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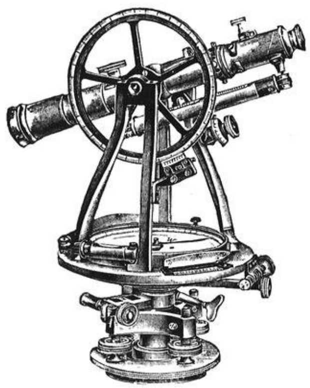

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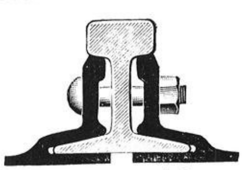

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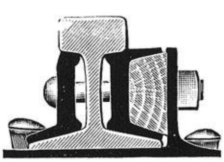

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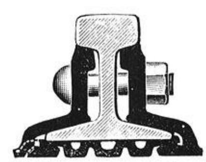

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The Wisconsin Engineer

VOL. XV NOVEMBER, 1910 NO. 2

THE CASE HARDENING AND HEAT TREATMENT OF LOW CARBON STEELS.

A THESIS BY A. C. SLADKY, '10, AND A. F. SCHULTZ, '10.

Abstracted by A. C. Sladky.

Introductory note by John G. D. Mack, Professor of Machine Design.

INTRODUCTION.

In the earlier days of the scientific design of machinery, specifications and stresses were based almost entirely on data derived from physical tests made under static loads. The work of Wöhler on the effect of repeated stress, caused radical changes to be made in the factors of safety, which, having been based on static load tests, were proven to be too small for active loads producing varying stresses.

After the chemical analysis of iron and steel came into general use, it played a constantly increasing part in specifications dealing with these materials, until the somewhat general opinion prevailed that the physical test combined with the chemical analysis gave all necessary data for the proper use of the various iron combinations as regards allowable stresses.

Certain properties of some of the steels, however, were not indicated by either of the above methods and the microscopic study of metals or metallography was introduced as a supplementary method of analysis.

Metallography has proven of great value in research on steels, particularly in regad to the influence of heat, or distortion, on the character of the material.

Among recent developments of methods and instruments for the study of the properties of metals, are several devices for measuring relative hardness, and from the results of extensive research on the hardness of different steels after various treatments a great many additional facts of value to the steel user have been obtained.

Regardless however of careful design, great trouble has been caused in some machines by the failure of steel parts to withstand required loads, even though the steel had been carefully made according to specifications, and had withstood various standard tests.

These failures have been particularly marked in automobiles and other machines receiving severe shocks in service.

Difficulties were also encountered fom the fact that similar parts made from the same steel would not give equally satisfactory results.

It is now known that many of these failures were caused by irregularities in the manufacturing processes, particularly in the varied heat treatment which was employed.

Until recently but little attention has been given to the effect of heat treatment on medium and low carbon steels, a matter which is proving to be of the greatest importance.

An experimental study of "The Case-Hardening and Heat Treatment of Low Carbon Steels" was made in 1909–1010 by Messrs. A. C. Sladky and A. F. Schultz in the mechanical engineering department of the college of engineering of the University of Wisconsin, the results of this research being embodied in their thesis, an abstract of which is given below.

This line of work offers many opportunities, both in the commercial and research fields, and it is planned that additional research work on the heat treatment of steels and allied subjects will be carried on in the university shops in conjunction with other departments.

Abstract of Thesis.

The advent of light, heavy duty machinery, notably the automobile, has brought the steel consumers face to face with the problem of treating both "machinery" and special steels so as to obtain maximum strength and service from the lightest possible machine members. This discussion is limited to carbon steels such as are used for all ordinary machine members, that

is, steels in which a fairly high elastic limit, and considerable elongation and reduction in area are desirable, and which are comparatively low in carbon.

Of the processes now in general commercial use heat-treatment and case-hardening are the most important.

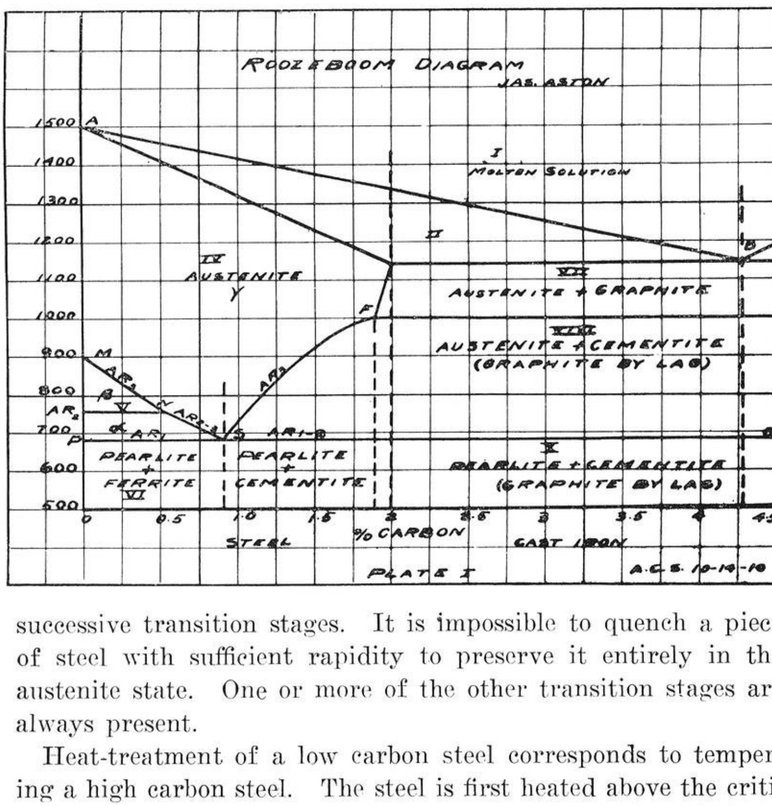
Heat-treatment will be defined as a thermal process other than simple annealing which will change the "grain" of the metal, so as to make the steel tough without losing any of its desirable physical properties.

Following is a brief discussion of the principles of the mettalography of the iron-carbon alloys.

Within the range of the steels which this thesis covers, steels containing from 0.10 per cent. to 0.45 per cent. carbon, the structure will n every case consist of a matrix of ferrite, relatively pure iron, with an excess consisting of little islands of pearlite. Pearlite is a eutectic structure with 0.90 per cent. carbon, and existing as a composite structure of ferrite and cementite, the latter a defininite carbide of iron, Fe3C, in the ratio of 13.5 per cent. of cementite to 86.5 per cent. of ferrite. Cementite, on the other hand, a very brittle and extremely hard compound, appears as the excess substance in all slowly cooled steels containing more carbon than the eutectic proportion of 0.90 per cent.

Austenite is a state of the metal in region IV of the Roozeboom diagram. The Roozeboom diagram is a solubility curve of the carbon iron series, the region from 0 to 2 per cent. C. being the steels, the region from 2 per cent. C. up, being the cast iron region. The line P-O is the line of recalescence temperature which is constant throughout the entire series. Ar_3 is the critical temperature, at which the transformation from the pearlite state to Austenite is completed. Ar_2 is the temperature at which the metal loses its magnetic properties. It will be seen that the recalescence point and the critical temperature coincide only at 0.90 per cent. C.; and that only for a small range of carbon content do the temperatures Ar_2 and Ar_3 coincide, showing that the magnetic test for hardening will hold good only for a limited range of steels. Austenite is a solid solution of carbon and iron. It is hard and brittle when cold, and above the critical temperature Ar_3 it is normal and therefore stable. It is slowly transformed into pearlite with an excess substance in cooling across region V into region VI. In the transformation from austenite the metal successively passes into the states of structure, martensite, troostite, sorbite and then into region VI.

Since it takes an appeciable length of time for the transformation to be completed, it follows that sudden quenching from the critical temperature will arrest the transformation, so that the cold steel, instead of consisting of pearlite and ferrite, or pearlite and cementite, will be by lag, preserved in one or more of the



successive transition stages. It is impossible to quench a piece of steel with sufficient rapidity to preserve it entirely in the austenite state. One or more of the other transition stages are always present.

Heat-treatment of a low carbon steel corresponds to tempering a high carbon steel. The steel is first heated above the critical temperature Ar_3 and in the passage through region V of the Roozeboom diagram the grain structure changes, the change accompanying a rise in temperature only. When the temperature rises above Ar_1 the pearlite of the meshes changes to austenite and as the temperature continues to rise the net work of ferrite is absorbed by the austenite meshes, and grows thinner and thinner, though not necessarily changing in size. The austenite within the network again divides into grains, but they are not surrounded by a layer of weak ferrite.

A piece of steel quenched from above the critical temperature will thus have a structure which has maximum resistance to rupture, as the weak ferrite network, which determines largely the plane of rupture, is almost entirely replaced by the harder stronger structure of austenite and its successive changes by lag. The mechanical operation is simple, and is as follows: Consulting the Roozeboom diagram, it will be seen that 900 degrees C., or a bright cherry red, will surely bring the steel above the critical temperature. The bars are heated to this temperature in a furnace, or a forge with a deep, slow fire, to make certain that the bar is heated uniformly throughout, and then plunged into a tank of cooling brine. They are next polished and "drawn back" to about 350 degrees C., indicated by a dark blue oxide on the surface.

NOTE.—The writer recently had a talk with Mr. W. G. Lottes regarding the quenching temperature. Mr. Lottes found that in handling Bessemer steel he was forced to raise the temperature in some cases above 1000° C. in order to obtain the minimum size grain, but this was necessary only with a limited number of bars. In most cases 900° C. gave the best result. Impurities in the steel may require a raise in temperature, but it is a safe rule to keep the quenching temperature as close to 900° C. as possible and eliminate the danger of making the grain too coarse.

Case hardening is a process by which the carbon content of the surface of a low carbon steel is raised some times above 1.00 per cent. so that the shell is really a carbon tool steel, which is of extreme hardness, and will resist wear and abrasion. The interior, however, is still in the original state, possessing all the desirable properties of a low carbon steel.

