lacher, c'07, who was initiated into Tau Beta Pi in 1906, and who came from La Grange, Illinois, to be present at the initiation of his son, Richard Lacher, just 30 years later.

Those initiated were:

Seniors, Kenneth M. Brown, Ronald L. Daggett, J. Robert Hafstrom, Philip H. Kern, Donald H. Kutchera, Richard W. Lacher, Charles L. Miller, Spaulding A. Norris, Chester D. Rudolf, Karl E. Sager, Lawrence E. Simon, Carl B. Sohns, Frederic D. Utter, Everett C. Wallace, Gerhard A. Vater, Robert F. Zwettler; juniors, Reinhardt N. Sabee, William N. Wright.

ETA KAPPA NU

Eight students were initiated Monday, December 14, into Theta chapter of Eta Kappa Nu, honorary electrical engineering fraternity. The initiates were: senior, Gerhard A. Vater; juniors, Everett H. Davies, Paul M. Ketchum, Aldro Lingard, Wayne T. Mitchell, Fred C. Neumann, Alan K. Ross, and Lee M. Zawasky.

Prof. R. R. Benedict was toastmaster at the banquet which immediately followed the initiation. A very interesting address illustrated with slides was given on the work of the physics department by Prof. H. B. Wahlin. The president, Herbert Luoma, welcomed the new members. Paul Ketchum responded for the initiates. Mr. Anton B. Zerby, national executive secretary of Eta Kappa Nu, was one of the distinguished guests of the evening.

A.S.C.E.

Thursday, November 19, the student branch of the American Society of Civil Engineers held a meeting in the auditorium of the hydraulics laboratory at which Mr. A. T. Lenz of the hydraulics department lectured on the construction in TVA work, showing slides and large pictures. He described construction at the Wilson and Norris Dams, on both of which he has been working recently.

After the lecture beer and pretzels were served, with William Littleton as bartender.

ON THE CAMPUS

ELECTRICAL AND MECHANICALS VISIT CHICAGO

On October 19 to 22 about 86 senior electricals and mechanicals spent an interesting four days inspecting the various manufacturing plants in and around Chicago. Chartering two Greyhound buses, the group stopped at Beloit on their way to Chicago to visit the Fairbanks-Morse plant. The same afternoon the mechanicals inspected the Elgin Watch factory at Elgin, Illinois, while the electricals were in Chicago going through the Chicago Lighting Institute. Other plants visited by the mechanicals led by Profs. Pat Hyland and G. C. Wilson were the Carnegie-Illinois Steel Company, the Crane Company, Western Electric, Mars Incorporated, and the Crawford Avenue Generating Station.

Professors Watson and Koehler were in charge of the electricals and took them on a tour which included the G. E. X-Ray Corporation, Illinois Steel Company, and Western Electric. One of the most interesting places, however, was the Electro-Motive Corporation, a subsidiary of General Motors, where stream-lined trains are manufactured.

PROF. ORTH ELECTED SECRETARY OF S.P.E.E.

At the annual meeting of the Society for Promotion of Engineering Education held at Iowa State University, November 6-7, Prof. H. D. Orth, head of the mechanical drawing department here, was elected secretary of the organization. He will succeed Prof. J. B. Kommers of the mechanics department. Thirty members from the University of Wisconsin attended and took an active part in the activities. Prof. G. L. Larson spoke on "Research for Benefit of Industry and General Public," and a round table discussion of the subject "Securing and Maintaining Interest" was led by Profs. Orth and K. G. Shields. Prof. B. G. Elliott was chairman of a division meeting on mechanical engineering, in which Dean Turneaure gave a talk on "Young Engineers in Design" and Professor Elliott one on "Short Course Relation to Colleges." Another division on mechanics and hydraulics was led by Prof. M. O. Withey.

During the business meeting the name of the section was changed from "Iowa-Wisconsin" to "North-Midwest," and representatives from Minnesota were asked to attend the next meeting to be held at Marquette.

CONSTRUCT NEW WLBL TRANSMITTER

Work was started on a 5,000 watt transmitter for WLBL here in the electrical engineering department about a month ago. It will be installed some time in April in the new location of the state-owned station at Auburndale, near Stevens Point. The present location of WLBL is to be abandoned in favor of the new 22½-acre tract which will include a completely new transmitter house and vertical radiator 450 feet high. Construction of the transmitter is under the direction of Professor Koehler who also helped build the transmitter now in use at WHA.

HOLD WATER WORKS SHORT COURSE HERE

Under the joint sponsorship of the university, the state board of health, and the state laboratory of hygiene, the fourth annual short course for water works operators was held here at the hydraulics lab last November 18 to 21. Fifty-three men attended, representing 45 cities in Wisconsin and Illinois.

The object of the course is to keep water works operators informed concerning latest developments in water treatment and distribution. H. W. Ruf of the hydraulics department had charge of arranging the course which consisted of lectures in the morning and practical demonstrations in the lab in the afternoon.

Some of the speakers were Prof. L. H. Kessler, Dr. W. D. Stovall, and Dr. M. S. Nichols of the university; L. Enslow, editor of "Water Works and Sewage," from New York; and W. Birdsell and Oscar Gullans of Chicago.

GEOLOGY FIELD TRIP

Led by Prof. A. M. Leith, 92 civils and miners in the engineering Geology 9 course spent a chilly day last month inspecting rocks in the Baraboo Range near Ableman, Wisconsin. Two of the more important highlights of the trip were the blasting in the quartzite quarry and listening to the Wisconsin-Northwestern football game in a convenient tavern.

MOVE TO NEW HOMES IN SHOREWOOD

Prof. W. S. Cottingham of the structural engineering department, and Prof. R. R. Benedict of the electrical engineering department have recently moved to new homes in Shorewood.

