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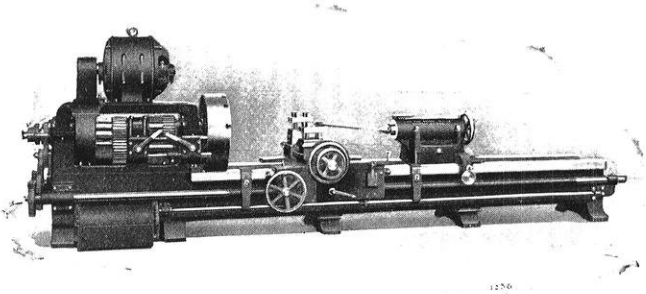

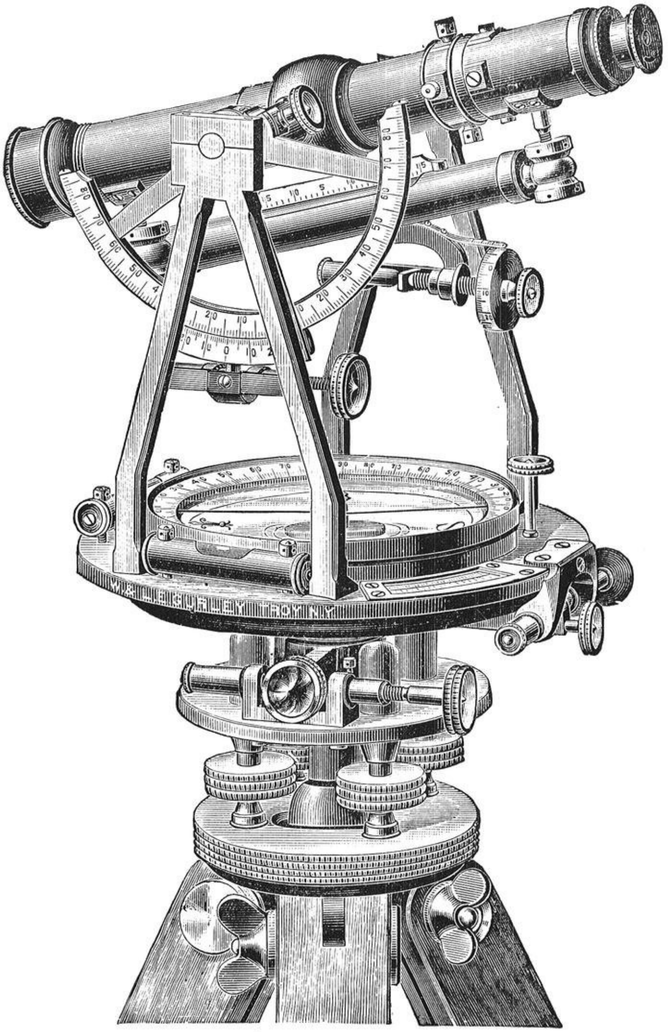
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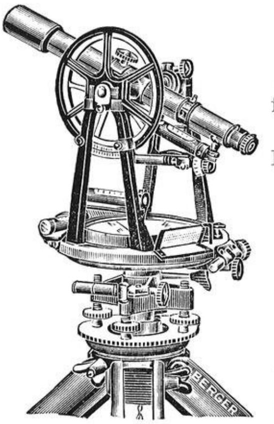
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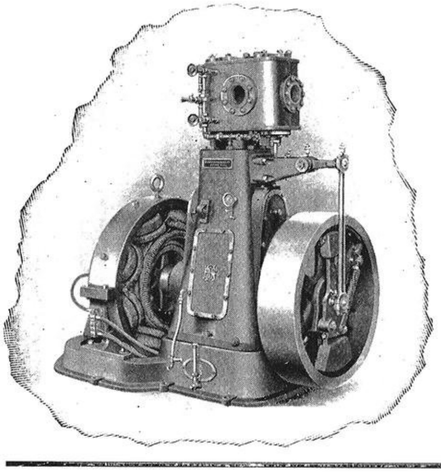

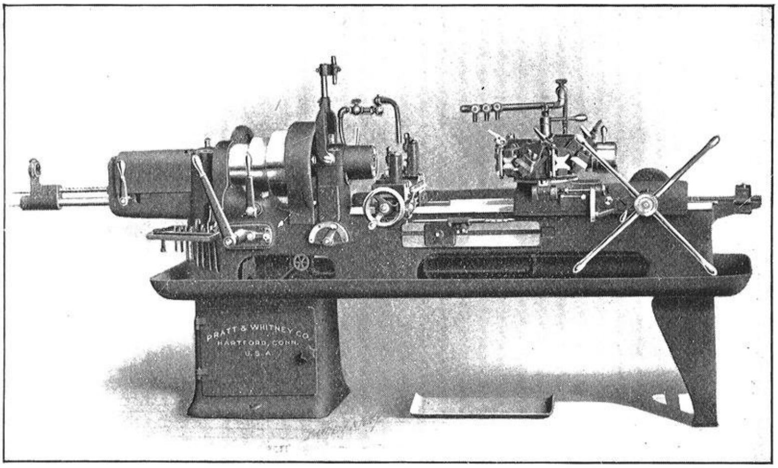
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THE WISCONSIN ENGINEER

VOL. 10 JUNE, 1906 NO. 4

SOME INTERESTING FEATURES IN THE DESIGN OF A 3,000 KILOWATT SUB-STATION.

S. J. LISBERGER, '03.*

It is the object of this article to present some of the interesting features of a new sub-station recently designed by the writer.

The sources of supply are two-fold; that is one source of power is from the 60,000 volt transmission systems of the Bay Counties Power Company and the Standard Electric Co., of California, and the other source is from an auxiliary steam station, feeding the sub-station in question over a double line at a potential of 4,000 volts.

The location of this sub-station, known as Lemescal or sub-station No. 2 of the Oakland Division, is in the northwest corner of the city of Oakland.

From a natural standpoint the location is ideal. To the east lay the hills of Berkeley; to the south and west the great bay of San Francisco stretches as far as the eye can see, while on the distant northern shore the peak of Tamalpias rises 3,000 feet above the level of the bay.

The district supplied is most important. Direct current at 550 volts is supplied to the Oakland Traction Co., while power and general lighting is supplied at 4,000 volts, alternating and redistributed on the secondary network at 220 and 110 volts. Besides this over 400 street arcs are supplied from this station.

The Bay Counties Power Co.'s double transmission line approaches from the north, while a double line connects with a

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* Of the California Gas & Electric Co., Oakland, Cal.

station several miles south, fed from the Standard System. The two 4,000 volt lines from the reserve steam station give additional security against shut downs.

The high tension lines enter the switch house from two sides. This house is 100 feet away from the sub-station proper, and is supported on a steel framing. The floor is 30 feet above grade line, and the house itself is 25 x 34 feet over all with a height of 20 feet from the floor. (See Fig. 1)

Fig. 1.

Triple pole double break open air switches are provided before the lines enter the tower. These switches are mounted on a simple frame on top of three poles. All parts are clamped to regular line high tension insulators. The double break is accomplished by means of a swinging blade, pivoted at the center. The mechanism is arranged so as to operate the three legs simultaneously. Simple cranks and levers with the operating handle near ground level provide a means of operation.

The lines enter the tower through double glass ports with large holes in the centers. Long overhanging eaves afford a protection against beating rain.

There are in all six switching compartments in the tower.

The construction of the compartments is fire proof, the floor being of reenforced concrete, the side walls and top of hollow tile. Each switching compartment is 9 x 6 x 9 feet high.

A bus bar compartment runs the entire length of the switching compartments. The arrangement of compartments is shown in Fig. 2.

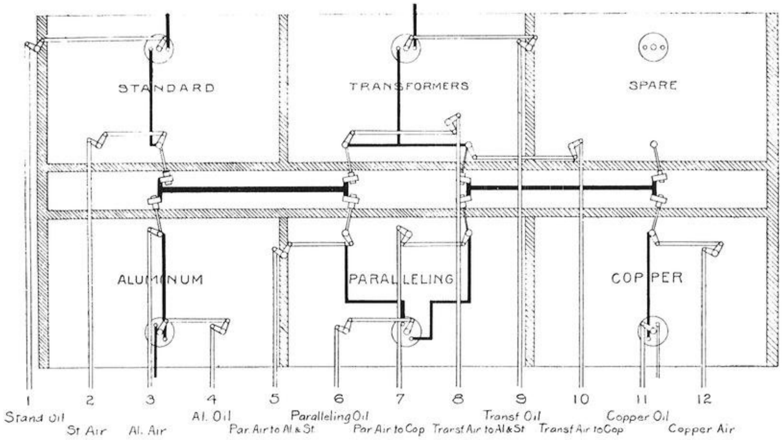

Fig. 2. *

A compartment is provided for each incoming and each outgoing line, for the station transformers, and a compartment for paralleling or transferring one line to the other.

The line entering the compartment through the top first passes through an oil switch consisting of three elements. Each element controls a leg of the line. The switch proper is of tube form. The wires enter through large corrugated porcelain bushings.

The break is made under oil. The three elements are interconnected so that they act as a unit when operated.

Besides the oil switch there is an air switch used under load only in emergency cases, but used otherwise to protect men while working on the oil switch.

This air switch is likewise composed of three elements, which act together.

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* The Lemescal Arrangement is a duplicate of this except Standard and Spare are replaced by Aluminum Out and Copper Out.

The center compartments differ from the others in that each contains two sets of air switches, and one oil switch. This arrangement assists in flexibility of operation and switching.

It is thus possible to work *Copper in*—back through *Aluminum in*—or *Aluminum in* through and out on *Copper Out*, while station transformers can be from either circuit.

Perhaps the most interesting feature of the high tension system is the method of operation of the switches in the tower.

These are manually operated from the sub-station floor.

The longest mechanism operates 207 feet, and the shortest 193 feet. No difficulty is experienced in operating.

Fourteen lever handles control all switches—the controlling arrangement being very similar to the mechanism used for the operation of railroad switches from a tower.

In front of the handles is a working model of the compartment switching system in the tower.

Each switch is represented by a small brass arm which moves in unison with the switch itself.

Before the operating handle can be moved, a trip must be released, this trip mechanism being mounted on the main handle; the act of releasing this trip lights a small pilot light mounted on a small miniature switch. The lamp now stays lit during the actual movement of switching, and when the trip drops into the closed position, the light goes out. The miniature switch then shows by position what has been done. The model moreover shows the operator just what switch he is going to throw, and greatly lessens thereby the liability of making mistakes.

The air and oil compartment switches are provided with a safety interlocking device whereby the attendant must close the air switch before he can close the oil switch, and likewise open the oil switch before the air switch. In emergency, however, should it be necessary to reverse the order of operation, due to failure of one switch to perform its function, the interlocking device can be released and the switches operated irrespective of one another's open or closed position.

The sub-station proper consists of a tranformer room and a generator room.

The level of both floors is enough above grade here to provide a basement for all wiring, etc.

The finish is of brick. Concrete steel floors are provided throughout.

The roof of the transformer house is of steel covered with corrugated iron; that of the generator room of woo d trusses with a corrugated iron covering.

Large windows provide ample light and ventilation.

The transformer room is in direct line with the switch tower, so that wires leaving the end of the tower enter the end of the transformer room.

The floor of the transformer room is six feet above ground (or grade) level. The steel concrete floor is designed for a uniform load of 900 pounds per square foot.

The high tension transformers are 1,000 k. w. each. They are oil water cooled, each transformer being piped so as to give independent regulation of cooling water. Temperature gauges are placed on each transformer. These thermometers have an alarm attachment which can be set to ring at any predetermined temperature.

There are four transformers in all. Three are regularly connected in service, the fourth being on hand and in place in case of any accident to one of the others.