The shell is carbonized by packing the specimens in an air-tight box containing some substance high in carbon, such as charcoal, leather, barium carbonate or old bones. The box thus packed is heated in a furnace to about 900 degrees C. and this is maintained until the proper depth of carbonizing is obtained, this depth being indicated by a small bar inserted in the box so that it can be removed from time to time, quenched, broken and examined.

There is a difference of opinion as to the heat at which a carbonizing furnace should be operated. It is certain that the heat required must be above the critical temperature, but not sufficiently high to make the grain coarse and injure the steel by overheating. At higher temperatures the process may be more rapid, but the steel will certainly show the ill effects of such a high temperature, if continued for any length of time, both in appearance and physical properties. There is no reason why the temperature should be higher than the critical temperature, and both Mr. W. G. Lottes of the university, and Mr. Chas. Wesely* have found by practical work that this temperature gave the most uniform and satisfactory results. Alloy steels, such as nickel-chromium, nickel and vanadium, require a higher heat, about 1050 C.

After the bars are carbonized, they are cooled either by sudden quenching or by allowing the boxes to cool to room temperature. Since the bars contain steels with greatly differing carbon contents, there should be two heat-treatments. The bar is first heated to the critical temperature of the low carbon steel, 900 C., and quenched. This will refine the interior, but will make the grain of the shell too coarse. Then the bar must be heated to a point below the transition point of the low carbon interior, but above the transition point of the high carbon shell, and quenched again. This last treatment will refine the grain of the shell. Quenching from the box when taken from the furnace may or may not take the place of one heat-treatment, depending upon the heat at which the box is taken from the furnace, and upon the carbon content of the stock. For all ordinary work two heats are sufficient, but as a further safeguard against failure, the bars may be drawn to about 300 C.,—a deep straw oxide—to relieve all quenching stresses.

John A. Mathews of the Halcomb Steel Company, in a paper given at a meeting of the Franklin institute, speaking of nickel steels, says:—"Better still, however, if nickel steel is used, is to give it a double quenching for then one obtains a really remark-

* Steel expert with A. O. Smith Co., Milwaukee, Wis.

able product of extraordinary toughness and remarkable wearing qualities. An ideal way of making a nickel steel gear consists in first annealing the blank, then rough machining, then giving a light reannealing before taking the finishing cut, then carbonize to a depth of 1-16 to 1-32 inch, at a temperature of 1625 to 1630° F. Cool in pots, heat to 1500° F. and quench in a hot brine or calcium chloride solution. This will put the core in excellent physical condition. Finally reheat to about 1400° F. and quench in oil. This last operation will refine the grain and harden it with results. The temper need not be drawn."

Various mixtures are used as cooling mediums from a saturated solution of common salt to most elaborate mixtures. All of the mixtures contain salt. The function of a quenching brine is to cool the steel suddenly and prevent as much as possible the transition from austenitic state. No definite reasons have ever been given for the use of a brine in preference to pure water, but since our practical men have obtained the best results with a brine, we may as well continue its use. It is certain that sudden, slow, and very slow cooling have certain definite effects on the physical properties of steel, and if a brine will quench a piece of steel more rapidly than water, then there is every reason for continuing its use.

The process just described is used for hardening small machine parts, gears, gun parts, bolts, etc. The thesis also contains a full description of the Harveyizing and the Krupp processes. The Harveyizing process is used for case-hardening armor plates, etc. The Krupp process is used for hardening large machine parts, large guns, etc.

(*To be continued.*)

THE POSSIBILITIES OF ARTESIAN WATER SUPPLIES FOR IRRIGATION IN WYOMING.

ELIOT BLACKWELDER,
Associate Professor of Geology.

Central Wyoming is dry, generally much too dry to permit the growth of ordinary crops without constant irrigation. In many places not even the hardy sage brush can flourish. Twenty or thirty years ago the settlers of the region were largely cattle ranchmen who turned their stock out upon the open range. The cattle found grass in valley bottoms and other favored spots and by roaming over a large area the herds were able to shift for themselves even in winter. The only attention paid to them consisted in rounding them up once or twice during the year, to brand the calves and cut out the beef cattle for market. Many of the old time ranchers raised little or no produce, and some did not even keep a kitchen garden, nor maintain a milch cow.

As more and more of the land has been taken up by settlers and put under fence, the open range has shrunk, while the demand for it among the increasing population has grown. The cattle men have thus found it generally necessary to feed their stock more and more, especially during the winter. In order to be able to do this, they have been obliged to grow hay in quantity. Only by irrigation is this possible. In a typical Wyoming valley such as the Wind River valley the only irrigible areas are the bottoms adjacent to the river and the larger tributaries which rise high up in the mountains; for they alone are likely to have permanent streams. At present, in the more populous valleys, many of the ranches are raising on a commercial scale not only hay, but grain and even potatoes and other vegetables. All this of course requires irrigation. It has been the common practice to tap the main stream some distance above the ranch and lead a ditch around the lower slope of the valley on a more gentle gradient than the creek. The water is then allowed to run down lateral ditches or merely to soak through the surface soil on its way back to the stream. By this method, however, only a comparatively small area can be put under cultivation. Broad terraces and level plateaus between the tributary valleys are in many instances covered with good loamy soil which is admirably suited to farming if only it could be supplied with water; but such places are generally too high to be reached by ditches of the ordinary kind. In a few of the more populous valleys, ditch companies have been formed, and these,

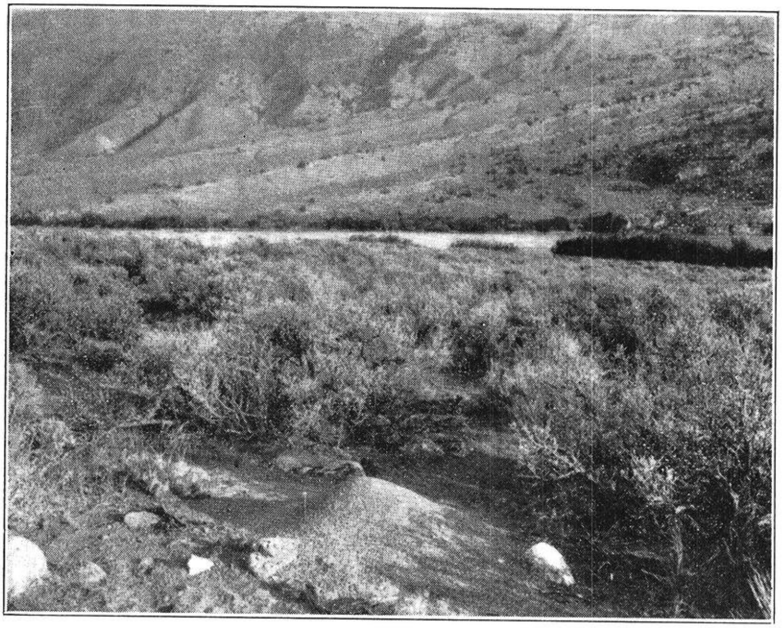


FIG. 1.—*Home of the so-called "farmer ant." Under present conditions he has no competitors in the business, but the rank growth of sage brush shows the soil is potentially rich.*

through collective capital, have been able to construct reservoirs and large ditches. By taking their water from far up in the mountains, these companies can carry the water out to the valley at a higher level and distribute it out over some of the high terraces and plateau surfaces in such a way as to permit the cultivation of them. The projects undertaken by the United States Reclamation Service are of this character, and may be taken as among the best and greatest examples of such improvements.

There are still, however, large areas which cannot be treated in this way, because they lie too far from the sources of surface water supply such as the larger rivers or mountain lakes. Furthermore, in some areas which could be reached by ditches, there is far more land than could be irrigated with the water which can be obtained from the streams or lakes of that particular district. In some of these places there is still another possibility of obtaining water and it is here that the training of the geologist comes into use.

More water and snow falls upon the mountain ranges of Wyoming than upon the intervening valleys and lowlands. Some of this precipitation is taken off by the streams, but a large part of it sinks into the ground and joins the great body of water with which all the rocks and soil beneath a moderate depth are saturated. This water underground flows in directions which are more or less determined and controlled by the character and structure of the rocks. In the Wind River valley the prevailing rocks comprise alternate layers of sandstone, shale and limestone. In its slow movement, the water tends to follow the more porous beds such as the sandstones, and is confined and checked by very fine grained rocks such as shale or beds of clay. Where the rock strata consisting of such alternately pervious and impervious beds have been bent into folds, part of the water which falls as rain upon the mountain slopes and that derived from the melting of the winter snows accumulates in the lower part of the basin under considerable head. When tapped by a boring in the middle portion of the basin, the water will rise to or near the surface and in the most favorable localities will flow out in the form of gushing wells. Just which result will be obtained in a particular place depends upon several factors to be noted later. Some drilled wells of this kind near the Black Hills of South Dakota yield an enormous volume of water under high pressure. In other cases the water does not rise quite to the surface, and it is then necessary to install windmills or other pumping devices.

The Wind River valley and many others in central Wyoming have the favorable basin-shaped structure (Fig. 2) and are separated by arches which are the sites of broad mountain ranges. At any given place in order to determine whether or not an artesian flow could probably be obtained by drilling, it is necessary to make a somewhat careful study first of the succession and character of the rock strata and second of the geologic structure in that particular district. It is necessary to know whether there are porous beds in the series and whether they are exposed favorably on mountain slopes or summits; to know the depth beneath the surface at which possible water-bearing layers may be encountered in drilling. By taking into consideration the height of the outcrop of the porous beds above the mouth of the well, the horizontal distance which the water has to flow underground and the relative porosity of the stratum through which it passes, it is possible to make a very rough estimate,—largely from analogies,—as to whether or not the water will reach the surface if the well is drilled. Since the last of these factors is,

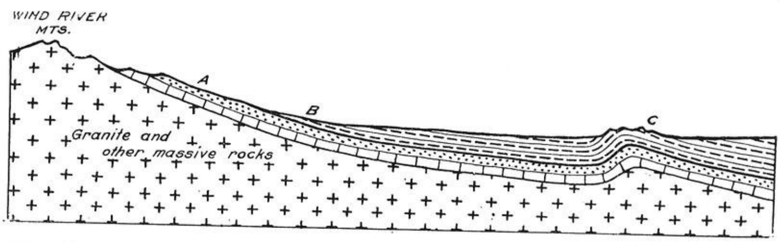


FIG. 2.—*Rough section to show the geologic structure of a part of the Wind River valley. Near A is the outcrop of a thick sandstone bed covered on the right by shale. From B to C deep wells could probably obtain a flow of water from the sandstone.*

however, a very difficult one to valuate, it is clear that such an estimate should not be relied upon. In a coarse friable sandstone water loses less of its head through friction than in passing through a fine grained sandstone or one the pores of which are largely filled with clay or cementing minerals. It therefore rises higher in the well in the first case. For a similar reason the distance counts, for the toll of energy paid to friction in a given layer accumulates with each mile the water is obliged to percolate through the rock.