RELAX . . . AND GET LEFT

B. W. Meek, instructor of the Geology 9 course, Frank Stone, and two other unknown engineers found themselves in a sorry plight last November 7 while on the geology field trip to Ableman, Wisconsin. The story goes that the above sturdy engineers stopped in at a tavern to relax and inhale a few beers before the group left for home after a strenuous field trip. The idea was fine, but unfortunately they tarried a bit too long, and the train pulled out without them. How they finally got back to Madison is another story, but you may be assured that there were four very worried engineers in Ableman for an hour of two.

THEY MUST BE SLEEPY

Entertainment during the evenings on the senior inspection trips varied from light opera to burlesque. These evenings coupled with the added fatigue of hiking long, weary miles through huge steel mills and the like caused more than one sleepy engineer to miss the bus and be forced to arrive later via a taxi. Carl Sohns and John Myers, both mechanicals, were victims of this fate. Red Carlson, civil, arrived late at the Allis Chalmers plant by the same method of locomotion, while another angle is found in Heinrichmeyer being left sitting on the steps of Electro-Motive Corporation waiting for his girl to come and get him. She must have arrived, because he was in classes the next day.

As the results of a little night life at Kitty Davis' rendezvous, General Benjamin C. Dicke (pronounced Dick, not Dicky) still carries fond thoughts of one glamorous entertainer called "Peaches."

SENIOR CIVILS TRAVEL TO MILWAUKEE

Forty-six senior civils made the annual inspection trip to Milwaukee on October 22 to 24. Messrs. L. H. Kessler, A. T. Lenz, and W. F. Walton of the hydraulics department and Prof. W. S. Cottingham were in charge of the trip.

To start the trip off in a jolly mood, Al Scheuter surprised the boys by coming tearing down the street just as the bus was leaving. The first stop was at Jefferson, en route to Milwaukee, where they inspected the Racine Street bridge. In Milwaukee various structures visited included the Greendale Housing project, South 84th Street Underpass, and Rawson-Howell Overhead.

Besides these structures the civils also visited the Wisconsin Bridge and Iron Company where they saw a Carnegie beam section weighing 425 pounds per foot. Allis Chalmers's plant, Jones Island Sewerage Treatment plant, and the Riverside Pumping Station were also on the list. At the High Pressure Pumping Station, which supplies river water at high pressure for fighting fires, they were given a startling demonstration.

PROF. BENNETT PRESENTS PAPERS

Early in October, Prof. Edward Bennett of the electrical engineering department presented a paper entitled, "Electric Heating by the Proximity Effect," before a convention of the American Welding Society held in Cleveland.

On October 5, Professor Bennett appeared before the Federal Communications Commission when he presented another paper on "Some Governing Considerations in the Allocation of Frequencies in the Broad Band." Professor Bennett's interest in this subject comes from the fact that he is the technical adviser of the university station, WHA, and as a member of the university radio committee is concerned with the development of radio policy.

His paper was under the heading of "Considerations of a Social and Economic Nature," the theme of it being—"to create and to firmly establish non-centralized and nonmonopolizable rights to the use of the nation's limited broadcasting facilities."

PROF. KESSLER SPEAKS IN CHICAGO

At the annual meeting of the American Society of Agricultural Engineers held November 31 to December 4 at the Hotel Stevens in Chicago, Prof. L. H. Kessler of the hydraulics department presented a lecture on "Results of Experiments on Flow of Water Through Drop Inlet Culverts and Other Soil Erosion Control Structures." His subject was based on experiments carried on in the hydraulics lab, but also included recent research on the subject as well. The paper was of interest not only to those interested in soil erosion work, but to other fields into which soil erosion is entering, such as highway engineering.

Prof. E. R. Jones of the agricultural engineering department also presented a topic headed "Use of Drop Inlet, Soil Saving Dams in Wisconsin Soil Conservation Program."

RESEARCH CONFERENCE

Held once a month in the various branches of the engineering college, the first research conference of the year was held Tuesday, November 24, in the hydraulics laboratory. Subjects presented were: "Action of Inhibitors in Pickling Solutions," by R. M. Max of the chemical engineering department; "Mechanical Pneumatic Water Hammer Arrestors," with a demonstration in the laboratory by G. A. Rohlick of the hydraulics department, and "The Testing of Appliances," by Royce Johnson of the electrical engineering department.

"STATIC"

By **ENGIN EARS**

There's an ugly rumor going around to the effect that winter is on its way. Not that the snow and ice mean anything; but when the civils start wearing gloves—that's cold! This is the one season when the engineer, in high boots and flannel shirt, is envied rather than frowned on by the campus nonentities of Law and Bascom. It is also, lest we forget, the season of Santa Claus (ain't that peachy, freshmen?). All of us will, before you hardly can say root-mean-square, be lamming it back to mother, home, and the old girl friend, to forget for a brief week the approaching finals, and to rake in a few choice handkerchiefs, razors, neckties, and other stuff so useless to ye complete engineer. But do we ever pause to think of the poor, friendless instructors we leave behind. As with the miners, no one ever gives them a thought. Can't you picture the seniors proffs weeping with loneliness, their tears blotting the ink on the reports overdue lists which lie before them, the freshie mentors sitting dejectedly about listening as of yore for the patter of tiny feet across the classroom floor. Fellers, we just can't do this to 'em. So, to brighten their Yuletide we have mailed to Santa the following appropriate list:

To—

Hartenburg—One new and louder bow tie.

Orth—Some hair-raising mystery book to read during those long 2-hour classes.

Hollander—A text on "How to Overcome an Inferiority Complex" and a spot on radio's Voice of Experience hour.

March—A megaphone.

Ingersoll—A boy scout or a box of matches for his fire-making demonstration.

Withey—A Monroe calculator.

Neill—One can of Postum.

Hansen—A feather duster or a swing band to keep his mechanics class awake.

Bird—A calculus answer book.

Calderwood—A new green eyeshade.

Wahlin—One half dozen assorted geniuses to be distributed among his quiz sections.