This transformer has a high tension tap that can be connected to any leg of the high tension bus, while the secondary lead is provided with three selector switches by which it can be connected in any secondary leg.

In case of accident to one of the regular transformers, service would be interrupted only long enough to make the high tension tap and close the proper secondary switch. This would not take over five minutes the way things are arranged. A regulator head is provided for each transformer; the function of the regulator head being to assist in regulating the line voltage at times of the peak loads.

All piping and wiring lead directly into the basement which was provided especially for that purpose.

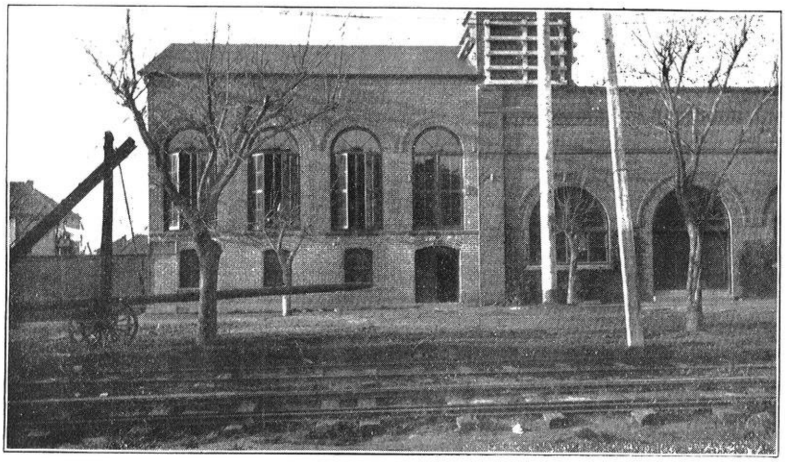


Fig. 3. Front of the Station.

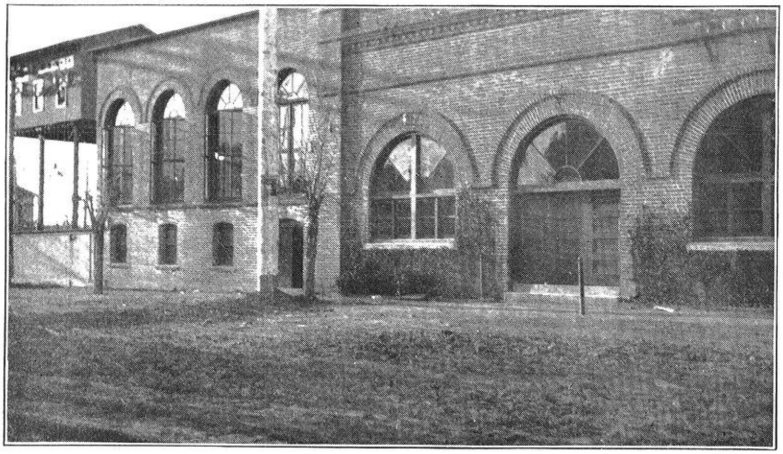


Fig 4. Fron View Showing H.T. Tower.

Since the generator or operating room adjoins the transformer room, the toilet is located in one corner of the transformer room, as well as a wash basin.

The attendant has no cause to leave the operating floor of the station.

The doorway between the transformer and generator room is protected with an automatic closing, fire-proof roller door. This insures the isolation of a fire should one occur.

The generator floor is 8 feet higher than the transformer room floor, this being so designed in case oil should leak in any quantity from the transformers, the generator floor would not be harmed thereby.

In the generator room are located the motor generators, switchboards, etc.

There are two 450 kilowatt motor generators of General Electric design. The motor is of synchronous type—having a revolving field excited at 110 volts direct current—the armature being wound for 2,300 volts delta or 4,000 volts star at 60 cycles. The speed is 400 R. P. M.

The generator end is wound for 575 volts direct current. These machines are provided with automatic end play and runaway release devices, as well as low voltage release.

They are guaranteed for 50 per cent. overload for two hours without undue heating. These machines supply power for the street railway system only.

The machines are started from the direct current end, the battery supplying starting current. Four point knife edge starting switches are used in conjunction with iron grid resistances.

An interesting feature is the speed control arrangement used in synchronizing.

The direct current end of the motor generator is run as a motor. To vary the speed of the unit the field strength must be changed. With the rheostat handle on the direct current panel, and the direct current panels some feet away from the alternating current motor panels, it is difficult for the attendant to get from the direct current panel to the alternating current panel to close the alternating current circuit when synchronous speed is reached, as the varying load of a railway system changes the speed of the machine enough to lose synchronous speed.

The use of a chain drive from one panel to the other was considered, but not thought favorable, as the length of drive was too great not to complicate matters.

A concentric handle rheostat equipment mounted on the alternating current panel was decided upon.

The outer handle controls the field of the alternating current motor. The inner handle controls a small rheostat in series with the main rheostat of direct current field.

Thus in starting the attendant closes the switches on the direct current panel, regulates the speed to *about* what is required, then goes to the alternating current panel, and there does the final adjusting, closing the switch when the synchronizer indicates synchronous speed.

This enables quick synchronizing with very simple apparatus.

Of course, when adjusting the load of each machine when running normally, the main rheostat of the direct current panel is used.

In connection with the railway supply there is a storage battery of the Electric Storage Battery Company's Type G 41, having 276 cells.

The maximum rate of discharge is 1,600 amperes at the hour rate.

A most interesting feature of the battery equipment is the new carbon pile regulator, a late development of the Battery Co. The equipment, while apparently complex is very simple.

Instead of using the old differential battery booster, a new use of the booster is brought into play.

The summation of the matter is that the load of the machines is adjusted for a certain amount, and by an automatic device the machines are made to deliver this predetermined amount, while the battery takes care of all fluctuations. The battery thus takes care of the peaks, discharges an overload and otherwise charges when the machines are underloaded.

In case the predetermined amount the machines are delivering is desired to be changed, a small hand wheel is turned and the desired change can immediately be noticed by watching the machine ammeters.

The apparatus consists of a booster exciter in conjunction with a battery booster. The carbon regulator is made up of a number of carbon discs which form a variable resistance. This resistance is used in connection with pilot cells to vary the exciting current supplied by the small exciter to excite the fields of the booster.

Referring to the accompanying diagram, the lever "L" is supported at the fulcrum and carries on one end an iron plunger which is suspended in a coil, carrying the current of the combined generators; a spring is attached to the other end.

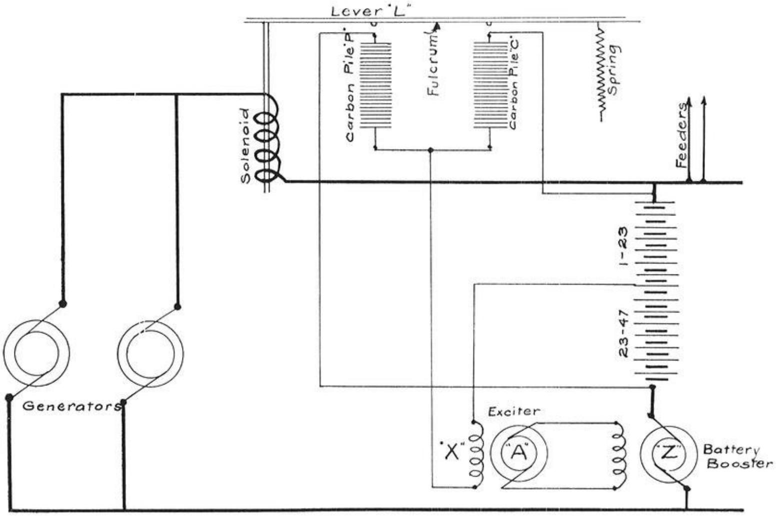


Fig 5.

The carbon regulator itself is represented by the vertical lines P and C.

Since the piles are made up of carbon discs, a slight mechanical pressure will serve to vary the resistance. X is the field of the booster exciter A; Z the battery booster and its field coils; 1–23 represents one set of pilot cells, usually about 23 in number, while 23–47 represents a second set.

The lever is adjusted by means of the spring for a certain output at the generators. As the plunger is moved up or down, due to a variation of the generator output, the resistance in one set of piles is decreased, and increased in the other.

This causes a change in voltage across the exciter field coils, and even causes the direction and intensity of the current in the coils to vary likewise.

It can thus be seen that with the field of the booster exciter, and in turn the field of the booster itself, varying in intensity, and the polarity of the booster changing, it is possible, by means of this regulator, to make the battery carry part of the load, or charge, by automatic methods.

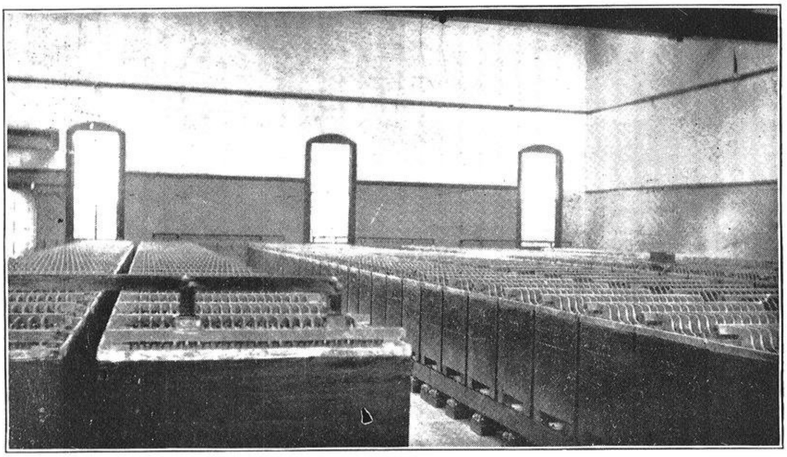


Fig 6. Storage Battery Room.

The effect of this regulation is self-evident.

The switchboard marble is Blue Vermont. Each panel consists of a sub-base 28 inches high and a main panel 62 inches high.

A totaling panel, two motor-generator alternating current and three alternating current lighting and power panels complete the alternating current end; the direct current end comprises an exciter panel, two direct current generator panels, a four-piece battery panel and eight railway feeder panels. (See Fig. 6.)

The alternating current panels are provided with General Electric Type F, Form K-2 and K-3, 4,000 volt oil switches, all of which are double throw except those on the total panel. Each panel, of course, is provided with its full quota of necessary instruments.

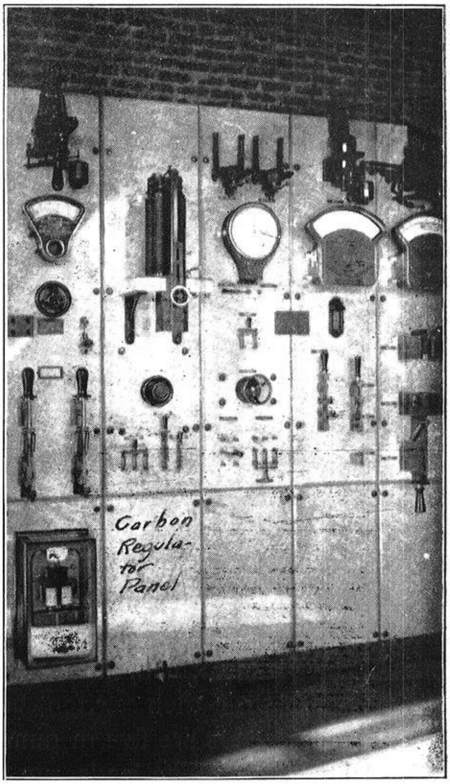


Fig 7. D.C. General Electric Battery Panels.

All oil switches, bus bars, instrument transformers, etc., are located in the basement, the oil switch handles being at the board—mechanisms controlling the operation of the switches. There are two complete bus systems.

No high tension is brought to the board. All oil switches are equipped with triple pole time limit overload relays of the late bellows type. These relays are operated by current transformers, but trip the switches by means of direct current.