It will be seen at a glance that the great advantage of an artesian water supply in a region such as central Wyoming lies in the fact that water may thus be obtained in some places where there are no permanent streams of sufficient volume, and where for that reason the necessary irrigation would be quite impossible. There are probably several reasons why the settlers of the Wyoming valleys have not already taken advantage of this resource to a larger extent. First, the drilling of the well is a somewhat expensive matter, especially where it is necessary to go down 1500 or 2000 feet for an adequate supply. Many of the settlers of the West have gone out there with very little capital and would be financially unable to meet the cost of a deep drill hole. It is probable, however, that much of the failure to use artesian water supplies is due to a lack of knowledge that such a supply exists or can be made available. In much of that region it is necessary to dig more than 100 feet for drinking water in making an ordinary well. A windmill, drawing its water from such a well, could give but a small supply,—perhaps not enough to irrigate a garden patch. With the large artesian wells, however, it is very different, for some of them have flows far exceeding the discharge of the average ranch irrigating ditch. Near Salt Lake City, Utah, there are artesian wells which are used to irrigate fruit orchards of considerable size. And in some other parts of the west wells of this kind have been successfully used on a comparatively large scale. Whether or not in any given place it would pay to drill for artesian water, requires the combined knowledge and training, on the one hand of the geologist, to determine whether or not a flow could be obtained and under what conditions, and on the other hand of the practical ranchman to estimate whether the cost of the well and interest on the investment can be repaid by the probable returns from the land to be irrigated. That the question will in the near future find an affirmative answer in a large number of cases is a prediction which I believe can safely be made.

LABORATORY REPORTS.

GEORGE J. DAVIS, JR.,
Assistant Professor of Hydraulic Engineering.

The research laboratory is a very ancient institution, having existed in some form since the earliest times. The Chinese, Egyptians, Greeks and Romans all had laboratories in which search was made for the philosopher's stone and in which were manufactured elixirs, drugs, charms, etc. The use of laboratories for instructional purposes did not develop, however, until the nineteenth century. The first important step in the establishment of the laboratory method of instruction was the erection by Liebig of a chemical laboratory at Giessen in 1825. The first physical laboratory was opened in 1846 at Heidelberg. Engineering laboratories were not developed until still more recently; most of them having been established in the last fifteen or twenty years. Notwithstanding its late origin the laboratory method of instruction has already been practically universally adopted and has become the distnguishing characteristic of present-day technical education.

Laboratory courses are intended to teach the principles and methods of experimental work rather than the mere technical execution of test work. The methods of instruction used in engineering laboratories differ widely; depending on the adequacy of the equipment, the number of students and the ability and experience of the instructors. But it has been found advantageous in almost all laboratories to require the students to prepare a report of some sort on each experiment.

USES OF THE LABORATORY REPORT.

In determining a student's grade in a laboratory course the factors usually considered are, (1), his ability as an observer and recorder, (2), his understanding of the problem, including the construction and use of the apparatus and the methods of conducting the experiment and computing the results, and (3), the excellence of his report. An approximate estimate of the first two of these factors may be made by the instructor from the students' general deportment in the laboratory, but his proficiency is more clearly shown in the report, which contains his experimental results and his descriptions of the apparatus and methods used. The report is therefore the principal means by which the student's grade is established.

A more important function of the laboratory report than the above is that of crystallizing the student's conception of the experiment into concrete form. In order that he may explain the construction or use of an apparatus, or the method of computing results it is necessary that he have a clear understanding of the matter himself. The thought which is required to gain such an understanding of all features of the experiment and to arrange the descriptions and explanations in the report in a logical manner must result in a growth of the student's knowledge and mental power.

A third function of the laboratory report is the development of a literary style. This does not mean the use of flowery language. It refers to simplicity, directness and conciseness of expression. It is the right choice and placing of words; the best arrangement of clauses in sentences, and the euphonious sequence of syllables. The development of a good literary style is a matter of great importance to the engineer, for throughout his whole career he is called upon to write reports to his employers. In the earlier years of the engineer's career his employer is likely to be a chief-engineer; later, as chief-engineer himself, he may report to a president or to directors of a company; or as an engineer in private practice his employers may be clients who trust him to properly design and execute works in which they are investing. In either case the employer wants to be able to understand the report and to comprehend what it means. The unnecessary use of technical terms and phrases should therefore be avoided and the habit should be acquired of discussing technical matters in such a way that any business man may be able to understand the facts in the case, to follow the argument, to understand the basis of the conclusions, and hence, to form his own opinion concerning the subject of the report. If the language is involved, and especially if its meaning is obscure or ambiguous, there may result considerable unnecessary discussion or controversy, due entirely to the style of the report. If the matter is one which relates to litigation or comes before a court, a poorly prepared report may offer many points of attack for the opposing counsel. Furthermore the evidence of an ability to arrange subjects systematically and to present information and opinions in a style and language which will be not only clear but pleasing, necessarily have some influence in convincing the reader as to the value of the writing and the ability of the writer. A good style can only be acquired by study and practice in writing.

Outline of a Laboratory Report.

Most laboratory experiments require the co-operation of two or more students, and it is generally desirable that they check each others calculations; but the reports, to properly fulfill their functions, should be prepared by each student independently.

The report should have an introduction, in which should be given a general statement of the problem in hand and of the particular features of the problem which form the subject of the experiment. This should be followed by a description of the apparatus and of the methods of experimentation and illustration of the method of computation. The report should be concluded by a discussion of the results obtained from the experiment, which should usually be plotted in diagrams showing the experimental relations of the variable quantities.

In some laboratories the reports are partially prepared before the experiment. The advantage of this method lies in the fact that the student has a more thorough understanding of the problem at the time of the experiment, on account of the preliminary study he has given to it. Where this method is used the discussion of the results is necessarily deferred till after the experiment and forms a supplementary part of the final report.

The report should be brief, but the briefness should be secured by conciseness of statement, rather than by the omission of any matter which is required to make the descriptions or discussions intelligible or the report complete. In a report on original investigations in which unusual apparatus is used the descriptions of the apparatus and methods of work should be very minute, in order that the reader may be able to judge of their fitness and of the reliability of the results. The requirements in a laboratory report on experiments in which standard apparatus is used, are not so severe. In this case the aim of the student should be to show that he thoroughly understands the apparatus and methods of the experiment. Hence in the description and illustration of the apparatus its essential parts and proportions only should be given, omitting reference to details which might be changed without affecting the results of the experiment. The wide differences in the complexity of the apparatus, the nature of the problems and the time available for their solution, necessitate variations in the requirements for the reports in different laboratories, but the general scope of the reports required in all of the engineering laboratories at the University of Wisconsin is illustrated by the following:

Sample Report.

Flow of Water in a Straight Pipe.

Part I.

(Written before the experiment is performed.)

Introduction. It has been found by experiment that the loss of head due to friction in pipes varies inversely as the diameter, directly as the length and roughness of the pipe, and approximately as the velocity head. The formula commonly used to express these relations is

$$h = \frac{f\,l}{d} \cdot \frac{v^2}{2g}$$

in which h = the loss of head due to friction.
v = the mean velocity of flow.
l = the length of pipe between piezometers.
d = the actual internal diameter of the pipe.
g = the acceleration of gravity, and
f = the friction factor, which depends upon the roughness and diameter of the pipe and the velocity of flow.

The purpose of the proposed experiment is to determine values of the friction factor, f, under different conditions of flow.

Column headings have been arranged in Table I for the tabulation of the observations.

TABLE I.

THE UNIVERSITY OF WISCONSIN, HYDRAULIC LABORATORY

Experiment on Loss of head in a straight pipe. Data by C. M. Kehr and A. F. Coleman. Computed by C. M. Kehr. Date of Experiment, July 29, 1908. Checked by A. F. Coleman. General Data Internal diameter of pipe = 2.063 inches. Length of pipe between piezometers = 10 ft.

No of Run	Weight of water		Time		Gage Reading	
	Gross	Tare	Initial	Final	Left	Right
1	2932.0	546.0	2:33:30	2:39:03	1.972	1.473
	Net=	2386.0	Dura-		1.971	1.472
			tion=	5^m-33^s	1.973	1.472
			=	333^s	1.973	1.472
					1.975	1.474
					1.976	1.474
					1.977	1.475
					1.975	1.472
					1.974	1.473
					1.975	1.473
				Average=	1.974	1.473
				Differ-ence=		0.501
2	3670.0	542.0	2:45:00	2:50:40	2.298	1.559
		3128.0		5^m40^s	2.299	1.560
			=	340^s	2.300	1.560
					2.308	1.564
					2.304	1.562
					2.302	1.561
					2.303	1.561
					2.308	1.566
					2.305	1.563
					2.304	1.562
				Average=	2.303	1.562
				Differ-ence=		0.741

TABLE II.