Kahlenberg—A subscription to the Chicago Tribune and a book titled, "The A B C of Atomic Structure."

Dean Millar—A box of safety pins to use in his frosh nursery.

Sokolnikoff—A shiny new Shick razor.

And to the M. E. building (adds a mechanical)—a supply of soap which will still clean hands yet not leave just gory stumps at the end of one's arms.

If all the sleepers in Professor Ingersoll's lecture were placed end to end . . . they would be more comfortable.

»» ««

One day last week one of the boys walked up to Mr. Young, czar of the foundry, and asked how to charge his mold. Quoth Mr. Young with a disgusted sigh, "We just go into a store and say—'Charge it'!"

»» ««

We had a good quote from Professor Ragatz, too, but the editor said, "This is the Engineer, **not** Octy," so you'll have to ask the boys in Metallography 119.

»» ««

The large gob of emptiness that is being driven into the earth behind the Chem. building to house the new centrifuge still draws a good crowd of professional steam-shovel watchers. As Heuser says, next to Mary Anderson its been the biggest distraction in the quant. lab all fall.

»» ««

The cast iron bathmat award this month goes to the unidentified engineer who in Economics 1a lecture some weeks ago so magnificently yet tactfully showed Professor Kiekhofer the value of a slide rule in writing a text. He endeared himself forever to his comrades by the concluding sentence of his note: "If you intend reading this aloud, may I suggest that you put a few simple figures on the blackboard so that the L&S students present may grasp what we are talking about."

»» ««

P. M. Ketchum, "the fuse companies' friend," editor of this rag, and already notorious in other ways, has found a new way to punish the circuit-breakers. Not content with the results obtained last spring when he put an ammeter across the line terminals to see if it was alive (it WAS!), he has taken up arc welding in the dynamo lab. The trick is to place a screw-driver across the switch terminals and watch the metal melt. It's more darn fun . . .

»» ««

As the Indian exclaimed when his third wife died, "This is the last squaw."

»» ««

The fraternity man explains it . . .

They have blind-dated me with oil cans, worn my shirts more than I have, used my toothpaste, broken my razor, opened my mail, ruined my golf clubs, borrowed money and never paid it back, gone to sleep in my bed when drunk, paddled me when I was a pledge, and the only reason I am sticking around is that I'm curious to know what the hell they are going to do next. **—Arkansas Engineer.**

ALUMNI NOTES

Electricals

ANDREWS, C. F., '28, has a position with the Illinois Northern Utility Co. located at Dixon, Ill.

FOSSUM, HAROLD, '36, married just recently, has taken leave of his position with the Sinclair Oil Co. to work for the Seargeant and Lunde Co.

HELGASON, ARNI, M.S.'25, reports business is very good at the Chicago Transformer Co., where he is an official.

MIESTER, MELVIN W., '36, formerly with the A. O. Smith Co., is now connected with the Filer & Stowell Co., manufacturers of Corliss type steam engines, located at Milwaukee.

MORSE, ERNEST B., '18, sales engineer for the W. A. Fallon Trading Co., died at his home in Appleton, Wis., on August 1.

REINHARDT, CLERMONT, '35, has a hardware store in Two Rivers, Wis.

WOOLRICH, W. R., '11, M.E.'23, has been appointed dean of the college of engineering of the University of Texas. Dean Woolrich has been in charge of the agricultural industrial division of the Tennessee Valley Authority for the past three years, preceding which he was for 14 years head of the department of mechanical engineering at the University of Tennessee.

Mechanicals

ANDERSON, ARTHUR E., vice president of the Colorado Utilities Corp. and general manager in Colorado for the Troy Graham Co. of Chicago, was electrocuted on November 22 in a substation accident at MacGregor, 12 miles west of Steamboat Springs, Colo. Anderson was graduated from the course in mechanical engineering by this university in 1903. He was a member of Tau Beta Pi and during his senior year was alumni editor on the **Wisconsin Engineer.** He had been connected with utilities in Colorado and Wyoming for more than 20 years. He is survived by a widow and one son, also named Arthur.

BROWN, ROBERT V., '29, M.S.'30, formerly a science and math teacher at Wayland Academy at Beaver Dam, Wis., is now plant engineer at the Malleable Iron Range Co. of the same city. Mr. Brown was very active in student activities while he attended the university, in addition to being a member of several honorary engineering fraternities.

COKER, THEODORE, '33, is now engaged in design engineering for the Globe Union Co. of Milwaukee, Wis.

GREEN, J. GREGORY, '33, has a position as design engineer in the two cycle diesel engine department of the American Locomotive Co. of Auburn, N. Y.

HEGER, LAWRENCE E., '33, has left the employ of the Trane Company at La Crosse where he was designing air conditioning equipment, to assume the position of plant air conditioning engineer for Swift & Company, Chicago.

HOYLE, ROBERT L., '32, acts as engineer in the acoustical division of the Burgess Battery Company, Madison.

KAHLENBERG, JAMES F., B.S.'30, LL.B.'34, is practicing general law in Manitowoc, Wisconsin.

KLATT, WESLEY E., '29, has been promoted from draftsman to assistant installation engineer at the Waukesha Motor Co., Waukesha, Wis.

LHOTAK, RUDOLPH F., '31, Law '35, is an attorney in the patent department of the Fairbanks Morse Co., St. Louis, Mo.

PARSONS, OLIVER L., '31, is engaged as an engineer in the air conditioning department of Allis Chalmers, Milwaukee.

PHILLIPS, HARRY A., '22, athletic editor on the staff of the **Wisconsin Engineer** during his student days, is engaged in manufacturing refrigerating specialties under the name of H. A. Phillips & Co. at 155 N. Union Ave., Chicago. He visited the campus on September 25.

ROBERTSON, L. B., '06, is now general superintendent of Wisconsin Steel Company, South Chicago, Illinois.

