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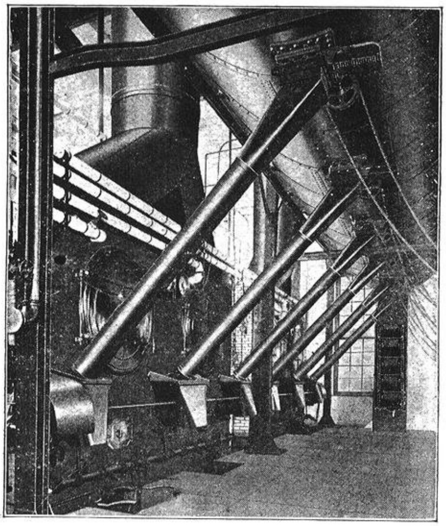


The Wisconsin Engineer

VOL. XVI FEBUARY, 1912 NO. 5

SHORT CIRCUIT TESTS OF A 12,000 KW 9,000 VOLT 25 CYCLE TURBO GENERATOR WITH EXTERNAL REACTANCE COILS.*

RUDOLF FREDERICK SCHUCHARDT, '97, E. E., '11.

During the early years in which very large high speed steam turbo-generators were used and especially after a number of them were operated in parallel, it was found that the disturbances to a system due to cable break-downs were much more severe than they had previously been when the energy was obtained from reciprocating engines. In a number of instances the end turns of the generator were torn loose, coils were short-circuited and the entire armature winding was destroyed. Oil switches also, while their design was materially improved, were often found inadequate for the heavy duties at times of trouble. This was due to the fact that the stored energy in the large revolving mass of the steam turbine and the comparatively low reactance of the winding permitted a very heavy discharge of energy into a fault, producing severe strains on all parts of the circuit.

The first and natural corrective step was to improve the method of fastening the end turns and the results of this change, which also included a change in the arrangement of the coils, have been quite satisfactory. This reduced the damage to the generators themselves to a negligible quantity, but oil switches still continued to be disrupted, and occasionally bus bars were jerked from their supports. The necessity for reducing the extremely high current which flowed at the instant of short circuit was clear. This, of course, could only be done by increas-

* A thesis submitted for the degree of ELECTRICAL ENGINEER.

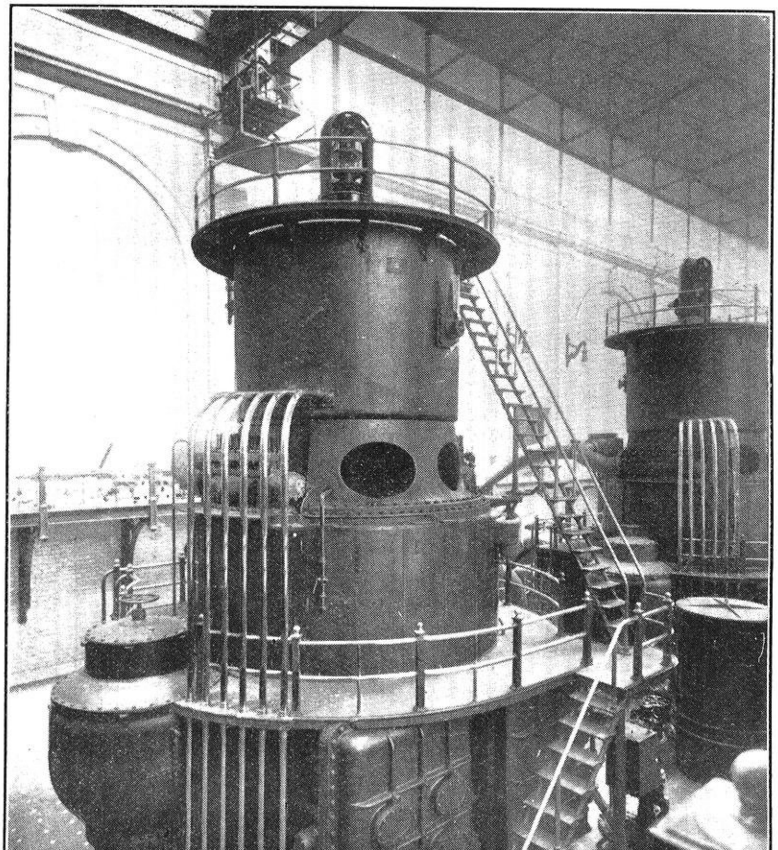


FIG. 1.—*Unit No. 10, Fisk St. Station, Commonwealth Edison Co.*

ing the reactance of the armature circuit, either by redesigning the generators or by installing external reactance coils in series with the armatures of the existing generators. As a further safe-guard and to limit the extent and magnitude of the disturbance the entire system was divided into sections operating without any connection between them at the station.

In order to obtain definite data and experience with reactance coils the Commonwealth Edison Company, in conjunction with the General Electric Company, has recently conducted a series of tests, using a 12,000 kw., 9,000 volt, 25 cycle, Curtis Turbo-generator (Fig. 1)—Unit #10 at the Fisk Street Station. The generator has a "barrel coil" winding made up of 36 coils, four turns per coil, laid in 72 slots. The generator field is of the indefinite pole, laminated core type. The resistance of the armature per phase of the "Y" winding is 0.0247 ohms at 28° C. A set of three reactance coils of which Fig. 2 shows one coil, was used, designed for a reactance voltage of 312 (or 6% of the "Y" voltage) with a current of 770 amperes, the full load current of the generator. By measurement the impedance per coil was 0.425 and the resistance 0.0075 ohms. The rated speed of the generator is 750 r.p.m. The calculated reactance of the generator is approximately 2%, but the effective value during heavy flow of current is in excess of this, due to the rapid dying down of the field at such times.

The points to be determined by the tests were the following:

1. The instantaneous short circuit current without external reactance.

2. The instantaneous short circuit current with an external reactance of 4%.

3. The instantaneous short circuit current with an external reactance of 6%.

4. Duration of the transient phenomena incident to the short circuit under conditions 1, 2, and 3.

5. The effect on the generator of these short circuit currents.

6. The behavior of the reactance coils.

7. The effect of the installation of reactance coils on the stability of the system.

A temporary structure was erected in the yard outside of the station building and in this were placed two oil switches, one

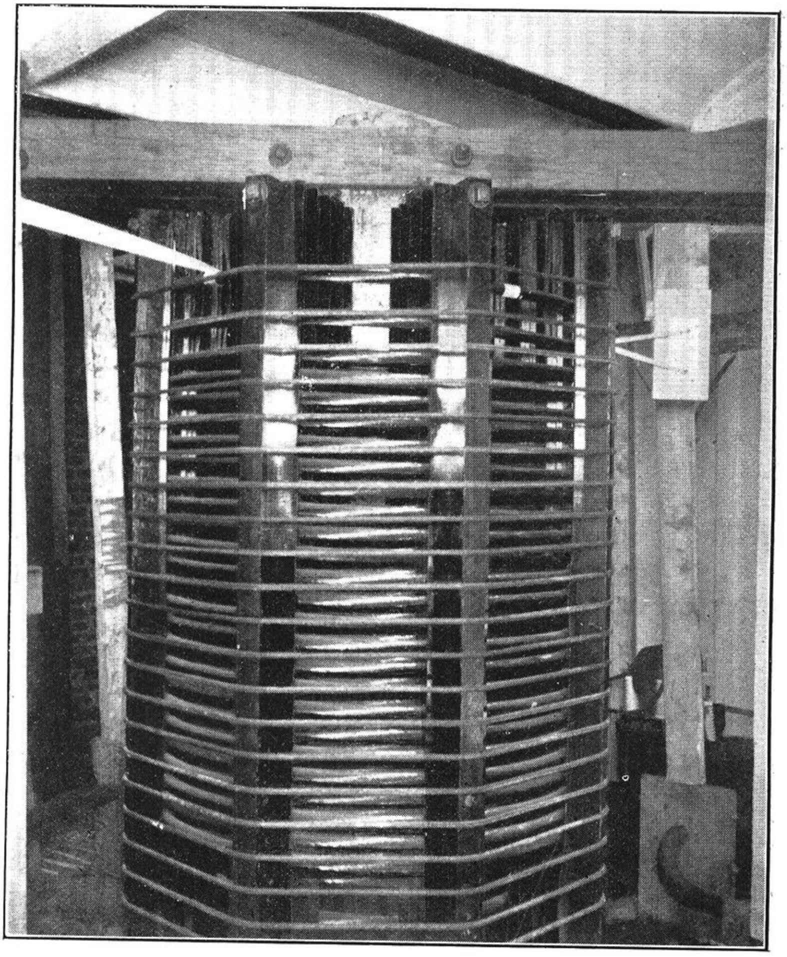


FIG. 2.—*One of the reactance coils used in the test.*

for closing the circuit and the other for opening. Incidentally a number of oil switches were also tested, but as they had no direct bearing on the subject of this thesis the details are omitted.

The short circuiting switch was closed in all cases with the generator at full speed, but the initial tests were for safety made at a very low voltage. Two oscillographs were used and records were obtained of various currents and pressures as indicated below. A large number of tests were made and the principal data obtained is given in the following:

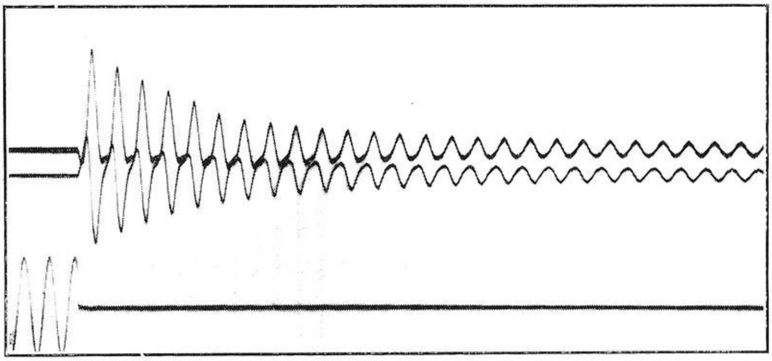


FIG. 3.—*The trace at the top of the oscillogram shows the A phase generator current; the middle trace shows the B phase generator current and the bottom trace shows the 4000 volt A B generator delta pressure.*

1. The instantaneous short circuit current without external reactance.

The trials were made with voltages of 1000, 2000, 3000, and 4000 volts. The characteristics are shown most clearly in the tests at 4000 volts, an oscillogram of which is shown in Fig. 3. The maximum current at 4000 volts was found to be about 13,600 amperes and at 3000 volts about 10,200 amperes. From this the current calculated for full voltage was found to be approximately 30,500 amperes or 28.0 times the full load current.