THE UNIVERSITY OF WISCONSIN, HYDRAULIC LABORATORY

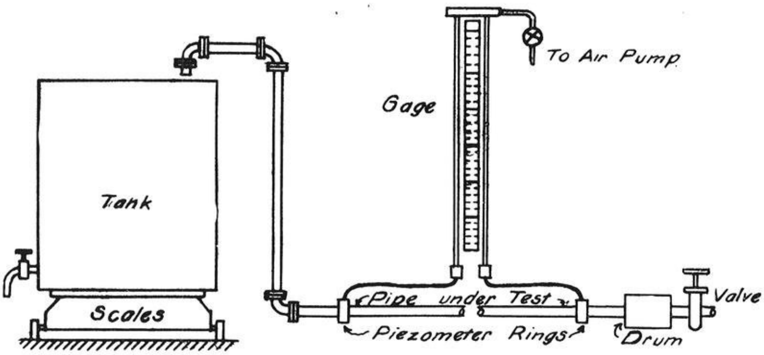
Experiment on Loss of head in a straight pipe. Data by C. M. Kehr and A. F. Coleman. Computed by C. M. Kehr. Date of Experiment, July 29, 1908. Checked by A. F. Coleman. General Data Internal diameter of pipe = 2.063 inches. Area = 0.0232 sq. ft. Length of pipe between piezometers = 10 ft.

No of run.	Weight of run in lbs.	Vol. of run in cu. ft.	Duration of run, in secs.	Discharge, in sec. ft.	Mean velocity.	Loss of head.	Friction factor f.
1	2386	38.18	333	0.115	4.94	0.501	0.0227
2	3128	50.00	340	0.147	6.34	0.741	0.0204

PART 2.

(Written after the computations are finished.)

DESCRIPTION OF THE APPARATUS. The pipe used was 2 1-16 inches in internal diameter and 10 feet long between the piezometers. A fluid differential gage, containing air as the gage



fluid, was used to measure the loss of head. The water discharged during a run was weighed in a tank on platform scales. A diagram showing the essential parts of the apparatus is given in Fig. 1.

METHOD OF EXPERIMENTATION. The pipe, piezometers, transmission tubes and gage were thoroughly flushed out to remove all air, after which air was pumped into the upper part of the differential gage, and the velocity of flow was adjusted to produce the loss of head assigned by the instructor.

METHOD OF COMPUTATION. The methods of computation used will be illustrated with the data of run No. 1, as follows:—

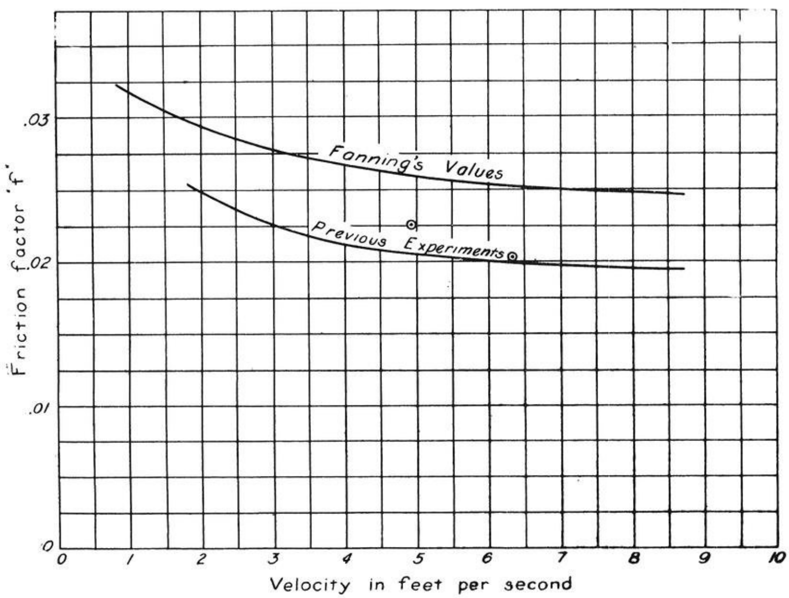
$$\text{Mean velocity} = \frac{Q}{F} = \frac{W}{wt\ F}$$

$$= \frac{2386}{62.5 \times 333 \times 0.0232} = 4.94 \text{ ft. per sec.}$$

$$\text{Friction fractor} = f = \frac{2g\ d\ h}{l\ v^2}$$

$$= \frac{2 \times 32.16 \times 2.0625 \times 0.501}{10 \times (4.94)^2 \times 12} = 0.0227$$

CONCLUSIONS. The results of the computations are arranged in Table 2. The values of the friction factor, f, have been plotted in Fig. 2 as ordinates against the corresponding velocities as abscissas. On the same sheet have been drawn curves from



previous experiments and from Fanning's table of friction factors. It may be seen that the results of the writer's experiments agree with those of the previous experiments within about one per cent and that the general law of variation of the values of the experiments agrees with that shown by the Fanning coefficients, though the values are larger.

PROGRESS IN THE ELECTROMETALLURGY OF IRON AND STEEL.

JAMES ASTON.

One of the most significant features in the rapid development of the various phases of electrochemistry has been the avidity with which iron and steel metallurgists are looking into the application of electric furnace methods in the manufacture of iron and steel.

The progress in the electrometallurgy of iron and steel may be said to be along three rather diverging paths. First, the direct production of pig iron or steel from the ore; second, the use of the electric furnace as an adjunct to existing plants, with the view of saving them for a further period of usefulness; third, the substitution of the electric furnace for existing apparatus, because of a resulting economy of operation or greater refinement of product.

The most radical application of electrical heating in the iron and steel industry, is its use in the electric blast furnace, so called, for the production of iron from the ore. The direct method, as exemplified by the original Stassano type of furnace, whereby the ore is reduced to steel in one operation, has made but little progress, in this country at least. Seemingly the simplest and most rational solution of the problem, it is in about the same catagory as the direct method with ordinary fuels, and the complications and details of its application more than offset its approach to idealism.

To attempt to replace that most efficient piece of apparatus, the modern blast furnace, with one using electrical energy, seems almost like "carrying coal to Newcastle." And it is in this field that the application of the electric furnace is likely to be the most restricted. By restricted, however, it should not be understood that the development of the electric smelting of iron ore has not made much progress, and that it has not a good future ahead of it. There are many districts where ore and water power are plentiful and metallurgical fuel is scarce. The development of this water power, and the use of the electrical energy generated in the electric furnace, enables one to dispense with two-thirds of the fuel requirement of the blast furnace. The one-third of the total, needed for the reduction of the ore, can be obtained from local supplies, usually charcoal.

Thus, while the general substitution of the electric smelting furnace for the modern blast furnace is probably a dream of the future, it has come to the fore as the proper solution for peculiar local conditions; such conditions as exist today in Norway and Sweden, in Canada, and on the Pacific slope of the United States. Development will be the result of an expanding local market for the product.

The furnace has passed though the embryo stage, typified by the simple form used in the experiments of the Canadian government at Sault Ste Marie, to the semi-commercial electric shaft furnace of today. And strange to say, two widely separated and independent lines of development have resulted in practically identical forms of furnace suited to the work. In California, and in Sweden, the furnace now consists of a shaft with outward-flaring walls, and the bell and hopper top of the blast furnace. But the boshes and tuyeres of the blast furnace are replaced by a large heating chamber and reservoir, into which project the several electrodes. In this chamber the iron is melted and collected, after its reduction from the ore in the shaft; this ore being heated in its descent by the ascending gases.

It was Alexander Holley, the father of the Bessemer process in this country, who was forced to the prediction that the open hearth process would be present at the death of the Bessemer. We have almost reached the stage where Holley's prediction is ready to become a realism. Ores of Bessemer grade are becoming scarce, and the demand for closer regulation of product is becoming so urgent, that even now our largest and most modern steel works has adopted the basic open hearth process as the solution of the problem. But the Bessemer process has such strong qualifications in small plant investment and large outputs that it will not be cast aside without a struggle. One effort is the duplex process, the combined acid Bessemer, basic open hearth. Will not that other duplex process, the combination of the Bessemer converter and the electric furnace, play an equal part?

Notable installations of this character are the large electric furnaces at South Chicago, Illinois, and Worcester, Massachusetts. The large furnace at South Chicago has passed the experimental stage and is now evidently working satisfactorily and steadily as a new cog in the machinery of this large plant.

The most wide-spread interest of iron and steel metallurgists has been, and will probably continue to be, in the development of electric furnaces for the refining of material produced by existing methods. There is a demand, continually growing more urgent, for higher grades of steel. This, in the face of the steadily greater inferiority of available ores, is taxing the skill of the steel maker. The value of the electric furnace lies in possibility of control of the furnace atmosphere—oxidizing or reducing as desired—and the accompanying ease of regulation of the slags. Again, the high temperatures possible result in a cleaner separation of the impurities of the bath and allow much latitude in the composition of the slags; the chemical activity of the slag, therefore, and not some fusibility limit, is the governing factor.

There is a further development along lines analogous to the above, but one having for its object the supplanting of present costly processes. The electric furnace has broken down the bulwarks of conservatism surrounding the tool steel and special alloy steel industry, and seems likely to supersede the crucible process, and produce an equally high grade product at a considerable lessening of cost. And no fact could be more significant of the utility of the electric furnace. Quality and uniformity of product are prime essentials in the manufacture of tool steel; careful selection of raw materials, costly, but simple and controllable crucible melting, and skill of the workmen are a means to the end. Several establishments are trying out the electric furnace as a means of cutting costs on all three of the above items.

In the actual furnace development, the prominent feature has been the marked increase in the size and capacity of the individual units. These have passed beyond the experimental stage with a capacity of charge of a few hundreds of pounds, reaching a climax in the 15 ton furnace at South Chicago. In fact, the size seems at present to be limited more by the temerity of the user, than by the inability of the furnace designer to meet any demand.

With the increased importance of the electric furnace in the metallurgy of iron and steel, there has naturally been a multiplication of the types employed. This is more especially true in Europe than in America, since Europe is developing, and we are largely adopting the successful developments. The types are in most cases, however, variations in the details of application of fundamental principles.

Of the induction furnaces, the Simple Kjellin type has been built in capacities up to several tons, but is suited only to melting operations. The extension of this principle by the employment of multiphase currents, in the Rochling-Rodenhauser furnace, has widened its field of usefulness, and resulted in larger units, until now furnaces of eight tons capacity are working, and much larger ones are contemplated.

In this country, the Heroult type of furnace has had the greatest application. It appeals to the steel maker because of its utilization of the bottom of the tilting open hearth furnace, its absence of electical connections at the bottom, and the double arc on the surface of the bath, thereby doubling the operating voltage.