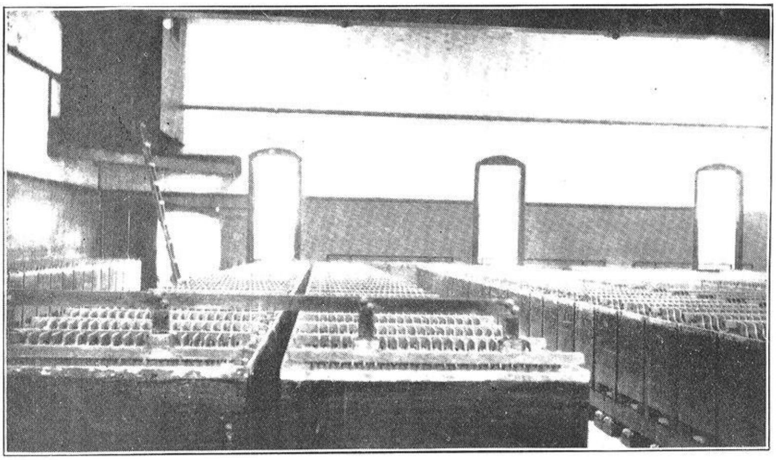


Fig. 8. Storage Battery Room.

All wiring is done in the basement.

The three phase circuits are run in three conductor varnished cambric cable covered with a layer of asbestos. This cable is guaranteed for a working potential of 5,000 volts.

The constant current transformers for arc lighting are located in the basement, with their switch boards on the main floor. These transformers are five in number and have a capacity of 100 lights each. The leads run under ground to the wire tower. This cable is insulated for 8,000 volts working pressure. A brick tower provides an outlet for all low tension (that is below 10,000 volts) outgoing leads.

WHAT RAILROADS MAY DO FOR CHINA.

ELIOT BLACKWELDER, INSTRUCTOR IN GEOLOGY.

We sometimes forget, in the midst of this age of machinery and railroads, that we are only one or two centuries removed from the day of primitive hand labor, of the cumbersome wagon and sailing vessel. If we look back to the seventeenth century we find our ancestors making use of methods of transportation, manufacture and agriculture which differ only in a minor way from those now used in China. The isolation of the Chinese has prevented them from joining in the great industrial revolution which is going on in western lands. Previous to this sudden development, ten or fifteen centuries had brought very little advancement in the mechanic arts in Europe. China was then undergoing a similar slow development, and has continued somewhat longer along the same path before reaching its point of expression in the present decade.

Omitting the innovations of the last few years, the Chinese employ the same methods of transportation and manufacture that were used by many previous generations. All are primitive, according to our western ideas, and all are very slow and tedious. Machinery of any kind is almost unknown and the little which they have is laughable to us in its crudity. But, if the signs of the times do not decieve us, these primitive ways are soon to be superseded by modern methods of greater rapidity and efficiency. It may require many decades, yet the change promises to be rapid as compared with the long lapse of centuries which preceded it. In view of this expectation of the awakening of China, it may be interesting to consider in some detail the conditions which the new order of things is to supplant.

In a country as large as China there is of course great diversity of climate and topography, and consequently there are many differences in the means of transportation employed in this province and in that. The densely populated plains, of which we hear so much, that we come to think of them as including most of the empire, comprise only one-twentieth of the land. A much larger part, lying principally in southeastern China, is hilly but is capable of supporting a large population in its broad valleys. The northern and western provinces, however, are largely mountainous, and only a scanty number of people live in the deep rocky valleys. Obviously the modes of travel in these various regions differ greatly according to the conditions.

Among the mountains, pack-animals and men afford almost the only means of transportation. Carts are available locally in the broader valleys, but they cannot cross the rugged passes from one valley to another, and hence the commerce of such regions is largely dependent upon pack-carriers. The two northwestern provinces, Shen-si and Kan-su, are thus situated. All goods which they import from the rich Yang-tzi valley to the southeast are carried across the Tsin-ling mountains on the backs of pack-animals or coolies. Passengers must travel in a similar way. Many ride ponies, while the few who can afford such luxury are transported in "chairs" or palanquins, which are carried by coolies. Traveling by chair represents the acme of comfort according to the Chinese idea, and is possible only to the official class and the wealthier merchants. There are, of course, no sleeping cars on such a route. The traveler spends the night in a wayside inn or village, after making a day's march of only twenty or thirty miles. The occidental reader will appreciate readily enough the advantges to be gained by the introduction of railroads into such a country, but, strange to say, the Chinese are not so easily convinced. They are rarely in a hurry, and the discomforts of their own method do not appear as such to them.

One of the richest provinces in the whole empire, Sze-chuan, is completely isolated from the outer world by belts of rugged mountains. Within these barriers is a fertile lowland from which an intelligent population produces some of China's most valued articles of commerce, such as silk, wax, laquer, and grain. For the export of this produce there is now only one avenue of any importance, the Yang-tze river. River navigation is usually an easy matter, and in China it has been brought to great efficiency; but here the difficulties which beset the traffic are enormous. After leaving the garden of Sze-chuan, the great river passes through a series of gorges of unsurpassed grandeur. Instead of a smooth avenue of commerce it becomes a powerful and dangerous flood, full of whirlpools and rapids. On both sides it is shut in by cliffs hundreds of feet in height. In spite of the dangers and difficulties, however, the Yang-tze carries every year an enormous burden of commerce between eastern and western China. Junks of all sizes are laboriously dragged up the stream by thousands of coolies tugging at bamboo ropes. The journey requires several months, and, of course, the freight charges rise so high that only valuable materials can be transported. Think what a service would be rendered by a railroad from Hankow, often called "the Chicago of China," to this rich western province! It would be an expensive undertaking, and would require a high order of engineering skill to build it, but it would pay handsomely. The thirty millions of industrious people of Sze-chuan would create a traffic of stupendous proportions.

These methods of transportation—on the backs of men or beasts of burden, or by boats laboriously tracked up the rivers—are the only ones now available in the mountainous provinces of western and much of northern China. In the lowlands of the east, conditions are more favorable, although the means used are quite as crude.

The wonderful system of canals which forms a network of routes for traffic in the plains of eastern China has been described by many writers. It affords a cheap and safe, even if not a rapid, means of travel throughout the length and breadth of the eastern lowlands. The horde of junks, large and small, which ply their waters, carry millions of tons, both

Freight by wheelbarrow over the great plain of East China.
Carrying coal from the mines of Shan-si.

Grain by pack train over the imperial highway to Peking.
How salt is carried from the mines in West China.

of native and foreign goods, each year. Nor is there any easier or more comfortable mode of travel to be found in China than by boat through these interior canals. It lacks nothing but the speed which the westerner demands from carriers in his own country.

On land two vehicles are most in use for both freight and passenger traffic—the cart and the wheelbarrow. The carts are small cumbersome affairs, very heavy in proportion to the loads they carry. This heavy construction has probably been adopted because the roads are so bad that a lighter cart would be shaken to pieces. In western countries local or general governments build and maintain the principal roads, but in China this is not the practice. Until very recently there has been no spark of public spirit among the natives—no appreciation of the fact that what benefits the public as a whole adds to the advantage of the individual. The idea of doing anything for the common good is utterly foreign to Chinese thinking. Thus it happens that instead of improving roads so that large vehicles may be used and drawn at a fair speed, both the vehicles and the speed are adjusted to the inexorable demands of roads which are usually as bad as they could possibly be.

The great popularity of the wheelbarrow in China is probably due to the fact that a vehicle with one wheel can more easily take advantage of the best parts of the road than one with two; furthermore, it requires no draft animals. The freight-barrow used by the Chinese has a capacity of 600–800 lbs, and, like the cart, is a very stout, heavy machine. It is made of wood throughout. There is no more characteristic noise in China than the incessant squeak which arises from the ungreased axles of the wheelbarrows in town and country. The barrow is not always a one-man vehicle; often a donkey or a mule is hitched to the front of it, after the manner of a plow; and when the wind is favorable the thrifty coolie not infrequently rigs a sail to aid him in his weary struggle with a load which always seems much too big for him. The wheelbarrow as a convenient carrier for small loads about farms and villages is familiar enough in western lands, but in China it is one of the most important means of transporting through freight, and even passengers. It is not uncommon to see a merchant, returning home from a distant city, riding on one side of a wheelbarrow, while his new stock of goods is packed on the other. There are coal mines in Shan-tung whose entire output goes by wheelbarrow to cities and towns 50–100 miles away. In the case of coal the sale is limited to a small radius by the rapid increase of the freight charges. More valuable commodities are often carried much farther.

At no very distant day, when railroads have been extended widely through the empire, we may expect the most profound changes in the present mode of living among the Chinese. The railroad will not drive out entirely the cart and the barrow, the donkey and the coolie-porter. It will merely supersede them in long distance hauling. Large benefits to the people will unquestionably accompany this change, and some of these may be pointed out in advance.

It is obvious that the cost of all imported articles in the interior and of exported articles at the coast will be greatly reduced by railway transportation. A more important change is that which will affect low grade commodities such as coal, building stone and grain, which can not now be carried any great distance from their sources on account of the excessive expense of coolie and cart traffic. One of the wonders of American civilization lies in our ability to buy in almost any city the products proper to almost any other part of the country. Here in Wisconsin we burn coal from Pennsylvania, build our public edifices of limestone from Indiana or marble from Tennessee, and buy at moderate cost the bananas of Cuba or the oranges of California.

Such things are not yet possible in China. The coal from Shan-si, carried on donkeys or coolies, is doubled in price every fifteen or twenty miles, and so can have only a local market. For this reason one sees the peasants of the great Yellow river plain burning corn-stalks for fuel in their cooking stoves and making no pretense of heating their houses during winter. Coal is beyond their reach now, but with railroads they might have an ample supply at $2 or $3 per ton.

Building material forms another group of commodities in great demand in China, but now limited to local markets by the primitive methods of transportation. The improvidence of the Chinese, like the reckless extravagance of Americans, has long ago permitted the destruction of the forests, so that lumber has become too scarce to be much used as building material. Mud bricks are the common but unsatisfactory substitute. Of good stone, however, these same deforested mountains could furnish all that would ever be needed. Railroads would carry stone all over the populous plains where it is now too expensive to be used for anything but mill-stones and ornaments. The extension of the use of these two natural products alone would more than justify the building of all the railroads now contemplated in China.

More than any other country, China is subject to famines, especially in the isolated northwestern provinces. The fact depends largely on the lack of free communication between different parts of the empire. In 1900 a severe drought destroyed the crops in Shen-si province and soon reduced three million people to starvation. More than a third of these actually perished for want of food. And yet, at the same time, bountiful harvests were gathered in the eastern and southern provinces. With railroads, supplies could have been imported at moderate cost, and nothing more than a period of "hard times" would have resulted. It would be impossible to-day to have a famine in Idaho, and yet the topographic situation of Idaho may be well compared with that of Shen-si. The difference in the two cases is largely—railroads.

These examples serve to indicate the sort of benefits which China should receive from the building of railroads. There will be much opposition from the ignorant and the mistaken among the natives, and there may be periods of halting and even retrogression in the process, but the overwhelming advantages of the railroad over all other means of transportation on land will eventually crush out all objections in China, just as they did in England in Stevenson's time. If China is to be modernized, it is difficult to see how the result can be accomplished without railroads, for freedom of communication is the very soul of our western civilization.

RARE EARTHS AND ELECTRIC ILLUMINANTS.

MURRAY C. BEEBE, '97, ASSOCIATE PROFESSOR OF ELECTRICAL ENGINEERING.

As scientists and engineers have come to a realization of the inefficiency of existing methods of illumination, the problem of improving upon these inefficient methods has received considerable attention. While the element carbon has heretofore been almost exclusively used commercially in both arc and incandescent lamps, the rare earth oxides, so-called, have recently been found to possess desirable properties for use as illuminants.