RUSCH, EDWARD W., '29, has a position with the Norge Company of Detroit, Michigan, where he is interested in testing and designing refrigerators.

SMERDA, AUGUST, Jr., '33, formerly of the Forest Products Laboratory, is assistant in charge of maintenance to the plant superintendent at J. I. Case Co., Racine, Wisconsin.

TAFT, HENRY M., '32, is assistant to the chief engineer at the Vilter Manufacturing Company, Milwaukee.

WAY, W. EDWARD, '30, acts as night foreman of the assembly floor at the Clearing, Illinois, plant of the Continental Can Company, Inc.

WHITE, HERBERT LOUIS, '29, is employed in the engineering department where he is developing mechanical radio volume controls for the Globe Union Manufacturing Company, Milwaukee.

WOOD, ROYAL H., '33, does drafting and layout work for the Babcock and Wilcox Co., Baberton, Ohio.

Miners and Metallurgists

BREMNER, ROBERT P., '36, having completely recovered from his illness, is now, on November 1, employed as a mining engineer for Pickands Mather Co. at the Newport Mine at Ironwood, Mich.

KIEWEG, BURTON R., '31, M.S.'32, has accepted the position of senior engineer under the United States Department of Agriculture, being located at Park Falls, Wis.

SCHULTZ, ROBERT F., '35, is now mill foreman of the Requa Hoover Syndicate of the West Dip Mining and Milling Co. at Ophir, Utah.

Chemicals

BURNHAM, THAYER W., '35, enrolled in the graduate school, University of Wisconsin, to study bacteriology.

CARLSON, A. W., '26, was married last summer in Colorado.

GAPEN, C. C., '35, says that the work at the Corn Products Refining Co., Argo, Ill., continues to be interesting for him.

JONES, W. R., '36, reports good business conditions for the charcoal and wood alcohol plant where he is working, near Escanaba, Mich.

McCAULEY, HARRY, '35, obtained leave of absence in July to serve as reserve officer at Edgewood Arsenal, Maryland.

PAGEL, L. C., '36, works for the Mautz Paint Co. in Madison, Wis.

PELTON, GLENN, '35, last September completed a year's service as reserve officer in the army at Fort Sheridan.

RAPP, ROBERT L., '35, got away from his job at the Hoberg Paper Co., Green Bay, Wis., to visit Madison at Homecoming.

WILLIAMS, TOM J., '36, joined the engineering staff of the Universal Oil Products Co. at Riverside, Ill.

Civils

BLOECHER, WALTER P., '14, who was with Stone, Webster Co. for many years, has recently joined the staff of the Philadelphia & Reading Coal & Iron Co.

BREIVOGEL, MILTON W., '24, until recently with the Milwaukee Board of Land Commissioners, is city planning engineer for Racine.

GUMPRECHT, HENRY H., '18, is engineer with TVA at Knoxville.

WEST, ALFRED W., '34, formerly with the American Well Works, is assistant sanitary engineer with the Wisconsin State Board of Health. Address: Rutledge Charities Bldg., Chippewa Falls.

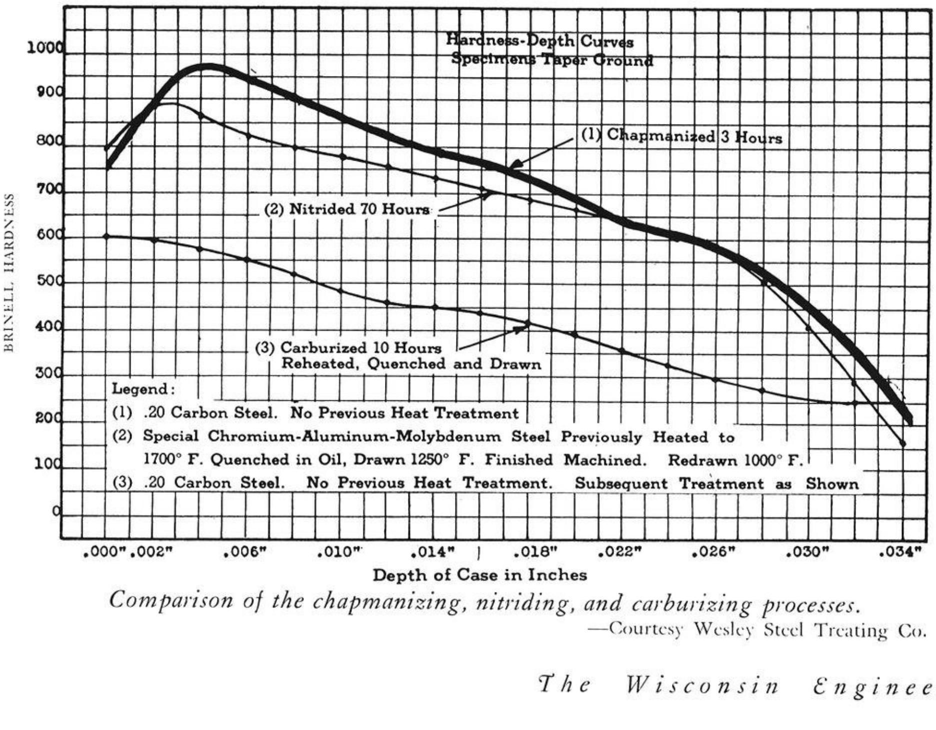
Saving the Surface of Steel

by LAWRENCE E SIMON, min'37

OF VITAL interest to all engineers is the question of "Saving the Surface of Steel." Millions of dollars worth of material are relegated to the scrap heap yearly because surface damage has made steel incompetent to render its original service. Although this scrap is largely recovered, the sums gone into the fabrication of the parts, and the costs of replacing these parts as far as labor and lost production time are concerned, represent an economic loss to engineering practice. The surface damage causing this loss may be laid at the door of two agents, corrosion and abrasion. Fatigue corrosion in underwater members; valve surfaces capable of resisting corrosive influences at high temperatures; light, hard surfaced pistons; piping, vat lining, still linings to resist high temperature and corrosive influences; wear of conveyor chutes; tough crankshafts with hard, wear-resisting surfaces are just a few engineering problems made important by the action of these two surface-affectors. As the title suggests, it is the purpose of this article to review modern engineering methods of dealing with these difficulties.

