The Wisconsin engineer. Volume 15, Number 4 January 1911

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

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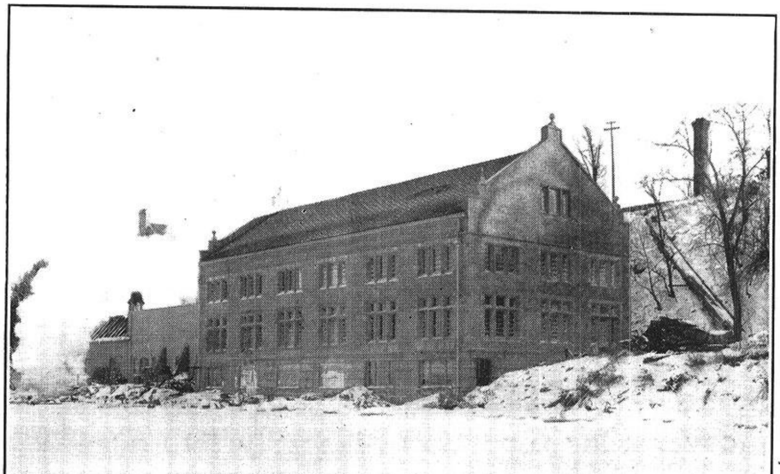

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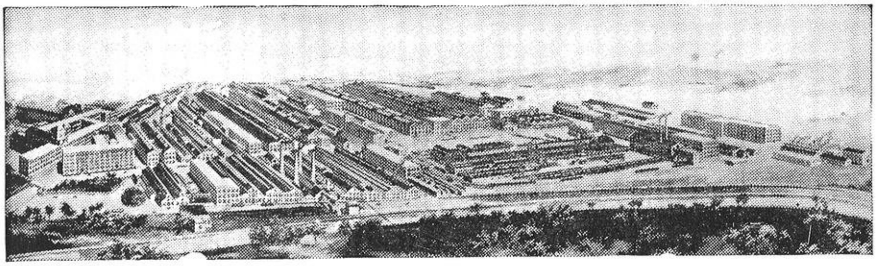

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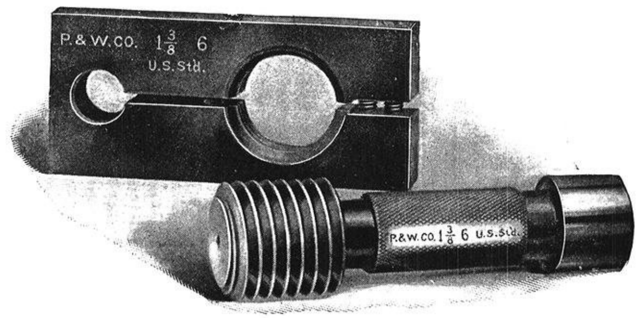

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January, 1911

Published monthly from October to May, inclusive, by the WISCONSIN ENGINEERING JOURNAL ASSOCIATION, Room 215, Engineering Bldg., Madison, Wis.

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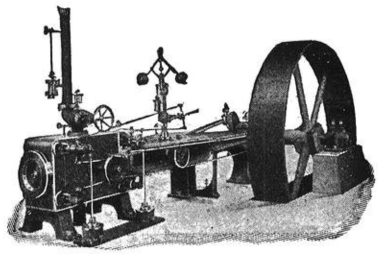

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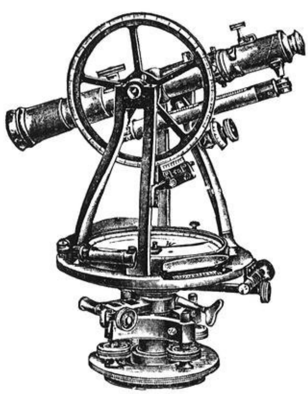

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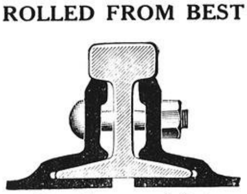

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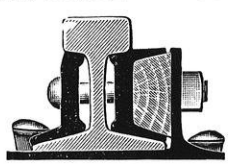

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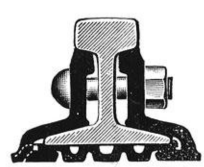

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The Wisconsin Engineer

VOL. XV JANUARY, 1911 No 4

THE STRENGTH OF OXYACETYLENE WELDS IN STEEL.

A Thesis by Herbert L. Whittemore, B. S. '02; M. E. '10.

Abstracted by F. Carl Ruhloff. '12.

INTRODUCTION.

The following article is an abstract of a thesis submitted for the Degree of Mechanical Engineer by Mr. Herbert L. Whittemore, now Director of Tests, U. S. Arsenal, Watertown, Mass. The thesis embodies the results of a most careful study of "The Strength of Oxyacetylene Welds in Steel." The experimental work upon which this thesis is based was performed at the University of Illinois. Besides setting forth the results and conclusions derived from the experimental work, Mr. Whittemore also gives a complete bibliography of the subject of oxyacetylene welds. The references cited are numbered and are grouped according to the special phase of the subject they deal with. In an appendix of some thirty-five pages these references are quoted rather fully and present a comprehensive synopsis of the available information regarding the strength of oxyacetylene welds in steel.

This abstract of the thesis will consider only the experimental work.

Among the recent developments which give promise of widespread use in the field of working metals, is the oxyacetylene blowpipe. Due to high temperature of the flame, it accomplishes results heretofore impossible. The most important of these is the welding of two pieces of metal by fusion without the necessity of adding either flux or any additional material. This is known as autogenous welding. Its use is commercially important because it provides the only method of joining two pieces with a strength approaching that of the unwelded metal.

It is claimed for this process, that, when its possibilities are fully understood, even the smallest metal-working shops will make continual use of it. The reasons for this opinion may be briefly stated as follows:

1. The combination of oxygen with acetylene produces one of the highest temperatures known; the highest due to combustion and about equal to that obtained in the electric furnace.

2. Recently perfected methods of producing calcium carbide in the electric furnace and oxygen by the distillation of liquid air, and by other means, have reduced the cost of these gases to the point where they are commercially available.

3. The oxyacetylene blowpipe, formerly liable to dangerous explosions, has been perfected until absolute safety is claimed.

4. The necessary apparatus consisting, when light weight is necessary, of a small tank of compressed oxygen and another of acetylene dissolved in acetone both connected to the blowpipe by a rubber hose, is easily portable and can be used in almost any place or position.

5. Skill in operating the blowpipe is readily obtained by an ordinary workman.

The process has been used successfully for the following work:

1. Welding tanks and sheet metal work of all descriptions.

2. Welding frame joints for automobiles, making a rigid structure all in one piece.

3. Adding metal where needed; usually in small quantities. For example, eliminating defects in castings, particularly steel castings, such as blowholes, etc., or adding metal to a piece which has been machined under size.

4. Repairing boilers by either welding cracks, patches, etc., or adding metal where "grooving" or "pitting" has occurred.

5. Bonding of electric traction rails by fusing the copper bond to the rails.

6. Repairs of all kinds, made necessary by breakage.

While the oxyacetylene blowpipe method of welding may be applied successfully to a very wide range of work in emergency, such as "break-down repair," the cost of the necessary gases is so high for welding thick pieces, that it will never entirely displace coke, gas, and electric welding outfits for certain manufacturing conditions. Its field is particularly repair work, field work, and manufacturing operations on pieces of small cross-sectional area, say, plates not exceeding ¼ inch in thickness.

The general use of this process depends upon two things; (1) the strength and other physical properties of the welds; and (2) the cost of the work. Of these, the first is the more important. An extensive search for data upon this matter of strength showed that almost nothing had been published except a few general statements.

The following experiments were undertaken, therefore, to add to the information regarding the physical properties of oxyacetylene welds in steel, choosing this metal because of its importance in commercial construction. While circumstances limited the work to a small range of thickness of the steel plates, an attempt was made to determine the effect of other variables which might have an effect on the welds.

No attention was paid to the matter of cost as such data is of doubtful value, unless obtained under commercial conditions.

The apparatus used in this series of tests consisted of:

A. Work bench, covered with fire brick,
B. blowpipe,
C. oxygen pressure regulator,
D. oxygen tank,
E. hydraulic pressure regulator,
F. acetylene pressure regulator,
G. water "U" tube reading pressure supplied to blowpipe,
H. gauge reading acetylene tank pressure.
I. acetylene tank.

These parts were arranged as shown in Plate 2.

THE BLOWPIPE.—The oxyacetylene blowpipe is an outgrowth of those in common use which are supplied with coal gas and air. Attempts to increase the temperature of the flame led to the use of combustible gases having higher thermal values per unit of volume, and of pure oxygen. Thus the oxyhydric blowpipe was brought into common use. Acetylene as a substitute for hydrogen offered theoretic advantages as its thermal value is 1846 B. T. U. per cubic foot. This is over six times the thermal value of hydrogen which is 293.5 B. T. U. Attempts to use it, however resulted in serious explosions. The first successful oxy-acetylene blowpipe was devised by Ed. Fouche, a Frenchman, who experimentally determined the rate of propogation of an

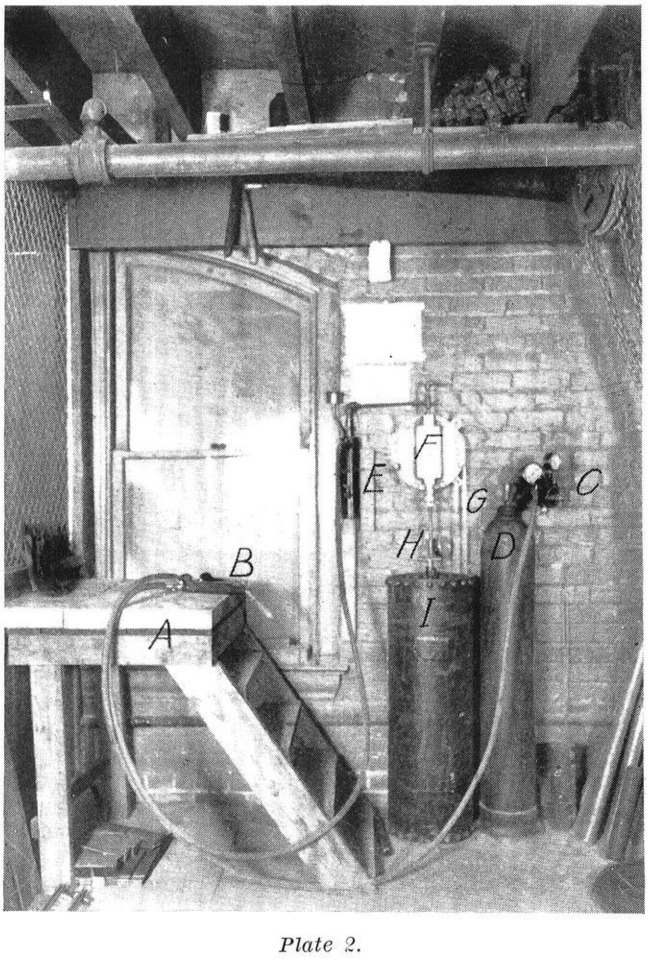


Plate 2.

explosion in tubes of varying cross-section, when they were filled with an explosive mixture containing acetylene. He then perfected a blowpipe in which the acetylene is supplied through small tubes at a rate greater than that of the propogation of the explosion back toward the acetylene reservoir. The Fouche blowpipe made by the Linde Air Products Company was selected for these experiments as it is the first successful design and probably the best known and most widely known.