An interesting development of the conducting hearth type, heretofore necessitating the use of carbon linings, is seen in the Keller furnace, where a large number of metallic conductors are embedded in a rammed refractory lining of magnesite.

Perhaps nothing has had such influence in arousing the interest of the steel maker in the application of electrical heating to his industry, as the success of the large gas engine operating on blast furnace gases. This substitution of gas driven for steam driven blowing engines leaves available about one-fourth of the energy of the tunnel head gases. As approximate figures, the total energy of these gases may be taken as 40 H. P. per ton of iron produced. A moderate sized blast furnace is, therefore, a huge gas producer capable of supplying 10000 H. P. Of this, 2500 H. P. becomes available for outside distribution. And to what better use can it be put than to convert it into electrical energy; either for employment in driving the mill motors, or for that other application, as a source of heat for the refining of iron and steel in the electric furnace?

WITH THE A. S. M. E. IN ENGLAND.

By A. G. Christie.

In 1904, at the time of the World's Fair in St. Louis, the British Institution of Mechanical Engineers were guests of the A. S. M. E. at meetings in St. Louis and Chicago. The invitation to the A. S. M. E. this year to visit England, was intended as an appreciation by the British members of the Institution, of the entertainment their visitors were given in 1904. While not a participant in the meetings of 1904, the writer does not hesitate in saying that the recent visit to England eclipsed anything we could attempt in this country. The reason for this is very simple. The business meetings themselves only occupied about 25 per cent of the time at our disposal. The remainder was spent in visits to industrial works and to places of historic and literary interest. The latter was an experience entirely new to most of the American visitors and hence of very great interest. In this new and vast country of ours one could not select a place where there would be the same opportunity in so short a time to visit modern centres of industry and monuments of a past so intimately connected with the early history of the Anglo-Saxon people.

The Americans reserved the first class accommodations of the White Star Steamer "Celtic" for the trip over from New York and had a very delightful voyage. There were about 140 of the members and their wives in this party. They were joined in Birmingham by about 100 more who had gone over previously, which group included the writer. Those coming by boat arrived at Birmingham on Monday afternoon July 25, by special "train de luxe" from Liverpool. The train service on this and other trips by rail during our visit, was provided by the Institution and was the best the British roads could offer. This consisted of corridor trains of the British type with two seats on one side and one on the other of the corridor with similar seats opposite in each compartment. The furnishings and general style were equal to if not better than our Pullman cars, while there was also the added advantage that dining car service was provided on each car, tables being set between the seats. This made travel very comfortable and also allowed luncheons to be taken en route. Hence no time was lost on arrival at our destination.

Monday was spent in getting settled in our hotels, in registering at the temporary headquarters at the Birmingham and Midland Institute, in visiting the city clubs, which were thrown open to us, and in seeing the sights of Birmingham.

Birmingham is a city of over half a million and is probably one of the largest metal manufacturing cities of England. It is provided with a splendid water supply system, with efficient street railway service and with good gas and electric lighting supply systems which in common with most British cities, are owned, managed and operated by the municipality. The surrounding country is a soft coal mining district, and consequently the large factories produce an atmosphere which recalls Pittsburg, Pa., very realistically. The people are wholly English and an American at once misses the large foreign element so common in our large cities. There did not seem to be the great mass of unemployed, hopeless looking individuals in this city that one sees in almost all the English towns, but the writer was unable to learn whether this was due to greater thrift on the part of the people or to better industrial conditions. The citizens give the Hon. Joseph Chamberlain credit for the great expansion of Birmingham in recent years and, though still living, his monument is a prominent feature in the heart of the town. The city contains no buildings of particular interest though the Town Hall, the Council House and the Law Courts are quite imposing.

On Tuesday morning the first business meeting was held. The A. S. M. E. and the I. M. E. were welcomed to the city by the Right Honorable the Lord Mayor of Birmingham, Alderman Bowater. Addresses were also given by Mr. Geo. Tangye, President Aspinwall of the I. M. E. and Dean Goss of Illinois. Professional papers on Locomotive Terminal practice were then read and discussed. A number of us felt that as we had already read these papers and others to be presented later, we could make the most of our time by visiting industrial works and thus studying British engineering.

A small party went to the Austin Motor Car Co. where Mr.

Austin himself received us and we were shown over the entire plant. English practice in motor car manufacture differs from our practice in many ways. There each manufacturer builds his own frame, engine, body, wheels, axles, gears, carburettor, chassis, etc., in fact the entire car from the raw material. He then feels that he can safely guarantee his completed car as he is positively sure of the material and finish put on each portion. The Austin plant, covering 8 acres, was one of the best arranged and best equipped that the writer visited in England and while not an authority on motor cars, the Austin car certainly looked good and ran well.

In the testing department a number of interesting machines were installed for testing hardness of metals and also devices for checking accuracy of work, etc. In the machine shop there were large numbers of American machine tools, though a leading official expressed himself in favor of the newer German tools as they stand up better under the high speeds and heavy cuts introduced by the use of high speed steel. He made one exception, however, to this general rule, and that was with regard to turret lathes where the Gisholt of Madison, Wis., easily held first place. The engines are tested by prony brake first and then with an electric dynamometer. The process of "close-plating" brass onto steel lever arms, links, etc., was quite new to us. Many of the other interesting features at this plant must be omitted for lack of space.

After returning to Birmingham, we took luncheon on the train while on the way to Worcester. This excursion proved one of the most interesting of our trip. On the way down our train passed through the model village of Bourneville connected with Cadbury's Cocoa Works. It was certainly a delight to see such home-like and artistic houses, well ordered streets and lawns and nice gardens. We were met on our arrival at Worcester by a line of street cars and taken to a quaint old town hall, on both inside and outside of which were many statues of former monarchs of England. We were to have been welcomed by his Worship the Mayor, but unfortunately his auto broke down and we were deprived of that honor. We were next provided with guides and set out to the Cathedral, which is one of the best preserved and most famous in England. Here we were met by the

Dean and in a short address he told us the history of the Cathedal, pointed out the different styles of architecture in the building and called attention to many of its attractive features and especially those of interest to engineers. It is impossible in a few words to convey an adequate conception of the form and beauty of one of the old English Cathedrals, especially as there is no similar familiar structure with which to compare it in this country. One portion of especial interest is the tomb of King John, one of England's worst rulers. On his death bed he ordered his body to be placed in Worcester Cathedral between the bodies of St. Wulfsten and another saint buried there so that his soul would have a good chance in the hereafter. Another interesting relic was a recently discovered piece of parchment containing the Latin translation of a book on Geometry which was Arabic in the original, and which is claimed to outdate that of our familiar old friend Euclid. Space prevents a reference to the many other interesting details.

From the Cathedral we were conducted to the Royal Porcelain Works where such goods as table dishes, artistic vases, statuary, etc., are made. The process is most interesting. The raw materials are first ground with water, by abrasion in electrically driven mills until they pass through silk lawn with 4,000 meshes to the square inch. The materials are then of the consistency of thick cream. The mixing comes next and again this is carried out in electrically stirred mills. The water is afterwards squeezed out until the mass resembles thick paste. The thrower takes this on his rapidly spinning potter's wheel and presses it with his thumb into the shape required, such as a bowl or a cup. A turner finishes it ready for burning. Handles for cups, vases, etc., or arms of figures are pressed and afterwards attached to the turned vessel by a little of the liquid clay mixture of which both handle and cup are made. Forms are also cast in many cases. These formed pieces are next placed in an oven in specially formed fire clay receptacles and burned for a period of possibly two days and are allowed to cool an equal length of time.

The resulting unglazed porcelain is next dipped in a mixture to produce a glaze, dried and fired in another oven. Then it is ready for the decorator. Cheap porcelain has the decorative work printed on from an engraved copper plate carrying the pattern. But where several colors are present or where gilded figures are employed, the decorating is all hand work by a staff of skilled artists. One realizes the reason for high prices in this class of porcelain or china ware when it is kept in mind that the piece is burned again after each separate color or tint is added. Thus some work may be in the firing oven six or seven times. The articles are next burnished with agate or blood-stones and are then ready for sale. In the exhibition room were some beautiful examples of the various products of this work, some of them of exquisite design.

Worcester is one of the oldest cities in England and has many quaint old houses, some very peculiarly constructed. We were conducted through several of these old streets to "Ye Olde Commandery," one of the oldest houses in the city and famous as the scene of one of Charles I's exploits.

From Worcester we returned to Birmingham by special train and after dressing, were conveyed to the Edgebaston Botanic Gardens by motor omnibus. These conveyances were also provided by the I. M. E. to carry us to the different functions and visits in and around Birmingham. They were double decked and carried about forty people, being propelled by 40 H. P. motors. There were about a dozen or fifteen of these omnibuses.

We were entertained there at a Garden Fete by the Birmingham Reception Committee, who received. To the Americans this proved one of the greatest delights of the trip. The gardens were lavishly illuminated by small candles, each rose in the rose garden seeming to have its individual light. The rock garden was transformed into a veritable fairy land. Music was supplied by the band of the Royal Marines, and luncheon was served in a large covered pavilion. The night was very dark, though fair and warm for England, so that the illuminations were shown to the best advantage. The entertainment concluded with a magnificent display of fireworks. The beauty of the place itself, combined with the delicate suggestion of the English garden party of which we had all read, made this probably the most charming evening of our trip.

Besides the places mentioned above, excursions were also provided to Dudley Port Gas Plant, to the Metropolitan Amalgamated Railway Carriage and Wagon Co., to the Filter Beds, to Stonleigh Park, to Mr. Geo. Tangye's "Watt Museum," and other places.

Business sessions were held on Wednesday morning for the reading of papers on Machine Shop Practice in high speed tools, tooth gearing, etc., and interesting discussions followed.

The writer with several others went in the morning to Coventry to visit the Diamler Motor Car Works. Coventry is known as the City of Three Spires, and is an interesting old city with narrow crooked streets and overhanging second stories on the houses, in many of which the heavy oak timbers of the framing stand out black against the white plaster. It reminds one of the prints that can be seen in old books. The town is also associated with the story of Lady Godiva and Peeping Tom.