You are already familiar with the work of Auer von Welsbach in producing gas mantles of thoria and ceria. To use the rare earths in electric illuminants was a logical step. However, the problem presented difficulties not encountered in the production of a serviceable gas mantle. We should remember that an electric illuminant, to be an improvement over the Edison or carbon filament lamp in the matter of efficiency, must be capable of withstanding a higher temperature than the carbon filament, for a length of time sufficient to make it commercially attractive. One might at first suppose that it would be difficult to improve upon the carbon filament in the matter of efficiency, or the ability of the filament to operate commercially at a very high temperature, since the carbon is practically infusible while the rare earths are fusible in a carbon arc. Carbon, however, slowly vaporizes at the temperature at which it operates in the incandescent lamp, and finally, after 400 to 600 hours has depreciated in light-giving power to such an extent that it is an economy to replace it. It is the vaporizing properties rather than the melting-points of the materials with which we are concerned in this problem. It has long been known that substances which are commonly regarded as insulators, such as glass and porcelain, become quite good conductors of electricity at higher temperatures.

Prof. Buff, in 1854, read a paper "On the Conductivity of Heated Glass for Electricity," and Faraday's "Researches" give a number of examples of such conductors. Jablochkoff attempted to use refractory materials, such as lime, to separate and insulate the carbon electrodes of his Jablochkoff candle. He soon found that these supposed insulators in reality became conductors and emitted light by virtue of the current passing through them from one electrode to another. He even designed terminals with which to carry the current of electricity to the lime conductor, with the idea of making a lamp based upon this principle. It is probably safe to say that had it been possible to produce electricity as cheaply then as now, lamps of the Nernst type would have been known commercially much sooner than they were, for Jablochkoff's persistent attempts at commercial exploitation were baffled largely by the undeveloped state of electrical engineering.

That the rare earth oxides are exceedingly refractory and do not readily vaporize at a high temperature, makes the Welsbach mantle possible; that some of these oxides will conduct electricity when hot, makes the Nernst lamp possible. Of all the oxides which conduct electricity but few are refractory enough for an efficient filament or glower. It was in determining the most desirable of these and in fixing the best proportions to use that Nernst did his greatest work in the development of the Nernst lamp.

Ordinary red iron oxide, when formed into filaments and baked, will conduct electricity at ordinary temperatures, but such filaments do not withstand sufficiently high temperatures to be used as light sources. Magnesia and thoria, on the other hand, withstand exceedingly high temperatures, but these conduct electricity only with great difficulty. In general, mixtures of two or more oxides conduct better than a single oxide, and, in turn, the fusing-point of the mixture is lower than that of either oxide alone. It seems that the vaporizing point is not necessarily lowered, judging from the fact that thoria and the small amount of ceria used in a Welsbach mantle form quite a stable mixture, or possibly a chemical combination, while ceria alone or uncombined has a rather marked tendency to vaporize.

It would be a long story to take up the various properties of all the rare earth oxides and the possible combinations with one or more of the others. A mixture which is used largely in lamps of the Nernst type, is composed of 85 per cent. zirconium oxide to 15 per cent. of yttria earths. Zirconium is not properly classified among the rare earths, though it is customary to do so. The term "yttria earths," as used here, means in reality a mixture of many oxides occurring together in certain minerals and closely allied in physical and chemical properties. Zirconia was used in comparatively large quanities for the first Welsbach mantles and, hence, considerable attention had been given to various methods of producing it for such use. While many of the experimental glowers were made from zirconia bought from chemical supply houses, it was impossible to obtain uniform results from such material. Good zircon ore, which is a zirconium silicate, occurs in abundance in Henderson county, North Carolina, and this ore contains about 60 per cent. of zirconium as oxide. By treating this ore in the following manner quite uniform results are possible.

The ore is ground very fine in a ball mill and mixed with twice its weight of crude acid potassium fluoride. This is placed in an ordinary graphite crucible and heated slowly until thoroughly fused, and the ore is completely dissolved. The fused mass is then ground and dissolved in hot water containing a quantity of crude hydrofluoric acid equal to about one-tenth the weight of the fused mass. The silica remains undissolved as potassium silico-fluoride (K_2SiFl_6), and the potassium zirconium fluoride (K_2ZrFl_6) is drained off while boiling hot into a silver-lined vessel. Upon cooling the filtrate develops crystals of potassium zirconium fluoride, and, doubtless, small quantities of other elements in similar crystalline form. Iron and many other impurities which are present in the ore, or have been introduced by the use of the crude reagents, remain in the liquor which is drained from the crystals. The crystallizing process may be much hastened by artificial cooling. Rinsing the crystals with cold water is likewise beneficial in removing all of the mother-liquor. The crystals are gathered and fused in a platinum dish. By this means any silica present seems to be vaporized, and other impurities, like titanium, are made insoluble. The fused mass is ground and dissolved in hot water and crystallized as before. A few of the first crystals are removed, or, instead, alcohol may be added to the solution until a small amount of crystalline precipitate is formed. These first crystals contain much of the undesirable impurities. They are, therefore, removed and the crystallizing process is continued. The pure crystals are then dissolved in hot water, and the solution is made rather acid by the addition of pure hydrofluoric acid. Ammonia is now carefully added to the hot solution until a small amount of precipitate is formed. If the solution of the crystals has been made acid the addition of ammonia, even until alkaline, will precipitate iron and some other foreign metals, but will leave the zirconia in solution until it is cooled and diluted.

This method was found to be an exceedingly simple one for removing iron from zirconia, which by other methods is a troublesome operation. The hot filtrate, after removing the precipitate of iron, is dropped directly into a cold ammonia solution which at once precipitates zirconia as a hydroxide. Up to this stage of the process it has been necessary to use vessels and utensils not affected by hydrofluoric acid. The last precipitation may be made in glass or wooden receptacles. The precipitate is washed several times by decantation, and then pressed out on suction filters, and, after a thorough drying by heat, is powdered and sifted through fine bolting cloth, and is then ignited in a platinum dish with a very gradually increasing temperature and with constant stirring. The ignition process requires several hours, or sometimes days, the final temperature being a good red heat. Traces of silica are removed by this operation.

The physical condition of the precipitate is dependent to a great extent upon the amount of hydrofluoric acid in excess. When precipitated from an almost neutral solution, the precipitate dries into hard pieces translucent in appearance, and which are difficult to pulverize. With the greater excess of acid the material dries in lumps resembling starch, in which condition it is much more suited to our purpose.

The zirconium made by this process seems to be reasonably pure. Special precautions must be taken to keep out dirt, and to that end it has been found advantageous to purify the air admitted to the rooms where the glower materials are prepared, by passing it through a water spray. An absolutely pure zirconia is not required, and though a trace of silica improves the efficiency and seems to diminish the initial depreciation of candle-power of a glower, it is a dangerous element to have present, for slightly more than a trace will cause a rapid change in potential difference at the glower terminals besides causing a lack of uniformity in the behavior of the glowers of one batch, due to the fact that the silica becomes unevenly distributed among the glowers by vaporization and condensation occurring in a roasting process, which will be described later.

Although the purest materials make the best glowers for direct current, it cannot be said that an absolutely pure zirconia is desirable for alternating current glowers, in fact it seems that good alternating current glowers require the presence of certain impurities though in small amounts. Silica is particularly undesirable in direct current glowers. In general, a glower which operates well on direct current, showing almost no change in potential difference, will show a greater change when operated upon an alternating current circuit.

The purity of the zirconia may be controlled, to some extent, by the number of times the material is crystallized during the purifying process, though each operation is attended with some loss of material. Physical properties are quite as important as chemical properties and the procedure above described was evolved to give proper physical, as well as chemical, properties, to the material.

After all, the real test for the glower material lies in its ability to make good glowers. Test glowers have been made from hundreds of lots of zirconia and these, together with careful chemical records of each lot, have been the guide in developing the chemical process necessary for the production of good glowers. For direct current glowers a crystallizing process is also considerably used, but from a solution of zirconia in hot dilute hydrochloric acid. After two or three such crystallizations it is necessary to precip tate from a hydrochloric acid solution, as in the first process, to get the material into proper physical shape.

As to the yttria used, this is principally obtained from the minerals gadolinite or yttrialite. Gadolinite is found in Norway and Sweden, and also in Llano county, Texas. The Texas deposit seems to be confined in a very small district, and there is every evidence that it is the result of a volcanic eruption. It is found in crystalline form associated with yttrialite, cyrtolite, fergusonite, rowlandite, allanite, thorogumite and other minerals. The ores from the Llano county district are radioactive and the presence of a pocket in the surrounding quartz and feldspar is generally indicated by bluish discolorations radiating from the pocket through some distance into the surrounding matrix. It is also claimed that the ores, particularly the thoro-gumite, contain small quantities of confined helium gas. Gadolinite contains roughly, 42 to 45 per cent. of yttria earths, 23 per cent. of silica, 13 per cent. iron as oxide, and 9 to 12 per cent. of beryllia. Yttrialite contains 43 to 47 per cent. yttria earths, 30 per cent. silica, 5 to 6 per cent. ceria, didymia and lanthan, as well as small percentages of urania. Fergusonite contains 32 to 42 per cent. yttria earths and 32 to 46 per cent. columbic oxide. Rowlandite contains 47 to 62 per cent. yttria earths, 26 per cent. silica, and small percentages of iron and magnesia. Allanite contains 20 per cent. ceria and didymia, with a small percentage of yttria earths and considerable percentages of iron, calcium and aluminum.

It is a comparatively simple matter to obtain and purify the yttria earths from gadolinite and yttrialite so that they are suitable for glower making. About 1,000 gms. of ground ore are dissolved in crude aqua regia. The residue is filtered off and the solution evaporated to dryness, repeating this operation several times or until all the silica is removed. The neutral solution is then diluted to several liters and the addition of a hot solution of oxalic acid to the hot solution containing the earths brings down the rare earths as oxalates, leaving iron and other impurities in solution. The oxalate is washed thoroughly with hot water and ignited, and the crude yttria earths are dissolved in dilute hydrochloric acid, just sufficient in amount to dissolve the oxide. To the rather dilute and neutral solution, which is cold, crystals of potassium sulphate are added in excess. After standing twenty-four hours the cerium group has been quite thoroughly separated as double sulphates and the filtrate is then treated with ammonia to bring down the hydroxides of the rare earths, thus freeing them of the great excess of potassium sulphate. The washed precipitate is dissolved in a quantity of pure hydrochloric acid, just sufficient to dissolve it, and treated with boiling oxalic acid solution as before. This brings down the rare earth oxalates in sufficiently pure form. The oxalates are thoroughly washed with hot water and ignited, and any remaining potassium is separated from the ignited oxides by washing upon a filter with hot water.

With the yttria, as well as the zirconia, physical properties are important, and the oxalate method gives an exceedingly fine precipitate which requires no mechanical treatment.

Experiments indicate that the yttria earths of the greatest atomic weights give the most satisfactory results in glowers. In other words, ytterbia is better than yttria. Owing, however, to the great difficulty of separating the yttria earths from each other, which is possible at present only by laborious fractionation processes, entailing great losses, not much has been done commercially toward using the higher atomic weight yttria earths beyond selecting ores which are rich in these earths.

The Llano county ores seem to be superior in this respect to the foreign ores, the atomic weights being from yttrialite 115, rowlandite 107, fergusonite 103 and gadolinite 100, while the foreign ores may be as low as 90 or 92.

The zirconia and yttria earths mixed in the proportions given above, namely, about 85 and 15, or 90 and 10, and about 5 per cent. of starch or gum tragacanth, are thoroughly mixed and kneaded into a hard dough and squirted by pressure through a die of proper size. This string, as it may be called, is dried and then broken into suitable lengths, which are roasted to an intense white heat in a platinum box. The pieces are then ready to have terminals placed upon them.