Tanked oxygen and acetylene were used. The oxygen tank had a capacity of 100 cubic feet when charged to 120 atmospheres pressure. The oxygen was obtained from liquid air and was thus absolutely free from the oxides of carbon, hydrocarbons, or chlorine. The acetylene tank had a capacity of 225 cubic feet, when charged to 150 pounds per square in. pressure. The tanks are packed with asbestos disks before the ends are closed. "The asbestos is then saturated with acetone (a species of wood alcohol) which at 150 pounds pressure absorbs twenty-five (?) times its own volume of the gas at normal pressure, thus increasing the storage capacity of the tank ten-fold." Chemical analysis showed the acetylene gas to be 99.6% pure. Regulators were provided to adjust and maintain a constant pressure of the gases suitable for use in the blowpipe.

The experiments were divided into three series of tests. The first series was made to determine, if possible, the variables affecting the strength of the welds. The second series was a continuation of the work of the first series under somewhat altered conditions; and the third series was made to investigate the proportion of the acetylene in the discharged gas and the effects upon the flame due to variations of the proportion.

First Series of Tests.

Preparation. Four steel plates, 26 by 120 inches and ¼″ thick, were secured. Plate 12 shows the method of cutting these plates so that the tension specimens lay, some with their axes perpendicular to the direction of rolling and some parallel to that direction.

From each section, designated by letters, two unwelded specimens were first cut from each end of the plate. Then it was cut lengthwise down the center and this cut was welded to form the welded specimens. Each specimen was about 1½ inches wide and the whole section of plate was cut into specimens and tested so that the properties of the weld at every portion of its length were determined. First cuts were made on the planer or shaper with a cutting-off or parting tool so that the material was not injured as would have been the case had the metal been sheared.

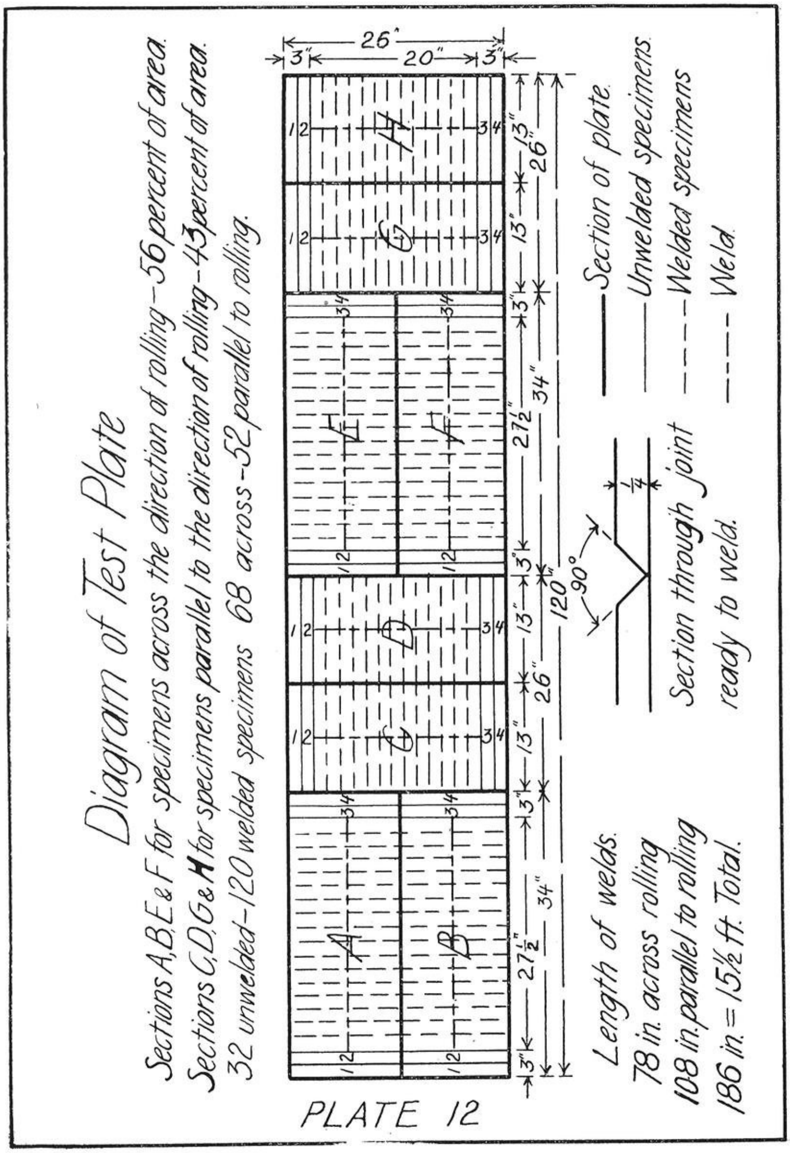


Diagram of Test Plate
Sections A,B,E & F for specimens across the direction of rolling–56 percent of area.
Sections C,D,G & H for specimens parallel to the direction of rolling–43 percent of area.
32 unwelded–120 welded specimens 68 across–52 parallel to rolling.
Length of welds.
78 in. across rolling
108 in. parallel to rolling
186 in. = 15½ ft. Total.
Section through joint
ready to weld.
Section of plate.
Unwelded specimens
Welded specimens
Weld
PLATE 12

Plate 12.

As this proved to be a tedious job, after the first few sections the power hacksaw was used and proved satisfactory.

The plates were beveled and clamped with the edges at one end of the joint in contact and at the other end ½ inch apart to allow for "creeping." This dimension, however, was varied in several instances and the proper allowance for creep was found to be 2.2 per cent. of the length of the weld.

MANIPULATION. Welding was started at the closed end of the joint. The blowpipe was directed against the sides of the beveled joint until fusion occurred and the slight circular motion caused the molten metal to flow together at the bottom. The blowpipe was advanced, still describing small circles, as fast as this weld was formed for an inch or two, then a return was made to the starting place and the metal again brought to a state of fusion. Single strands of soft steel wire, No. 14, were then fed into the small pool of liquid steel until the blast from the flame threatened to blow it over the comparatively cool steel. The blowpipe was then swung in larger circles which extended the area of fusion somewhat while allowing the center of the pool to harden. These pools of molten steel were ½ to 1 inch in diameter. Another pool was then formed just beyond the first so that their edges overlapped.

In adding the wire difficulty was found in preventing the full flame playing on the wire if the blowpipe was given a circular motion so it was, at times, held nearly stationary and the wire pushed, as rapidly as it melted, into the pool just beside the flame. Working in this way, it took some time to build up the required thickness of metal at the weld. If depressions appeared after cooling occurred, the surface was again fused and more wire added until no portion of the welded surface was below the adjacent surfaces of the plates. This series of operations was repeated until the weld was completed.

METHOD OF TESTING. Each of the specimens, approximately, ¼ inch thick, 1½ inches wide and 13 inches long, having the weld in the middle of its length, was tested in tension to failure. This was done in a 100,000 pound Riehle testing machine having an autographic attachment.

The dimensions of the specimens were first taken. A thread micrometer with contact surfaces about 1/32 of an inch in diameter was used for obtaining the thickness. This was especially necesary due to the roughness of the surface of the weld when it remained as it came from the blowpipe. The surface of the specimen was divided in such cases into strips ¼ inch wide and the micrometer readings for thickness taken at the center of each strip and averaged for the thickness of the specimen.

A 6 inch gauge length was laid off on each specimen and marked with a center punch. The shortness of the specimens made an 8 in. gauge length impracticable. When placed in the machine, the clamps for the autographic apparatus were secured to the specimen at the punch marks and a record made as the test progressed. From this the elastic limit and ultimate strength of the specimen were determined with sufficient accuracy for this work. The elongations were measured with a steel scale from the specimen after rupture, not from the graphical record.

The stresses at elastic limit and ultimate strength were computed by dividing the load from the graphical record by the actual area at the place where the rupture occurred, usually at the weld.

The efficiency of the weld was determined by dividing the ultimate stress (when ruptures occurred at the weld) by the average ultimate stress of the unwelded specimens, for the same section of plate. Thus

$$\frac{\text{Ultimate stress in weld}}{\text{Ultimate stress of unwelded material}} = \text{Efficiency of weld.}$$

This efficiency is then the ratio of the strength of the weld to the strength of the material and measures, at least in some degree, the value of the welding process.

In this first series of tests, 12 sections were welded. Five of these welded sections were cut into specimens perpendicular to the direction of rolling while seven were cut into specimens parallel to that direction as indicated by the dotted lines on Plate 12. The material as shown by averaging the tests of the unwelded specimens from each section had the following properties:

	Yield point lb. per sq. in.	Ultimate lb. per sq. in	Elongation in 6″ gauge length.
Perpendicular to rolling....	40,800	65,500	16.2 per cent
Parallel to rolling..........	39,900	63,000	23.8 per cent
Average	40,350	64,250	20.8 per cent

EFFICIENCY OF WELDS. The average efficiency of the welds for the sections perpendicular to rolling is 70 per cent., which compares favorably with that for the sections parallel to rolling, which is 67 per cent. Due to the many variables in this series of tests it may safely be concluded that this slight difference in efficiency is entirely accidental and that the direction of rolling, so far as these tests permit an opinion to be formed, has no influence upon the efficiency of the welds.

The efficiencies for each section are plotted in Plate 36. The maximum and minimum being shown as well as the average. To avoid confusing the end specimens, which occurred at the beginning or end of the weld, with those from the body of the weld, their efficiencies are plotted as open circles and the lowest efficiency of the inside specimens plotted for the minimum for the section. While there is a marked decrease in strength at the ends of the weld, this is not entirely due to the method of welding. In some specimens the width of the end specimens, at the weld, could not be accurately measured because one end was not machined, and again, little effort was made when welding to obtain maximum strength at the ends.

A comparison of the sections shows that of the twelve, in one only, Section G, did the minimum efficiency occur at an inside specimen. Of the remainder the minimum occurred at the beginning in three only (Sections D, E, and H), while in the other eight it occurred at the end specimen, where work was stopped. Apparently any error in measuring the area of end specimens would act impartially to either raise or lower the efficiency so that this marked showing for low efficiency at the beginning and end of the welds must be taken as evidence that such a tendency exists.

Inspection of Plate 36 shows that there is little change in the average efficiency from A to F, inclusive, but a marked decrease in the variation from that average which shows probably better workmanship and increased skill on the part of the operator.

Sections U and Y are butt welds. These sections had square edges which were practically in contact along the seam before welding. This may be expressed by saying that the edges of the plates were beveled at 90° instead of 45°, as in the other sections. No filling material or wire was added.