The Diamler Cars are built in four and six Cylinder sizes up to 57 H. P. The most interesting feature of these cars is the new "Knight" sliding-sleeve type of engine. There are no mushroom valves as in an ordinary engine. Their place is taken by a series of ports in the cylinder and in two concentric sleeves inside the cylinder operated from the crank-shaft by eccentrics, and these inlet and exhaust ports are thus opened at the required periods of the cycle as in an ordinary engine. This makes a very quiet and smooth-running machine and one that has given splendid satisfaction as far as the writer could learn from outside sources.

The works cover fourteen acres of actual floor space and here, as at the Austin works, all parts of the cars are built on the spot. An interesting department was the power plant where two Diesel oil engines of 350 H. P. each, drive electric generators to supply the motors around the shops. These engines have no electric ignition. Air only is drawn in on the suction stroke and is compressed to about 500 lbs. per sq. in. and the oil fuel is then sprayed in. The heat is so great that the oil burns spontaneously as it enters and at practically constant pressure. The resulting expansion provides the power to drive the piston down and to do external work. These engines work very well, and, as they use cheap oil fuel, are very economical power producers. At the Diamler works power costs about one cent per K. W.-hour with only one engine running.

Another very interesting process was that of welding the metal parts of the carriage body by the oxy-acetylene process, which is now quite generally used for light metal work all over Europe.

A product of the Diamler Co. that is novel to Americans is their "road train." This consists of a large powerful engine mounted on a heavy truck with specially constructed wide solid wheels, followed by a number of trucks which may be loaded with the material to be transported. The engine shaft is connected by universal joints between trucks, to a shaft running to the last truck. This shaft is geared on each truck to a similar large driving wheel as on the motor truck. Thus each individual truck has its own motive power, and, consequently, the trains can be used in rough or sandy country. They find a large market not only in England for trucking purposes, but also in South Africa, Australia, and elsewhere. Motor trucks, steam, gasolene or electrically driven, are used to a far greater extent for moving merchandise in England than in America.

Returning to Birmingham we were entertained at luncheon in the Town Hall by the Corporation.

In the afternoon excursions were arranged to the University of Birmingham, to the factory of Birmingham Small Arms Co. and to Mitchell's & Butler's Brewery. The University has one of the best technical colleges in Britain. The buildings are arranged on the brow of a small hill with a long frontage and a large semi-circular portion from which stretch radiating wings. In the center of the large enclosed semi-circular court rises the Chamberlain tower, 325 feet high, erected as a memorial to Hon. Joseph Chamberlain, who was the moving spirit in the founding of the University. A detailed description of this institution is impossible in this article. They have, however, splendid steam and gas engineering laboratories, also large shops, testing laboratories, mining and metallurgical laboratories. Some of the buildings are still under construction, so that all equipment is of the latest type. Prof. Burstall, who has charge of the Mechanical Engineering Department, took great pleasure in showing the writer a very early American lathe which he had secured and which embodied all the essential features of our best modern lathes, though of course somewhat crudely constructed.

There is one thing about the European Technical Schools that leaves a strong impression on American engineers, and that is the large amount of machinery donated by manufacturers to the laboratories, not so much in the hope of receiving advertising returns as in a spirit of aiding technical education itself. It is to be hoped that our American manufacturers will take a similar view in the near future.

The writer had already visited the University, so on Wednesday afternoon he accompanied one of the American Engineers on a visit to the South Staffordshire Mond Gas Plant. This company manufactures and distributes producer gas for industrial purposes over an area of 123 square miles having a population of three quarters of a million. The plant consists of eight producers of a capacity of twenty tons of bituminous coal a day, and includes apparatus to recover tar and ammonium sulphate. The plant is splendidly designed for the saving of every available B. T. U. and includes many interesting details. When one remembers that for such long distribution lines, and for metering on its delivery to customers, this gas must be absolutely dust free and tar free, then one has some idea of the problems met with and successfully overcome in this plant. Anyone interested in the subject of producer gas should give this plant careful study.

Adjoining the Mond Gas Plant is the testing station of the Pump & Power Co. Here we had the pleasure of meeting Mr. Humphrey, the inventor of the new Humphrey internal combustion pump, and were shown over the station by him. There were four of these pumps in the station, either on test or for experimental demonstration. The principle of the pump is as follows: An explosive charge is pumped into a suitable chamber directly connected by large pipe lines without valves to the reservoir into which water is to be pumped. On exploding the charge, the column of water is put into motion and, due to inertia, the expansion of the gases resulting from combustion is carried below atmospheric pressure. Suitable valves open at that point and let fresh water from the supply into the chamber. Then the column of water, having spent its energy, is forced back into the chamber by the head in the reservoir. An exhaust valve opens and the burned gases are driven out. The returning water closes this valve and some remaining gases are compressed in the top of the chamber. By this time a reciprocating motion has been set up in the pipe connecting the chamber and the reservoir. On the return surge towards the reservoir, a fresh mixture is drawn in and the cycle repeated. The results obtained from this pump are phenomenal. On one test of a small unit of 32 H. P. a coal consumption in the producers of 0.95 lb. per water horse per hour was obtained. It has been suggested to raise water to an elevation by this pump and afterwards use it in high efficiency water turbines to produce electric power. The pump by certain modifications can be used as an air compressor. It is probable that a pump of such possibilities will soon be taken up by some of our American manufacturers.

In the evening the Lord Mayor and Lady Mayoress of Birmingham gave a very charming reception in the Council House of the city. This gave us a chance to meet many of the British engineers of note and to see the splendid art galleries owned by the corporation. Music and an entertainment followed. As this concluded the program at Birmingham, President Aspinwall on behalf of the I. M. E. and Prof. Goss on behalf of the A. S. M. E. spoke briefly thanking the Birmingham friends and also the Lord Mayor and Lady Mayoress for the splendid entertainment they had given us. The Lord Mayor replied in a characteristically humorous speech.

On Thursday an excursion was arranged to Coventry and Rugby, visiting the Diamler works already described, Alfred Herbert, Willans & Robinson and British Thomson-Houston Co.

Alfred Herbert is the most prominent of British tool builders, making a specialty of all classes of milling machinery, automatic screw machines, turret lathes, grinders, etc. Frequently the firm is merely furnished a sample of a given piece of work and asked to design the machine with its equipment of tools to automatically reproduce this sample, and to make guarantees on production. Their work is of a special nature and very high grade. Since this firm has developed, they have captured a great deal of the trade in this class of machinery in the British market which in former times went to American builders.

Willans & Robinson are located at Rugby. This firm has large engine building shops, foundries, etc., and formerly manufactured the well known Willans Central Valve Steam Engine. When the

Steam Turbine was introduced this company adopted a form of Parsons turbine, which embodied the Fullager system of balance pistons and the Sankey method of retaining the blades. In America this type is manufactured by the Allis-Chalmers Co. Willans & Robinson have now introduced a still further modified form by replacing the original Parsons high pressure stage by a Curtis stage, the remainder being practically unchanged. This new form of turbine combines the best features of the Curtis type with the well known high economy of the low pressure portion of the Parsons turbine. The machine is superior to the ordinary Parsons as there is no steam at extremely high temperature or pressure present in the cylinder, it being expanded down in the nozzles of the Curtis portion. Besides, the machine is also shorter and more compact than the Parsons. It is said in England that this type has almost monopolized the market since its introduction. The company also builds turbo air compressors, pumps, and oil engines. They have a large testing department where all engines are fully tested before shipment.

The British Thomson-Houston Company are probably the largest manufacturers of electrical machinery in England, and control similar patents to the General Electric Company in America. They have very large works at Rugby and turn out immense quantities of electrical goods. Their works include large shops of standard and special machine tools, testing departments for raw materials and for finished machines, as everything is thoroughly tested before shipment, tool rooms for the manufacture of jigs, tools, etc., switchboard departments, transformer departments, etc. A specialty is the manufacture of railway motors. They also build Curtis steam turbines. The Vertical Curtis Turbines, so common in America, never found favor in England, so that almost all Curtis units are now being built of a horizontal type.

Rugby itself is familiar to almost every boy as the scene of "Tom Brown's School Days." A visit to the old Rugby school formed one of the pleasantest features of the trip. Rugby is one of the prettiest of the home towns of England, and of modern appearance. Most of the streets have bass-wood trees along the curb, which at the time of our visit were just in blossom, and the air everywhere was filled with the honey-like and luxuriant odor of the bass-wood flower.

Another excursion visited Lichfield, which contains a famous cathedral and was also the birthplace of Dr. Samuel Johnson, famous as an English scholar. Another attraction here was the old grammar school which had been attended by Darwin, Addison, Garrick, Johnson and others. A visit was also paid to the Pipe Hill Pumping Station of the Staffordshire Waterworks Co.

As the writer had already visited both Coventry and Rugby, an alternative trip to the Shakespeare country was selected. This trip ws one of the unique, novel and intensely interesting features of our visit, though dissociated in every way from anything pertaining to engineering.

We were taken by motor omnibus from Birmingham, 23 miles to Stratford-on-Avon, over some of those splendid English roads. This route was very attractive and there were interesting views, quaint old houses and country villages to be seen, and glimpses of rural English life to be had throughout the whole ride.

At Stratford we visited Shakespeare's birthplace. The old house is almost the same as in Shakespeare's time, and is now national property. We were shown around the various rooms and through an interesting museum of Shakespearean relics. In the rear is a garden with specimens of each variety of flower mentioned in Shakespeare's works.

Next a visit was made to Anne Hathaway's cottage, which is practically the same as in Shakespeare's day. Some of the old furniture is also exhibited.

Returning to Stratford we visited the new Shakespeare Memorial Theatre in which a series of performances are held each year. It also contains an interesting historical library of Shakespeare's works, and a large collection of pictures and photographs of actors and actresses who have produced Shakespearean plays, among whom are recognized many leading Americans. In the garden adjoining stands a fine monument to Shakespeare.

The last visit was made to the church of the Holy Trinity where Shakespeare and his family are buried. The old church is quaint and interesting. It is beautifully situated on the banks of the Avon, along which river there are many beautiful views in and around Stratford.