2. The instantaneous short circuit current with an external reactance of 4%.

A portion of the 6% coil which included a reactance corresponding to 4% was connected in each armature lead and short circuit tests were made with voltages of 5000, 7000, and 8000 volts. The maximum currents at the different voltages were plotted and the probable maximum at 9000 volts was found to be about 18,000 amperes or 16.5 times full load current.

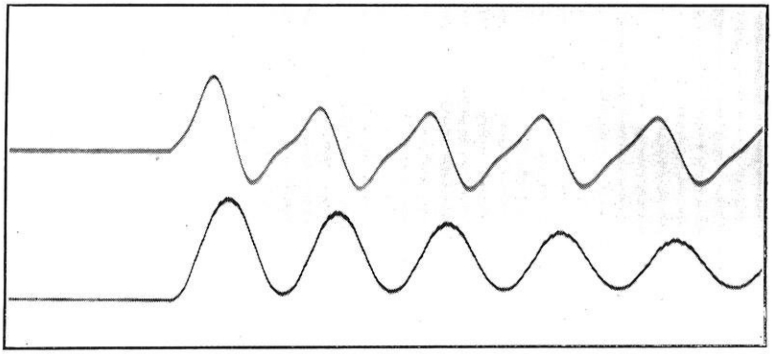


FIG. 4.—*The top trace shows the C phase generator current, and the bottom trace shows the generator field current.*

3. The instantaneous short circuit current with an external reactance of 6%.

Most of the tests were made with the full coils in use beginning with a voltage of 1000 and carrying the tests on to the

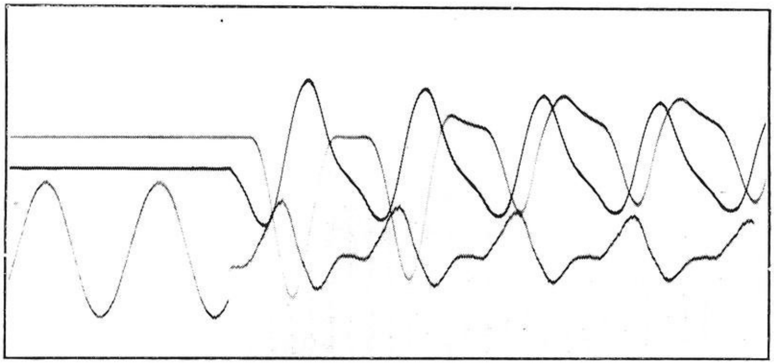


FIG. 5.—*The top trace shows the A phase generator current. The middle trace shows the B phase current. The bottom trace shows the 9000 volt A B generator A B delta pressure.*

normal operating voltage of 9000 volts. Figs. 4 and 5 show two oscillograms taken simultaneously during a short circuit at 9000 volts.

In Fig. 5 the "A" phase current shown has a maximum value of 15,000 amperes. From a number of trials the maximum current was found to be about 15,300 amperes. This shows that the instantaneous short circuit current has been reduced by 6% reactance coils to approximately 14 times full load current or one-half of the same current when no external reactance coils were used. Oil switches can be designed to open the circuit safely with this reduced current.

4. Duration of the transient phenomena incident to short circuit under conditions 1, 2, and 3.

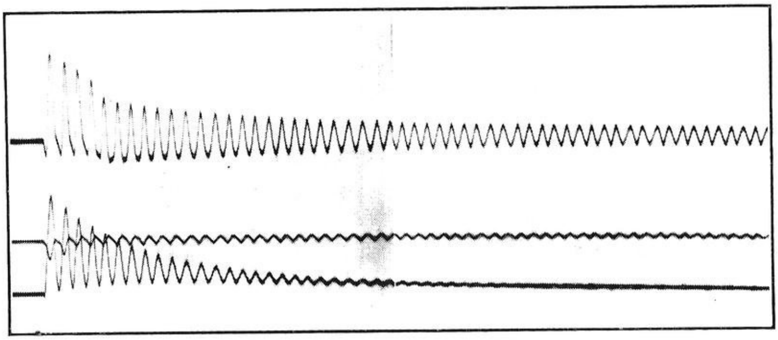


Fig. 6.—*The top trace shows the C phase generator current. The middle trace shows the pressure across the A phase oil switch breaks for data for switch tests. The bottom trace shows the generator field current.*

A number of tests were made in which the oil switch was kept closed for several seconds as shown in Figures 6 and 7. These figures show two oscillograms taken simultaneously during a short circuit at 9000 volts with 6% reactance. The 25 cycle time reference wave taken from the system varies slightly but is sufficiently uniform to show the retardation of the generator. The oscillograms show a retardation of 1/4 of a cycle in five seconds and also that the short circuit current reaches a constant value in about two seconds. The effect of the field and armature transients is shown clearly in the "C" phase current trace in Fig. 6, in the difference in the rate of decrease in amplitude of the first four cycles as compared to that of the subsequent cycles. A complete discussion of this point may be found in the paper by Mr. Miles Walker on "The Short Circuiting of

Large Electric Generators," read, in 1909, before the Institution of Electrical Engineers (England). The constant value of the short circuit current, from the oscillograms, is about 850 amperes. Full load excitation would have made this about 13,500 amperes.

5. The effect on the generator of these short circuit currents.

A careful examination of the generator was made after each series of tests, but no effect whatever could be detected. At the instant of short circuit in many cases a flash was seen within the generator. This was caused by the volatilized parts of the carbon brushes at the collector rings of the field circuit, and also by the induction of very large eddy currents in the field core. Figs. 4 and 6 show oscillograms of the field current. The field current at the time of short circuit may rise as high as 3500 amperes due to the induction from the armature circuit. The normal excitation at full load and unity power factor is 380 amperes.

6. The behavior of the reactance coils.

The coils consist of bare copper cable of 1,000,000 c.m. section wound on a hollow concrete core. There are 76 turns arranged in three layers, the inner diameter being approximately 2 ft. 9 in. and the outer diameter about 4 ft. 3 in. The coils used in the test had an outer layer of ½ inch cord as shown in Fig. 2. This for the purpose of preventing persons or materials coming in contact with the conductor. The total height of the coil structure is approximately 8 feet and the copper turns extend over about three-fourths of this height.

The coils were originally installed 6 feet between centers and anchored into the concrete floor and they were held in position by 6"x6" oak beams 14 feet long across the top of the concrete cores. The clearance between the copper of adjacent coils was 27 inches. The 76 turns were distributed as follows: 26 turns on the outside layer, 24 in the center and 26 turns in the inside layer. The vertical distance between turns was 3 inches and the horizontal distance between turns was 2¼ inches. The diameter of the copper was approximately 1–3/16 inches.

The upper bracing was later removed and it was found that there was absolutely no movement of the coils when short circuit currents were flowing. The coils as built apparently have sufficient strength to successfully withstand the strain of the short circuits. Various pieces of brass, bolts, and structural iron were placed in the magnetic field within 18 inches of the coils to determine the heating. With full load currents through the coils at the end of five hours all temperatures were constant. It was found that there was practically no heating of the brass or copper placed near the reactance coils. Iron bars (1″x¾″) in iron screens showed a maximum temperature rise of 24° C. when placed 12 inches from the coils. The maximum

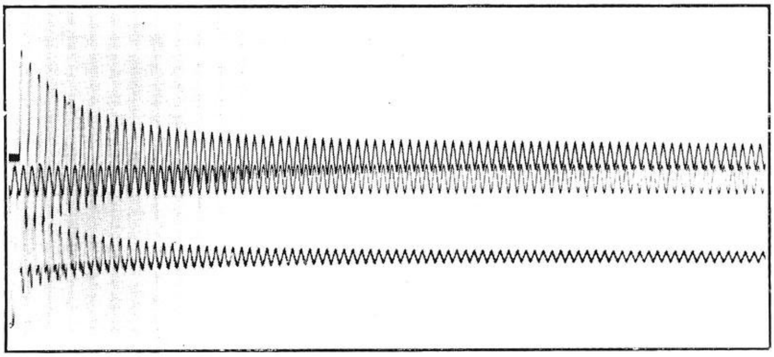


FIG. 7.—*The top trace shows the A phase generator current. The middle trace shows the time referenc wave from the 25 cycle system. The bottom trace shows the 9000 volt A B generator delta pressure.*

temperature rise of the coils themselves was found to be 26° C.

During the test no rise in voltage on the end turns of the coils could be detected.