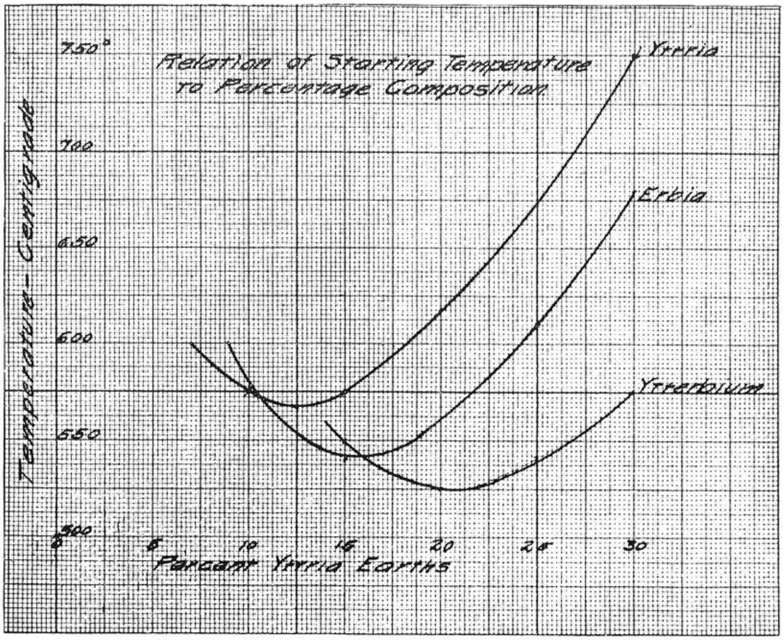
A Nernst terminal is made by winding stranded platinum wire about the end of the stick of material and pasting over with a paste composed of ground glowers and zirconium chloride, thus forming a hard cement.

The Hanks terminal has the platinum embedded in the glower material, the operation being carried on by the aid of an electric arc in which the glower material is fused.

It appears from extended tests that, with the zirconia and yttria mixtures, the Nernst terminal is not at all satisfactory for operation upon alternating current circuits, considered commercially; and, likewise, the embedded terminal is equally unsatisfactory for operation upon direct current circuits. It appears that for operation upon direct current that the oxygen liberated at the positive terminal must have free outlet from the terminal. Upon alternating current the reverse seems to be true. This statement being based in part upon the fact that the Nernst terminal operates more satisfactorily upon alternating current if it is carefully painted over a great number of times with a special glaze which covers the platinum wire entirely over with a dense non-porous coating.

It appears certain that the mode of conducting the current is partly electrolytic in character. The specific resistance varies with the relative proportions of the constituents. In order to obtain glowers of the same specific resistance when using yttria earths of high atomic weights as when low atomic weight earths are used, it is necessary to have the presence of the higher atomic weight materials in proportion to the atomic weights.

The accompanying curves, showing the relation of starting temperature to percentage composition, are instructive in this connection. Ordinates to these curves represent temperature in degrees C., while the abcissæ show the varying proportions of yttria earths in the composition. It will be noticed that there is a well-defined composition of maximum conductivity in each case, this maximum occurring at the higher percentage of yttria earths in the case of those glowers in which the earths of higher atomic weights are used. Also there is a distinct advantage in the use of the higher atomic



weight yttria earths, in that the lowest starting temperature is obtained by the use of yttria earths of the higher atomic weights. Tests have also shown that at equal efficiencies, measured in watts per candle power, the glowers made with the higher atomic weight yttria earths also have correspondingly longer life.

Upon direct current circuits the positive end of the glower generally runs much hotter than the negative end, and a black discoloration appears at the negative end, especially if impurities are present. In fact, this is one of the most certain indications of the presence of an impurity, especially silica.

A glower operated in vacuum soom destroys the vacuum, probably due to oxygen gas liberated by electrolytic action. That all the current is carried by electrolytic means seems incredible, for the current carried per square unit of cross-section is far greater than can easily be accounted for by our usual conceptions of electrolytic laws. For example, upon direct current and calculated by electrochemical equivalents the entire glower would be decomposed into its constituent elements in a very few minutes. Doubtless electrolytic decomposition and recombination do take place to a considerable extent, but is it possible to account for the entire transport of current in this way? The assumption that the current is all carried in this way seems unnecessary in view of what is known of the power of highly incandescent bodies to ionize air to render it conducting. The air in the neighborhood of a glower is conducting, and to such an extent that the leakage currents from glower to heater had to be reckoned with early in the experimental work, and the difficulty was obviated by the use of a double pole cut-out which disconnected the heaters completely from electrical connection with the remainder of the lamp after the glower started.

In connection with these speculations as to the real nature of the process by which the current traverses the glower, it is a fact that glowers which have operated for even a short time upon direct current will, when the current strength is diminished sufficiently to maintain the glower at only a good red heat, explode with considerable violence. The ionization of the surrounding air at low temperatures is insufficient to conduct the current. The means of conducting the current then being largely electrolytic in character, the combination of the products of electrolytic decomposition cannot so readily take place, since the ions cannot so readily diffuse at the lower temperature to recombine, and consequently disruption occurs.

The suggestion that has so often been made, namely, that the current be reversed in direction at intervals, as, for instance, every time the lamp is started, is altogether impracticable for the reason that a glower once operated upon direct current must never have its poles reversed, for a reversal means almost instant disruption. The potential difference across the terminals of the glower immediately after such a reversal is much lower, indicating something analogous to polarization effects as we know them in aqueous electrolytes.

In general, with the Nernst terminal the potential difference across the glower at the normal current value is the same with alternating or direct current. With the Hanks terminal, or embedded type, the potential difference with direct current may be as much as 20 volts lower.

The life of the alternating current glowers is almost directly proportional to the frequency, at the commercial frequencies from 25 to 133 cycles per second, again suggesting electrolytic conductivity, at least, in part. Some tests are now being made to determine the behavior of such glowers when operated at much higher frequencies. It would seem that electrolytic decomposition should almost, if not entirely, disdisappear at the higher frequencies, in which case there is the possibility of satisfactorily operating the glowers in vacuum, resulting in a decidedly better efficiency, perhaps twice what is now attained in the Nernst lamp. Operated in vacuum, a blue aurora, or luminous haze, surrounds the glower operated either upon direct or alternating current, and this has been thought to be due in some way to the (zirconium or yttrium) recombining with the slight amonnt of oxygen liberated. This idea seems plausible from the fact that objects such as wire or glass near the glower become coated with a white deposit of the glower oxides in a comparatively short time, and the resistance of the glower increases rapidly.

It would seem that oxygen necessarily plays a part in conducting the current, for a glower in an atmosphere of hydrogen or nitrogen behaves similarly to the one operated in vacuum. In carbon monoxide or dioxide the glower exhibits the same characteristics as in air. The glower operated in vacuum exhibits a peculiar sluggishness in responding to changes in voltage at its terminals.

The small glowers, up to 0.5 ampere, are made solid in cross-section, the larger ones are generally made tubular, and in fact, one-ampere glowers must be made so. The reason for this is not that greater efficiency is sought by increasing the ratio of surface to volume, which is, of course, a fallacy, but inasmuch as the glower possesses a decided negative temperature coefficient with respect to electrical conductivity, the center of a large solid glower would become molten before the outside surface reached an efficient temperature, the center being the better conductor. Glowers which have been greatly overrun often exhibit this truth by the appearance of a nodule of molten material which has spurted out to the surface.

The decided negative temperature coefficient is well illustrated by the fact that a thin flat strip of the glower material, provided with the proper terminals, will conduct current along one edge while the remaining parts are comparatively cool and non-conducting.

A commercial glower must operate at a high temperature in order to be efficient. Nernst glowers operate at about 2,300 degrees C., it is supposed from determinations made by photometric means and at about twice the efficiency of a carbon incandescent lamp. The spectrum of a glower is a continuous one and no evidences of selective emission are noted in any particular region of the visible spectrum.

During the life of the glower, which averages about 800 hours under normal conditions of manufacture and voltage regulation, a depreciation of candle power takes place, due to a number of causes. In the first place, all oxides of the rare earths do depreciate rather rapidly in light intensity per unit of surface at any given temperature. This is true whether heated by gas or electricity, and a platinum plate coated on one side with rare earths and heated from the rear by an oxyhydrogen flame behaves similarly. It is an inherent property of these oxides and a depreciation of 10 or 20 per cent. may occur during the first hour. There is then a slow diminution of intensity of light, also inherent, and seemingly accompanying the tendency of the glower to change from an amorphous to a crystalline structure. A rise of potential difference across the glower terminals is usual, though it is possible to counteract this tendency, at least in part. The effect of a rise in potential difference, obviously, is to diminish the intensity of light by permitting less current to traverse the glower running on a constant potential circuit.

With carbon incandescent lamps the useful life or "smashing point" is considered to be that number of lamp hours during which the candle-power decreases 20 per cent. from the initial candle-power. Nernst lamps are similarly rated, counting as initial candle-power that measured after the initial decrease above mentioned.

Another cause of the depreciation in candle-power is blackening of the enclosing glassware and reflecting surfaces. In this connection the blackening is due largely to platinum which has been vaporized and deposited upon these surfaces. It has been found that the purest platinum is far better than that containing iridium or others of the platinum group, since pure platinum vaporizes much more slowly than alloys with these other metals.

To produce uniform chemicals and glowers in which the tendency to depreciate in light intensity and to increase in potential difference shall be a minimum makes the problem intricate and fascinating, and still worthy of much study and investigation.

Curiously enough not the least of the problems to be solved in the development of the Nernst lamp was to overcome the tendency of porcelains to conduct electricity, the very property which in the case of the rare earths made such a lamp as the Nernst possible. A heater is necessary to start the glower. The heater is made by winding fine platinum wire upon a porcelain tube. It was necessary to produce a suitable porcelain which would withstand the high temperature required and at the same time not conduct electricity. A porcelain composed of kaolin, alumina and silica is sufficiently refractory and porous to withstand the heat and is an almost perfect non-conductor at high temperatures. The porcelain piece upon which the glowers and heaters are mounted is also of the same composition.

Another form of heater, used more abroad than in this country, is helical in shape, and the glower is mounted in its axis. This is made of pure kaolin, and after squirting into tubes about a millimeter in diameter, winding with fine platinum wire and covering over the wire with paste, the small tube is bent into a helix upon a mandrel, a pointed blowpipe flame playing upon the kaolin tube at the point where it bends on to the mandrel.

Possibilities of Self-starting Filaments—Many oxides will conduct at room temperature. A mixture of iron and tin oxides, about 70 iron to 30 tin, will start without preliminary heating and withstand rather a high temperature. There are many other similar combinations; likewise other possibilities exist, such as carbides, silicides and borides, operated either in vacuum or gases.

A Nernst glower may be made to conduct the current at low temperatures by running it for a short time in a rarified atmosphere containing a carbon gas. If to a globe in which a glower is operating in a good vacuum an amount of hydrocarbon gas is admitted sufficient to lower the vacuum even less than a millimeter, the potential difference across the terminals of the glower will decrease rather rapidly, and in the interval of a few minutes, or even seconds, and the glower will have become a conductor when cold, or, in other words, self-starting.

