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A. V. Millar

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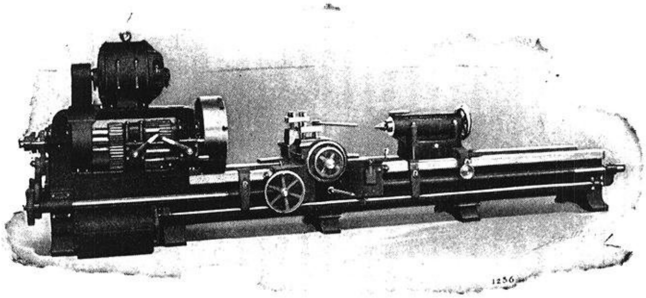
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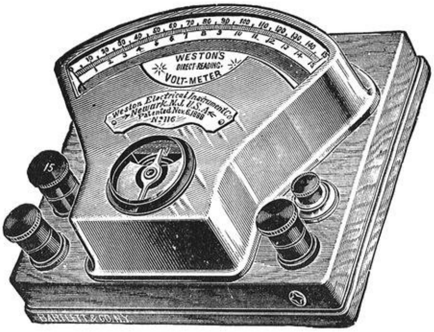
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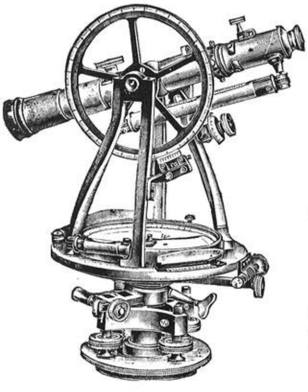