7. The effect of the installation of reactance coils on the stability of the system.

The stability of the system during cable break-downs depends primarily on two things: 1st—steadiness of voltage, and 2nd—steadiness of speed. The use of reactance reduces the torque on generators to such a point that the speed is not materially affected even by short circuits on the bus. This is shown clearly by the small retardation of the generator shown in Fig. 3 spoken of previously. The voltage on the bus, however, is directly dependent on the resistance of the short circuits from the bus to the fault and back, as well as on the nature of the fault, and is, therefore, practically independent of the reactance. If then the voltage drops to such a point that the synchronous apparatus connected to the system feeds back sufficient energy to actuate the overload relays on the substation units, the oil switches on these units will be opened, i. e., the load will drop off. If the bus voltage does not reach a very low point or if the overload relays in the substation are provided with fixed time elements which will make them inoperative, short of, say one second, then the reactance in the gene-

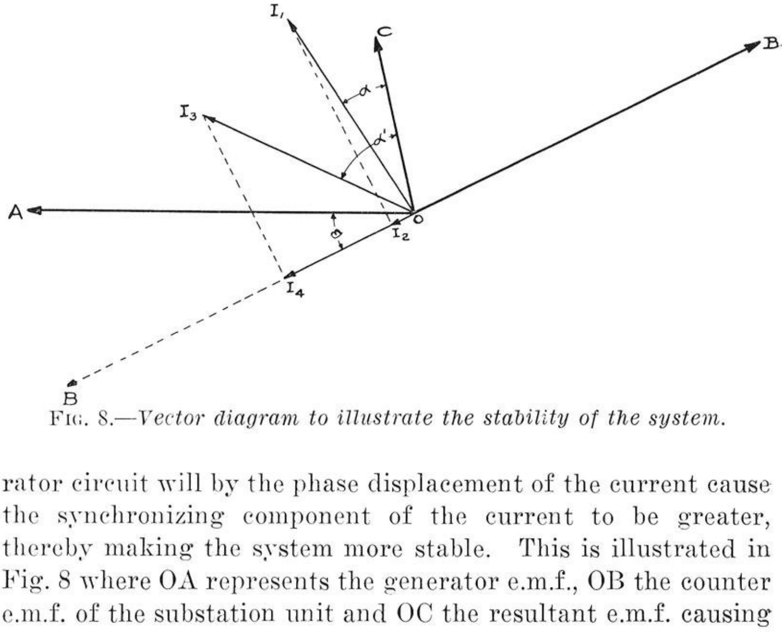


Fig. 8.—*Vector diagram to illustrate the stability of the system.*

rator circuit will by the phase displacement of the current cause the synchronizing component of the current to be greater, thereby making the system more stable. This is illustrated in Fig. 8 where OA represents the generator e.m.f., OB the counter e.m.f. of the substation unit and OC the resultant e.m.f. causing a cross current to flow. This cross current with only a small amount of reactance in the circuit has the direction OI_1 lagging behind OC by the angle α. This angle is increased to α', the current vector then being OI_3, when the reactance in the circuit is increased by the installation of generator reactance coils; the greater the reactance, the greater will the angle α be. The component of I in phase with the negative vector of OB, or OB′, is the energy or synchronizing current, and the increase in this value from OI_2 to OI_4 due to increase of angle

α is clearly seen. The angle β is purposely very much exaggerated for sake of clearness.

Various substation units of the operating system were connected to the turbo-generator under test and short circuit currents were then produced to note the behavior of these substation units. For this purpose the following substation apparatus was used: A 1000 kw. General Electric rotary converter with induction regulator, a 1000 kw. General Electric split-pole rotary converter, two 2000 kw. railway rotaries with reactances, and one 1000 kw. frequency changer consisting of a 9000 volt 25 cycle motor driving a 60 cycle 4000 volt generator.

In these tests with a short circuit on all three phases at or near the station bus bars the voltage dropped so low and remained low for a sufficient time so that the overload relays on nearly all the substation apparatus operated their oil switches. The synchronous apparatus, except the rotary with induction regulator, always tripped out. With a single phase short circuit between two phases of the bus bar, only the frequency changer and the split-pole rotary converter dropped off due to their overload relays opening the oil switches. With the short circuit produced by an artificial fault on one phase to ground in a short length of cable, only the split-pole rotary dropped off. A further test was made on the rotary converter with induction regulator in which the time setting of its overload relay was increased to a longer period than that on the switch which opened the circuit containing the fault at the station, and in these tests the converter "held on" throughout the disturbance.

SUMMARY.

The general conclusions which are proper from a study of the above test are as follows:

1. In order to reduce the severity of disturbances on the system due to short circuits, it is desirable to have generator reactance of approximately 8%. Where generators are designed with a reactance considerably less than this, it is desirable to install external reactance coils of a value making the total reactance approximately 8%.

2. Such reactance coils will reduce the current to a value where it can be safely interrupted by properly designed oil switches, and will keep the torque on the generator down to so low a value that even when feeding into a short circuit at the bus bars there is no appreciable lessening in speed nor is the unit subjected to severe strains.

3. The use of such reactance coils tends to make the operation of the system as a whole more stable, and therefore, increases the reliability of the service.

GOVERNMENT IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER.

J. E. KAULFUSS, '08.

Page upon page can be written upon the relation of the railroads in this country to our navigable streams, a comparison of our inland waterway development with that of European rivers, or, in particular, the feasibility of improving especially the Mississippi in order that this water route may compete successfully with the railroads for both freight and passenger traffic. Our expansion has been westward, our great export cities lie on either coast, the disposition of our resources is primarily east and west; therefore, it is consequent that our trunk rail-lines extend through the breadth of our commonwealth. Will the north and south traffic ever be such as to warrant the use of the Mississippi and its tributaries to such an extent as make their improvement imperative? What will be the effect of the Panama Canal on our commerce? What will be the result of a possible future Canadian reciprocity pact on this freight transportation? A board of U. S. engineers has announced that a fourteen foot channel from the Great Lakes to the Gulf of Mexico is feasible, surveys having been made and estimates of cost given. The question arises: Will such expensive improvement be economically advisable? Upon this point alone, there has been considerable discussion and dissension. It is accepted that the improvement of German rivers has been wise commercially; but the position of the German railroads is different from that in this country. That, even now, the river in its present condition of partial improvement has a tendency to decrease the rail freight rates between river cities and adjacent communities seems to be a weighty argument for the perfection of the Mississippi as a useful waterway.

It is not the purpose of this article to dwell upon the economics of this question, but rather to acquaint some of the future engineers with the scope of the work of improvement.

The national government has spent vast amounts on the improvement of our harbors and rivers. From the annual report of the Chief of Engineers, U. S. Army, 1910, Part I, is taken the following:

Total appropriations for rivers and harbors to June 30, '09	$608,793,517.78
Amount appropriated by sundry civil act approved June 25, '10	8,051,428.00
Amount appropriated by rivers and harbors act approved June 25, '10	41,327,238.50

which with other appropriations totals to the large sum of $660,604,209.74. The total amount actually expended under the direction of the Chief of Engineers in connection with the improvement of the rivers and harbors during the fiscal year ending June 30, 1910, is $29,685,583. Besides which there was an item of about $35,000.00 for the enlargement of Governor's Island, New York Harbor and for the removal of ice gorges in the Ohio River. Also there was expended $191,263.22 contributed by states, municipalities, corporations, and private parties. The following estimates have been submitted by the Chief of Engineers for the fiscal year ending June 30, 1912:

Under continuing contracts	$7,368,077.00
Rivers and harbors (general, including Mississippi River Commission, examinations, surveys, and contingencies)	22,627,361.00
California Debris Commission (expenses)	15,000.00
Prevention of deposits in New York Harbor	85,260.00
Total	$30,095,698.00

which "estimates are intended to cover only the minimum requirements, etc. Of the above $22,627,361.00 practically 70 per cent is to be devoted to prosecuting work on the Ohio, Mississippi, Detroit, Hudson, Delaware, and Columbia Rivers and at 11 important harbors." These figures have been given with the primary purpose of showing the magnitude of the work. It is inconceivable that this work will soon discontinue.

There is the probability that the contemplated 14 foot channel from Lake Michigan to the Gulf will materialize. If a channel of that depth can be maintained at the low water stage, surely there shall be a wonderful increase in freight traffic. Barring the limit of speed on inland waters, there seems to be no reason why this new waterway will not compete very well with railroad traffic. The improvement may well result in a complete success, especially since the Panama Canal and the possible Canadian reciprocity may have a wholesome effect toward this end.

Regarding the present depths of the Mississippi River it can be said that minimum depth (in the channel) maintained in the South Pass is now 31 feet, where formerly a few spots showed only 9 and 13 foot depths. This improvement, at an expense of over $8,000,000 (1875–1901) has increased the number of deep-draft, fully loaded steamers docking at New Orleans, where the earnings and the business have increased, and the freight rates decreased. Other outlets in the delta have been similarly deepened. There is a marked decrease in the depth of the Mississippi between New Orleans and St. Louis, due largely to the ever-shifting of the channel, sedimentary deposits, snags, wrecks, etc. However, directly below St. Louis an 8 foot channel is maintained to the mouth of the Ohio. The present plan of improvement is to maintain a minimum depth of 6 feet from St. Louis, Mo. to St. Paul, Minn. It is a noticeable fact that wherever navigation is made better, there is a most decided beneficial influence on the freight rates. What effect a permanent channel of 6, 8, 10, 12, or 14 feet may have on traffic and rail tariff remains to be seen. Some reaches of the river have been permanently improved to the present plans of 6 feet depth for the Upper Mississippi and 8 or more for the lower portion, these figures being minima. These depths will naturally require shallow draft boats and barges. Therefore, it may be believed that the style of vessels adapted to the river, when the water traffic warrants such investment, will be radically different from the present kind. This in itself presents an entirely new field for development and enterprise.

There are innumerable topics in our waterway improvements which might be discussed to a very great length. Snag boat work, dredging, the building of dikes or levees, shore protection, shifting of the river channel, canals, locks, etc., etc., all are interesting and instructing but it is the purpose of the writer to deal with the Upper Mississippi because the probable readers of this article are fairly well acquainted with this portion of the river and because the writer has been twice in the governmental service on this work. Therefore the remainder shall be devoted to the actual work to a maintain a 6 foot channel from St. Louis, Mo. to St. Paul, Minn.