The following experiment was tried:

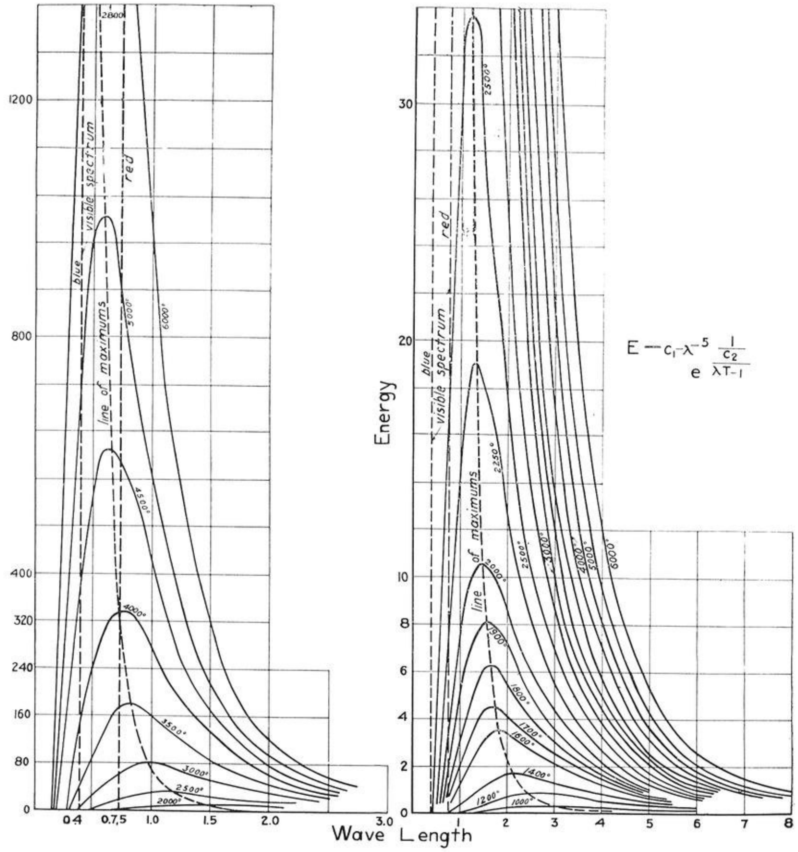
A glower was mounted in a glass bulb and in the axis of a carbon filament of helical shape. The bulb was well exhausted and sealed off. The carbon filament was used four or five times to start the glower, alternating current being employed. After the glower had run a few hours it was noted that it was changing color at its terminals. The dark discoloration gradually crept toward the middle, and after about twenty-four hours the glower could be started without preliminary heating. Apparently enough of the carbon filament was oxidized during the short time it was in use to give a slight quantity of free carbon monixide in the bulb, the source of oxygen being the glower itself.

It is uncertain whether this gas was effective in reducing some of the glower material to its metallic form, or whether a conducting carbide was formed by the action of the carbon gas upon the glower materials. The former explanation seems preferable, for the reason that it was noticed that the darkened portion at the negative end of direct current glowers is of higher conductivity than the glower proper, and it seems quite likely that this deposit is a metal separated out by electrolytic action. Metallic zirconium, for example, withstands very high temperatures in the open air without oxidizing, and its melting and vaporizing points where air is excluded must be very high.

Many possibilities exist, such as are suggested by the above experiments, and many of them have been tried. Boron carbide, for example, withstands very high temperatures and is a conductor while cold, though it seems to vaporize somewhat too rapidly; at least this is the case with samples tried, which probably were not very pure.

A Nernst glower, as well as those composed of thoria, magnesia, and almost any of the refractory oxides, may be made conducting by treatment with a hydrocarbon gas. Sodium and potassium vapors also effect a reduction to the self-starting condition, though not generally so readily as carbon.

There is a broad field still open and much that is not known of the properties of the rare metals. Oftener than not the supposedly pure metal is impure, and the properties generally ascribed to it are in reality those of its carbide or other little known combination. Note the difference in properties of pure iron and iron containing even less than one per cent. of carbon. Is it not a fact, then, that almost nothing is known of the physical properties of the rare metals? A good example of this point, and one bearing directly on our subject, is the recently developed tantalum lamp, the filament of which is a fine thread of tantalum metal. Tantalum



metal, until recenlly, was not known to possess properties which now make it a promising addition to electric illuminants.

More or less experimental work has been done, particularly in Europe, in using the rare earths in electric arcs with the idea of obtaining better efficiency and more pleasing light. Arc lamps have even been tried with electrodes composed entirely of the rare earth oxides, though at the present time the greatest advances in arc lighting are being made along the lines of introducing such elements as boron and titanium into the electrodes.

In conclusion your attention is directed to a set of curves which has been plotted to show the relation between the temperature and the energy radiated in the various wave lengths of light for incandescent black bodies. Various temperatures are assumed, and curves calculated, showing the energy radiated at each wave length. The visible spectrum is defined by the vertical broken lines marked red and blue. The exceedingly small proportion of the total energy which is radiated within the limit of the visible spectrum even at a temperature as high as 3,500 degrees C., is startling enough. We are, apparently, at the present only on the border of the possibilities.

MEXICAN LABOR.

C. M. LARSON, '05.*

Of late years there has been an enormous flow of foreign capital into the Republic of Mexico. This is drawn from many countries, but by far the largest portion, of late years at least, comes from the United States. The rapid progress of the Mexican financial system toward stability has naturally attracted capital to her numerous resources, and the fact that she has, within the last year, been placed upon a gold basis, will have a tendency still more to increase this great current of latent wealth which has steadily been setting in for the last two decades.

Little local capital is used in the development of semi-public enterprises, and so there is always found a fertile field for this foreign capital as fast as it may enter the republic. The Mexican, even though he may invest in such an undertaking, usually prefers to see a competent foreigner at the head of it, and it is needless to say that capital from the United States is almost entirely directed by people from that country. Thus there is always a growing demand for good men in any of the work that may be undertaken, and especially is this true concerning the engineer. Even where the whole management is in the hands of the Mexican himself, a foreign engineer is often desired. There are many Mexican engineers to be had, but they can scarcely compete with those from the best schools of their northern neighbor, to say the least.

To whatever line one turns, he finds a call for competent Americans. In the fields of mining, electrical development, mechanical and civil engineering of all kinds, there is a de-

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* Mr. Larson has been, up to a few weeks ago, assistant engineer on the Mexican National Railway, in charge of the construction of a branch line into the coffee district near Cordoba, Vera Cruz, Mexico.

mand far in excess of the supply, for engineers to direct the investment of the money brought down for that purpose.

Having these conditions in mind, it may readily be seen that many of our young engineers can expect, within a very short time, to be called upon to fill positions in Mexico, where they will be required almost at once, to direct the labor employed in these enterprises. This labor consists almost entirely of Mexican peons, the people of the lower classes; a people always very ignorant and indolent, and so much different from the laborer with whom the ordinary engineer is acquainted, that it becomes necessary to make somewhat of a study of them and their characteristics. An understanding of their peculiarities is essential if one is to make a success of his undertaking, and failure to fully appreciate and take into account this difference, has been the stumbling-block of many an otherwise well established enterprise.

It must not be understood, however, that when the shortcomings of the laborer are learned, the Mexican "labor problem" is solved, for she has such a problem at the present time, and it is an ever increasing menace to her own development. However, through a knowledge of a few of the peculiarities of these people, the engineer may be able to save his company from a great deal of loss, or even disaster, and is sure to be much better equipped for any position he may be called upon to fill.

These remarks apply primarily to that part or Mexico called "tierra caliente," or hot country, being that part lying below an altitude of about 1,000 or 1,500 meters above sea level. The laborer of Northern Mexico and of the central tableland, is much more industrious, as well as more vicious and dishonest, though is otherwise much the same. There, the conditions are such that he is required to exert himself more for the very means of subsistence, and is benfited by so doing. Besides the weather is much cooler, and he is not subjected to so much discomfort in doing his work.

Some years ago, a company took a large contract on the western coast, having calculated upon labor at the then current rate, about $0.25 per day. It was only a short time until they were paying $1.25 per day with every prospect of having to pay even higher very soon. This indicates a scarcity of labor which is quite general throughout Mexico, and it can be traced to several distinct causes.

In the first place, nature is too abundant. The native can very easily sustain life with a small amount of physical exertion (of mental exertion he is quite incapable). He sees no good reason for working if he has all he wants. If he is to be persuaded to work more, it is necessary to teach him to desire something more that he is accustomed to have. At present about the only things that he desires and must work for are his drink and his cigarettes. These he must have and will work for, provided he does not have to work in the rain to get them. He will even forego them rather than to expose himself to the inclement weather. For this reason, if the engineer has an important piece of work to be finished quickly, the ideal conditions would be fine weather and plenty of drinking houses very near, where the laborer is sure of spending all his money in the least possible time.

Second, a peon cannot be persuaded to wander far from his "home." Where he was born is where he intends to live and die. He does not want to get away so far that he could not walk back if necessary. At first this may not appear of much importance, but when one considers that the laborers are scattered very sparsely over the country as it is, there being scarcely enough to supply the local and regular demand of the ranch and hacienda owners, it is seen that in the case of a foreign enterprise coming which absorbs a large amount of labor, such, for instance, as the building of a railroad, or a large water system, then it is that the impossibility to secure labor from any great distance assumes enormous proportions. Again, a railroad company doing a piece of repair work at one point on its system may have to secure an entirely new gang of workmen for a similar piece of work at a point a couple hundred kilometers away, even though they may have cars conveniently fitted up for the transportation of the men and their families. Here is another phase of it. Even if his work takes him but a short distance away, his family must invariably accompany him. There are very few exceptions to this rule, and the company has always to take this fact into account. Where he goes, his household goods go also, but this item does not usually cut much figure.

Again, the above statement of that company having raised the laborers' pay from $0.25 to $1.25 per day gives an idea of another cause of the scarcity of labor in Mexico; that is, the very fact of the raise in pay. The peon has certain ideas as to how much money is required to supply him with those things which he desires badly enough to work for. He will work until he has earned that amount and then stop. If he needs $3.00 per week and receives $0.50 per day, he is willing to work five or six days out of the week to get the amount required; but if he is paid $1.00 per day, he works three days and no more. This fact has been the cause of the demoralization of labor in many districts. There have often been sent down as managers of plantations, Americans who were ignorant of these things, and at once began bidding for the labor against the native hacienda owners, by paying higher wages. The result has been to actually reduce the amount of labor in the market by making it possible for the workman to earn his required amount in less time than formerly. Besides, and in this respect the Mexican is very similar to his northern neighbor, the efficiency of the labor is in inverse proportion to the pay received.

One needs to have an almost unlimited amount of patience to get along with these people. In dealing with them, they must be treated very much as small children would be treated, for they are no more, intellectually.

They can not be trusted to do a thing as it ought to be done unless they are under constant surveillance. They appear to be entirely lacking in any sense of responsibility. This fact is about the most striking of any characteristic of the Mexican people. It is very general, not being confined to the people of the lower classes particularly, but prevailing to a surprisingly large extent among all, from the highest down. The instant the peon receives his pay or reckoning for the week he stops work, and it does not in the least matter to him how serious may be the result of his leaving his task uncompleted. Though the results of the whole week's work may thus be lost, it is of no consequence to him. It may all be summed up by saying that he is, in every sense of the word, working solely for the amount of money which he is to receive at the end of the week. Not even does it matter to him whether or not he will be hired again the following week; he does not look so far ahead. Anyway, when he needs work again he can very easily find it somewhere else; there is always plenty of work to be had. The trouble is to get him to do it. So it is apparent that to discharge a man for inefficiency, or almost any other reason, is of little avail as regards increasing the quality of the labor or of the laborers. It is a common saying that if one discharges a Mexican he invariably gets a worse one in his place. Few of them care to remain long enough at one kind of work to become what we would call skilled laborers. In fact, they dislike the monotony of such a proceeding, and prefer making changes often.