In section U, the welding was performed by causing fusion of

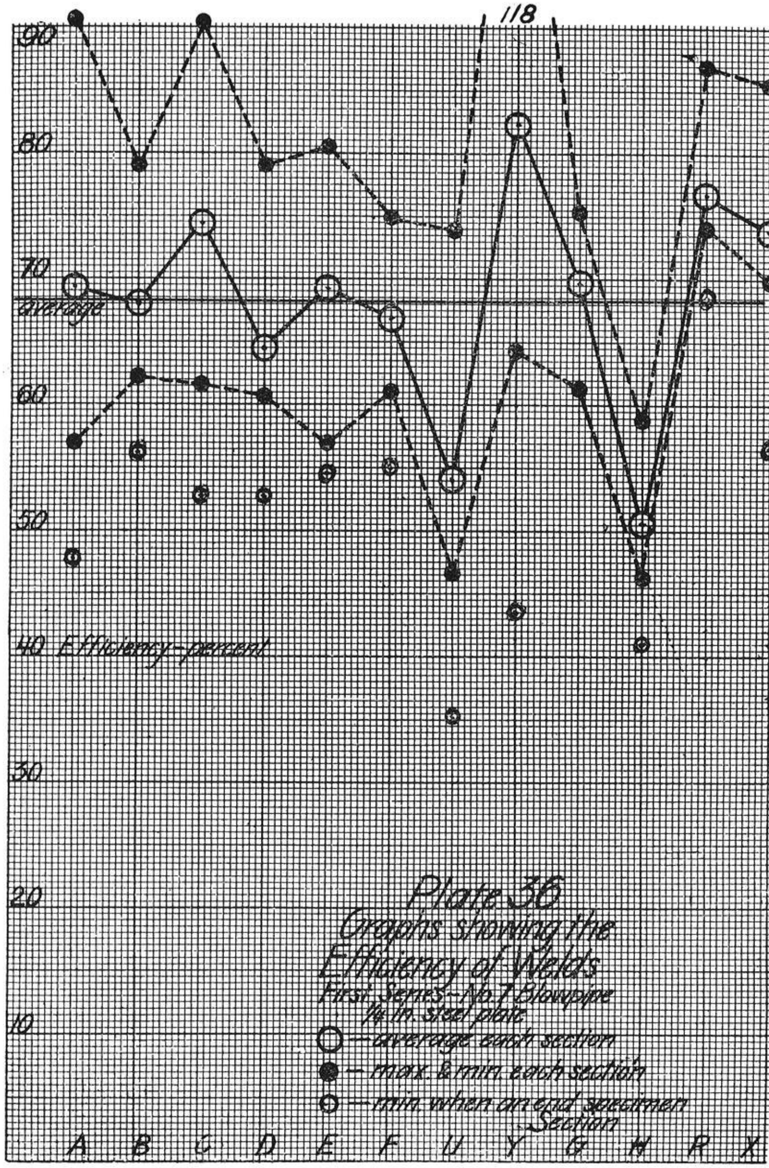

118
90
80
70
average
60
50
40 Efficiency-percent
30
20
10
Plate 36
Graphs showing the
Efficiency of Welds
First Series-No 7 Blowpipe
¼ in. steel plate
—average each section
—max. & min. each section
—min. when an end specimen
Section
A B C D E F U Y G H R X

Plate 36.

the metal on one side only of the seam and causing the metal to flow together by the blast of the flame as it swung back and forth. The metal was melted as deeply as possible and left rough with no attempt to add metal or grind the weld. Upon breaking the specimens of this section, the fracture clearly showed that the welds only extend about 1/16 in. below the surface of the plates. The metal which has been melted shows a coarse crystaline fracture. Below that is a band of white which probably became pasty in welding but did not fuse thoroughly. This metal appears to unite to a slight extent but the weld there is weaker than through the molten metal. This acounts for the low efficiency of this section. Considering the small areas actually fused and welded the efficiencies seem quite remarkable.

In Section Y, the specimens were welded from both sides without the addition of filling material. The very high efficiency of this section, in which thorough fusion occurred, may be explained, possibly, by the fact that as the blowpipe flame was confined almost entirely to the surface of the weld the metal did not suffer the deterioration which occurred in the beveled welds in fusing in wire for filler. Possibly, also, the low efficiency of Section H can be explained on the same basis by noting that a very slow rate of welding was employed, less than one foot an hour.

Grinding the Weld Surface. The necessity for removing the rough surface of the weld became very apparent when specimens from Section Y ran over 100 per cent efficiency. This was undesirable as it introduced another factor whose influence upon the welds was unknown. The unground sections are A, B, F, U, and Y, and their range of efficiency is very much greater than those of the ground sections C, D, E, G, H, R, and X. As care was taken in grinding to cool the specimen frequently, there is only a slight chance for annealing in these specimens.

Consumption of Oxygen and Acetylene. The pressure gauges attached to both the acetylene and oxygen tanks enabled the amount of gas consumed for each section to be computed. The actual average consumption of oxygen was 20.6 cu. ft. per hour. The acetylene value is 22.7 cu. ft. These values are not to be relied upon since the tank gauge reading are wholly unreliable for computing the quantity of gas used.

The Welding Rate. The rate of welding, of course, varies considerably with the skill of the workman and the conditions under which the work is done. Manufacturers of welding equipments claim a value of 5 ft. per hour. In these experiments this value was not reached but it appears reasonable that an average, experienced workman could maintain that speed for several hours if not the whole working day.

Second Series.

This work was a continuation of the first series under somewhat altered conditions. An effort was made to determine the variables affecting the efficiency of the welds.

A recent form of the Fouche blowpipe was used which was provided with a number of interchangeable heads, in this case, No. 3, 4, 5, 6, 7 and 8. The size best suited to the work could be quickly fitted to the blowpipe body, the result being an apparatus somewhat lighter than the design previously used but one operated in the same way.

A special wire, recommended by the blow pipe manufacturers, was obtained from John A. Roeblings' Sons Company. This was designated by them as 1/8 in. diameter, liquor finished, bright, annealed, genuine Norway iron wire.

Instead of the 1/4-in. plates used for the first series, similar sheets which were 1/8 in. in thickness were used. Plates of this thickness are better suited for practice welding and experimenting than either thicker or thinner ones. Each sheet was divided into sections so that all specimens lay with their longest dimensions parallel to the direction of rolling. The sections were cut as for the first series, except that a sharp shear was used instead of the cutting-off tool. All sections were beveled at 45° as shown at A-1, Plate 51. Each section was clamped, as usual, and welded by fusing in 1/8 in. iron wire with the No. 5 head fitted to blowpipe.

A cross section through weld is shown at A-2. As is the case with all sketches in Plate 51, an attempt is made to show the general features of the weld under discussion, not to represent them accurately to scale, which would be difficult if not impossible.

All specimens were cut from the sections with the power hack saw and the surface of the weld ground, as shown at A-3, top and bottom on a dry emery wheel, to give a reasonably smooth surface.

MANIPULATION. The welding process was carried on for all these sections as for the last sections of the first series. The difficulties involved in the pool system of welding, as was used for the first specimens of the previous series, can be better understood by reference D, Plate 51. In these diagrams, comparatively cool metal (black hot) is represented by cross hatching, metal heated to redness by white and molten metal by black. The arrows indicate the direction in which the weld is progressing.

In the pool method, first used, the bottom of the groove was first welded for a short distance, D-1, by melting down the sides of the groove, E-5, and adding some filler. The thickness was then increased by a pool, D-2, to the required thickness of the plates, D-3. Working in this way it was somewhat difficult to prevent the filler cooling on metal imperfectly fused.

The method used for these sections is shown at E; a longitudinal section along the weld at E-1, and cross sections through several points at E-2, 3, 4, 5, and 6. The bottom of the groove was closed by material from the sides of the groove and from the filling wire, E-5, then the thickness of metal was gradually increased until somewhat greater than the surrounding plates. As each drop of melted filler reached its place, the blowpipe was directed against it until it spread out over the molten material below and lost its outline. The oxide on the surface was driven off before more was added. Usually the distance from the flame tip to the metal was 50 to 100 per cent of the length of the first cone of the flame.

In this series eleven sections were welded. On one of the welds, AG, the molten metal was hammered frequently as it was put into place. The results for this section tend to show that hammering the weld during the blowpipe operation is laborious and detrimental rather than beneficial.

A gasolene torch was used to preheat the beveled edges of the plates of Section AH. The torch flame was directed against the seam, from below, an inch or two in advance of the weld. Enough heat was thus supplied to bring the bottom of the groove to redness, which considerably reduced the time required to melt the metal. Preheating increases the welding rate and so lowers the

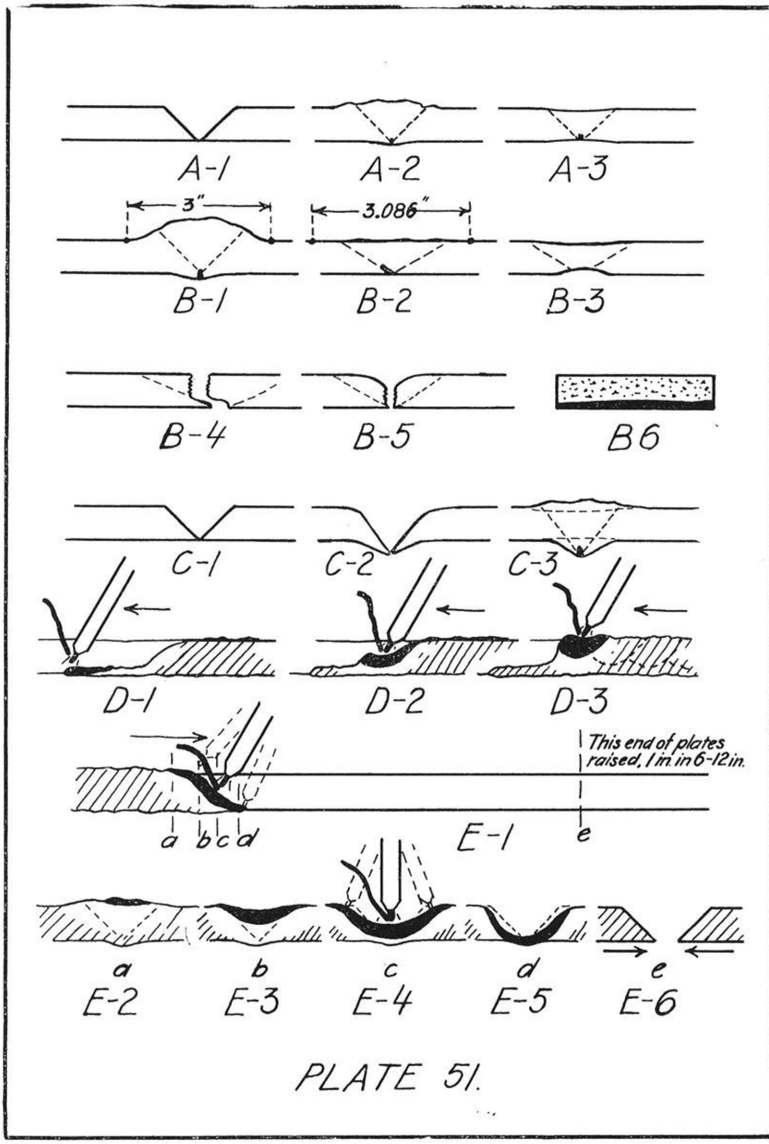

A-1
A-2
A-3
3"
3.086"
B-1
B-2
B-3
B-4
B-5
B6
C-1
C-2
C-3
D-1
D-2
D-3
This end of plates raised, 1 in. in 6-12 in.
a b c d
E-1
e
a
b
c
d
e
E-2
E-3
E-4
E-5
E-6
PLATE 51.

Plate 51.