The valley of the Upper Mississippi is narrow. The hills, or bluffs, about 300 to 600 feet high, are steep and abrupt. The minor streams when in flood bring into the river large quantities of sediment, sand, gravel, drift-wood and vegetation, all of which must be deposited when the flood ebbs. When the main channel of the river washes the hills on one side of the valley there is usually found on the other side channels called sloughs, connecting with the main channel by numerous cross sloughs. Consequently, there are many islands formed, some of which are submerged during high water. With a given discharge, these various sloughs afford a large cross-sectional area, which naturally reduces the velocity of flow, causing rapid deposits of all suspended matter. In other words, nature would soon have no definite channel, but would have instead numerous smaller ones, shallow, broad and with a low velocity. Navigation would soon cease under this condition, because sand bars would form in the very channel of the river proper leaving a depth of perhaps but a foot or two. These sand bars are formed by the river current cutting against one bank and depositing on the other as the stream meanders through its flood plain. The channel is also sometimes obstructed by snags, boulders, and ridges of rock extending across the river, forming rapids, which condition can be remedied by canals and locks or by cutting a clear channel in rock.

Former plans held for maintaining a channel 900 feet wide and 6 feet deep, but the present are for a channel 625 feet wide and 4½ feet deep, this being ultimately increased to 6 feet. These depths refer to the low water elevation of 1864. In the summer of 1910 the writer set gauges at all river towns between Winona, Minnesota, and Prairie Du Chien, Wisconsin. Due to the abnormal drought of that year a new low water mark has been determined for many parts of the river and the minimum depth of the channel will be referred thereto. The maximum draft that could be carried June 30, 1910 from the

Missouri River to St. Paul, 658 miles, at mean low water was, as nearly as could be ascertained 4.5 feet. However, during the late navigation season all river passage was practically suspended as far as Winona, Minnesota on account of low water. The existing project, for the purpose of ultimately securing and maintaining a depth of six feet is estimated at $20,000,000 provided it can be completed by 1927. For care and maintenance after completion $300,000 per annum is appropriated.

The navigation interests are important though less so than formerly, since the lumbering industry in Minnesota and Wisconsin is fast decreasing. The amount of freight carried in 1909 was 1,916,904 short tons valued at $25,354,524, both tonnage and valuation being about 25 per cent less than in 1908. The number of ton-miles was 131,290,621. As instances of the effect of water competition on freight rates applying to that portion of the Mississippi River in question the following table is taken from the previously mentioned Engineer's Report:

"Freight rates charged by rail and river from St. Louis to several points on the upper Mississippi on classes 1, 2, 3 and 4, western classification, and also from these points to Chicago where no river competition exists."

A study of Table I, taking fourth class as an example, will show that the steamboat rates are about 66 per cent of the rail rates where there is water competition, but on the inland routes to Chicago the rail rates are much greater than for the corresponding distances along the river. Also it may be said that the published first class rates from Quincy to St. Louis, by rail 140 miles, is the same as that from St. Louis to a point 36 miles south, or from Chicago to a point 51 miles west. Between Burlington and St. Louis, 221 miles by rail is the same rate as from the latter 61 miles south, or from Chicago 110 miles west. It is natural that river navigation has decreased the freight rates to St. Louis but it is very surprising that it affects the Chicago rates. While it can not be claimed that the river improvements have been solely responsible for these differences and results, it is a well known fact that wherever water competition exists, its effect on rail rates is always beneficial to the public, and "that as long as this navigation is

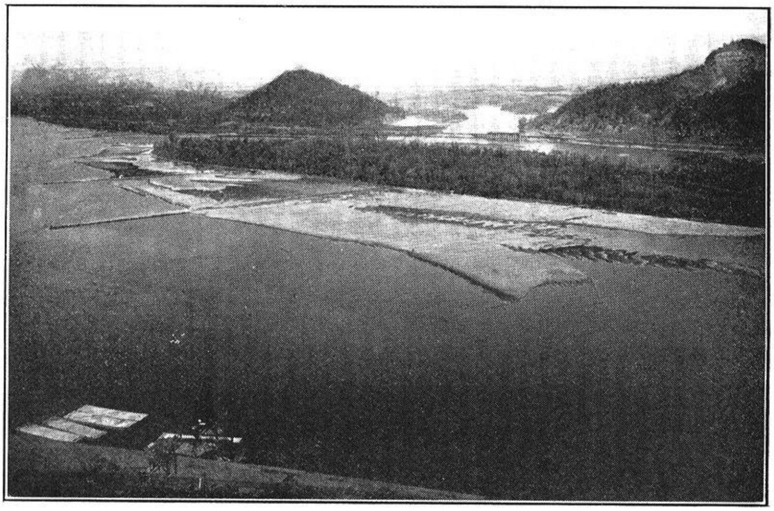
TABLE I.—(In cents per 100 pounds)

To	By Rail Miles	By Water Miles	1. Rail.	1. Water.	2. Rail.	2. Water.	3. Rail.	3. Water.	4. Rail.	4. Water.	To	Miles	1.	2.	3.	4.
St. Louis	......	......	......	......	......	......	......	......	......	......	Chicago	284	43.3	35.2	27.5	22.0
Quincy	140	155	27.0	22.0	21.0	17.0	15.0	12.0	12.0	8.0	"	263	42.0	34.7	27.0	21.7
Burlington	222	234	39.6	33.0	32.0	26.0	24.8	20.0	18.0	13.5	"	206	39.6	32.0	24.8	19.9
Rock Island	249	313	41.2	33.0	33.4	26.0	25.9	20.0	20.8	15.0	"	181	37.5	29.8	23.1	18.7
Clinton	287	349	42.8	33.0	34.7	26.0	27.1	20.0	20.8	15.0	"	138	37.5	29.8	23.1	18.7
Dubuque	347	411	45.9	33.0	37.6	26.0	29.7	20.0	23.0	15.0	"	167	38.4	30.7	23.5	19.1
La Crosse	461	532	50.0	34.0	42.0	28.0	33.0	22.0	23.0	16.0	"	271	50.0	42.0	33.0	23.0
Winona	488	560	50.0	34.0	42.0	28.0	33.0	22.0	23.0	16.0	"	297	50.0	42.0	33.0	23.0
St. Paul	576	676	63.0	40.0	52.5	34.0	42.1	27.0	26.0	17.0	"	410	60.0	50.0	40.0	25.0

feasible, and largely in proportion to its feasibility, such benefits will accrue even if but little river commerce is carried on."

It has been the custom with the railroads along the Mississippi to make special or commodity rates on some particular class of shipments, especially at local points and such articles may be shipped by only one shipper at such local point, presumably with the understanding that the railroads are to get all the business. It is also well known that the railroads strive keenly for the north and south freight business, make much lower rates where there is water competition, cut their rates on certain commodities, and, it is said, make especially low rates for the navigation season to be increased during the winter. This latter practice was common years ago. The average rate of floating logs down the river is 1 mill per ton-mile. The lowest rail rate on lumber in carload lots between river points is 6 mills per ton-mile, showing a saving of 5 mills per ton-mile, which resulted, in 1909, in a profit or saving of $537,941 on lumber alone. Besides such instances of actual savings, there can be added the general saving due to the general reduction of freight rates on all commodities. These must aggregate to enormous quantities and it surely seems advisable to make the Mississippi more and more navigable.

It may then be said that the river would, if not improved, be soon in such a condition as to have no well-defined channel of any great depth, recalling the physical condition of the river that its flood plain lying between steep hills on either side is cut up into islands by the meanders, by-passes, sloughs, etc. If this large volume of water—and the discharge at St. Paul is 2,000 and 85,000 cubic feet per second at low and high water respectively—can be forced into a narrow cross-section, its velocity will be increased, scouring will result, and all suspended matter will be deposited outside of the main channel. This means, then, that all the secondary channels be shut off by means of closing dams, and that the main thread of the river be contracted by wing dams which project out into the river. Such a procedure would then result in shunting all water to a confined portion and, as the old channels, sloughs, etc. are filled with sand, silt, drift-wood, etc. due to the low velocity therein, the given discharge at low water would form a navigable channel during the dry seasons. If the channel is then navigable at low water, it would obviously be more so at the higher stages. The above is exactly what the government is doing and this embodies almost all the work in the Upper Mississippi. The greater portion of the work on the Upper Mississippi consists of building closing dams, wing dams and shore protection to the construction of which the remainder of this paper is devoted.



Projecting wing dams with deposits of sand.