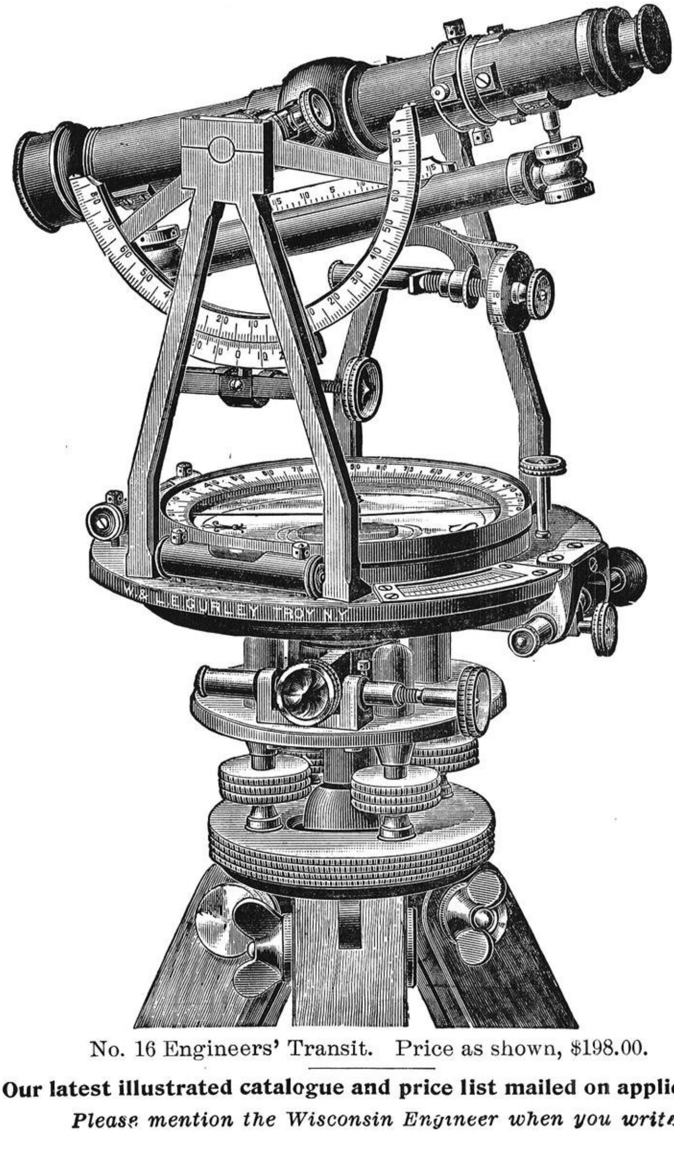

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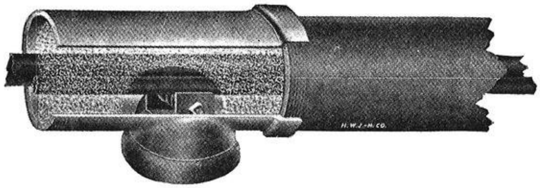
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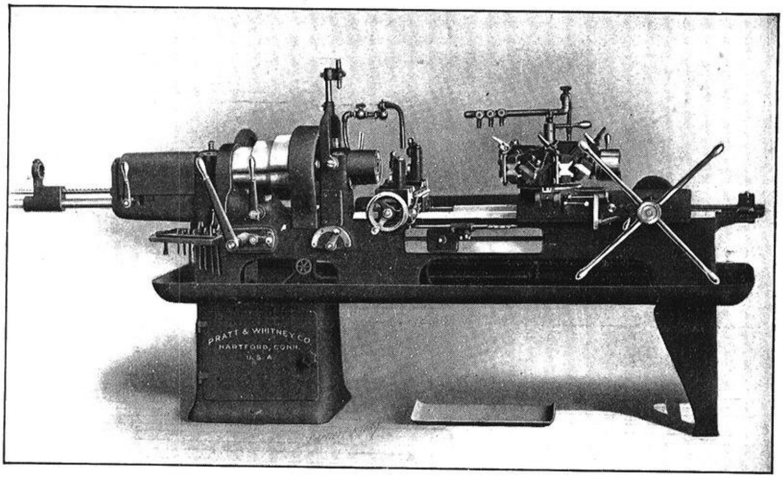
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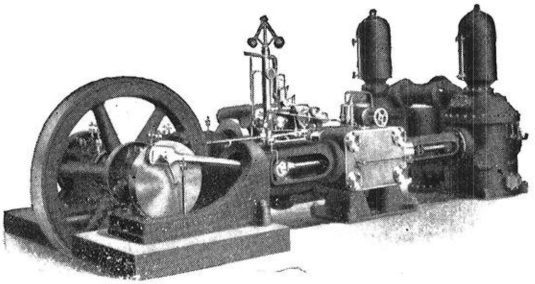
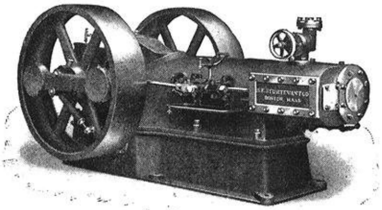




THE WISCONSIN ENGINEER

VOL. XI DECEMBER, 1906 NO. 1

AERIAL CABLE CONSTRUCTION FOR TELEPHONE EXCHANGES.

C. W. BURKETT, E. E., A. M. A. I. E. E., Chief Engineer Wisconsin Telephone Company.

[Read before the Madison, Wisconsin, branch of The American Institute of Electrical Engineers, March 15, 1906.]

One of the problems met with by the telephone engineer of today, is that of providing a pair of wires from a predetermined centre to each telephone. To accomplish this requires, in many instances, the extensive use of aerial cable, and it is the purpose of this paper to outline, in a general way, the present day practice in aerial cable construction for telephone exchanges. The subject is one of very great importance in telephone work today, as this extensive use of aerial cable requires considerable capital.

With the invention of the telegraph came the necessity for continuous metallic conductors between points often many miles apart and, strange to relate, the first several miles of telegraph wire from Baltimore was laid underground in lead pipes and placed in a plowed furrow. But the wires so laid were not operative for reasons at that time not known, and one of Morse's contemporaries made the suggestion that the wires be "hung up in the air."

Following the suggestion to "hang up the wires," a small portion of this first telegraph line was placed on poles with cattle horns for insulators, and so successful was this scheme that the remainder of the whole line from Baltimore to Washington was built in this way.