In beginning with corrosion a short review of the action itself may well serve as an introduction to the subject. There are at present two outstanding theories regarding corrosion, the acid and the electrolytic. The electrolytic theory is most widely accepted and it is this one which I will discuss.

If a piece of iron is placed in a test tube containing only pure boiled water, and sealed, the piece will remain bright and unrusted over a long period of time. An explanation of this phenomenon shows the water to be saturated with iron ions and the metallic iron to be covered with a film of hydrogen. It is the hydrogen film on the iron which retains the metallic luster. If the seal of the test tube is broken, a brown precipitate immediately forms in the water. The breaking of the seal has admitted oxygen from the air and the iron ions in solution in water are oxidized to a higher form of iron, which is insoluble and brown in color. Oxygen also combines with the hydrogen which has been protecting the metal surface and the metal, free from the protecting coating of hydrogen, dissolves more iron in an effort to maintain equilibrium. It is this brown oxidized form of iron that we call rust. According to this idea it can then be seen that oxygen and water must be present for this type of corrosion of iron.



Comparison of the chapmanizing, nitriding, and carburizing processes.

—Courtesy Wesley Steel Treating Co.

Cell action often is an important corrosive influence in duplex alloys or broken coatings of metals on iron which are cathodic toward iron. The difference in electro-potential of the constituents, or of base and coating metal makes an e.m.f. exist and a current to flow between them. This cell action causes material to be corroded from one of the constituents.

There are many ramifications of the theory dealing with acidic solutions, concentration cells, stray current corrosion, cells set up due to differing degrees of cold-working, etc., but space does not permit their discussion here.

In metallurgical practice, several of the methods used for corrosion protection are: metal coatings—spraying, dipping, electroplating, and other methods; chemical coatings; alloys; passivity; and balancing electromotive forces.

Zinc is most used as a protectant and as such may be applied in any of four methods. Hot-dip galvanizing was the first use of this metal. In this process the object to be galvanized is first treated to give it a clean surface. It is then immersed in a bath of molten zinc, the time of immersion depending upon the desired thickness of the coating. The molten zinc alloys with the iron forming iron-zinc compounds and all intermediate alloys of iron and zinc. It is the presence of these intermetallic compounds which often causes difficulty with galvanized pieces. Compounds have an inherent brittleness which may cause cracking and scaling if the galvanized piece is subjected to too much bending or elastic deformation. The cracking may also have a notching effect on the steel beneath and may cause a more rapid failure of the entire piece.

In order to meet the last objection in zinc coating, two other methods have been evolved, spraying and electro-

plating. In spraying the surface is first prepared by a shot or sand blasting operation. The purpose of this operation is to obtain a perfectly clean surface and also to somewhat roughen it in order that the molten sprayed metal may flow into the crevices and key itself to the surface. The impinging of the hot molten zinc upon the surface causes a weld to exist between the metals and this coupled with the above-mentioned keying process gives a very adherent coating. Electroplating serves the same function as spraying except that the adherence is believed to be due to the existence of atomic bonds between the two metals. The absence of intermetallic compounds by the last two methods does away with the brittleness layers and so there is a better correlation of the ductilities of the two metals. Of interest in the electroplating field has been the success recently of a means of continuous electroplating of wire to give a very ductile protective coating.

Sheradizing is a method of zinc coating which is much used for small articles of intricate shape where a very uniform covering is desired. It is carried on by tumbling the pieces to be treated in a barrel filled with zinc dust, the process being carried on at 660 to 700° F. The coating formed is of the same nature as the hot-dipped with intermetallic compounds being present. The coating is thinner and much more uniform, however, and does not affect the dimensions of the piece seriously, which may be important as in treating threaded pieces.

Besides zinc many other metallic coatings are used as protectants. In the field of electroplating tin, copper, chromium, cadmium, and even lead being used. Chromium has been widely used recently both for its protective and for its decorative qualities. It does not have a strong adhering power on iron so that often copper and nickel plates are first applied to prevent any peeling action. Chrome plate is also fairly brittle and so cannot be used where it may be subjected to heavy shocks. A thin flash of lead has been developed recently by electrolytic pickling which forms a specialized corrosion resistant against sulphate compounds. In action it forms a protective decomposition coating of lead sulphate which is insoluble in sulphuric corrodant. Copper plate also usually acts by forming an insoluble decomposition coating of oxide.

In the last two years the metal spray has made rapid gains. This is due to the expiration of basic patents making the process more economically available. In action a rod of the spray material is fed to a melting flame at a regular rate. As the rod melts the molten metal is taken by an air blast and atomized. This atomized spray impinges on the surface to be coated and solidifies there. A great variety of coatings may be applied by this method. Copper, zinc, cadmium, stainless steel, tin, lead, alumnium, or brass may be used, depending on conditions which must be met by the coating.

Calorizing is another means of protective coating. It is quite similar to Sheradizing except aluminum is used instead of zinc. The aluminum on the surface oxidizes at higher temperatures and prevents the oxidization of the iron underneath. It is used in coating steel pots employed as salt or lead bath containers and has found some use as a means of protecting superheater tubes, pyrometer tubes, and oil refinery equipment exposed to high temperature and corrosive surphur compounds.