During the late fall of each year, a survey is made of those portions of the channel which have been found to hinder navigation and need improvement. The surveying party in our district consisted of the Junior Engineer, a U. S. Surveyman, a sounder, and four others acting as rodmen and oarsmen. Our equipment consisted of the usual surveying instruments, i. e., a transit, stadia boards, skiffs, sounding pole, lead-line, etc. Our quarters were a U. S. quarterboat which was moved down the river as our work progressed. A cook and helper rounded out the outfit. The first step in making the survey consisted of setting out sounding stations such that a straight line connecting two of them, one on either side of the river were at right angles to the channel and about 300 or more feet apart. The stations themselves consisted of whitewashed laths nailed on an upright stick driven into the ground at the water's edge. These laths were nailed so as to form Roman numerals. The even numerals were placed consecutively, II, IV, VI, VIII, X, II, IV, and repeated on the right bank of the river while the odd ones I, III, V, VII, IX, I, III, and repeated were placed correspondingly on the left bank. The sounding lines then read thus: line oI to oII, line oIII to oIV, line oV to oVI, ... line oIX to oX, line oXI to oXII, ... line oXXI to oXXII, due to the above repetitions. There would then be recorded in the sounding book when the soundings were taken "line o221 to o222," or "line o439 to o440," etc., the stations being numbered progressively as the numerals were repeated. When a mile or so of the river had been so stationed, a traverse was run (on magnetic azimuth) down the river and the following points located, with rodmen on both sides of the river:—all the sounding stations, the shore line, the shore—and river-ends of all dams, projecting sandbars, islands, creeks, rip-rap, or shore-protection. In taking frequent readings on 4 rodmen, 2 on each side of the river, the sounder acted as recorder. Intersection azimuths were taken on sounding stations, visible because of white-washing. The needle was read at every hub as a rough check. The only other check that could be employed on this traverse that did not close was the sighting at some distant object, and cut off between hubs. Following the location of these stations, points, etc., came the sounding. A large skiff containing two or three oarsmen, the sounder in the bow, the instrument man as recorder in the stern was rowed at a uniform rate across the river, being lined in on any sounding line by a flagman at one of its ends. Soundings were taken every 15 seconds, the depth noted as well as the nature of the bottom determined by the impact sound of the steel shoe at the end of the 16 foot sounding pole. For depths greater than 16 feet, occasionally encountered a 30 foot lead line was used. Unless the weather was exceedingly rough, about 1 mile of river was completely surveyed in a day. The work then consisted of putting out sounding stations, locating them, the dams, the water's edge, creeks, islands, etc., and sounding the river between stations. Besides this, a log of the day's work was kept, with the weather, temperature, and stage of water noted, the last being very important. The stage of the water is the height of the water above low water, so that it has a marked effect on the depth of water reduced to low water stage. It might also be stated that notes regarding the condition of dams, rip-rap, creeks, islands, bars, were taken, where they might possibly have some bearing on the need of early improvement.

During the winter, the field notes are plotted, a map is made showing the shore-line, sloughs, bars, dams, rip-rap, and soundings at a given stage. There can then be drawn lines similar to contours but with plane of the low water (of 1864) elevation as the datum. Or, it can be seen where the depth of the channel at its specified width is less than the required minimum. From this data then it can be decided where new dams must be built, old dams extended or repaired, new shore protection to be put in, old shore protection to be repaired, all with the view to forcing water into the proper place so as to scour out and maintain the proper navigable depth at low water stage. The entire river and its main tributaries has been mapped, placed on consecutively numbered sheets, "miled," all islands numbered, all dams numbered, and all shore protection numbered. These maps are very complete and in themselves constitute volume upon volume.

(To be continued.)

A BRIEF DISCUSSION OF THE FOURTH DIMENSION.

FRED R. ZIMMERMAN, '12.

One of the subjects which is constantly arising is that of "the fourth dimension," and for this reason a general summary of the principles involved in the term would not only be instructive but also of considerable interest to the majority of the readers of this magazine. Although there are several works upon the subject, yet they are either of too great a length or too technical in their scope to be of any practical assistance in explaining an expression which, if not understood, possesses for the average person some mysterious meaning, and indeed proves upon examination to be fully as curious a topic as one would expect. The writer wishes neither to discredit nor prove the statements contained in this article, but desires rather to present to the reader for his consideration the discussions of others along this line.

The reasons for the existence of the expression, "the fourth dimension" are so numerous that one is impressed not so much with its unusualness, but rather with the fact that some relation, which we must never allow to lead us into absurdities, connects the various ideas. One of the most common of these terms involving the fourth power of a dimension is the moment of inertia used in mechanics, but just as this is derived from the mathematical conception so we find the best analysis in the pure mathematics, where the subject, being speculative rather than practical, naturally belongs. Indeed the "fourth dimension" has rightly been called the play-ground of mathematics, and one of the great mathematicians of history was so misled by its possibilities as to explain the deceptions practiced by the tricksters of the time with the employment of its aid. We will see how these relations could so easily delude one as to become almost ludricous by proceeding to its explanation.

Everyone is familiar with the fact that two lines can be perpendicular to each other, and proceeding to the next higher order we are also aware that the same is true of three lines.

At this point, however, we must hesitate before saying that four lines can be mutually perpendicular, because our perceptions are limited entirely to the three dimensions of the physical universe. Still, if there were another direction which we will call the **w** direction, for convenience, although we are not able to understand it any more than we are able to visualize $\sqrt{-1}$ or even a negative quantity, could this relation not actually exist? That is, we know that if we have one dimension or a line along which to measure distance from an origin, a point is located on this line by the equation:

$$x = a,$$

In the same manner a line is located in a surface or two dimensional system of ordinates by the equation:

$$ax + by = c,$$

and a surface is located in a three dimensional or volume system of ordinates by the equation:

$$ax + by + cz = d.$$

However the equation:

$$ax + by + cz + dw = e,$$

expresses a relation or locus of points just as truly as the previous equations, and analogy at once suggests that although non-existent in the sense in which we understand it, yet analytically a hypothetical or *w* direction can be employed to take care of this case. Nor is it necessary, if dealing with the next higher power equations, to stop with the fourth dimension, but one may consider the fifth and so on to infinity; the difficulty being that the possibilities and relations increase at such a rate as to render it almost impossible save for the mathematical genius to be familiar with any but those of the ordinary three dimensional system. Another conception is embodied in the following analogies: in the case of two similar triangles, abc (Fig. 1), and a'b'c' although similar and equal, no movement of these triangles in the plane of the paper itself can cause them to be coincident. However, if abc is revolved about the line ab through a third dimension the two can be made entirely coincident, and in the same manner, if we can conceive of such an idea, in order to make the tetrahedron ABCD (Fig. 2), coincident with A'B'C'D', it has but to be revolved about the surface ABC, similarly as the triangle abc was revolved about the line ab. Thus it is apparent that although the right glove is similar to the left, yet in order to make it the same as the left it is only necessary to revolve it through a fourth dimension, or actually turning it inside out,

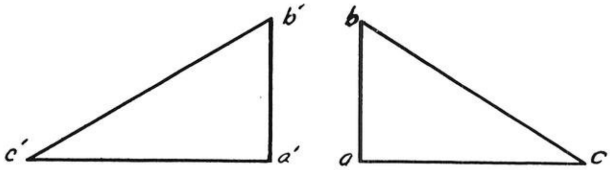


Fig. I

which has been variously explained as a method of revolving solids through the fourth dimension. Just how this revolving or developing takes place, however, is beyond the scope of this article, yet a glance at a few of the physical possibilities is very entertaining. Thus a person could tell exactly how he would look after having been revolved through the fourth dimension by glancing in the mirror. If, for example, a flat or two dimensional world peopled by two dimensional beings

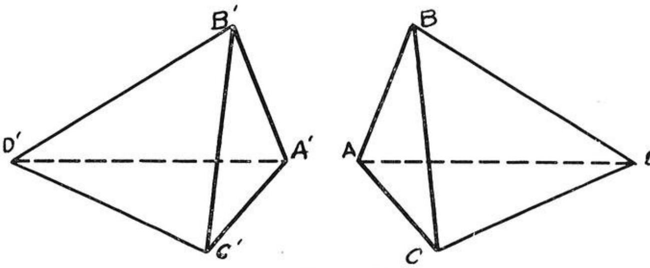


Fig. II

could exist, any movement in this world would be limited to two directions, and a three dimensional object would appear flat to a two dimensional being; while in a similar manner it is apparent that in a universe such as ours a four dimensional object would be visible or perceptible to us as a solid. In other words, the striking result is obtained that just as a surface is the projection of a three dimensional object, so a solid of our universe may be the projection of a four dimensional object, while in order to reconvert many similar objects such as the right hand to the left, we have but to revolve them through the fourth dimension. It is not to be wondered at that the juggler and spiritualist are able to give a pleasing explanation of their deceptions, such as passing a ball through the eye of a needle, by the use of the fourth dimension. In fact one investigator of the subject was so impressed with its possibilities as to even hint at the idea that birth might be the unfolding from a two dimensional existence and death a still further unfolding to a fourth dimensional existence.

In conclusion, however, the fourth dimension may be said to exist only in the analytical or mathematical conception, for so far as we are concerned all that we know is limited to the spatial or materialistic universe, and for this reason no one can either prove or disprove its existence. Nevertheless, this does not prevent our working with it and developing relations which might even lead to important discoveries, and we cannot, in trying to imagine its existence, help wondering whether, after all, the trouble is not really with ourselves.

OILS AND OIL TESTING.

CHARLES A. MANN.
Instructor in Chemical Engineering.

The word oil generally means to an engineer a substance which he can use as a lubricant or at most as a fuel. When we consider that Germany alone exports 314,000 kilos of essential oils valued at 5,179 million marks [1] and that the import of linseed oil into the United States in 1890 was valued at 14,000,000 dollars [2] to say nothing of other oils of this class, we must agree that lubricating and fuel oils make up only a small part of the oils to be considered by the engineer. It seems natural at first for an engineer to think of lubricating and fuel oils as being the only oils of importance; but there is little question that it is worth while to know something of other kinds of oils since in finding new methods of production and new uses for the oils there is a wide field for engineers.

Oils can be classified in various ways: according to their method of production, their constituents, their uses. The latter classification seems most satisfactory. Oils are therefore lubricating oils, fuel oils, edible oils, essential oils, and a few others which we may call miscellaneous oils. Lubricating oils are those used to overcome friction in bearing parts and are either simple or compound. Lard and petroleum oils are examples of the first kind and cylinder oils are examples of the second kind. Of the fuel oils there are the petroleum products, which are the only ones produced cheaply enough so that they can be considered as fuels. Among the edible oils are the olive oil, cotton-seed oil and cocoanut oil. The essential oils, some of which are cinnamon, anise, rose and mint, are used in confections and perfumes. Miscellaneous oils are those which do not rightly come under any of these heads; among these

[1] Schim. & Co. Semi-Ann. Report for Oct. 1911, p. 7.

[2] U. S. Census Report 1891.

oils are paint vehicles, drying oils and oils used in medicines, such as Dippel's oil.