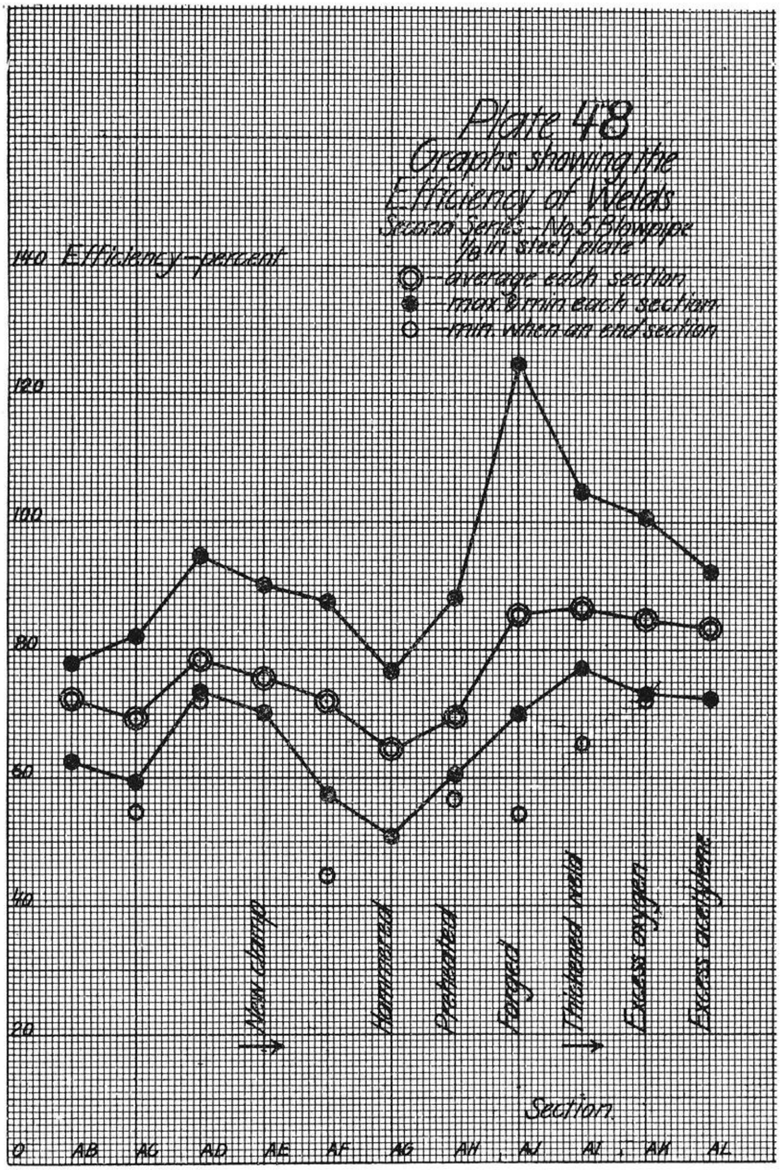


Plate 48
Graphs showing the Efficiency of Welds
Second Series—No. 5 Blowpipe
1/8 in. steel plate
—average each section
—max. & min. each section
—min. when an end section
140 Efficiency—percent
120
100
80
60
40
20
0
New clamp
Hammered
Preheated
Forged
Thickened weld
Excess oxygen
Excess acetylene
Section
AB
AC
AD
AE
AF
AG
AH
AJ
AI
AK
AL

Plate 48.

cost, but insofar as these results show, has little effect on the strength of the weld.

The specimens of Section AJ of this series were heated in a forge and drawn down on an anvil to a uniform cross section. They showed an average elongation, due to forging, of 0.086 in. in 3 in. as indicated by B-1 and B-2, Plate 51.

Forging produced a decided increase in the strength of the welds and also in the ductility of the fused metal. Apparently the increase in efficiency is about 10 per cent.

The most important results of this series are obtained from the last three specimens. The high average efficiency of Section AI, 86.6 per cent, confirmed as it is by the values for Sections AK and AL, may be taken as fairly representative welds for 1/8 inch steel when fusion has occurred throughout the weld. A number of welds showed after rupture a narrow strip, just at the bottom of the groove, apparently poorly welded. To allow the poorly welded portion at the bottom to be ground away, leaving only material which had been thoroughly fused, the plate edges, C-1, Plate 51, were bent downward from 1/32 to 1/16 inch. The weld was much like C-3 and was ground about as shown by the dotted horizontal lines. The high efficiencies of the last three sections are due to this treatment of the plates.

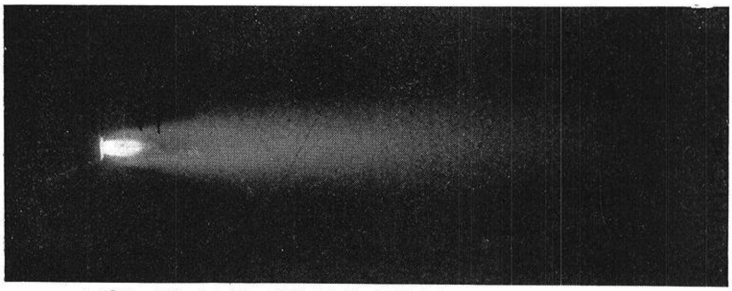
The average efficiencies and also the variations of this series of test is graphically shown in Plate 48.

To determine the effect of improper flame regulation Section AK was welded with excess of oxygen and AL was welded with an excess of acetylene. The decrease in efficiency due to the excess oxygen flame was only 1.9 per cent and for the excess acetylene flame was 3.5 per cent. There seems to be no excuse for greater variation in commercial work due to improper regulation.

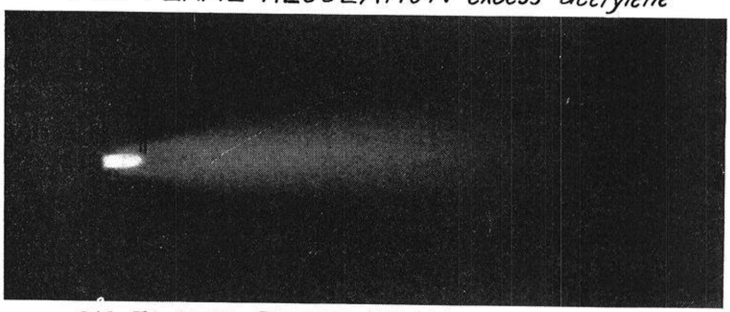
Third Series.

As varying the flame regulation seemed to have little effect upon the welds, interest was renewed in the proportion of acetylene in the discharged gas and the variation in this amount for a visible change in the flame.

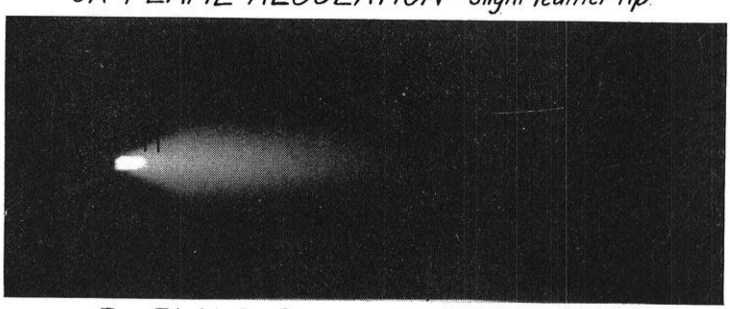
Apparently, the only way to determine the amount of acetylene was to light the blowpipe, secure the desired regulation, then, after extinguishing the flame, to collect a sample of the discharged gas which could be analyzed chemically.



+50 FLAME REGULATION excess acetylene



OK FLAME REGULATION slight feather tip



−50 FLAME REGULATION excess oxygen

PLATE 54.

Three characteristic flame appearances were selected for this work. These flames are shown in Plate 54. The +50 indicating that length of the flame was fifty per cent longer than when properly regulated. The —50 regulation was obtained by reducing the amount of acetylene until the length of the first cone was half that when normally regulated.

The most striking feature of this work is the very remarkable characteristic appearance of the blowpipe flame and its sensitiveness in showing changes in regulation. It seems safe to conclude that a change in the amount of acetylene of one per cent of the gas could be detected by the change in the appearance of the flame, providing this change occurred near normal regulation.

The average proportion of acetylene for all sizes of blowpipes at normal regulation is 42 per cent. This is a ratio of 1.38 volumes of oxygen to one of acetylene.

CONCLUSIONS. Consideration of the results of these series of tests leads to the conclusion that only forging and thorough fusing of the material in the weld resulted in any noticeable increase in the efficiency of the welds.

The average technical article on this process apparently lays too much emphasis upon the necessity for very careful flame regulation, pure oxygen and acetylene, as well as the value of preheating and hammering the weld in securing high efficiency. Certainly they are in error when 100 per cent efficiency is claimed. About 85 per cent appears more probable.

A TRAVEL ON HUDSON BAY.

EXTRACT OF AN UNPUBLISHED NARRATIVE.

C. K. LEITH.
Professor of Geology.

THE HUDSON'S BAY COMPANY.

The Hudson Bay posts visited were strikingly similar in architecture and atmosphere to Moose Factory. Indeed, this similarity extends throughout fourteen posts which it has been my privilege to visit this and other summers, though each post has also its peculiar and distinguishing features which are of the greatest interest to the visitor, and which I would enjoy telling about did space allow. The comfortable house of the manager, with its well kept yard, hewn picket fence, huge gate, usually a garden plot for potatoes and other hardy vegetables, and buildings and pens for cows and chickens, form the central feature of most of the posts. Near it is the store, containing everything necessary to the needs of the country, from pork and flour to sewing machines and phonographs. The large warehouses are conspicuous features. In a central point, high flagstaffs are to be seen at all of the posts, on which is displayed the Hudson Bay flag on the approach or departure of visitors. Life is ordered in much the same way at all the posts. Staff and employees rise at 5:30 and drink a cup of tea, work from 6 to 8, breakfast 8 to 9, work from 9 to 1, dine 1 to 2, and work from 2 to 6. A bell mounted on some central building announces each of these hours. Two additional formalities, tea at 11 and 4, are observed by some of the post-managers. The complete control of the post-manager over the affairs of his subordinates and dependent Indians, together with the regularity of the day's proceedings marked by the bell, give an air of military precision to the place quite at variance with the straggling architecture and with the appearance of some of the inhabitants.

The Hudson Bay region has been under the almost exclusive control of the Hudson's Bay Company for two hundred and forty years. A few brief attempts at competition have hitherto met with failure, but for the past nine years Revillon Brothers, of Paris, have been making a strong attempt to gain a foothold and have accomplished more than any of their predecessors. Of this more later. The Hudson's Bay Company has from the first devoted its attention exclusively to the fur trade, and has deliberately discouraged all efforts on the part of its own employees or others to develop any other resources. So far have they gone in this direction as to discourage even minor changes in the manner of conducting the business, such as introducing more satisfactory means of travel and communication, which in their judgment would tend to take any attention away from their principal business of securing fur. While the employees of the Company have done much geographical exploration of a good grade this has been often in spite of, rather than because of, the attitude of the Company. Even such knowledge as they have gotten has been turned over to the public very tardily or not at all. The large blank areas on existing maps of the region about Hudson Bay are eloquent testimony of the attitude of the Company in this regard. There is today outside of the Hudson Bay posts and the posts of their competitors, Revillon Freres, so far as the writer knows, not one habitation of wood or stone. Probably nowhere else in the world could there be cited a similar case of arrested development of a great region under control of white people. This is not written in a spirit of criticism. The Company was organized to trade in fur and with characteristic British conservatism has kept it strictly to its text. The stock is in strong financial hands in England, partly in the nobility, whence a conservative attitude would be expected. The Company doubtless foresees that as soon as the region opens up for anything else which will bring in a population not giving its attention to fur, its primary business of trapping will rapidly disappear.