A number of coatings chemical in nature are used as protectants. Parkerizing is a means of applying one of these. The piece to be treated is immersed in a bath of manganese dihydrogen phosphate. It is then boiled until effervescence ceases. This process provides a phosphate coating on the metal. The Bower-Barff is another method whereby the piece is heated to 1600° F.; superheated steam is then injected forming Fe_3O_4 and Fe_2O_4 coating on the surface of piece. The Fe_2O_3 is then reduced to Fe_3O_4 by an atmosphere of CO and the process is finished leaving an Fe_3O_4 coating on the piece. Both the Bower-Barff and Parkerizing are much used as surface preparation prior to painting.

By anodically polarizing iron in a sulphuric acid bath or by immersion in a strong caustic bath the iron may be made passive. In this passive condition corrosion from nitric influences is strongly resisted. Iron does not retain its passive condition long. Chromium, however, does, forming spontaneously in the air the oxygen layer which is the cause for passivity. It is this tendency of chromium which gives stainless steels some of their corrosion resistance.

Oils and greases, commonly termed "slushes," are also used as corrosion protectants by applying a thin coating over the surface. They are mainly used to prevent rusting in storage or shipment.

An e.m.f. may be used to buck out the e.m.f. existing between the corrodant and the metal being corroded. This method has been successfully applied to prevent corrosion and scaling in boiler installations.

Equally important with corrosion as a means of surface damage is abrasion. With the advent of simple machinery man was brought face to face with abrasive action. Friction of two surfaces on one another causes a breaking away of small particles from the surfaces and soon can materially alter the original dimensions of the parts so that they may not be able to perform their original function. In order to meet this action in his machines man has applied his inventive mind to find a number of means of minimizing the action. Lubricants, bearing metal, alloys, were all tried and although these methods did a great deal in aiding to overcome abrasion, there were many places where these could not be used or were, in themselves, insufficient to minimize abrasion. Sometimes, too, toughness was needed, coupled with abrasion resistance, and, of course, paramount in all cases, was the economic factor. Although alloys often were efficient, man, for economic reasons, was concerned with treating a cheaper, more abundant material, steel, in order to handle his abrasion problem, and so a variety of surface treatments of steel were resorted to to meet his need.

Probably the first thing resorted to was carburizing. This process is carried out by two methods, pack, or gas carburizing. In pack carburizing the article to be surface hardened is packed in a carbonaceous material. It is then heated to 900° C. and held there. The holding time depending on the depth of case required. The action is a penetration of CO gas formed from the carbonaceous material at the elevated temperature along the boundaries of the grains. Some carbon then combines with the iron leaving CO_2. This CO_2 is then again converted to CO by contact with the carbonaceous material, and thus the process proceeds. The treatment results in a case of higher carbon around a lower carbon core. The piece may then be heat treated to form a hard, wear-resistant case, with a tough, ductile core. The action in gas carburizing is similar except that the pieces are heated in an atmosphere of carbon rich gas. Pack carburizing is used on large sections which might sag and distort at the carburizing temperature if not supported, while gas carburizing is used to treat small parts in a tumbling barral arrangement. The depth of case varies up to 0.030 inch depending on the time of treatment.

Another process much used to produce a hard superficial case of a few thousands is cyaniding. The piece to be treated is immersed in the cyanide bath until it has attained a temperature of 1550 to 1600° F. It is allowed to remain for 10 to 15 minutes and then quenched. There is a penetration of carbon to form the case and also a penetration of nitrogen to form hard iron nitrides. This operation takes less time than carburizing, but produces only a superficial case.

Nitriding is also used to produce a hard case. The operation is carried on by heating the piece at 525° C. for a period of 5 to 50 hours in a nitrogenous atmosphere, usually ammonia gas. This operation produces a very hard case of a depth up to 0.030 inch. The mechanism consists of the formation of a case containing iron nitrides which make it very hard. Most steels used today in nitriding contain some aluminum since it has been found that aluminum combines with nitrogen more readily than iron to form hard aluminum nitrides, thus giving a faster operation. One advantage of nitriding is that it is carried on below the critical of the steel, hence having no grain growth effect.

Chapmanizing is an offshoot of nitriding. The process is quite similar to nitriding except that an activated nitrogen is passed through a liquid bath in which the piece is immersed. The result is a much speedier process with the same or even better results as far as case is concerned.

It has long been realized that heating of the entire piece in order to obtain hardening only on the surface as in the above methods is wasteful since the heat put into the core ordinarily is of no value except in its effect on the grain size of the core, in most cases being detrimental since the operations are carried on at such elevated temperatures that grain growth results, requiring further heat treatment. In view of this waste, efforts have long been made to harden only those parts desired hard without affecting the rest of the piece.

The first success in the direction has been flame or torch hardening. In practice it consists in a progressive flame passing over the surface to be hardened, travelling at a rate calculated to bring the temperature of a surface layer of the steel just above its critical. Immediately following the torch is a water spray which quenches the heated portion and so hardens it.

A newcomer in the field of differential hardening is the Tocco hardening process. Tocco hardening is an interesting application of some electric and magnetic properties to the hardening problem. A high frequency current is known to travel on the surface of its conductor and also iron is known to have hystersis and eddy current losses which are dissipated as heat. It is on these two facts that Tocco hardening is based. A high frequency current passes into two inductor blocks which are clamped around the surface to be hardened. These inductor blocks act as the primary of a transformer and are separated by a small air-gap from the surface to be hardened. There is thus induced in the secondary, the piece of steel, a surface current. This surface current through hystersis and eddy current losses causes the piece to be heated on the surface. When the heat has penetrated to a sufficient depth water is sprayed on the surface through holes in the face of the inductor blocks. This water acts as a quenching agent and hardens the heated portion. The core and surrounding material remains unaffected since they were not part of the heated region. As yet the process has only been applied to crankshaft bearing surfaces, but it has great possibilities and its application to other hardening problems is only a matter of time.