Tracing the development of the construction of electrical conductors, we find that this first method has been improved only in construction details.

The first public exhibition of the telephone was made at the Centenial Exposition at Philadelphia in 1876. Subsequent development in the demand for telephone service required an enormous wire plant construction. This unusual demand created new problems of great moment and complexity.

At first telephone wires were placed in the way that telegraph wires were placed, but the number of wires needed increased so rapidly that the placing of wires in cable form became imperative if the business was to develop, and the use of the telephone was to become universal.

These old time telephone plants were called "open-wire plants," and much of this construction is to be seen throughout the country today. It is, however, disappearing quite rapidly, and in a few years the open-wire telephone exchange will be an exception.

It is believed that the first aerial cable for telephone use was installed at Philadelphia in 1881. About this time, experiments were being made at Providence, Brooklyn and Boston. These first telephone cables were made of parallel rubber covered wires and the electrostatic capacity was so great that, with a third of a mile of such cable inserted in a telephone line, subscribers complained that they could barely hear.

It was found also that the induction between the parallel wires of the cable was so great that serious cross-talk resulted. This induction was overcome by placing the wires in twisted pairs, and later the electrostatic capacity was reduced and transmission correspondingly improved by insulating the wires with paper. It was found later, however, that the improvement was due, not to the paper, but to the occluded air among the twisted paper.

Improvements have been made from time to time in the design and manufacture of telephone cable, until today as good telephone transmission can be secured without special devices, such as loading coils and repeaters, over (10) miles of standard No. 19 B. & S. gauge cable as over 285 miles of No. 8 B. W. G. copper aerial circuit. At present the theoretical limiting distance of standard telephonic transmission over a No. 19 B. & S. gauge circuit in cable without special devices is, approximately, 29 miles.

Some of the reasons for constructing telephone exchange wire plants on what is known as the "all-cable" basis are as follows:

1st. Because wires in cables are more economical to maintain than those in the open.

2nd. Because the larger number of wires necessary in telephone work makes all open wire plants physically impossible.

3rd. Because of the unsightliness of structures carrying great masses of open wires.

4th. Because of the greater surety of uninterrupted service with wires in cables than with wires in the open.

5th. Because the first cost and fixed charges of an all-cable plant are less than that of the open or partly open-wire plant.

An all-cable plant must be designed so that pairs of wires are available in cable from the central station to within a few hundred feet of any subscriber—present or prospective. In the early days of telephone construction there was no thought of a comprehensive or systematic aerial construction. Cable was expensive and the rule was to get along with as little as possible. But the present day remarkable demand for telephone service has made carefully engineered plans for all parts of the telephone plant a necessity.

I will outline briefly a routine for the preparation of plans for an all-cable system of distribution for a given exchange area with a center previously determined:

Initial Construction, Economical Period.

The economical period for which the initial construction should provide must be determined. The length of this period varies inversely with the price of cable, being derived from the first cost and fixed charges.

With the present cost of construction it is economical, in general, to install aerial cable to care for all business that may be secured within five years. This economical period will probably be increased in the future rather than decreased.

Future Population.

An estimate of the population of the exchange area at the end of the economical period must be made, as the number of telephones to be provided for will depend upon the population. This is arrived at according to the method described in the United States Census Bulletin No. 135, of Jan. 30, 1902.

Amount of Business to be Provided For.

An estimate of the number of subscribers to be served in the exchange area within the given period must be made. To do this with any degree of accuracy is one of the most difficult problems at present in telephone engineering, as there is a considerable diversity of opinion concerning the amount of telephone development to be expected in different sections.

At present a 15 or 20 per cent development, depending upon the community, is considered saturation. That is, in an exchange area, 15 or 20 per cent of the population in five years will be the number of telephones for which provision must be made.

A study of the present development is most interesting. The development in the New England states is 3.48 per cent. Of the foreign countries, Sweden has a ratio of 2.11 telephones per 100 inhabitants, and Great Britain has a ratio of .86 telephones per 100 inhabitants.