Perusal of the daily journals kept at each of the Hudson's Bay Company's posts brings vividly to mind the permanence of the institution. Wishing to know the probable condition of the weather for some of our trips, we were able to ascertain exactly what has happened in the past in the way of weather, hunting and other incidents the same date the year before, two years before, fifty years or even one hundred years before, and so far as the nature of the record is concerned and the character of the events noted, there is little evidence of change of conditions. These statements concerning lack of change by the Company would perhaps be questioned by people living on the Bay. One hears many stories from them of change of conditions from the good old days when furs of a certain kind were more abundant, or when the Indians were more easily controlled, or mails were less frequent (!), but to an outsider these differences seem so slight and the present conditions are so redolent of the past, that the changes in the Hudson's Bay Company's method and condition seem almost negligible.

The Hudson's Bay Company controls fifteen posts on Hudson's Bay, located usually near the mouth of some river. Each post has its Post Manager, foreman servants (natives and mixed breeds) from one or two to twenty, depending on the importance of the post, and its quota of natives dependent upon the post. It is only during the summer when furs are not in prime that most of the people are to be seen about a post. Then the Indians and their families come in with their furs of the preceding winter, trade in their supplies and have a period of social relaxation before returning to their camp grounds in the wilderness. Then the posts present lively scenes, the buildings and yards being surrounded by a fringe of tents of the visiting Indians. At this time church services are held two or three times daily and there is a vast amount of visiting, dancing, and feasting. Then comes the annual feast given to the Indians by the Hudson's Bay Company, consisting of tea and cake, cake being the Hudson's Bay name for a baking powder biscuit with dried currants in it. During the winter the Indians are scattered about the country in small groups within a radius of 150 miles or more from the post and at the posts there are only the people immediately concerned in the operation of the post, together usually with a considerable number of natives incapacitated by age or infirmity for trapping, or the families of the natives who are out hunting. The total population dependent upon each of the posts ranges from 50 to 800 or 900 people.

RELATIONS OF HUDSON'S BAY COMPANY TO NATIVES.

The unit of trade is the beaver, an arbitrary value represented by a brass coin issued by the Hudson's Bay Company, nominally worth a dollar, that is, a dollar in trade. In cash a beaver is worth fifty cents. In cash purchases the company still makes its profit. When, therefore, a native is paid a beaver, and takes it out in trade, as he must, he really gets something in the neighborhood of forty cents in value. When we take into account the low scale of prices for furs arbitrarily fixed by the Company, it appears that the dependents of the Company have little opportunity to "get rich quick".

Each Indian has a debt to the Company. When he buys his supplies for the year's hunting he is said to "get his debt." The size of the debt the Company will allow him depends somewhat upon his ability as a hunter. At the end of the year he turns in his furs in liquidation of his debt. Often he does not succeed in getting a surplus. The result is that the Company has a debt on the books for many of the Indians of which it has control. On death the debt is wiped off. Under these circumstances it is apparent that strict business methods cannot apply. The Post Manager must use his judgment as to the size of the debts to be allowed to different men, in order to get the maximum results. The principle is to get all the furs possible, and to allow the men such debts as will in individual cases bring the best results. With two companies now in the field, there has been a marked tendency for the Indian to "get his debt" at one company and turn his furs in at the other. The church, however, has been active in preaching against this particular form of dishonesty and seems to be getting it into check.

None of the natives are independent. Attached to each of the posts are natives said to be well-to-do. These people possess few evidences of worldly wealth beyond comfortable clothes, substantial food and good rifles and guns, but they have such credit with the Hudson's Bay Company as will enable them to buy such articles as they may need to live comfortably. This simply means that they have been sufficiently successful as hunters and have turned in enough furs to establish a certain prestige with the Company, and the Company treats them well as a reward for faithful services and as an incentive to others. Should any of these men wish to cash in and leave the country it is very doubtful whether they would succeed in drawing much cash from the Company. This, however, is a mere surmise from our limited observation of the conditions. As a matter of fact, we are discussing an hypothetical case, for few have ever tried to leave the region.

To a stranger on the Bay, at first thought, the native's condition does not seem to be an enviable one. The Indian is in a condition not far different from that of slavery. With his best efforts he can only secure for himself food and clothes. He cannot secure independence. On the other hand, he is almost certain of a living if he is reasonably diligent in fur getting; he will be taken care of in case of incapacitation; his family will not be allowed to starve, and above all, he is in a reasonably contented and happy frame of mind over the situation. He certainly is better off than in the days of uncertain supplies before the Husdson's Bay Company came, and he seemed to us also to be better off and happier than many of our laboring people. While he undergoes hardships, he seldom suffers the extremes of poverty, never feels that he is suffering injustice greater than that of his fellows, he is on a substantial social equality with the rest of the population, and altogether appears to be a decent, self-respecting, efficient and contented being.

The attitude of the Company toward the Indian is a curious combination of stern and relentless control with a sort of furtive kindliness. When an Indian is asked to do certain arduous work or to make a dangerous trip, he has been taught to obey unquestionably and to accomplish his mission at any cost to life or limb. He carries his message to Garcia without the prospect of being greeted as a hero on his return. He will get no sympathy either from the Company or from his friends if he fails to carry out his orders absolutely. In our own traveling from post to post we had occasion to use a number of Indians who were picked out by the Post Manager to go with us, sometimes on a trip which would mean hard work, exposure and perhaps some hardship for weeks, and while often these Indians disliked very much leaving a comfortable post and wives and families to go off on a trip with strangers in whom they had no personal interest, there was never any murmuring when once they had been selected to go. In coming out in the fall from Moose Factory to the railroad track, so late in October that there seemed some prospect of being frozen in before we could reach civilization, the three Indians sent with us were ordered by the Post

Manager to see us through at any cost. We had everything to gain by getting out and much to lose by being frozen in. They had nothing to gain in making the trip. One could not but admire the grim, even fierce, persistence with which they drove their way through these discouraging conditions.

About the posts the Indians are, for the most part, treated rather gruffly. The Post Manager may spend his time mostly at house rather than at the store. The Indian wishing to trade hangs around the kitchen door until he learns through the servants that the manager may be seen, then timidly knocks and comes in, hat in hand, and is given a straight-backed chair against the wall near the door. The manager, after a time, looks up from his business or paper, or from any conversation he may be carrying on, and asks what is wanted, and if the Indian's credit is good he will give him an order on the store for such things as he needs. The length of time the Indian is kept waiting and the graciousness of the Post Manager's behavior toward him are an excellent barometer of the Indian's standing with the Company and in the community. Let an Indian come in who has not been diligent in his trapping, has allowed himself to get considerably in debt to the Company, and it is almost painful to see how servilly he has to approach the Post Manager.

With all this external show of authority and harsh control, there is much quiet kindliness and generosity toward the Indians which does not come to the surface. While the Indian is away on duty for the Company his family will be taken care of. If there is sickness, some care will be given and extra supplies will be granted them. As a reward for faithful service the Indian will be allowed to purchase an unusually good rifle or other desired equipment, even if beyond his credit.

By this combination of sternness and kindliness the Company has been able to foster a loyalty among its servants and natives which is very unusual to a commercial concern. Loyalty to the Company seems to be a watchword which is more effective than money. Natives will take pride in telling of the number of years they have been in the Company's service and how their ancestors have been there before. One hears the same things from the Post Managers. One will tell you that he has been in the Company's service for 25 years with only one short furlough. When anyone leaves the Company's service to join the competing company he is branded as a renegade. In the recent competition with the Revillon Freres the few Hudson's Bay Company employes who have gone over to the new company, have felt keenly the force of public opinion about the Hudson's Bay Company posts. This force of opinion has, of course, been fostered and encouraged by the Hudson's Bay Company in helping to fight off the competition of the French company. Miss Laut's lively history of the Hudson's Bay Company summarizes the salient features of the Company's attitude toward its wards in the following paragraph:

"In the charter lay the secret of all the petty pomp—little kings in tinsel—with which the Company's underling officers ruled their domain for two hundred years. In the charter lay the secret of all the Company's success and all its failure, of its most paternal care of the Indians and of its outrageous, unblushing banditti warfare against rivals; of its one-sidedness in driving a bargain—the true caste idea that the many are created for exploitation by the few—of its almost royal generosity when a dependent fell by the way—the old monarchical idea that a king is responsible for the well-being of his subjects, when other great commercial monopolists cast their useless dependents off like old clothes, or let them rot in poverty."

THE INDIANS AND THE HUSKIES.

The natives, both Indians and huskies, show many shades of color, which fact may be correlated with the prevalence of Scotch and English names and characteristics. There is a strong family pride, a good deal of observance in form, and the language even shows Scotch modification, especially in inflection. A universal habit on the bay is to shake hands in meeting and parting. Wherever we stopped we found it necessary to shake hands with all members of the party, men, women and children. Neglect of this duty was likely to be resented. In some cases at the posts were fifty or more people were met simultaneously, the ceremony became a formidable one. The natives work hard and lack what most of us would call the comforts and conveniences of life, but they and their ancestors have known no other way of living and therefore no not miss the things we regard as very desirable, if not quite essential. There are few social troubles, for all are subtantially on the same social level.

Their lives are not complicated by a multiplicity of interests and distractions, but are concentrated on the hunt which furnishes the wherewithal to live, and incidentally affords most of their pleasures. Their family life seems to the outsider to be remarkably happy, notwithstanding a common method of choosing mates which is often intensely practical and lacking sentimental considerations. Mr. Nicholson, post manager for Ruperts house, told of an Indian from one of the interior posts coming to him just before our arrival, and after buying his supplies over the counter, added that he would like to have a wife. The Post Manager did not have one in stock, but not to be stumped, had a canvass made of the camp, found a suitable woman, and before night had the pair wedded and started for their post five hundred miles inland. Our great department stores sometimes boast that there is nothing they cannot furnish, but in diversity of stock it is a question whether they surpass a Hudson's Bay post. That marriages so made should result satisfactorily is surprising at first thought. I suspect the explanation lies largely in the unity of material interets in the family and lack of outside distractions. From the start the entire energies of the family are devoted to making a living by hunting under strenuous conditions. The man kills the game and the wife skins it and prepares the fur and food from it. There is scarcely a day of their daily life in which close co-operation is not necessary. In time of stress and adversity they must look only to themselves for help. The result is a close welding of interests and development of team work to enable them to cope with their conditions, which seems to make a contented, if not happy family. To active women adapted to complex social conditions, this life would be quite unendurable, but in the absence of possibilities of more complex interests, in fact without knowledge of them, the simple and strenuous life accomplishes wonderful results. Time and again in our travels, as we spent a few hours in some lonely Indian camp, we felt the good cheer and the inspiration of a happy and well regulated family life. The solicitous, detailed and unremitting care of each of the members of the family for the others could not but reach the sensibilities of the onlooker. We came to regard these families as little spots of love and light in the wilderness.

Coming from a part of the continent where the Indian has not inspired must respect, it took a little time to realize that we were in contact with intelligent and self-respecting people who had solved the problem of living under the local conditions better than we could hope to, and to learn to follow their judgment rather than direct them. We came to trust them implicitly in all matters relating to travel, even where at first we could not see reason for some of their decisions, and to admire their simplicity, directness and efficiency in meeting their difficult conditions. The diversity of methods used by the natives in meeting a given situation was often bewildering. Scarcely had we come to know the methods of one group of Indians and felt some confidence in ourselves, than we had to begin over again with a new crew. There are so many effective ways of ''skinning a cat'' on Hudson Bay that one hates to describe any one method as general or as *the* way. The difference in this regard is especially marked between posts, so little is the intercourse between them. Their separation is as great in some respects as between countries separated by oceans on which travel is common. The result is a certain provincialism and dogmatism about methods at the posts conspicuous to a traveler visiting them in rapid succession.