As said above, the instant a peon receives his pay he quits work; and, furthermore, it is impossible to prevail upon him to go to work again as long as he has any money at all in his pocket. He always considers that he has money until the last cent is spent; so, again, we see why there is a decided advantage to the engineer when the peon spends all his money in the shortest possible time. For the reasons above stated it has become the invariable custom to pay the men off on Saturday evening or Sunday morning. The former is the better time, for the sooner drunk the sooner sober, and the sooner will they be compelled to return to work, and this increases the chances of their getting back on Monday. However, very seldom is much done on that day.

No Mexican will work on a "feast day," as a general thing;

neither on the day following it, for the same reason as that given for not working on Monday. The amount of time thus lost, due directly or indirectly to holidays, is a very large item in the course of a year, for the Mexican calendar is well interspersed with red-letter days.

If a peon does not care to work on any day he seldom takes the trouble of telling the foreman about it beforehand; he just simply fails to put in an appearance on that day, with absolute indifference as to the importance of his presence. He may not show up again for a week or more, and then wonder seriously what is the matter if anything is said about the intervening absence. And he is honest in his failure to see wherein his presence or absence can make the least difference in the world. He may leave at any hour of the day, or, if he is not watched closely, he will improve the first opportunity to slip away and take a nap for a few hours.

The significance of the Mexican word "mañana," to-morrow, is now quite generally understood. The Mexican will promise to do it "to-morrow," and repeat that promise every day indefinitely, without any serious thought whatever of ever doing what he promises to do. One may know that a Mexican really has good intentions of doing a thing only after it is done. He utterly fails to comprehend the reason for all this rush and hurry which always seem to characterize the American engineer. There is another day coming, "mañana" —what is the use of being so particular about doing everything to-day?

Physically, the peon is a very weak man. Seldom is one found whose strength is anything like that of the ordinary laborer in the states. These lower classes in Mexico are really a starved people in the midst of plenty; for would they but work, they might live upon the best to be had in any land. Their food consists almost entirely of "tortillas," a kind of pan-cake made of corn, and of beans. Besides, the drink of these people, alcohol made of cane, or the "pulque" drunk by the inhabitants of the higher altitudes, is exceeding injurious to them. Thus their food, drink and exposure, all combine to the making of a very weak race. Their rude huts in no wise form a sufficient protection from the disagreeable weather that sometimes prevails.

The only satisfactory method of getting a peon to work is to lay his work out for him by the "tarea," by which is meant the laying off of a certain amount which he must do for a day's pay. This quickly comes down to our ordinary "task" method, or "piece work," and the workman is paid, not by the day, but by the amount done. This method lends itself readily to railroad building, in which the men are paid by the cubic meter. In fact, the "tarea" method of working is the only one at all satisfactory in dealing with these people, and it is the one almost exclusively used where it is at all possible. If a man is a good laborer, he always prefers that system, as he feels that whatever he does counts towards his own benefit. While if a peon applies for work by the day, it is almost certain that the applicant is of the class that prefers doing little or nothing. Quite often a man who will work very well by "tarea," will do scarcely anything if paid by the day.

Usually a "cabo," or foreman, of a little higher social class, is put in charge of the peons, but even he cannot be trusted, for he will often make a bargain with the men that for a small part of their daily wages, to be turned over to him, he will allow them to do as little work as they may see fit. However, peons often refuse to work at all unless they are under a "cabo," as he usually understands them better than a foreigner. Thus, unless somebody who can be held responsible, and to whom responsibility has some meaning, can be on the work, it is almost impossible to get anything accomplished by day labor at a reasonable cost.

The Mexican workman takes no pride whatever in his work, and will do things that may cause any amount of disaster, simply to ease the task upon his own shoulders a small amount. He is also almost innocent of the meaning of the word honesty. Even the tools with which he works, he considers as objects to be appropriated at the first opportunity.

At best, the peon is a very poor workman. One has to be prodding him constantly to get him to work at all, and even then the amount accomplished is very small. He sticks rigidly to obsolete methods, and it is hard or impossible to get him to accept any changes in these methods. If the engineer begins at the first of a job to try to teach him how it should be done, as for instance, mixing concrete, he will still be telling him the same things at the last, even though it may be a job of several months' work .Unless he is gifted with an unusual amount of patience, however, he will probably be making his explanations in a far different tone and manner from that with which he started out. The peon does not have the least desire to learn, and it would be difficult for him to learn much if he had the desire, for his powers of observation are almost if not quite lacking.

It is said that the fastest naval coaling station in the world is in Japan, where a ship is loaded entirely by hand baskets. So in Mexico a railroad cut or embankment will be built in a a remarkably short time by these people without the use of any machinery whatever, except a pick, shovel, and a basket in which to carry the dirt. So if the engineer can work them on the "tarea" system, and can get plenty of them to work, he can accomplish his labor rapidly and cheaply. Such constant supervision is usually necessary, however, that the item of engineering expenses is quite high.

To get along with his men the engineer must be indulgent to a certain extent. He should not be too harsh or too exacting, but he must always keep the upper hand. Never let them succeed in their numerous little tricks which they will employ at first as "feelers," but which will very soon increase to large proportions if it is thought that the engineer either does not see them or that he lets them pass unchallenged. If he shows them in a quiet but unmistakable way that he knows his business, but at the same time intends to deal fairly with them, he will have placed himself in a position to get from them as much work as they will give anybody.

PROSPECTS FOR ENGINEERING GRADUATES WITH THE ISTHMIAN CANAL COMMISSION.

MAX W. KING, '05, LEVELMAN, ISTHMIAN CANAL COMMISSION, EMPERE, CANAL ZONE, PANAMA.

One reads in newspapers and magazines so many unfavorable and conflicting reports about the conditions of work and life on the Canal Zone, that it is hard to form a true idea of the real conditions.

In the spring and early summer of 1905 there was a general dissatisfaction on the part of the employes as regards conditions for life and work. In those days a man was considered an old timer when he had stayed two months. The quarters there were no where near adequate for the number of employes. For many the quarters which were promised, consisted of nothing but a roof and a canvas cot. The board was far from satisfactory. Malaria and yellow fever were prevalent. Therefore, it is not strange that the employes did not remain long on the Isthmus.

On the other hand, promotions were rapid and salaries were high. At the present time the conditions of life are entirely changed. The quarters and board are all that one could expect, while the cases of yellow fever are very few. Malaria is ever present, so that one must take it as one of the necessary evils. Now that the conditions of life are better, the employes remain longer, and as a result promotions are slower.

In the spring of 1905 the requirement for a rodman was a college training. Now rodmen are being hired who have had no college training and but little experience. The force of engineers has been more than sufficient to perform the necessary work. Within the last month this force has been cut down. Those who have been dropped were mostly of the higher ranks; still enough of the lower rank men have resigned or expect to resign in the near future to make it likely that there will be a number of new men taken on in the early spring. The chances for promotion are not as good as might be supposed, nor is the experience to be gained as valuable as one would think. The work required is of a low class, and this leads to giving the work to unexperienced men at low pay. A good share of the topography has been done by a party of two rodmen and a gang of negroes. The railroad work is of an inferior class, and so does not give the experience that might be gained elsewhere. Again a large party of engineers is engaged in cross-section work. This kind of work gives the needed practice in instrument work, and the familiarity with actual work that the beginner so much needs. For this reason, a year or perhaps eighteen months can be put in with the I. C. C. to a very good advantage. One should not underestimate the experience to be gained on a big undertaking like this, through careful observation. The prospects for work will likely be improved if contractors are given the construction of the canal. This would be another good reason for getting a foothold on the Isthmus before the contractors come.

The general feeling here among the younger men, however, is that a year or eighteen months is sufficient time to spend on the Isthmus, at least while the present conditions prevail.

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With this issue THE ENGINEER closes another year of its history, and we pass the work on to the new staff with the single comment, "It's up to you." In closing up our year we desire to take this opportunity to thank our advertisers, students and faculty for the valuable aid they have rendered the ENGINEER, and to ask that this same aid be extended to the staff which succeeds us.

The demand for Wisconsin men this year is greater than ever, and will far exceed the supply. Already a number of companies have written for from one to ten or fifteen men each, and the bulletin boards are well covered with offers for positions. In the midst of these evidences of prosperity the seniors seem at a loss which position to accept, and a number of very good positions are as yet unaccepted. Representatives of the larger electrical companies have visited the school and explained the offers which their various companies make to the graduates. Among the companies looking for Wisconsin men are the Western Electric Company, General Electric Co., Westinghouse Electric and Mfg. Co., Chicago Telephone Co. and New York Telephone Co.

Among the civil engineers the demand is equally as active. The larger railroad systems have openings for a number of men, while several structural firms and cities have openings. Surely this is a year for engineers.

At the April meeting of the Board of Regents the position of Professor of Railway Engineering, made vacant by the resignation of Professor Taylor, was filled by the appointment of W. D. Pence, Professor of Civil Engineering, Purdue University. Professor Pence graduated from the School of Civil Engineering of the University of Illinois in 1886, having had, previous to graduation, considerable experience in railroad work. After graduation he entered the service of the Santa Fe system, serving successively as road master, assistant engineer of maintenance of way, and resident engineer. From 1892 to 1899 he taught in the Civil Engineering department of the University of Illinois, his last position being Associate Professor of Civil Engineering. Since 1899 he has been in charge of the school of Civil Engineering in Purdue University. During his seven years administration the enrollment in the department increased to about 400, a result due in large measure to his enthusiasm and energy. While devoting most of his time to instructional work, Professor Pence has maintained an active connection with engineering practice. He has been connected with several interurban enterprises in the state of Indiana, and is now a member of the committee appointed by the United States Department of Agriculture to study the drainage of the Kankakee marshes. He is a very active member of the American Railway Engineering and Maintenance of Way Association, being editor of their publications. Other prominent societies in which he has a membership are American Society of Civil Engineers, Western Society of Engineers and the Society for the Promotion of Engineering Education. He is author of "Standpipe Accidents and Failures," and of numerous papers on railroad engineering and other subjects, and joint author of "Surveying Manual."

The last engineering lecture of the season was given March 30th by Mr. Ralph Modjeski, Consulting Engineer of Chicago. Mr. Modjeski gave a very interesting description of the latest Mississippi river bridge, that at Thebes, Illinois. This is one of the largest pieces of work in bridge construction which has recently been executed, and is a very interesting example of that field of engineering. In his lecture Mr. Modjeski first described the conditions which determined the size and type of structure. One of the most important of these appeared to be the whims of the river pilots in determining just where the piers ought to be placed and what should be the length of the channel spans. The progress of the work was followed through all its stages, from the sinking of the first pier to the placing of the last pin, numerous lantern slides being used to illustrate the work. The bridge is of the cantilever type, and one of the most interesting features of construction was the means taken, through toggle joints, to raise and lower the end of a long overhanging span. It was a good illustration of the fact that engineers must plan and carry out safely many schemes without ever having tried the like before. Mr. Modjeski kindly left with the college several fine photographs of the bridge.

At the recent meeting in Chicago of the American Railway Engineering and Maintenance of Way Association, one of the subjects which received a great deal of attention was that of impact formulas for bridge specifications. One of the principal committees of the association is the committee on iron and steel structures, and it is the duty of this committee to prepare and report standard specifications for steel bridges. A very important feature of these specifications, and one on which there is much difference of opinion, is the fundamental question of working stresses. The difficulty arises from the uncertainty of the effect upon the structure of rapidly moving trains. The subject is such an important one that after much discussion, the association voted that the committee should proceed to carry out an elaborate series of experiments, comparatively little experimental data being available. This subject has been investigated to some extent by members of our faculty, and in view of the interest already taken by this institution, the proposed experiments will be placed in charge of Dean Turneaure as chairman of a sub-committee appointed for the purpose. It is expected that the experiments will continue for some years and will involve the testing of a large number of structures under moving train loads. Various railroad companies are taking a great deal of interest in the matter, and will undoubtedly be ready to furnish the necessary facilities in the way of experimental trains and such help as may be needed other than expert observers. For the latter, instructors and advanced students from this and other colleges will be employed. Experimental apparatus is now being developed in the shop of the mechanician, and it is expected that preliminary tests will be made in a few days.