In the larger cities of the United States there is a more uniform development. It is peculiar, however, that the greatest development in the United States has been on the Pacific Coast. This has been attributed to the fact that the population is "new" and has the characteristic of all new places, *i. e.*, of making use of every new idea. The city of San Francisco has a ratio, January 1st, 1905, of 12.5 telephones per 100 population, while Chicago has a 4.7 per cent development, and New York a 4.6 per cent development.

In the state of Wisconsin, Milwaukee has a 5.6 per cent development, while many of the smaller towns have from 7 to 12 per cent. development.

Some telephone engineers believe that the number of telephones that may be required in a community is limited only by the number of families in that community. Estimating that the average family consists of five and that the population of the United States is eighty million, sixteen million instead of four million telephones (which is the estimated total number in use by all companies) would be required to give each family telephone service. These facts are mentioned to give an idea of the magnitude of the problem which confronts the telephone engineers of to-day.

Distribution of Estimated Number of Telephones.

The distribution of the total estimated number of telephones predicted for the end of the economical period must be made by blocks or by other small areas. This is accomplished by making a careful survey of the exchange area to classify telephonically the business houses, residences and unimproved real estate. The finished map showing the result of this survey is called a "character map."

This map shows the character of buildings and of unoccupied land in the exchange area and, briefly, by legend, office buildings, wholesale business districts, retail districts, manufacturing districts, residence districts, divided into first, second, third and fourth class, undeveloped land capable of future development and undeveloped land incapable of future development.

The classification of residences is relative, and a first class residence in one city might be rated second class in another city. The division is made entirely on the basis of the possibility of demand for telephone service. A first class residence is defined as one which under all ordinary circumstances should be provided with telephone service, while second class residences are those in which a telephone would be expected in one-half of the residences and third class residences would have a telephone in every third or fourth house. Fourth class residences would be those which would require telephone service only in rare cases.

Occasionally exception must be taken to these rules, for example, a railroad man living in a poor residence, but having a special need for telephone service. This condition exists in the northern part of La Crosse, Wisconsin, where there is a telephone in nearly every residence, none of which could be classed as first or second class La Crosse residences.

Location of Cable Routes.

Cable routes are determined largely by the topography of the exchange area and other local factors. The routes should be as short as possible so that the subscribers' loop will contain a minimum amount of conductor, and in city work, leads should preferably be placed in alleys.

Where alleys do not exist, privilege of the use of rear property lines can usually be secured.

The Size, Kind and Location of Cable Terminals.

The size of the cable terminal depends on the number of telephones to be served from the same, as determined by the development study. The average sized terminal used today is 15 pair, but both 10 and 25 pair terminals are used extensively.

Terminals may be either protected or unprotected. Where the lines served from the terminal are especially liable to become crossed with high potential and lighting wires, or are exposed to damage by lightning, the protected terminal is used. This protected terminal consists of a fuse, and for very long lines, is supplemented by open-space cutouts made of carbon plates separated with mica of .011 inch thickness. The fuse is of tubular form of 5 amperes capacity and is rated to blow on 8.5 amperes in less than five minutes.

The unprotected terminal is so arranged that the open wires may be directly connected to the cable wires without any protective apparatus whatever. This type of terminal is used where the open wires are not exposed to danger from lightning or contact with foreign electrical conductors.

Size and Kind of Cable.

The number of pairs of wires to be placed in a cable depends upon the number of telephones to be served by the cable. Unlike power and lighting cables, no overload can be cared for in telephone cables. A cable that will care for 400 telephones will not care for either one or twenty more telephones. This, together with the fact that the largest sized cables in place ready for service may cost as much as $4,000 per mile, makes careful engineering a necessity. From the economical standpoint, a cable too small must be replaced before it has earned the charges against it, while a cable too large represents investment upon which no return can be secured. At present the standard sizes of exchange aerial cable are 15, 25, 50, 100, 200, 300 and 400 pairs.

To serve five subscribers a 15-pair cable is ordinarily specified. To serve 45 subscribers a 100-pair cable would be specified, while 100-pair cable would also be specified to serve 60 subscribers. For 280 subscribers a 400-pair cable would be installed.