On the other hand, as soon as the natives pass the boundary of their field of experience they are as children. They have not the mental training which will enable them to reason successfully from known to unknown conditions. An Indian can scarcely be improved upon as a guide over ground he knows, but is inferior to the skilled white man in meeting new and unknown conditions.

Perhaps the most striking of the natives' characteristics is their prevailing good humor. Their chatter, jokes and laughter, sometimes under distressing circumstances, often served as an antidote to our own tendencies to growl over adverse conditions. Their method was so much more effective as a practical proposition than ours, that we tried conscientiously to adopt it, thereby adding much to our pleasure. Especially is this characteristic marked in the Husky who gets enjoyment out of the most trivial incidents. The Indian has a certain reserve which hides this characteristic for a time when one first meets him, but with few exceptions he is found to be the same interesting, good-natured individual when one penetrates his reserve.

THE UTILITY OF THE METALLOGRAPHIC MICROSCOPE IN ENGINEERING.

JAMES ASTON.
Instructor in Chemical Engineering.

While the use of the microscope in the examination of the structure of metals and alloys had its beginning in the work of Dr. Sorby of England in 1864, and the later independent investigations of Martens in Germany in 1875, the real development of this application has come about within the past ten years. Previously, it was possible to develop the structure of the material under examination, but the full measure of the value of the work was missed through the inability to interpret the developments; again systematic research was handicapped by this lack of knowledge. The rapid progress in physical chemistry, particularly a better understanding of the theory of solutions, has supplied the missing link, so that today we have a rational interpretation of the results of solidification of molten mixtures, and a consequent explanation, more or less developed, of the variations in the structure of alloys occasioned by changes of composition or treatment.

The pyrometer and the microscope are of service in the study. The former, while having a direct practical bearing in certain instances, notably in the determination of the critical points of tool steels, may in general be said to be of more scientific interest, and of immediate value in the determination of the solubility relations of the components of the mixture; it furnishes the basis for the theoretical deductions of results to be expected on solidification of the melt. The microscope, on the other hand, has a more direct application in the industrial laboratory, since with it one is able to make an examination of any desired material as it is used or exists, and to interpret from the structure, backed by experience, the condition of the material and its suitability for the purpose in view.

It is particularly with this latter field, the application of the microscope to the examination of the structure of materials, that the present paper has to deal. Naturally, we meet the extremists of both kinds: the enthusiast, who would claim for the microscope the power to usurp the functions of other testing methods; and the skeptic, who treats it as a toy and scoffs at any suggestion of utility outside of the laboratory of the scientific investigator. The chief argument of the latter is that the field of view of the microscope is only an extremely small part of a very small sample cut from a large mass of material and it can disclose, therefore, only local conditions. Such argument is hardly tenable; it would apply with equal force to the one gram sample, the chemical analysis of which controls the 60 ton heat of a steel furnace; or to the purchase of a carload of coal or a boatload of ore on determinations of heating value, composition, etc., made on equally small units; or to our method of design of structures from materials whose strength is taken, as that of a small test sample. In fact, all testing methods are based upon the principle of a fair average sample of the material under test.

Microscopic examination is today passing through the same cycle that chemical analysis of iron and steel did some years ago. The conservatives opposed it as being of doubtful value; but its worth was apparent enough to overcome all objections, and today it would indeed be a loosely managed concern that did not base the control of its product on suitable chemical analyses. But chemical analysis falls short of giving us sufficient information regarding our material. Substances owe their properties solely to their make-up or structure. Composition is but one of the determining factors; chemical analysis, therefore, fixes but one of the variables. The relations of these chemical elements, or the make-up of the material, is most vitally dependent upon its history. Temperature and pressure conditions, or the proximity of disturbing influences, are of importance. In steels, for example, we consider the effects of heat and mechanical treatment; that is, for identical analyses, a steel annealed at 1200° C. would be weaker than one annealed at 900° C.; one quenched at 900° C. would be harder than the same material slowly cooled from that temperature; while cast material is weaker than that which has had subsequent rolling or forging.

This gap is the field of utility of the microscope. It is an auxiliary to chemical analysis and the other methods of test, and is of value mainly in determining the structural relations of the constituents of the material. Dealing in generalities, it is need-less to point out that microscopic examination is useful in the detection of incipient cracks or flaws, slag or foreign inclusions, porosities, and numerous other ills which metals are heir to. And it is treading upon well-beaten ground to emphasize the importance in engineering practice of the knowledge which we have gained of the constitution of steels. We now understand the role of varying percentages of carbon in affecting the ductility, strength and elasticity, of the steel. We recognize that the hardening of steels by quenching is due to structural influences occasioned by changes of the relations of carbon and iron; and can apply this knowledge to advantage in the so-called heat treatment, whereby we can manipulate the properties as desired by taking advantage of the ability to check the structure at any stage between the abnormal one of the quenched state, and the normal one of the annealed steel. Again, the beneficial influence of judicious annealing and the baneful one of overheating are readily accounted for by changes of structure which are evident under the microscope; and the same analogy holds in the comparison of cast and rolled or forged steels.

Among the materials with very high carbon content, the microscope reveals gray cast iron as nothing more than a matrix of mild steel, embedded in which is the bulk of the carbon existing as free graphite; white cast iron becomes a very high carbon steel, with the combined carbon in great excess; between these extremes are the various grades of mottled irons. In this same group, metallographic examination has been most beneficial in our understanding of the malleable casting processes. The initial casting is of white cast iron, with its characteristic structure. Proper heat treatment, or annealing, breaks this down, leaving a matrix of iron, embedded in which is the carbon as free graphite; and the greater ductility of this product compared to gray cast iron is seen to be due to the fine state of division of this graphite, because of its separation from the iron after solidification.

By way of illustrating the above discussion there is reproduced in Fig. 1 the familiar "Roberts-Austen Circle" showing the effect of various heat treatments alone on the structure of a piece of steel containing 1.5 per cent of carbon, the original structure of which is shown in the center of the circle.

In no field does the microscope become such a useful auxiliary as in the examination of the special, or alloy steels; here, too, its usefulness is rather of the future than of the past. It is impossible to dwell upon this phase which is beyond the scope of an article of this character; it is of interest to note, however, the most important revelation, that in spite of the multiplicity of alloying elements and their various combinations, their influence is largely one of degree, and that, after all, the underlying structural considerations are common to all.

The foregoing discussion has been concerned particularly with steels; but equally important facts have resulted from metallographic investigations of other industrial alloys, notably the brasses and bronzes, and the antifriction, or bearing metals. In

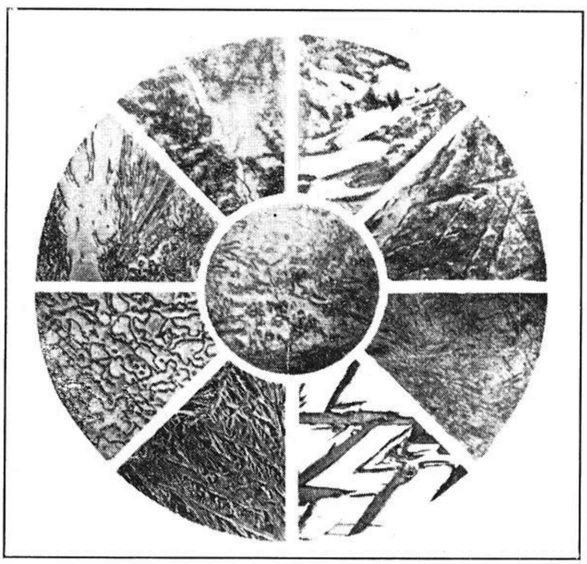


Fig. 1.

the last named division, particularly, much information has been gained. The desiderata of a bearing metal are two: a low coefficient of friction, and a certain plasticity to conform to the shape of the journal as wear proceeds. The former necessitates a hard material, the latter a soft; and to satisfy these conflicting conditions we resort to those mixtures of metals which on solidifying separate into two constituents of the desired qualities. Although bearing metals were used before microscopic examination, was practiced, it was study of this nature which revealed the characteristics of those materials which were of known value, and set the standard to be aimed at in the improvement of the art. A typical structure of such an alloy is indicated in Fig. 2 and shows the well known Magnolia metal, with its hard white antimony constituent bedded in a plastic eutectic of lead and antimony.

A few concrete examples will best illustrate the application of metallographic investigation to special problems.

Two brass manufacturing concerns, A and B, were putting on

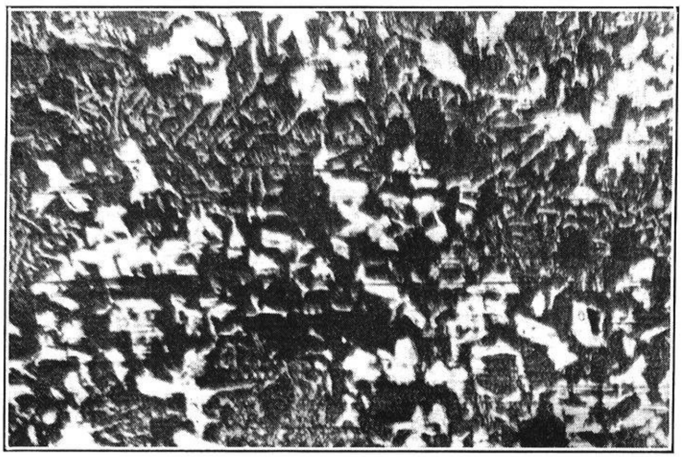


Fig. 2.

the market a standard article for which there was a large demand. But B's proved stronger than A's, and analysis of B's goods indicated the presence of one per cent of iron in the brass. However, when A tried out the new composition, it failed to give the strength of B's. Although the compositions are identical, the structure differences are pronounced as indicated in Figs. 3 and 4, and this difference, together with the marked dirtiness of the one compared to the other, lead to further investigation, with the final development that the one per cent of iron in B's product had little direct bearing on the strength, and was only that something which was inevitably left behind on the addition of ferromanganese to deoxidize the bath; the manganese being slagged off, and the brass castings left with a clear, fine-grained structure of great strength.

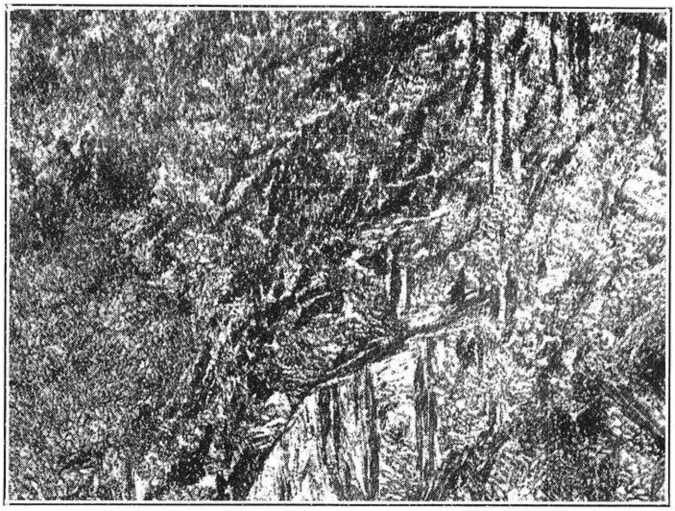


Fig. 3.