Many methods are used for the production of oils, but they can be classified as follows: compression, extraction, distillation, maceration and enfleuration. Some oils which occur naturally, like turpentine and petroleum oils, do not need any special method of production, but only need to be purified. A large number of oils are obtained by compression by means of apparatus and machinery suited to the oil in question. Some lubricating oils, fuel oils and many edible and essential oils are produced in this way. When an oil is soluble in benzine, ether, or carbon di-sulphide, it is extracted by solution. These solvents are insoluble in water, do not harm the oils, and are easily evaporated leaving the oil almost pure. The extraction method is generally applied to edible and essential oils. By distillation of petroleum most of the fuel oils are obtained as well as the lubricating, essential, and a few edible oils. Since volatile, or essential, oils are easily broken up by heat, these oils are distilled with steam, which, in lowering the combined vapour pressures, lowers the temperature of distillation. Some oils are macerated with water when the broken plant cells give up their oil, which rises to the top and can be skimmed off. As inferred, this method is used for vegetable oils, which largely comprise the edible and essential oils. The enfleurage method belongs exclusively to the production of essential oils. In this method flower petals are strewn on lawyers of pure cold lard, which takes the odoriferous principal from the flowers, and this is then extracted from the lard by solvents which are easily evaporated.

In most of the above methods of production the apparatus and machinery used are still quite crude and inefficient. Here is a chance for an engineer of broad knowledge to improve this machinery and to overcome these various difficulties of production. Besides this, more uses in engineering lines for all oils ought to be found. In the Schimmel & Co., *Semi. Ann. Report* for October, 1911, p. 49, is a statement that the Barrier Mines of Australia use ten tons of essential oil of eucalyptus monthly for preparing sulphides of lead and zinc, a method which recovers ninety-five per cent of the gold and silver. The problem of lubrication of aeroplanes, which require a constant viscosity over a great range of temperature, needs some further investigation. Many other problems offer themselves, and if the engineer wishes to solve them he must know something about the testing of oils.

Each class of oils has its specific tests, but a few of these tests are common to a number of classes. The specific gravity of all oils is important because the specific gravity of an oil is constant within small limits. Any adulterant, such as inferior oil, is likely to change this property in one direction or another. This change can be determined by means of a pycnometer, hydrometer or a Westphal specific gravity bottle. Sometimes it is possible to keep the specific gravity of an oil unchanged even though it is adulterated, and in this case this test must be supplemented by some other more specific test. For lubricating oils one of these tests is the viscosity which is distinctive to this class of oils. Since the viscosity is a measure of the body of an oil it is of great importance. One way of determination is by the rate of flow of an oil through a standard orifice at a definite temperature. The standard apparatus used is the Tagliabue Viscosometer. Even this test is not conclusive, as an oil containing suspended particles has its viscosity decreased. Some lubricating compositions depend on this principle. The other tests common to lubricating and fuel oils are the flash, fire, evaporation, acidity, and chill tests, and sometimes a special friction test. Of greatest importance is the determination of heating value with fuel oils which is made in a Mähler bomb.

In the case of edible oils it is necessary to know the quantities and kinds of constitutents which are good for food and those substances which may be adulterants which are harmful to the human system. Let it suffice to say without going into the methods, that besides the common test of specific gravity, the tests made are viscosity, acidity, Koettstorfer value of a measure of the amounts of fatty acids, Reichert-Meissl value or the volatile fatty acids, the Polenske value or the amount of soluble acids, the Hehner value or the insoluble fatty acids, the iodine number or measure of unsaturated compounds, acetyl value or a measure of the hydroxyl groups and index of refraction with a special apparatus, the butyrometer.

Specifications for essential oils usually give the specific gravity, index of refraction, angle of rotation and saponification numbers. Special tests are then made for definite oder producing compounds like menthol, an alcohol in pepperment oils and citral, an aldehyde in lemon oil. Adulterants are then detected by comparison of these results with those obtained from a standard oil whose properties are generally quite constant. For miscellaneous oils very specialized tests are made, as the uses of these oils are very limited.

In order that the engineer may be more fitted to improve the machinery for the production of these oils it is first necessary to know the nature of substances with which he is dealing. If he is then acquainted with a few of the properties of the oils, their source and uses, he can better decide on the essential materials, and the shapes and forms of the apparatus and machinery required for their production. Besides this, the planning of the buildings for the economical production, transportation and storing of these materials offers many other opportunities for the engineer.

MINING AND METALLURGICAL LABORATORIES AT WISCONSIN.

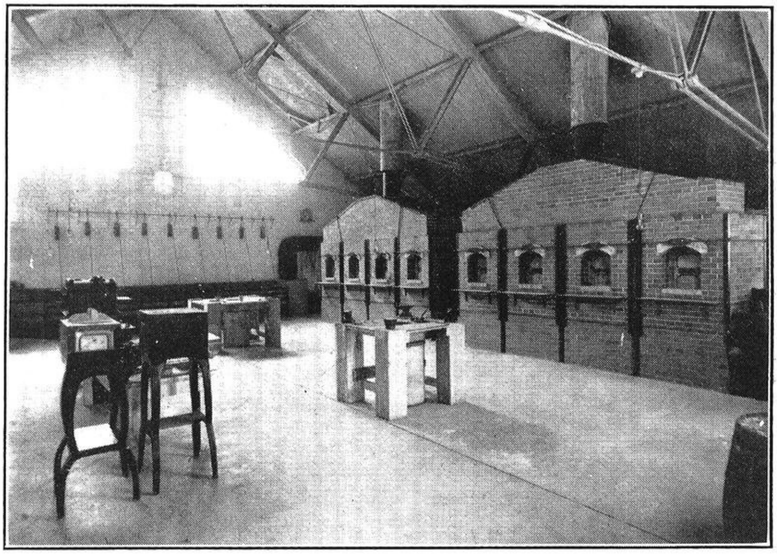
EDWIN C. HOLDEN.
Professor of Mining and Metallurgy.

The Department of Mining and Metallurgy at the University of Wisconsin was provided with a building of its own two years ago. The building was formerly the power plant of the University, and was therefore, in some essentials, a make-shift for laboratory purposes. It presented, however, certain advantages: it was practically fire-proof; it allowed of thirty-five feet of head room; by running a second concrete floor half through, it provided ten thousand square feet of floor space, and with it the department inherited a sixty-foot stack of generous flue area. About the base of this stack the assay and metallurgical furnaces naturally congregated, and there has been no resultant draft problem, except that of throttling.

The assay laboratory, which has been in commission over a year, using the western type of double-muffle tile furnaces and brick wind furnaces with coal fuel, is now being enlarged and equipped with a battery of gas and gasoline furnaces. The gas furnaces are run by city gas, with an air blast supplied by a Root blower. The gasoline furnaces are fed from reservoirs located for safety in an underground vault outside the building and below the furnace floor level. The feed pressure is obtained from an air compressor in the ore dressing laboratory and it is carried to a maximum of eighty pounds.

In the metallurgical equipment a special type or reverberatory furnace for smelting tests, a small high temperature kiln for clay testing, and accessory apparatus, pyrometers, etc., are being installed. When a crude oil burner and a producer plant are added to this equipment next year, all types of metallurgical fuels will be in use, the electric furnace being already widely used by the Chemical Engineering Department.

Most educational laboratories are now more or less standardized in their equipment and general arrangement. It is difficult to conceive, for instance, of a radical departure in the design of a chemical laboratory which would still be efficient. Assay laboratories also partake largely of this character, and there are only three or four general arrangements of assay laboratories conceivable which are at once convenient and workable;



Assay furnace room, University of Wisconsin.

but the laboratory methods of teaching such applied subjects as metallurgy and ore dressing vary so widely that if a tourist unfamiliar with these subjects should visit all of the mining schools in the United States, he would probably require at many of them to be told when he was in the mining laboratories, so slight is the resemblance between them.

In the metallurgical laboratories a few schools have full fledged blast smelting equipment, which is either not used at all, or is run at unjustifiable expense for a day or two each year in a vain attempt to reproduce the conditions of actual practice. Such instruction can well be left for inspection trips to smelting works. On the other hand, it is to be feared that many metallurgical graduates have been introduced to a pyrometer only on the blackboard.

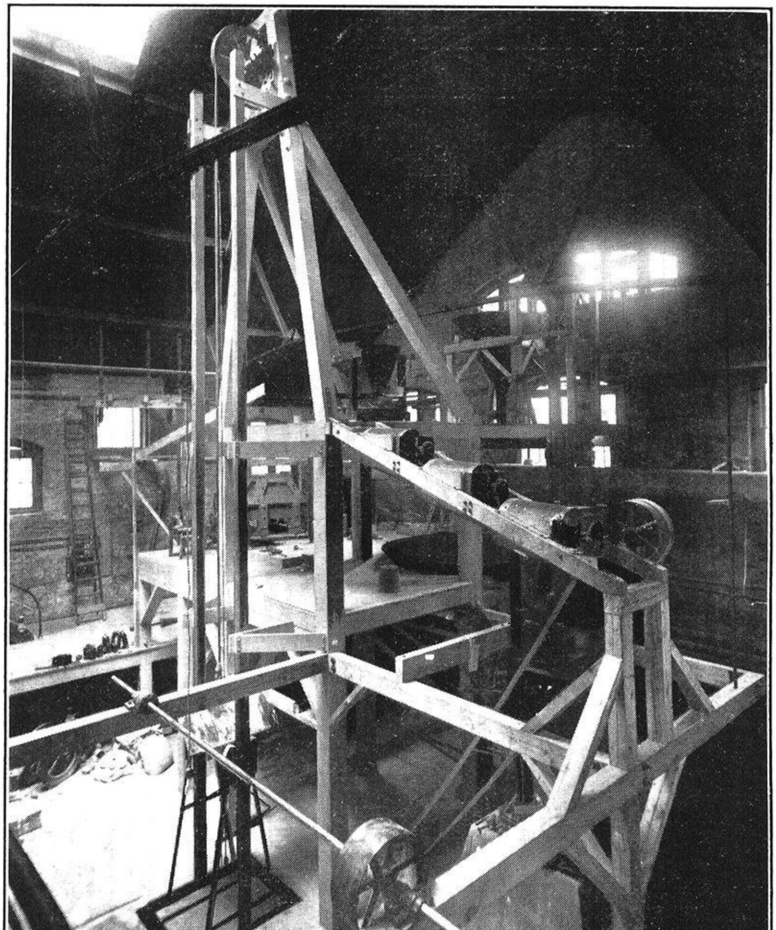
Ore dressing laboratories show possibly greater diversity. They vary from the spectacular "model mill" to a modest equipment of hand and laboratory machines, and it may safely be said that those approaching the latter type usually show more indication of active use and pedagogic value than the former.