After lunch at the famous Red Horse Hotel we were motored 8 miles to Warwick Castle where we were met at the gates by the agent of the estate and told that the Earl and Countess of Warwick had telegraphed regrets at not being able to receive us in person, but inviting us to inspect the whole castle. The castle is entered through a large masonry arch in which still hangs the old spiked portcullis. The holes where hot water and tar could be poured down on any attacking parties were also pointed out. On the left hand side of this gate stands a tower of great age. Inside the gate stretched one of the most beautiful lawns in England, hemmed in on one side by the castle and on the other side by the circular walls. Several peacocks wandered freely over this velvet sward. In the castle the rare furniture and picture collections were pointed out to us as well as the arrangement of rooms, collections of armor, etc. The castle stands high above the river Avon. In one direction there were beautiful elms all along the banks, on the other side ranged stately cedars. The fine views from the living rooms of the castle can scarcely be equaled anywhere. The Countess of Warwick has had the castle equipped with modern hot water heating systems. This was one of the few places visited in England where American ideas of home comfort have been adopted. In the conservatory we were shown a beautiful marble vase of immense size found a number of years ago in Hadrian's Villa in Italy and presented to the Earl of Warwick.

From here we motored to Kenilworth Castle. This was formerly the home of the Earl of Leicester and is the subject of one of Scott's novels. In Queen Elizabeth's time this was the finest castle in England but was destroyed in Cromwell's time and never rebuilt. Nothing remains but ruined walls and portions of some of the towers. Unless one is very familiar with the former history and appearance of the place, there is little of interest to be seen.

Leaving Kenilworth Castle we motored to the neighboring station, and after changing cars at Leamington we proceeded to London on special trains on which we had tea. Our hotel accommodations were reserved for us in London and our baggage had been forwarded from Birmingham.

In the evening we were entertained at a Conversazione at the Institution of Mechanical Engineers. They have a commodious home in London on St. James Park, around which are grouped the War Offices, Buckingham Palace, the Royal Residence, and other interesting places. A few blocks away stand the Houses of Parliament and Westminster Abbey. Again we had opportunities to meet our English hosts and hostesses and to enjoy good music. Besides the social features, Prof. Hele-Shaw, a leading authority on aviation, gave a short lecture on "Stream Line Experiments Illustrating Aeroplane Stability." He pointed out that for stability, the greatest weight in an aeroplane must be well to the front as is the case with birds. He performed some experiments with models to prove this point. Next by means of colored liquid flowing between glass plates and projected by a lantern on a screen, he showed the conditions in the air which cause a machine heavier than air to rise. The whole discussion was of the greatest interest to all as it touched the most fascinating subject of the day.

Friday morning was taken up by the last professional session. at which papers were read dealing with the Electrification of Railroads, and very interesting discussions followed. Three of the papers were written by Americans, one of these being by Mr. George Westinghouse, and two more by Englishmen. At the close of the meeting, votes of thanks were passed to those who had assisted in the entertainments and to the Institution itself.

In the afternoon garden parties were given by Mr. and Mrs. William Maw and by Sir John and Lady Thornycroft, both of which were very enjoyable. Mr. Maw is the editor of London "Engineering." Excursions were also arranged to the Patent Record Office where the "Doomsday Book" was shown, and to the mechanical plant of the "Times."

The writer was forced to spend a greater part of the morning securing passage home and arrived back at the hotel too late to take in any of these excursions. Finding others who had been left behind, a party was organized and a brief visit made to a portion of the British Museum, and afterwards a taxi ride around London was taken, in this way getting a glimpse of its most important sights.

In the evening we were entertained at the Institution dinner held in the Connaught Rooms, Freemasons' Hall. This was the principal social function of our visit. The programs and seating plans were perfect and showed the greatest care and forethought in their arrangement. After doing justice to a lengthy and highly enjoyable menu, toasts were proposed to the King and to the Royal Family. President Aspinwall then proposed the "President of the United States of America," to which our Ambassador, Mr. Whitelaw Reid, replied. "The American Society of Mechanical Engineers" was proposed by Sir William White, formerly chief engineer of the British Navy and the man who introduced the Dreadnoughts. Prof. F. R. Hutton responded in one of the ablest speeches of the evening, indicating many of the points of variance between British and American professional engineering practice. Mr. E. B. Ellington, Vice-Pres. I. M. E., proposed "Our Other Guests," including, besides the ladies, the representatives of other scientific organizations present. Dr. Glazebrook, director of the National Physical Laboratory, responded. The concluding toast to "The Institution of Mechanical Engineers" was proposed by Dean Goss of Illinois and President Aspinwall responded.

We were given another delightful excursion on Saturday. The party was divided in halves covering the same trip in opposite directions. The writer went with the party proceeding to Marlow, where we embarked on special river boats and proceeded down the Thames to Windsor, taking about five hours to make the trip. The river all along here is most picturesque. As a rule, if an Englishman has a fine city or suburban home, he builds a wall around it so that one cannot possibly see any of his lawn or garden: He is most exclusive in respect to his home life. But should he be fortunate enough to have a home on the Thames, he builds no walls along the banks, and hence a trip down the Thames gives an American visitor a more real insight into the charming homes and gardens of England than almost any other excursion. A regatta was under way on the river as we approached Windsor. We had the privilege of seeing several crews come down the finish. They row with a much shorter and quicker stroke than our Wisconsin crews.

At Windsor we were met by his Worship the Mayor and by permission of King George were shown all over Windsor Castle under special guides. We were shown through all the state rooms and saw the furniture used when royal visitors were entertained. The picture galleries are most extensive. The banquetting hall and the armory restored by the late King Edward were of great interest. We were favored by being the first visitors to St. George's chapel in the castle, which had been closed since the death of King Edward. This chapel is a very beautiful place, some of the memorials being of great interest. Tea was served to us in the Guildhall of the City of Windsor. As we still had some time before our special train left, several secured taxis and visited Eton College, the great boys' school just across the river, and then went on to Stoke Pogis, where still remains the old church and cemetery made famous by Gray's "Elegy in a Country Churchyard," and where the author himself was buried.

In London that evening, we were invited to the Garden Club at the Anglo-Japanese Exhibition, which is held in the beautiful grounds and buildings laid out and built several years ago for the Franco-British exhibition, and known locally as the "White City." The plan of the grounds reminds one somewhat of the Pan American at Buffalo, though the detail is more carefully worked out. In the writer's opinion the grounds and buildings were far superior to the World's Fair at Brussels. Among the many interesting things on the grounds was a series of Japanese panoramas depicting the four seasons in Japan. These were prettily planned and arranged, as also were the Japanese gardens.

On Sunday a visit was specially arranged to the Zoological Garden in Regent's Park, and in the evening, by kind invitation of the Dean, a visit was made to Westminster Abbey, the Hall of Fame for England's great men and the burial place of many of them. Places were reserved for the American visitors for the evening service following the visit.

Unfortunately, the writer was unable to take these in, as he left early Sunday morning for the Continent in company with some Americans.

It is hard, especially for an Engineer, to do justice to many of the places visited, and in a few pages to convey to the reader any adequate idea of the information and the pleasure to be gained on such a trip. One of the greatest sources of enjoyment was the pleasure of actually meeting and talking with leaders of engineering in England who one has heard of and read about for years. Among these men might be mentioned Sir William White, Prof. Unwin, Capt. Sankey, Prof. Hopkinson, Prof. Hele-Shaw, Mr. Robinson, Mr. Longridge, President Aspinwall and others too numerous to mention. The whole trip was both a pleasure and a profit to all, for one cannot but profit by the widened point of view, by practical observation of both manners and customs of a people with whom we have common ties of blood and of fundamental institutions and by personal contact with them, by inspection of the engineering achievement of others, and by becoming interested in subjects associated with general culture, fostered to a great extent by visits to places famous in history and literature.

It would be improper to close this article without expressing the deep appreciation of every American visitor of the magnificent entertainment provided for us, which the preceding pages have been but a faint endeavor to describe.

THE FIRST BULLETIN TO BE ISSUED BY THE NEW FEDERAL BUREAU OF MINES.

From John L. Cochrane, Bureau of Mines, Washington, D. C.

Washington, D. C.—The Volatile Matter of Coal is the title of the first bulletin to be issued by the new Federal Bureau of Mines. The authors, Horace C. Porter and F. K. Ovitz, conducted their investigations at the Pittsburg station while it was under the Technologic Branch of the Geological Survey, the work being a continuation of the fuel investigations begun several years ago at the Louisiana Purchase Exposition, St. Louis, Mo. The results obtained at that plant showed that the work of determining the fuel values of the coals and lignites in the United States with a view to increasing efficiency in their utilization would be incomplete if it did not include systematic physical and chemical researches into the processes of combustion. Hence in their later investigations the authors carried on such researches, concentrating attention on those lines of inquiry which promised results of greatest economic importance. This bulletin is therefore a report on an investigation of the volatile matter in several typical coals—its composition and amount at different temperatures of volatilization.

Quoted directly the authors say: "The investigation has already shown that the volatile content of different coals differs greatly in character. The volatile matter of the younger coals found in the West includes a large proportion of carbon dioxide, carbon monoxide, and water, and correspondingly small proportion of hydrocarbons and tarry vapors. The older bituminous coals of the Appalachian region yield volatile matter containing large amounts of tarry vapors and hydrocarbons, difficult to burn completely without considerable excess of air and a high temperature. Coal of the Western type, moreover, gives up its volatile matter more easily at moderate and low temperatures than that of the other type. The volatile matter produced at medium and low temperatures is rich in higher hydrocarbons of the methane type, such as ethane and propane, which contain a larger portion of carbon than is present in methane.

"These facts help to explain the difficulty of burning Pittsburg coal, for example, without smoke, the low efficiency usually obtained in burning high-volatile Western coals, the advantage of a pre-heated auxiliary air supply introduced over a fuel bed, and the advantage of a furnace and boiler setting adapted to the type of fuel used. They bear directly also on the question of steaming 'capacity' of coal for locomotives, the designing and operation of gas producers for high-volatile fuels and the operation of coke ovens and gas retorts.