Measuring Small Currents--

(continued from page 48)

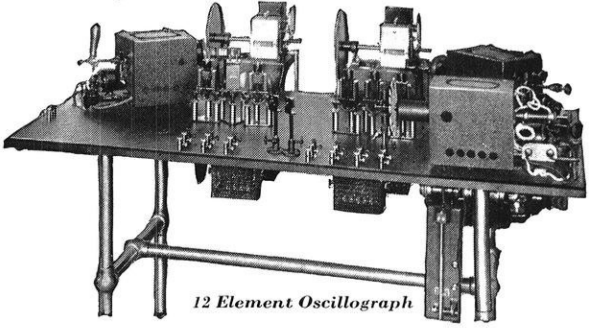
uniform leakage of charge from the grid and for work at the highest sensitivity, the tube must be put into a low pressure chamber. Connection to the grid of the tube can then be obtained by a wire passing through an amber insulator sealed into the vacuum enclosure. However, the really troublesome causes of fluctuations as one tries to increase sensitivity are those over which one has no control.

If the grid is connected to the filament through a low resistance like that of a bias battery, no fluctuations may be observed, but as the external grid resistance is increased variations of the voltage between its terminals begin to appear, due to the thermal motion of the electrons in the resistance. These fluctuations in voltage are known as the Johnson effect. A similar effect occurs when the grid is entirely disconnected. In this case the grid may be thought of as connected to the filament through a very high resistance; namely the resistance of the glass or quartz insulation.

Another effect, the shot effect, may be important especially when the tube is operated with the grid disconnected. In this condition the grid current is zero by definition. That is, on the average, equal numbers of positive ions and electrons are reaching the grid every second. Actually the positive ions and electrons are in rapid thermal motion and equal numbers are not always coming up to the grid. The number of either kind fluctuates, and although on the average the numbers of positive ions and electrons may be equal, either one may exceed the other at particular instants. As these variations occur, there will be corresponding changes in the potential of the grid, and consequently fluctuations in plate current. These changes set a definite limit to the sensitivity of vacuum tube electrometers, for, under the best conditions, other fluctuations are small in comparison with them.

Fluctuations in galvanometer current with grid insulated are shown in the two curves of Fig. 4, which the photographic records of galvanometer deflections. The sensitivity is indicated on the figure. A magnification four to eight times as great could easily have been obtained but would not be useful since the fluctuations would also be magnified.

The convenience of compact circuits of the type described has already been demonstrated and for many applications they have entirely superseded the conventional quadrant electrometer and the sensitive galvanometer.



EDITORIALS

COOPERATIVE EDUCATION

Perhaps no course in the university receives as much adverse criticism as does our engineering course. Either it is too heavy, they say, or it has too few electives, or the hours are too long. These and innumerable other criticisms have long been current on the campus, yet few constructive remedies have been offered.

There is, however, one new development in engineering education which has seemingly been overlooked in this connection, probably because the mechanics of it are not commonly known. This development (which is not very new, after all) is the cooperative plan.

As generally carried out, the plan provides for two years of a regular engineering schedule for the enrollee, fortifying him with a thorough knowledge of the basic sciences and math. Then, at the beginning of the third year, he is placed in some industrial organization at a job related to his field of interest. After four to six weeks of such employment, he returns to his studies for a like period. Thereafter, for the next three years, similar alternating periods of class and shop work are continued, and at the end of this time the regular engineering degree is granted.

The student now stands before the world with what?

First, with a solid engineering education, equivalent to that offered by an accredited school.

Second (and equally important), with a basic practical knowledge of the functions of his industry, obtained firsthand by the student himself.

This is a new version of "the five year course." However, the additional cost of the fifth year has been negligible. During the time the student has been working he has been earning his way. He is also prepared to step into a higher position than those to which his shiny new diploma would entitle him, for in the shops he has had the elementary training which is a prerequisite to responsibility.

Another angle to be considered is the student's opportunity to scrutinize his fields of interest, to decide if engineering is his destiny, and if so—which branch? Here, as under no other system, he may reconcile theory with practice as he goes along. And how much more real will engineering be to him. He leaves college with a head not swollen by the grand futures and dreams which afflict most of us at that time. And, more often than not, with the offer of a responsible job from the very company in which he has already served his apprenticeship. For the employers like this system and do hire the graduates who have worked under them. In fact, one large Milwaukee concern has swung decidedly toward Marquette co-ops in preference to Wisconsin graduates because the former have had the basic shop experience and background which is so essential to men "higher up."

Still, it can not be said that this plan is ideal for Wisconsin in any such form. Our school is probably too large and the city of Madison too small to furnish the required part-time employment.

Although we doubt that the plan is feasible here, we do wish to point out that, for the boy who can't easily afford to attend a regular engineering school, the cheaper cooperative plan holds many distinct advantages which make it worthy of his serious consideration.

> ***"The main difficulty with the average person is that we don't see the man who makes a material success of life until after he has achieved distinction. The man who is hitting the ball persistently does not always attract attention at first notice. He is generally recognized only after he has made his fight and won out."***
>
> —ANONYMOUS.

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FIRED BEFORE HIRED

Have you ever stopped to think what you are going to do about getting a job after you have completed your engineering course? Do you think that some organization is going to seek you out and offer you a job just because you have a diploma from the University of Wisconsin? Did it occur to you that you will have to do a good job of selling yourself to them or they won't even give you a second thought?

Recently, Mr. Clarence Francis, president of the General Foods company, made the statement that the average graduate has such a weak and feeble argument why the concern should give him a job that they could not be expected to have the least interest in him. He went on further: "'Why do you want a job with us?' we ask. Invariably an empty reply is given. His only real inspiration on the matter had been that people always have to eat, and a good job with a food company ought to be a stable one, and 'my professor said that General Foods was a good company'. A reply of this kind is the most dependable of all methods of losing a prospective job." The average concern taking on college men wants someone who can show that he has considered himself fitted to be an advantage to his employer.