We do not say all this as a preamble to introduce a perfect solution of the laboratory problem at Wisconsin, for a thoroughly commendable mining laboratory cannot be created; it must grow, and growth takes time.

As to our crushing equipment, ore, as received at the University, is rarely in lumps larger than six inches, and the crushing problem is simple. The coarsest crusher is a 7x10 inch jaw crusher of the Dodge type. The discharge from this crusher runs into an ore car and is either trammed to the storage bins or to a cage where it is elevated twenty-five feet to a Tullock feeder. By means of adjustable spouts this feeder can be made to deliver to a train of small trommels or to any of the jigs, classifiers, or other machines. The sized ore is returned to storage bins, or crushed further, as desired, in machines of laboratory size.

There is no novelty about the fine crushing equipment. Jaw and gyratory crushers, rolls, disc grinders, bucking boards, etc., are provided at present, and other types are to be added. The crushing and grinding machines, ore bins, sampling floor and hand screens are all located in one room, where it is intended to segregate all dust-producing operations. The machines receive their power from a line shaft driven by a motor in an adjoining room.

A two-stamp battery of 850 pounds stamps, with a suspended Challenge feeder, completes the present crushing equipment. The mortar is of the triple discharge type, but will usually be run with the side discharges closed. This design is a compromise between the five-stamp mill and the small laboratory types in order to get the tonnage within laboratory limits and yet use stamps of commercial size. It will be used for amalgamation



Ore dressing laboratory under construction, University of Wisconsin.

tests and for the production of pulp for cyanide treatment. The cyanide equipment has not yet been installed.

Physical principles may be demonstrated on a minute, a laboratory scale, and, while it is true that there are several excellent devices on the market for demonstrating certain ore dressing principles, this portion of the laboratory, to be complete, will require much home-made, or original apparatus. This section of our laboratory includes three Vezin jigs, three Munroe slime tables, nine glass tubular classifiers, a Jarvis jig, pans, sieves, etc. The home-made portion is not yet sufficiently advanced to justify description.

If the object of the laboratory is solely pedagogic, the equipment might well stop with the installation of these hand or very small power machines, but if it is to be of service directly to an adjacent mining community, or if it is to do ore testing or research work which can be literally applied, it must be very much more, and here is where the "model mill" temptation enters.

Ten to fifteen years ago a number of large silver-lead concentrators were built in the Northwest by designers who, in some cases, had never troubled themselves to look at a piece of the ore they were to treat. It was much easier to simply alter a stock set of plans to fit the topography and tonnage proposed in each case. This unfaltering confidence in the efficiency of their original design borders on the sublime, it is true, but today few ore dressing experts are willing to trust ore dressing theory *per se*, or the analogy of one camp to another so far as to design a large plant solely on that basis. Thus we find that all the important porphyry copper installations in recent years have been decided only after large tonnages have been treated on a commercial scale in experimental mills built for the purpose.

This conservatism has had much to justify it. The successful treatment of these low grade, finely disseminated copper sulphide ores may almost be said to have marked an epoch in the development of ore dressing practice, and it required caution. The test mill method not only gave reliable data on the concentrating efficiency, which can also be obtained in a well equipped laboratory, but it further determined such vital commercial factors as the relative power, maintenance and repair costs of different kinds of equipment, items which are beyond the province of laboratory experimentation. This limitation, however, does not seriously affect the practical usefulness of the laboratory, because it should not be necessary to determine these factors more than once for any given texture of ore, and data applicable to almost any conditions can now be found in technical literature, official reports and the experience of experts, to serve as a guide in making these cost estimates.

The other factor, concentrating efficiency, is almost invariably the most difficult and most important to determine.

It is unthinkable that the art of ore dressing should continue indefinitely so unscientific in application that whenever a thousand or a five thousand ton concentrating plant is to be designed, a test mill of at least one-tenth the size of the proposed plant must first be built and operated for a long period before the final specifications can be safely drawn. We have said that it should be within the province of a well equipped ore dressing laboratory to determine concentrating efficiency. In actual practice unavoidable imperfections in the construction and operation of most machines are such important factors in modifying theoretical, ideal conditions, that quantitative and even qualitative results can be accurately predicted only after making tests on machines which really duplicate practice. This requires the introduction of full-scale machines into the laboratory, and to this extent the "model mill" idea stands justified.

It is for these reasons that, despite the preciousness of floor space, the main ore dressing laboratory at Wisconsin contains a full-sized Johnston vanner, a No. 6 Wilfley table and a Hartz jig, together with a Richards pulsator jig and classifier and a Richards-Janney classifier of commercial size. The finished products from these machines are sampled, then re-combined, elevated by centrifugal pumps, dewatered in a series of three-, five-, and eight-foot Callow tanks, and returned for treatment, so that with a few hundred pounds of ore the operation of these large machines can be studied indefinitely. If it is desired to test an ore, rather than study the adjustments of the apparatus, these machines can each be run and sampled separately, or the classifier products can be run directly to the table or vanner or settling tanks for further treatment. This is as near as the laboratory comes to indulging in a flow sheet.

To handle the entire operation of course, fine and slime concentration in one continuous process, as is done in commercial plants, is not the function of a laboratory, and defeats both its educational and analytical objects.

The launders are of No. 16 galvanized iron of U cross-section, telescoped together and clamped in eight-foot lengths, with drop boxes where turns are necessary. They form a simple, flexible, water-tight system.

Power is supplied by the electric laboratories to two 9 and one 5 H. P. variable speed motors, and where special flexibility is desired countershafts with cone pulley drives are used. The ideal system, of course, would be individual motor machines, but this is a luxury that in many cases would double the cost of equipment.

Our mining and metallurgical laboratories are still incomplete, but a good start has been made, and we hope in the not very distant future they may not only prove effective educational equipment but be of direct benefit to the mineral industry of this and other states. The co-operation of our engineering alumni is invited to attain this result.

AN INVESTIGATION OF THE AIR LIFT PUMP.

A newly issued number of the University Bulletin is "An Investigation of the Air Lift Pump," by Professor G. J. Davis, Jr., and Mr. C. R. Weidner. Though the air life method of raising liquids has been known for over a century and is now quite extensively used, very little data has been available to the engineer in private practice. The experiments discussed in this bulletin present such data from tests on pumps of commercial size and of various types.

In the air lift pump, compressed air is admitted at the lower end of an eduction pipe submerged in the liquid to be pumped. The air thus introduced first forces out the column of fluid in the pipe. Subsequently the air enters the pipe in a series of bubbles which act as air pistons, lifting the liquid to the top of the pipe. Under the usual working conditions the air bubble does not entirely fill the cross-section of the pipe, causing a considerable loss due to the slip of the liquid past the bubble.

The air lift pump has a number of disadvantages, the principal ones being its low efficiency, the great depth of submergence required, and its poor adaptability to continuous requiring the discharge to be conveyed great horizontal distances. It possesses, however, many features which give it great advantages over other types of pumps. Its principal claim to superiority lies in its large capacity. When conditions are suitable for its installation, an air lift pump will discharge more liquid from a well of small bore than will any other type. Its low maintenance cost, due to simplicity, its adaptability to pumping dirty, sandy water, sewage, and corrosive liquids which would quickly ruin the delicate and expensive parts of a mechanical pump, its low operating cost, its adaptability to the pumping of liquids of high temperature, and its reliability are other considerable advantages.

The Wisconsin experiments consisted of 608 tests, comprising variations in percentage of submergence, lift, discharge, volume of air, and pressure of air in each of several sizes and types of pump, as well as in the tail piece, eduction pipe and other appurtenances. The conclusions have been summarized under twelve heads, the more important of which are:

The length of pump and the percentage of submergence remaining constant, a definite quantity of air causes the maximum discharge. This quantity of air for maximum discharge, as well as the ratio of volume of air to volume of water, differs for different percentages of submergence and lift, the length of the pump remaining constant.

The length of pump remaining constant, the maximum output occurs at about the same percentage of submergence for all rates of air consumption, or about 65 per cent for the pump used in the Wisconsin experiments.

The length and the percentage of submergence remaining constant, the efficiency increases as the rate of pumping decreases.

The lift remaining constant, the efficiency increases as the percent of submergence increases.

A diverging outlet which will conserve the kinetic energy of the velocity head increases the efficiency.

The Wisconsin Engineer.

EDITORIAL.

Before the next issue of the Wisconsin Engineer appears, it is probable that the Wisconsin Engineering Journal Association will have been incorporated under the laws of the State of Wisconsin. It will be a close corporation, not organized for profit; accordingly there will be no shares to market or distribute, and the student editors and managers will be remunerated from the profits in such a form that they will appear as paid employes of the corporation. The paper will remain the students' property; the responsibility of conducting it will be lessened only in so far as the advisory faculty committee may offer suggestions and tender advice from time to time. We appeal at this time to students to show their interest in this quite valuable asset both by contributions and by distribution of information of its character and purposes. The Alumni have proved ready to supply articles and material, the faculty is always willing to help, but it is to the students that we must look for expression of ideas, and perhaps in a lessor degree for technical material, if the magazine is to serve usefully the College of Engineering.