"The results show further that certain bituminous coals of the interior and Rocky Mountain provinces give promise of good yields of by-products of coking, notably ammonia and high candle power gas, comparing favorably in these respects with the high grade coking coals of the eastern province.

"They show also that inert, noncombustible material is present in the volatile products of different kinds of coal to an extent ranging from 1 to 15 per cent of the coal."

The bulletin will be of interest to fuel engineers, designers and builders of gas producers, gas and coke manufacturers, superintendents of power plants, railway master mechanics and those engaged in the suppression of smoke. The bulletin may be obtained by applying to the Director of the Bureau of Mines, Washington, D. C.

FUTURE ARTICLES

We are glad to announce some of the articles and their authors that we have secured for publication in future issues of THE WISCONSIN ENGINEER.

THE HISTORY AND ECONOMICS OF CENTRAL STATION RATE MAKING is the title of an article by M. D. Cooper, '08, which will appear in the December issue. It is a thorough treatise on the problem of rate values; a problem important to engineers and consumers alike. Mr. Cooper is a member of the engineering staff of the National Electric Lamp Association.

THE STRENGTH OF OXYACETYLENE WELDS IN STEEL, by H. L. Whittemore, Director of Tests, U. S. Arsenal, Watertown, Mass. This article, which will run through the December and January numbers, gives a comprehensive report of a series of tests on oxyacetylene welding recently performed in the University laboratories.

TELEPHONE SERVICE IN CHICAGO, by Alfred U. Hoefer, '06, Material Engineer with the Chicago Telephone Co. The telephone system of Chicago is the second largest in the world and this paper deals with some of the interesting features of this enormous public utility.

SUPERHEATERS is a report of tests made by the Great Northern Railway written by R. D. Lewis, '09, Engineer of Tests, Great Northern Railway.

Other papers which will appear from time to time are from the pens of men so well known and universally recognized as authorities in their various lines as C. F. Burgess, Professor of Chemical Engineering; D. W. Mead, Professor of Hydraulic and Sanitary Engineering; E. B. Norris, Assistant Professor of Mechanical Engineering in the University Extension Department; F. T. Havard, Assistant Professor of Mining Engineering; W. J. Mead, Assistant Professor of Geology; J. E. Kaulfuss, Instructor in Civil Engineering at the University of Maine; Frank E. Fisher, '06, Electrical Engineer with the Diehl Mfg. Co., Elizabethport, N. J.

We wish to urge that all students and graduates who have not yet subscribed do so at once Back numbers of this volume can be furnished and there is no better time than now to begin a file of THE WISCONSIN ENGINEER.

The Wisconsin Engineer

Monthly Publication of the Students of the College of Engineering, University of Wisconsin.

EDITORIAL.

The New Wisconsin Engineer.

A number of enthusiastic students, and members of the engineering faculty of the University of Wisconsin have felt that the quarterly Wisconsin Engineer has not completely fulfilled its mission in the past and that the establishment of a live monthly publication would be much more representative of the growth in size and importance of the College of Engineering.

The Wisconsin Engineering Journal Association has geen organized consisting of the Editor in Chief and the Business Manager—who are students selected because of their interest in and fitness for journalistic work—and five members of the engineering faculty representing the various courses, all of whom are taking an active interest in the welfare of the new magazine.

The staff of the paper is made up of students from the several classes and their interest is stimulated by competition for the more important positions as vacancies occur due to the graduation of the incumbents. The publication thus remains primarily a student enterprise, to which has been added more interest and encouragement on the part of the faculty, which will result in greater continuity, from year to year, of definite policies which may develop with experience. It is believed that experience gained upon the staff of the Engineer will be exceedingly helpful to students who may find in engineering journalism an interesting field after graduation.

Besides this important function, The Wisconsin Engineer hopes to interest the engineering students, and to retain the interest of the alumni by presenting articles of merit upon engineering topics, among others the results of thesis and research work at the university, and upon the progress of the university, particularly changes in personnel of the faculty and organization of the engineering college and its material equipment.

The various departments of the College of Engineering have of late made special efforts to keep in close touch with their alumni, and it is hoped that the rejuvenated Wisconsin Engineer may assist greatly in this important work.

Notes of the alumni will be printed from time to time and the editor will be particularly glad to receive articles or notes of interest to alumni, students, or faculty as well as suggestions for still further improving the character of the publication.

We ask for liberal support and encouragement from alumni and students primarily because we expect to give full value for the price which remains the same, but also upon the ground of loyalty to Alma Mater.

It is ever a primary object of the editors and managers of The Wisconsin Engineer to deserve and have the hearty support of the alumni of the College of Engineering. It is realized that with local student management there is almost certain to be some lack of continuity in the policy from year to year, at least in the efficiency of execution of that policy, upon which the magazine is conducted. This phase of the matter has received much consideration of late on the part of a special committee appointed by the Engineering Faculty to discuss ways and means of accomplishing even more than has heretofore been done through what may be regarded as the official organ of the College of Engineering. These discussions and inquiries have brought out quite clearly the fact that lack of continuity or uniformity in the manner of issuing The Engineer from year to year is a point which in the main can be elminated, and it is believed that means have now been adopted for the effectual safeguarding of this phase of the matter. It is realized that one of the most serious objections to the yearly change in the personnel of the staff has been the breaking contact annually with an interested list of graduate supporters. Beginning last year it was aimed to guard against that tendency by establishing a list of alumni representatives selected with reference to their supposed special personal interest, the choice being based for the most part upon a student day contact with the editorial or business problem of issuing The Engineer. These editors are called upon for continued support in finding or contributing material suitable for publication and in enlisting the support of other Wisconsin men through personal solicitation. The local governing body will see to it that changes are made from time to time, to the end that new spirit may be instilled and that a greater number of interested persons may derive the benefits to be had from engaging actively in a worthy cause. The cumulative value of this manner of gathering up the loose ends of alumni interest, is believed to be obvious. No effort will be spared to seize upon any opportunity which may arise to still further improve upon the plan. To this end the local staff will welcome comments and suggestions from our alumni friends and others who arė interested in seeing The Engineer brought to a plane of usefulness and efficiency even higher than has been attained by the active and worthy publication boards of other years.

WHAT THE GRADUATES ARE DOING.

This section is conducted with a double object in view—First, to give the alumni professional news of each other; second, to give the undergraduates an idea of the possible fields of employment open to them in the future.

C. C. Boardman, '10, is with the Western United Gas and Electric Co. of Aurora, Ill.

Carl A. Keller, '99, is with the Commonwealth Edison Co. He occupies the position of Assistant Electical Engineer.

John W. Cunningham, '08, is the Chief Draftsman and Bridge Supt. with the North Coast R. R. Co. of Spokane, Wash.

B. C. Adams, '03, is General Manager of the Lincoln Gas and Electric Co. of Lincoln, Neb.

A. B. Chadwick, Jr., '10, is with the North Shore Consolidated Gas Co. of Waukegan, Ill.

Oscar L. Uihlein, '07, is engineer in the Sales Dept. of the Cutler-Hammer Co. of New York.

M. H. Spindler, '98, is an Inspector for the city of Cleveland.

R. A. MacLaren, ex-'11, is with the T. M. E. R. & L. Co. of Milwaukee.

R. E. Robertson is in Spencerport, N. Y.

Louis S. Davis, '10, is an engineer for the U. S. R. S. of Babb, Mont.

Leonard F. Boon, '10, is with the Wis. Rate and Railroad Com. of Madison.

W. G. Weber, '09, is Supt. of the Boston Miami Copper Co. of Miami, Ark.

W. G. Gibson, '08, is a draftsman for the Flannery Bolt Co. of Bridgeville, Pa.

Oliver B. Zimmerman, '96, is a Mechanical Engineer with the M. Rumely Co. of La Porte, Ind.

R. F. Schuchardt, '97, is Chief Electrical Engineer for the Commonwealth Edison Co. of Chicago.

F. H. Rickman, E. E. '06, is with the Interstate Light & Power Co. of Galena, Ill.

A. B. Whitney, '08, is Ass't Engineer with the Chicago & Alton Railroad.

F. A. Vaughn, E. E. '95, is a Constructing Electrical Engineer with offices in Milwaukee.

Ernest Miller, '06, is an engineer with the Denison Chemical Co. of Baltimore, Md.

Wm. H. Kratsch, '97, is a Mechanical Engineer with offices in Oshkosh.

B. F. Lyons, '03, is General Manager for the Beloit Water, Gas & Electric Co. of Beloit, Wis.

J. L. Van Ornum, '88, is professor of Civil Engineering in Washington University.

Carl Zapffe, '07, is a geologist in Brainerd, Minn.

F. B. Cronk, '05, is Chief Engineer for the Oliver Iron Mining Co. at Coleraine, Minn.

Adolph F. Meyer, '05, is a civil engineer, 1471 Ashland Ave., St. Paul, Minn.

J. E. Kaulfuss, '08, was married Aug. 31, in La Crosse, the bride being Miss Louise Horn of that city. Mr. Kaulfuss has accepted the position of instructor in civil enginering at the University of Maine

Chas. J. Miller, '08, is a lieutenant in the U. S. Marine Service, and is stationed at Mare Island, Cal.

S. G. Lunde, '08, has been detailed in the U. S. G. S. to service in Alaska.

Alfred F. Coleman, '09, is with the Canadian Copper Co., Copper Cliff, Ontario.

Oswald Lupinski, '10, is now in the employ of the McClintic-Marshall Construction Co., Pittsburg, Pa.

C. O. Brandel, '09, formerly with the National Electric Lamp

Association, is now with the Warren Electric & Specialty Co., Warren, Ohio.

F. A. De Boos, '09, has left the employ of the Wisconsin State Railway Commission and is now with the Johnson Service Co., Kansas City, Mo.

A. Lowell Herrick, a Dartmouth graduate, who received his higher degree at Wisconsin last June, has accepted a position as instructor in Hydraulics at Columbia University. He was married on October 1st to Miss Una Davis of Gloucester, Mass.

John C. Beebe, also a Dartmouth and Wisconsin graduate, is in the service of the U. S. G. S. at Helena, Mont.