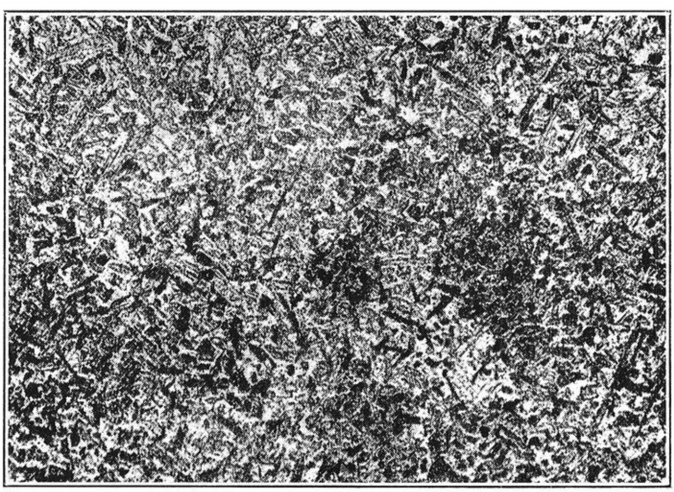


Fig. 4.

In the course of a manufacturing operation, steel rails which were used were subjected to considerable local heating. Whether this was the cause of troubles which sometimes developed, was a subject for microscopic study; and, following the generally recognized axiom that the strength of any steel varies inversely with the grain size, the large grains resulting from the high heat, and shown in Fig. 5, have surely deteriorated the quality of the original rail, the structure of which is indicated in Fig. 6.

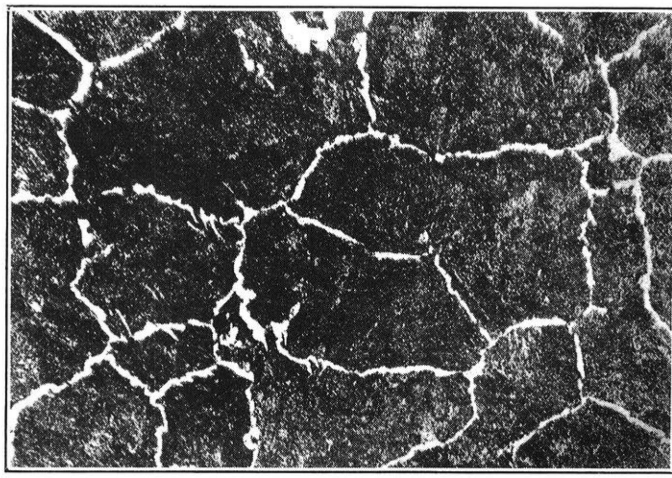


Fig. 5.

A certain manufacturer was exploiting an invention, the value and development of which depended largely upon whether it was a new substance, formed by interaction of the constituents, or a simple, mechanical mixture. Chemical analysis determined only the ingredients of the mixture but not their relations. Microscopic examination revealed a structure, typically shown in Fig. 7, which was decidedly heterogeneous, and therefore not a single chemical compound, or solution. Further examination of like nature and correlation of all facts served to fix very definitely the character of the material.

Numerous other instances of the value of microscopic examination have come within the experience of the writer. It has materially assisted in the determination of the nature of the various zinc coatings for the protection of iron surfaces; in indicating

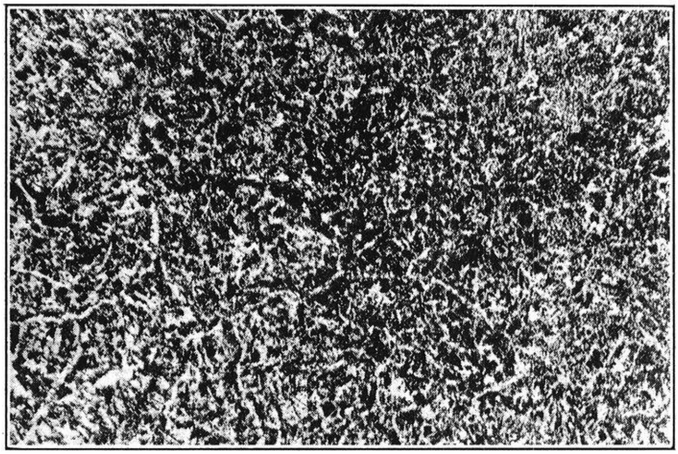


Fig. 6.

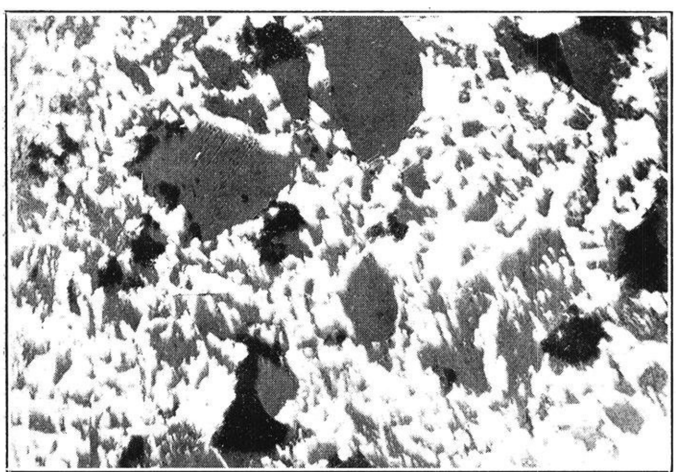


Fig. 7.

the depth of penetration of the oxidation in cutting steel with the oxyhydrogen blowpipe; and the amount of distortion caused in punching steel plate.

While the great field of application of the metallographic microscope is naturally to the metals and alloys, there is every reason to expect extension of its scope to allied lines, such as the examination of complex ores and slags, to ceramic materials, and, perhaps, to coal and coke. In all of these instances, we find good and poor materials of identical analysis; the probability is that the inter-relations of the constituents are different. An interesting application along this line has just been pointed out in the use of miscroscopic examination to detect iron blast furnace slags which are suitable, or otherwise, as a raw material for Portland cement. That vitrification which is essential in the proper slags is brought out very neatly.

The microscope has passed beyond the stage of being a toy of the scientific investigator; no better proof need be cited than its presence as a useful piece of apparatus in the best equipped metallurgical laboratories. It is not intended to displace other testing methods, but is rather an adjunct; and being that instrument which brings us into closest touch with the inner make-up of materials, which after all is the basis of all of their properties, it is surely a most valuable adjunct.

TELEPHONE SERVICE IN CHICAGO.

ALFRED U. HOEFER, '06.

The City of Chicago, extending 25.5 miles from north to south, and about 9 miles from Lake Michigan on the east to the western boundary line, comprises an area of 190.6 square miles; and is populated with 2,182,283 people.

The number of telephones in use throughout this vast area to-day is 234,000. These are directly available to over 1,000,000 people. No city in the world, with the exception of New York, has so large a telephone system as that of Chicago. The growth of this system has been remarkably rapid and the increase in stations in recent years has been little short of marvelous. The net increase in the number of telephone stations for the year 1909 was 31,179. In 1899 after the company had been in operation for more than twenty years, it had 27,663 telephone stations. *The number of new telephone stations added in 1909 is therefore greater than the number accumulated in the twenty years up to and including 1899!*

Telephone service for so enormous a number of people seems a staggering proposition when it is considered that any one of the million odd parties to whom the telephone is directly available, may in a few seconds be in communication with any one of the others; be it day or night, winter or summer. This is accomplished by means of a vast net-work of wires and associated equipment reaching from one end of the city to the other. At the end of 1909 there were 493,787 miles of wire underground; 69,666 miles of wire in aerial cable; and 62,985 miles of wire on poles, making a total of 625,438 miles of wire in the outside plant. Of the thousands of wires and pieces of apparatus, each has its own number, and the selection of any particular pair of wires for use is practically instantaneous. Notwithstanding the complex system involved in reaching a particular one of the 234,000 stations, the telephone service in Chicago is considered the best in the world.

There are 26 exchanges interconnected by about 10,500 trunk lines. About 1,300,000 originating calls are handled in an ordinary business day. In answering calls the operator's average speed is 4 seconds. It is the aim of the Telephone Company to

Main Office, Chicago Telephone Co.

have all the calls answered within a maximum of 8 seconds. The total time necessary to secure a complete connection is, on an average, from 20 to 25 seconds. These figures show the marvelous speed with which connections between subscribers, however re-

mote, are completed. One of the chief advantages of telephone communication is that it is practically instantaneous, and it is beyond the power of the imagination to estimate the value of this service to the people of Chicago.

The busiest hour of the day is between 10:00 and 11:00 A. M.; 10% of the day's telephone business being done in this hour. The busiest minute of the day is 10:10 A. M., and the busiest day of the year is the day before Christmas. Of the 9,172 employees about 3,800 are operators employed to make connections between subscribers.

The number of "busy" responses to telephone calls is decreasing and is now about 13% of all calls made. Of the day's traffic, 78.5% of calls are completed without trouble, 13% are held up on account of busy lines, 3% are not completed because the person called does not respond, 1.5% are not completed because of errors in giving the numbers on the part of the subscribers and 4% go astray due to other causes.

The magnitude of some of the branches of the service rendered by the company is unknown to the public. For instance, the number of requests received daily for the time will amount to about 60,000. The greater number of such requests come between 7:00 and 8:00 A. M. The Company's pay roll for operators is about $6,000 a day, and if the time taken for this service is charged pro rata, it costs the Chicago Telephone Co. $300 a day to tell its subscribers what time it is.

Another branch of the service, the magnitude of which is not generally appreciated, is in transmitting police calls and fire alarms. The number by which the company gives free service from any telephone in the city to the nearest police station is "Main—13". The use of this number is explained on the inside of the cover of the directory in large type under the caption "Police Alarms". "Main—13" is a special line used only for this purpose and the city's operator at Police Headquarters receives the call and summons assistance from the station nearest to the address given. This number was called 62,005 times during 1909,—about 12,600 more times than in the previous year. "Main—0" is also a free call and is used for reporting fires. This is a line used exclusively for this purpose and extends to the main office of the Fire Department. The City of Chicago has its own operator stationed there to receive such calls and report them to the nearest Fire Engine House over its own lines. This number was called 8,825 times in 1909, an increase of 986 times over 1908.

Maintaining telephone service throughout this enormous system necessarily involves the clearing of a great many cases of trouble. The figures, in this regard, for Chicago are, however, surprisingly low. The total number of actual cases of trouble cleared during 1909 was 452,000, which with an average number of 181,000 stations represents but 2½ cases per station per year. Rain and thunder storms in the summer, and snow and sleet storms in the winter, give the company considerable trouble. A severe storm may easily double the normal number of troubles. In case of a severe storm extraordinary measures are taken to meet the emergency, gangs of men being sent over all routes with orders to put all lines in good condition, regardless of actual cases reported. In many cases these gangs are given teams and wagons to enable them to cover more ground and to carry more material. The speed with which service is restored in cases of emergency troubles is remarkable. Regardless of weather difficulties or other obstacles service is restored at the very earliest possible moment, and in the majority of cases when lines are put out of service by storms or other unusual conditions, the lines are restored to service before the subscribers on the lines affected are aware that the trouble has occurred.

An interesting feature of the service supplied by the Telephone Co. is the directory which is issued three times a year. The Fall issue has just come from the printers, and, when delivered, will supersede that issued in June. The June issue was of the standard size 8½″ x 11″ and was 1¾″ thick; the weight of each copy was 56 ounces or 3½ lbs.; and more than 1,000 pages were included, each with three columns of names and the accompanying addresses and telephone numbers. Of this issue 221,000 copies were distributed, the work being done by scores of men who transported the books by means of heavy drays.

The Wisconsin Engineer

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

EDITORIAL.