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In this issue we have attempted to present the students' point of view of various matters. Several students have responded to our informal request and contributed editorial matter which we gladly submit. We hope that we may receive for every issue just such suggestions as are presented below.

An article by Mr. Zimmerman, '12, presents most interesting ideas on the fourth dimension. The composition of such an article is the best possible practice for engineering students, and we cordially invite the presentation for publication of such articles.

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Nearly every student at one time or another during his college course honestly believes that he has so much work to do that he can accomplish better results by doing a smaller amount, more thoroughly. Especially is this true of the students in the engineering courses. Again the complaint is frequently heard that one is hampered from engaging in other student activities because of the quantity of work, and hence is missing many of the acknowledged valuable advantages of an education. The problem in both instances, however, resolves itself into the same old, matter-of-fact proposition of efficiency. Are the wastes excessive, and is the output for a given input of time reasonable? Ability, of course, depends to a certain extent on the individual, but the average person is apt to rate his capacity far too low, and like the steam engine is working at a very much decreased efficiency when operating below this limit. The greatest losses, however, are attributable to the direct wastes, and it is common experience that time is no exception to these effects. Therefore instead of finding fault with the courses, let the effort rather be made to see how efficiently time can be spent, and there is hardly any question but that if this is done time will be available to every one to profit by the numerous opportunities offered in other things.

EXAMINATIONS.

Examinations, the dragon which terrorizes the otherwise Utopian existence of college life, are not so long past as to be entirely forgotten. We still hear cries of favoritism, graft, unfairness, and disadvantage. Much of this we know to be untrue; we realize fully that the ill-prepared students have failed to survive the crucial ordeal. But whenever there is so much smoke we believe there must be some spark of fire.

It is not our purpose to criticize examinations or examiners. We believe that both are necessary. They act as a spur of encouragement to the easy-going student of undeveloped determination and as a check to the incapable student who might otherwise pass undetected and be fostered upon the engineering profession.

It is our purpose to criticize the amount of stress laid upon examinations. But we do believe that there exists a peculiar difference in the mental equipment of students which gives to the one a good memory for the theoretical and to another a good reasoning power, but a poor memory. We know that it takes longer to reason than to repeat. We believe that the reasoning student will be just as valuable to the profession as the man who has the linguistic powers of a parrot. For this reason we advocate that ample time be given, in every examination, to *reason;* that the work of a five-fifths course and a two-fifths course should not each be crowded into a two-hour examination.

While not attempting to formulate any theories of pedagogy, we believe that a weight of one-third is sufficient to give an examination. Surely the class work and daily exercises, if properly studied and analyzed by the instructor, should be a criterion worth sixty-seven per cent in the estimate of a student's ability. These principles are not new. They have been tried and used in many places and courses and found perfect. They are not used in all of our courses here. Is it lack of interest, carelessness or incapability that results in many of the "general guesses" that are made at a man's ability?

DEPARTMENT NOTES.

DEPARTMENT OF TOPOGRAPHIC ENGINEERING.

The Topographic Department report the placing of an order for a new eight-inch repeating theodolite with Bausch Lomb Company. The instrument has specially designed level vials and a six-inch vertical circle read by double opposite verniers to twenty seconds. The horizontal circles are read directly to ten seconds and by estimation to five seconds. This instrument will be ready for delivery April first, in time for the astronomical and geodetic field work of Course T. E. 5.

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The City Planning course offered as an elective the second semester by Professor Smith has been changed from a two credit to a three credit course. The course as so arranged will require two meetings of the class each week and three hours spent in the library.

The subjects to be discussed are, the organization of a City Engineer's office, the City Engineer—his status and legal duties, the planning of a city, surveying and mapping a city, the law and usage governing city surveys.

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LECTURES.

Mr. C. E. Pickard, '75, of the patent law firm of Bond, Adams, Pickard & Jackson of Chicago, as announced in our last issue, lectured to engineering students in the engineering auditorium on Jan. 5th on the subject of "Patents." From the non-technical way in which it was presented the lecture proved exceedingly interesting as well as instructive.

* * *

Prof. Charles Francis Harding, Professor of Electrical Engineering at Purdue University, gave a most interesting lecture on "The Electrification of Trunk Lines" in the auditorium of the Engineering building on Monday, Jan. 15th.

After pointing out the shortcomings of steam operation, from the financial as well as the operating standpoint, he specified the advantages that would be gained by electrification, justifying his arguments by facts and figures from electric installations that have stood the test of practice, notably that of the N. Y., N. H. & H. R. R. out of New York City.

As Prof. Harding is an authority in this line, we cannot overlook his opinion that, within certain limitations, electrification is the best solution of the traction and operating problems confronting our transportation companies today.

* * *

Three lectures are scheduled for the month of February. H. P. Howland, '03, Superintendent of Blast Furnaces, Wisconsin Steel Co., South Chicago, will give an illustrated lecture on Blast Furnace Practice.

Mr. E. R. Townsend, consulting engineer for the Western Union of Fire Underwriters, will present the following topics:

1. Fire Protection Engineering.
2. A Technical Discussion of the Fire Underwriters Electrical Requirements.

ALUMNI NOTES.

Last year's graduates in mechanical engineering, while located for the greater part in the neighborhood of their home state, are well distributed as regards their particular line of work. Thus we find

H. A. Christie and R. C. Phipps are with the Raymond Concrete Pile Co., manufacturers of an extensively used patented reinforced concrete pile, Chicago, Ill.

H. W. Edmund is located at Aurora, Ill., with the United Gas & Electric Co.

L. L. Hebberd is with the Illinois Steel Co. at their plant at South Chicago, Ill.

R. Holverschied is with the Barker Coal Co., at Hinsdale, Ill.

R. S. Hoyt is located at Monroe, Wis., with the Invincible Electric Bank Protector Co.

K. L. Kraatz is with the Wausau Foundry & Machine Shop at Wausau, Wis.

J. S. Langwill is located at Rockford, Ill., with the Rockford Tool Works.

A. McArthur is located at Superior, Wis., with Whitney Bros.

J. D. McLean is a member of the Government force at the Forest Products Laboratory, Madison, Wis.

B. H. Muller is in the testing department of the Milwaukee Electric Railway & Light Co.

W. H. Pugh is with the W. H. Pugh Coal Co. at Racine, Wis.

A. C. Sladkey is superintendent for the National Enameling Works at Milwaukee.

G. E. Steudel is with the A. O. Smith Co., at Milwaukee, Wis.

N. C. Sweet has found employment with the large excavating machinery concern, the Bucyrus Co., at South Milwaukee, Wis.

R. D. Watson is employed in an engineering capacity with the Webster Mfg. Co., at Tifflin, O.

A. A. Wegner has affiliated himself with the Chain Belt Co., manufacturers of conveying machinery, at Milwaukee, Wis.

The 1911 graduates in mining engineering seem to have been uniformly successful in finding affiliations with concerns in their chosen line of work.

We note that L. G. Bonesteel and H. E. Schmidt are in the Minnesota iron district, the former with the Great Northern Iron Ore Properties at Bovey, and the latter as assistant engineer with the Oliver Iron Mining Co. at Hibbing.

From Wallace, Idaho, we hear that C. A. Fay is assistant engineer with the Federal Lead Co.

A. F. Robinson we find at Livingston, Mont. engaged as a mining engineer.

D. M. Grant is at Crystal Falls, Mich., with E. J. Longyear Co.

W. G. Pearsall, editor of the WISCONSIN ENGINEER during the year 1911, is a graduate student in the department of geology.

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Mr. Earl C. Bracken, '09, was married Dec. 31, 1911, to Miss Edna Hillstrom of Chicago. Mr. Bracken is with the Publicity Department of the Universal Portland Cement Co. Mr. and Mrs. Bracken will reside at 139 Vernon Ave., Chicago.

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A number of our Alumni are rendering a service to the engineering profession through their work in technical journalism. They are:

F. E. Schmitt, '00, C. E. '04, Associate Editor "Engineering News," New York City.

H. W. Young, '02, Editor "Popular Electricity," 100 Lake Street, Chicago, Ill.

Edward Wray, '05, E. E. '06, President Wray Publishing Co., 106 N. La Salle Street, Chicago, Ill.

E. T. Howson, '06, Civil Engineering Editor "Railway Age Gazette," 417 S. Dearborn Street, Chicago, Ill.

R. J. Hordacker, '06, Technical Copy Writer, Western Electric Co., 463 West Street, New York City.

O. W. Middleton, '07, Associate Editor "Railway Master

Mechanic,'' The Railway List Co., 431 S. Dearborn Street, Chicago, Ill.

J. D. Sargent, '07, in the Editorial Department ''St. Paul Despatch,'' St. Paul, Minn.

C. H. Kypke, '09, Field Manager for the Roach-Fowler Publishing Co., Kansas City, Mo.

Kennth L. Van Auken, '09, Associate Editor ''Railway Engineering and Maintenance of Waw,'' The Railway List Co., 431 S. Dearborn Street, Chicago, Ill.

Ralph Birchard, '10, Manager ''Railway Electrical Engineer,'' 106 N. La Salle Street, Chicago, Ill.

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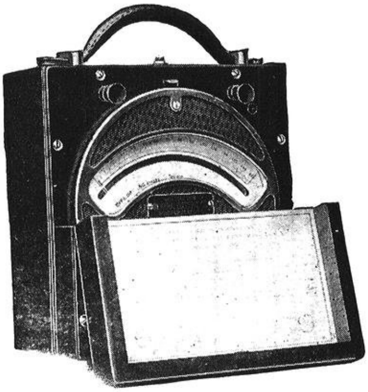

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