The minstrel show has come and gone. On the evening of March 30th, the Senior Engineers gave the third annual minstrel show, and it was a success in every way. Each member made a hit, and those taking part may feel well satisfied with their work. It is to be hoped that the following classes will keep up the custom now well started of making the "show" an annual affair.

We give the program:

PROGRAM

PART 1

1.	Overture	Orchestra
2.	Opening Song (Arranged by Musical Director)	Chorus
3.	Bye, Bye, My Eva	Trester
4.	When the Bees are in the Hive	Miller
5.	I'll be Back in a Minute	Sackett

Introduction of Premiers

6.	Selection	Quartette
7.	The Mormon Coon	Parker
8.	When the Moon Shines	Russell
9.	Movin' Day	Huels
10.	Closing Song (Arranged by Musical Director)	Chorus

PART 2.

1.	The Closer You Watch the Less You See	E. J. Noe
2.	Illustrated Song (Slides by "Butch" Moser)	A. U. Hoefer
3.	The Famous	John B.
4.	Mandolins	Shaad, Russell, Parker, Bush, Elmore
5.	Dialect Sketch	G. Maxwell Johnson
6.	The Microbes	Gym Team

Parker, Wadsworth, Seibel, Zeidlhack, Lautz, Faber
(Arranged by Mr. E. Angell)

A large amount of original research work is being carried on at the University. The new hydraulic laboratory, new equipment in the shops and electrical laboratories, etc., tend to encourage this work, and valuable results are being obtained in several lines of investigation. The Senior theses offer a means for the carrying on of the larger part of this research, and we give below a resume of the more important theses which are furnishing results of practical value to the engineering world.

The cost and comparative advantages of the sand blast and pickling processes for scaling rolled steel and cast iron, and the softening of the cast iron scale by pickling.—L. B. Robertson, C. V. La Dow and G. M. Johnson.

The determination of the constants involved in the design of strap brakes, involving determinations of the coefficients of friction for different speeds, materials and lubrications, and for different angles of strap contact.—D. E. Foster and E. L. Wachtman.

The water power resources of the upper Fox River Valley, dealing in considerable detail and thoroughly with all the opportunities for water power development in that area.—L. L. Smith.

The effect of freezing on concrete cubes.—W. C. Rath.

The determination of the coefficient N in Kutter's formula from current meter measurements of the discharge of the Niagara river.—A. E. Wright and F. A. Kennedy.

Laminated pole telephone receivers, with especial reference to increasing the distance of communication.—J. B. Kommers and B. H. Peck.

The breaking down pressures of different lubricating oil films in journal bearings under varying conditions of temperature and speed, this being a continuation of work commenced last year.—R. R. Ripley and H. M. Saubert.

The design of an electro-magnetic hammer—G. J. Jenista.

Efficiency tests of a Doble tangential water wheel—F. M. Johnson and H. J. Hunt.

The Portage Levee System, with especial reference to its effect on the flood height of the Wisconsin River—F. W. Lawrence.

A study of the application of the electric welder to different materials, especially iron and steel, and also to the welding of two different materials together as self-hardening and ordinary tool steels—E. N. Strait and A. P. Balsom.

A study of submerged weirs and orifices—M. E. Allen and W. C. Parker.

An experimental study of reinforced concrete tee beams—H. A. Parker, J. W. Buchanan, W. A. Van Hook and E. T. Howson.

The use, efficiencies and cost of operation of a small steam turbine direct connected to an electric generator—M. L. Derge and W. O. Sustins.

The investigation of the locomotive water supply installation at the West Milwaukee shops of the C., M. & St. P. Ry.

with special reference to the economy of operation—R. A. Manegold and T. H. Manchester.

The effect of alternating currents as regards the electrolysis of water pipes, etc.—F. H. Rickeman.

The magnetic concentration of the Wisconsin Zinc ores—O. L. Kowalke.

The detinning of scrap tin plate—R. S. Wile.

A very important line of work is being carried on in making comparative tests of the methods of electric train lighting now in service. The work is being carried on very thoroughly, and a large number of tests have been made. The dynamo and engine in the baggage car, steam turbine in the baggage car, and the four systems of axle lighting are all being studied. Tests are being made on trains on the Northern Pacific Railway between St. Paul and Portland, on the C. B. & Q. Railway between Chicago and Denver, and on the C. M. & St. Paul Railway between Chicago and St. Paul. O. B. Cade, A. J. Walsh, W. A. Bertke, and I. L. Reynolds, are working on the Northern Pacific, while A. U. Hoefer and E. Kearney are working on the Burlington tests. Edwin Wray, a graduate scholar, has general supervision over both series of tests. F. W. Huels, Irving Bush and H. L. Heller are making similar tests on the Pioneer Limited of the C., M. & St. P. Ry.

''A study of the best ways of protecting long distance transmission lines from lightning; also the carrying of high tension transmission lines through roofs of power houses, and the wiring on the inside of such power houses," is the subject of the thesis to be presented by Alvin Meyers, '01, of the Telluride Power Transmission Co., Provo, Utah, for an advanced degree.

The design of high tension sub-stations by S. J. Lisberger, '03, of the California Gas & Electric Co., Oakland, Cal., is another valuable thesis for an advanced degree.

At a recent meeting of the faculty the following were elected to scholarships in the College of Engineering for the next year: In Mechanical Engineering, O. N. Trooien, B. S., University of South Dakota, 1902, M. S., University of South Dakota, 1904; in Electrical Engineering, Lloyd L. Smith, B. S., George Washington University, 1905, B. S., University of Wisconsin, 1906; in Chemical Engineering, Simon G. Engle, A. B., University of Indiana, 1903.

The Department of Experimental Engineering has just received a twenty-five horse power Wiley suction gas producer. On account of the crowded condition of the Mechanical Laboratory the new producer is being installed beside the superheater, and will be housed in a separate room. The installation will be used for instruction and for special investigation.

ALUMNI NOTES AND PERSONALS.

Joe Bingham, '04, has resigned his position with the U. S. Reclamation Service to accept one in the bridge department of the D. L. and W. Ry., at Buffalo, N. Y.

John Flaig, '04, has left the bridge department of the D. L. and W. Ry., at Hoboken, N. J., to accept a position as instrument man in the maintenance of way department of the Great Northern Ry., at St. Paul.

E. J. Fisher, '04, is now in the construction department of the D. L. and W. Ry., at Hoboken, N. J., having resigned his position with the U. S. Reclamation Service.

H. P. Sawyer, '05, has left the bridge department of the Illinois Central Ry., to enter the employ of the McClintock-Marshall Construction Company, in their Chicago office.

Bert U. Shipman, ex-'06 is now in the bridge department of the C., M. & St. P. Ry., at Milwaukee.

Robt. Mannington, ex-'04, has resigned his position with the Isthmian Canal Commission, at Panama, and is now located with the C. B. & Q. Ry., in their Chicago office.

H. B. Gates, '05, who has been working on the terminal improvements of the Pennsylvania Ry., in New York City, is now with the Ransome Concrete Machinery Co., in New York.

A. W. Andrews, '05, has been transferred from the Chicago office of the C. B. & Q. Ry., to Lincoln, Neb., where he is now employed as draftsman with the same company.

G. H. Burgess, '95, has been promoted to the position of engineer of Terminal Improvements of the Erie Railroad with offices at 11 Broadway, N. Y.

Max Dering, ex-'06, has left school to accept a position with the C. M. & St. P. Ry. on their coast extension.

Chas. Thuringer, '93, is now assistant engineer on the Penn., New York & L. I. R. R., with office at 345 E. 33rd St., New York city.

J. L. Hanop, ex-'06, has been promoted to the position of resident engineer on Residency No. 10 of the Lake Superior & Southeastern R. R. This is a branch of the Wisconsin Central R. R., on which some very heavy construction work is being done.

W. A. Rowe, '04, has moved from Mountain Iron, Minn., to Platteville, Wis., where he is engaged in mining work.

E. W. Galloway, '04, has located in Michigan, and may be addressed at 116 Webster Ave., Muskegon.

F. H. Mann, '05, formerly timekeeper with the Great Northern Ry. at Spokane, Wash., has been promoted to assistant engineer on construction, and is located in British Columbia.

BOOK REVIEWS.

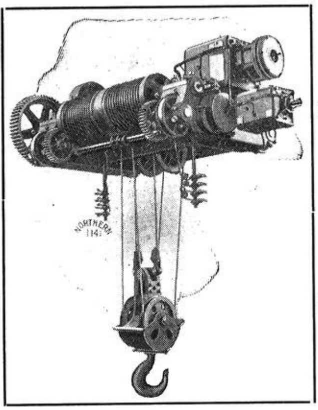
A Handbook on Reinforced Concrete, by F. D. Warren, published by D. Van Nostrand Co., of New York. $2.50 net.

This book deals with the design of reinforced concrete construction and is particularly adapted for architects, engineers and contractors. It is divided into four parts. The first gives a concise resumé of this subject from a practical standpoint, dwelling on the difficulties met with in practice and the means of overcoming them. The second part contains a series of tests used in determining the various constants used in preparing designing tables. In part three are given tables for designing, which apply to the common cases met with in practice, and in the last chapter is given the practical side of the design of trussed roofs.

As a whole, the book is a very handy one for use by those engaged in reinforced concrete construction, as a large amount of valuable information is gathered in a compact form.

Alternating Currents—their Theory, Generation and Transformation, by Alfred Hay, published by D. Van Nostrand Co., New York. $2.50 net.

In this book the author's aim has been to furnish the reader with a general account of the principles, construction and use of alternating-current measuring instruments, generators, motors and transforming machinery, with special attention to methods of testing. The theory of alternating currents is dwelt upon and explained in the first three chapters. The author has excluded matter of academic interest, and has brought the subject up to date, introducing the latest information into the book. It is well illustrated and will prove a valuable book for one engaged in this line of work.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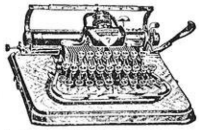

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E. R. CURTISS,

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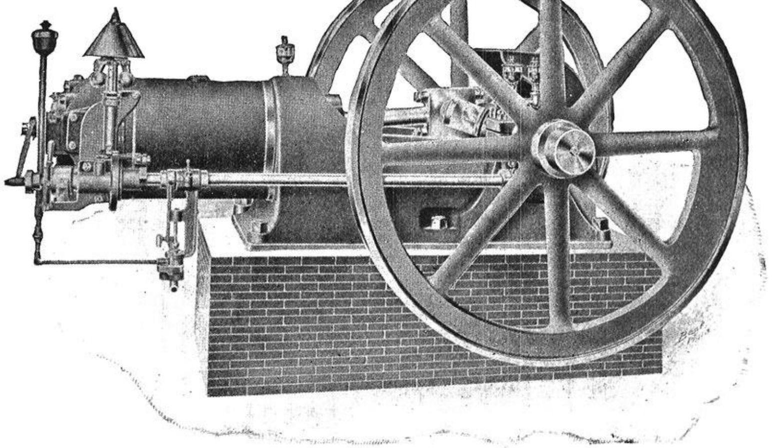

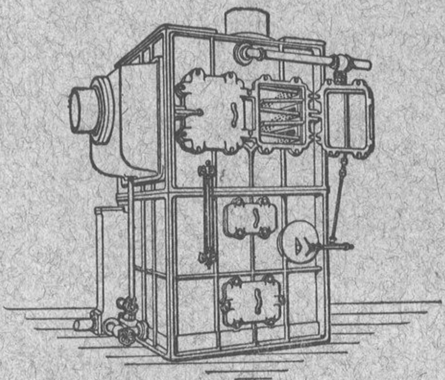

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