In a letter written to the issue of the "Mining and Scientific Press" of Dec. 10, a correspondent asks if Engineers are honest. He answers the question himself by saying that most of them are, but that there are some who are so honest that they would not accept a share of the promoter's commission unless this gentleman mentioned it first; that there are others who would not permit a sale to go through unless they did get a division of the commission. The correspondent cites four instances of Mining Engineers allowing the nature of their reports to be influenced by the commissions they obtained. These men are undoubtedly graduates of Universiies or technical schools, they are not by any means too advanced in years to remember their college life, so that we feel the reflection on the profession of college trained Engineers. Surely, then, college men should develop the spirit which will voice itself in the words "There are some things a man cannot do."

The work undertaken by the Engineer is in every sense difficult, and in itself calls for the practice of the greater virtues useful to civilization. We have then good grounds for disgust when a sneer is raised at the dignity of his labor or when any cavil at an Engineer's honesty is courted.

* * *

It cannot be emphasized too strongly that the Engineer in the practice of his profession and in the discharge of his duties to employers be above the meanness of small traffic in trade commissions and other lightly won emoluments. Although possibly not wrong in itself and at times not incompatible with good faith towards employers, yet the practice is dangerous and intolerable to one jealous of his profession and work. A certain machine may be selected from several because it is the best at the price, but the acceptance of a commission from the vendors places the engineer in a position, at least embarrassing, when a second machine has to be chosen from a selection offered by the same competing firms. He may not be independent if once it be known that he will accept presents: moreover, however innocent his conduct, he will find that his standing among the commercial agents of the manufacturers will suffer and that the constant menace exists of questionable interpretation which may be construed from such an action.

But a greater danger lies in the effect upon the engineer himself. The Descent to Avernus is easy, and he may not be too careful of reputation, of honor, of the dignity of the profession, not too sure of his own strength to resist the more subtle pitfalls hidden in "contingent fees," "fixed reports" and "graft."

The equipment of the young Engineer commencing his professional work in the world of industry or science is contained in his brains, his character and his experience. The last is made up of his technical and human knowledge, and is naturally very incomplete when leaving college. He may be satisfied that his faculties of observation and perception are trained, his understanding of technical problems ready his memory reliable and his imagination lively; yet he soon realizes that his senior in years is his superior in knowledge and experience, and that the commercial world knows it and places its value for services accordingly. The young Engineer will then, if ambitious, try to supplement this equipment with the knowledge of men, of affairs, of technical matters, which may be gained by experience, and, if wise, will accept the moderate estimate of the value of his services. He will neither make the mistake of accepting too early in a life position in which he will not be able to meet the responsibilities, nor be guilty of the fatuity of overestimating his services and risking the acquiring of good experience by pressing for a larger remuneration. He will not hazard any of the chances of a future great and useful career for an immediate mess of pottage.

* * *

It is possible that few students realize the important role which the "Cost Sheet" plays in the practice of Engineering. When all the theories and experiments have crystallized into a process, when the working drawings have been approved, it is the man who can make the biggest yearly net profit, and he who can build the bridge cheapest, that is crowned with success. It would be good practice for the engineer to develop the habit of keeping accounts both of his personal expenditures and later of the disbursements of the particular department or office for which he may be responsible. He will often be able to reduce the expenses of a previous Engineer by eliminating many petty expenses and by running his office in the same prudent and careful manner as his household is managed; he will become economical in a business sense and be classed as a good manager. Let him once become acquainted with the process of making up the "Cost Sheet" of a great operating company, and he will have a great interest in the commercial development of the business, and must develop into a good friend and adjunct of the accountant because of his understanding of the importance of his office and his willingness to do a small share to make that official's work even one iota less complicated.

DEPARTMENTAL NOTES.

CHEMICAL ENGINEERING.

The Chemical Engineering laboratories have produced, as a result of experimental work, a number of new products, for which there has arisen a considerable demand, although they have not as yet become of commercial importance. Electrolytic, or pure iron is one of these. Several tons of this material have been produced during the past few years. Samples of this material, in quantities of from one ounce to one hundred pounds, have been supplied upon requests coming not only from various parts of this country, but from England, Germany, and France. The requests for this material come from those who are engaged in experimental and research work on iron and iron alloys.

* * *

Another new product is magnesite crucibles for withstanding high temperatures. In the manufacture of iron alloys free from carbon it became necessary to secure crucibles in which the pure iron could be melted, but none were found on the market to meet these requirements. Magnesium oxide was determined upon as the most suitable material, and after many trials a satisfactory form of crucible was made from this material by electrical heating and shrinking processes. Numerous requests are now being received from others desiring to use refractory crucibles of this sort, and there appears to be a possibility of this product coming into commercial use.

* * *

Numerous requests have been received recently for Chemical Engineers, the openings being in several lines of industry. These include several for paper mill work, one for the management of an electrolytic plant, one as superintendent and one as assistant to the superintendent of a large chemical manufacturing plant, one in experimental station work, and one as instructor in electrochemistry and electric engineering.

Research fellowships are being established at various technical schools, the fellowships being supported by manufacturers who wish to have certain problems investigated. Opportunities of this sort are at the present time available to graduate students of suitable qualifications.

* * *

At the meeting of the American Chemical Society held in Minneapolis on Dec. 28, 29 and 30, Prof. C. F. Burgess presided at the meetings of the section on instruction in Chemical Technology, and presented an address entitled "The Efficiency of College Training for Men for the Chemical Industries."

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During the past three years investigations have been under way in the Chemical Engineering laboratories on gas calorimeters, comparisons having been made as to the merits of the various calorimeters on the market and determinations of accuracy have shown that some of the instruments are decidedly deficient. This work was originally undertaken in the interests of the Railroad Commission, and then in the interests of the American Gas Institute, who appointed a Committee on Calorimetry. The present committee includes in this memberhsip C. F. Burgess and O. L. Kowalke, of the University of Wisconsin. Two somewhat extensive reports have been published and it is proposed to issue another report at the end of this year.

About five new types of commercial calorimeters have been secured for test and the study of them is being carried out by Mr. O. L. Kowalke and Mr. J. N. Lawrence.

Mr. Lawrence is a graduate of Syracuse University, having obtained a M. S. degree last June and now holding a Fellowship in Engineering.

* * *

In the electric furnace room there is at the present time unusual activity in the electrolysis of fused electrolytes. In addition to the preparation of cerium by Alcan Hirsch, referred to in the last month's notes, F. H. Prittie, a graduate student from Sacramento, California, is engaged in the production of metallic lithium from the fused chloride. He has already secured several good sized pieces of this rarely seen metal. Since the metal floats on the bath, and has a very low melting point and takes fire easily, its isolation is decidedly difficult.

E. A. and L. T. Richardson have built a furnace for the production of aluminum upon which a trial run was made on the

12th. When certain changes are made in the anode construction it is believed that this furnace will operate satisfactorily, although it is too early to write definitely about a process which has given so much trouble as has the production of aluminum on a laboratory scale.

* * *

In the December issue of Metallurgical & Chemical Engineering appears a paper by C. F. Burgess and James Aston on "Alloys for Permanent Magnets." Over one thousand alloys have been made, using electrolytic iron as a basis, and those alloys which are of particular value as permanent magnet materials are described in this paper.

* * *

The International Congress of Applied Chemistry is to be held in this country in 1912. It is expected that this will be the greatest gathering of chemists ever held. The committee having the preparation of the program for this meeting in its charge is divided into twenty-three sections. A president and vice president for each of these sections has been appointed. President C. R. Van Hise has been appointed as Vice Persident of the Section on Political Economy and Conservation of National Resources, and Professor C. F. Burgess has been appointed as Vice President on the Section on Electrochemistry. The list of the presidents and vice presidents is given in the December issue of Metallurgical & Chemical Engineering.

* * *

A five-ton refrigerator formerly used in the College of Medicine has been installed in the Materials Testing Laboratory for making freezing tests on mortar, concrete, brick, stone, etc. The storage box was placed below the (basement) floor of the laboratory to save floor space and to secure the benefit of the surrounding cool earth. In a preliminary trial a temperature of +5° F. was produced in the box, and in 24 hours the temperature raised only five degrees, the refrigerator being left to itself. It seems probable that a —10° to —15° can be maintained indefinitely working the compressor during the day only. The storage box is four feet deep and five feet in diameter; thus it will take large building blocks if desired. Some thesis work with this refrigerator on "effect of freezing temperatures on setting concrete" will begin soon.

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.

ANNUAL MEETING OF THE U. W. CLUB OF CHICAGO.

The following is an account of the annual meeting of the U. W. Club of Chicago held on November 17, as described by J. G. Wray, E. E. '93, Sec.-Treas.:

This was the most successful of our Club meetings held since 1902. There were upwards of 250 alumni present. The meeting was styled an "Aviation Meet," and had been widely advertised. Decorations were miniature aeroplanes, toy balloons, etc., and each guest was well provided. The fellows indulged in much hilarity that brought back memories of our undergraduate experiences.

A number of stunts were pulled off, one being in the nature of a farce comedy with songs, depicting incidents from University life and portraying the qualities of the various prominent alumini.

After the revelry had continued for a couple of hours and some semblance of quiet was restored, perhaps due to the fact that the revelers were becoming worn and weary and had lost their voices, we were treated to a splendid talk by Mr. Geo. R. Ehler, Director of Physical Training at the Universiy. Mr. Ehler emphasized the necessity of encouraging athletic activities that will appeal to, and will be of benefit to, the student body as a whole, rather than to particular small groups, as has been the case in the past. Dr. Ehler's sentiments were received with interest and enthusiasm and there is no doubt but that the Club will act upon his suggestion to provide trophies of some sort to encourage such athletic activity on the part of the student body generally.

The banquet was held at the Grand Pacific Hotel.

In addition to Dr. Ehler there was present from the University Dean F. E. Turneaure, who spoke briefly in response to a general call from the fellows. The engineers' yell, "Three cheers, three beers, Varsity, Varsity, Engineers," voiced by fully two-thirds of those present, bespoke the interest and energy of the Engineering Alumni in University and Alumni affairs.

An election was held and the following officers were elected: President, Lynn A. Williams, '00; Vice President, Frederick Whitton, '89; Sec.-Treas., J. G. Wray, '93; Directors: Dr. F. E. Chandler, '86; Israel Shrimski, '88; Dr. A. H. Curtis, '02.

Directors (carried over from last season whose term expires on Dec. 1, 1911): R. T. Conger, '04; Allard Smith, '98; A. E. Van Hagan, '06.

C. D. Purple, '05, C. E., accidentally shot and killed himself in the woods near the Oliver Club House on Sturgeon Lake in northern Minnesota. His body was found by F. A. Kennedy, '06, C. E., and E. F. Kowalke, '08, C. E., late Thanksgiving eve in the thick woods not far from the Club House, where he was watching for deer. Mr. Purple was Chief Engineer for The Oliver Iron Mining Co. for the Chisholm District. His funeral was attended by the State Militia and a large gathering of Masons, of which he was a member of high standing. His body was taken to West Salem, Wis., where the last rites were performed.

J. F. Hahn, '03, is an engineer with the Wood Concrete Co., Flint, Mich.

W. Halvers, '09, has a position with the Westinghouse Co.

James K. Cook is Engine Expert for the Hart Parr Co. of Charles City, Iowa.

Chas. P. Bossert, '88, Mechanical Engineer with the Pfister & Vogel Leather Co. of Milwaukee.

Thos. P. Cook, '00, is with the Pennsylvania Lines.

F. A. Boos, '09, is with the Wisconsin Rate and Railroad Commission.

Thos. H. Ahara, '00, Chief Inspector for the Acme Harvesting Machine Co.