Mr. Francis said the reply should have been, "I have come to you because I have studied your company and others and have come to the conclusion that I am best suited for yours. I should much prefer a position in this definite branch of the work to any other. My previous experience in this work makes me best suited for it. I am willing to work for any salary you name while I am going through the stages of learning the ropes; have you a place for me?"

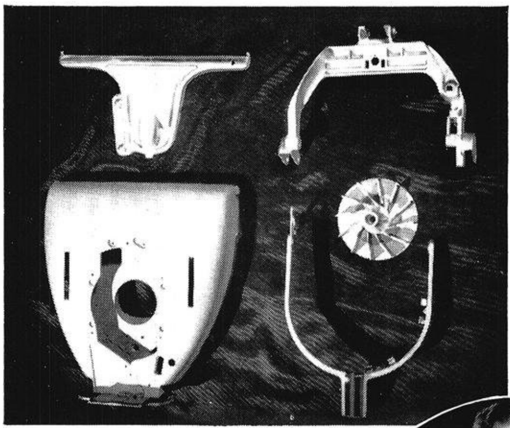
With an argument like that, the prospective employee is not starting with two strikes already called.

•

"Whatever your past has been, you have a spotless future."

At the right is shown the type of die-casting machines being used by The Hoover Company in producing the daily total of 5,000 Dowmetal die-castings for the new Hoover One-Fifty Electric Cleaner.

What DOWMETAL is doing for HOOVER



In the new Hoover One Fifty, Dowmetal is used in five different parts from the handle bail to the intricate main housing. In these five parts a total weight saving of over two pounds is achieved without the slightest sacrifice of structural strength.

The amazing lightness made possible by Dowmetal has caused thousands of women to abandon their present cleaner for the lighter, easier handled Hoover.

Lightness to the utmost limit, without sacrifice of strength or durability, was a major objective when Hoover set out to re-design its famous line of electric cleaners.

After considering every factor Hoover adopted Dowmetal.

For Dowmetal is actually *a full third lighter than aluminum* yet possesses comparable strength and durability. Thus, it carries lightness of construction far beyond the possibilities of any other commercial metal or alloy.

While the use of Dowmetal in the Hoover One Fifty constitutes its first appearance in a product of general public use, it has long demonstrated its value in portable power tools, trucks, machinery, foundry flasks and many other products.

Dowmetal opens the way to the complete—not partial—elimination of useless, power-consuming or sales-retarding weight.

Complete information concerning the characteristics, uses and methods of fabrication is contained in "The Dowmetal Data Book." A copy will be sent with our compliments to you.

THE DOW CHEMICAL COMPANY
Dowmetal Division • Midland, Michigan

And these women are praising the Hoover at every opportunity—and its lightness is one of the features they praise most.

DOWMETAL
MAGNESIUM ALLOYS
LIGHTEST OF ALL STRUCTURAL METALS

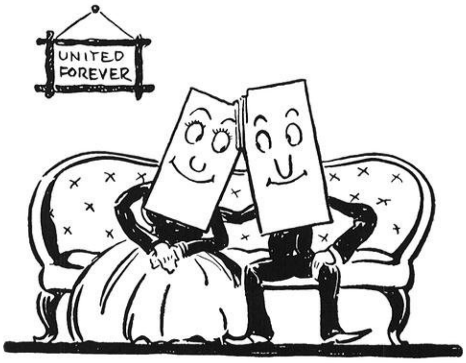
G-E *Campus News*

NUMBER 7000

JUST as if timed to take part in the 25th birthday celebration of the General Electric shops in Erie, Pa., Locomotive Number 7000 recently bowed its way out of its shed and took a brilliant turn on the test track.

The first of Number 7000's predecessors was begun in Erie in 1911, or just 25 years after electrical manufacture had commenced in Schenectady. Since that time locomotives weighing from 1½ to 300 tons have been turned out to improve haulage electrically. This range includes types for every sort of service—straight electric with trolley pole or third-rail shoe, battery types, internal-combustion engines, and combinations of different designs.

The Erie plant is notable for its contributions to practically every phase of modern electric transportation. The electrification of terminals and railroads has been accomplished largely with Erie equipment. Many of the new high-speed trains, which have aroused so much interest in rail travel, and many urban transit vehicles, such as street cars, trackless trolley coaches, and diesel-electric buses, likewise use Erie equipment.



FIFTY YEARS OF WELDED BLISS

TWO pieces of metal were joined in "weldlock" fifty years ago. That was in 1886, when Professor Elihu Thomson, one of America's greatest pioneers in the field of electrical science and co-founder of the General Electric Company, invented resistance welding—fusing metals by placing them in contact and passing an electric current through them.

To mark the golden anniversary and to honor the man who officiated at the "ceremony," the Detroit Section of the American Welding Society dedicated a recent program to Professor Thomson's invention.

The years have seen resistance welding develop from its purely experimental stage into a process of metal fabrication that is wide in application. Metal radio and industrial tubes and parts, automobile bodies, the high-strength aluminum alloys used in aircraft, farm implements, the new lightweight railway equipment—all are fabricated by resistance welding.

SUNSHINE IN MANHATTAN

AT last there is sunshine—sunshine for those who spend so much of their hurried lives in the shadows of Manhattan's financial district. For in his new downtown recreation and health center—largest of its kind in the world—Artie McGovern, famous trainer and physical director, has equipped both the hot room and gymnasium with ultraviolet sunlamps.

Installed by General Electric engineers in the form of 26 ceiling units—probably the largest installation ever made in a single location—they not only afford health-giving artificial sunshine but are the sole means of illuminating the two rooms.

This installation marks another step forward in the field of lighting. The development of better lamps to sell at greatly reduced prices, the campaign for safety on the highway by means of improved highway lighting, the "Better Light—Better Sight" movement for the protection of eyesight, and the search for methods to improve general health have all been given strong impetus through the efforts of the General Electric Company.

96-340DH

GENERAL ELECTRIC