The size of the conductors to be used in telephone cable is determined by the length of the substation loops to be carried through it.

Loops in single office exchanges must not have over 500 ohms resistance if No. 22 B. & S. gauge cable is used.

In multi-office exchanges, the resistance must not be over 350 ohms in No. 22 B. & S. gauge cable for subscribers' loops.

Two types of cable are used as concerns electrostatic capacity, and in this respect cable is known as being either "high" or "low" capacity.

Under certain severe transmission requirements, the low capacity cable must be used, although it is more expensive than the high capacity cable. In No. 19 B. & S. gauge, low capacity paper cable, the maximum mutual electrostatic capacity measured between a wire of a pair and the sheath (the remainder of the conductors being connected to the sheath) must not exceed 0.060 microfarads per mile of cable, while high capacity No. 19 B. & S. gauge cable must not exceed 0.087 microfarads per mile of cable.

No. 22 B. & S. gauge cable is manufactured with a maximum electrostatic capacity of 0.078 microfarads per mile.

The insulation of all wire in cable must be not less than 500 megohms per mile of cable, each wire being measured against all the rest and the sheath with an electromotive force of from 500 to 550 volts.

All cable sheath must contain not less than 3 per cent. of tin with a thickness of from $\frac{1}{12}$ (.83) inches for the smallest cables to $\frac{1}{8}$ (.125) inches for the largest cables.

The Distribution of Cable Conductors.

To actually provide a pair of wires from the central office to each terminal for each prospective subscriber would be a most expensive proceeding, and in order to accomplish this end, without actually installing the wires, multiple distribution of cable conductors has been devised. This multiple distribution of cable conductors is arranged, as the term implies so that the same pair of wires is multiplied to two or more diffferent terminals, at any of which it is available for use if not in use at some other terminal.

This arrangement provides a safeguard to cover small errors in estimating the number of future telephones. It also proves valuable in systems where party lines are used, as by this method stations may be connected to the same line at different terminals.

Many of these multiple distribution schemes have been developed, all based on the elemental idea of making one pair of wires available at quite a number of different points.

A 400-pair cable may have as many as 100—15-pair terminals. This means that every pair of wires will be available on an average at 3.75 different points.

The earliest multiple system of cable conductors, and one which is used to considerable extent at present, is called the "direct lap" system. Such a distribution would begin in this way:

Terminal No. 1—Pairs 1–20.
Terminal No. 2—Pairs 11–30.
Terminal No. 3—Pairs 21–40.

Another system is to have a certain group of conductors appear at all terminals.

These multiple distribution schemes become more complicated and involved when terminals of different sizes are used and where the ultimate number of telephones to be provided for becomes more and more uncertain. Some of the later systems devised are too complicated to be described in this paper.

Pole Plan.

The plans for the cable plant are are now completed with the exception of determining the location of poles for supporting the cable. For the main leads, poles with "six-inch" tops are used. A 30-foot pole of this class has a circumference of not less than 22 inches at the top and 36 inches six inches from the butt. Poles of other lengths should have correspondingly proportional dimensions.

Poles with "five-inch" tops should be used in alleys and on property lines where cables not heavier than 100-pair No. 22 gauge are to be supported. A 30-foot pole of this class has a circumference of not less than 18¾ inches at the top and 33 inches six inches from the butt.

The height of poles must be determined for each piece of work. In general, they should be as short as is consistent with municipal regulations or with such obstacles as may be met.

The practice at this time is to place all cables and telephone wires, where possible, below the lighting and power wires, because the telephone wires are usually greater in number than the lighting and power wires and break under sleet and wind before the lighting and power wires do.

Care must be taken that anchors and stubs are of the right sizes and are properly placed. With the larger sized cables, which may weigh from six to eight pounds per foot, this is a vital matter and one which must be determined for each piece of work.

Poles for cable work should be set to the following depths:

25 foot pole—five feet in the ground.
30 foot pole—five and one-half feet in the ground.
35 foot pole—six feet in the ground.
40 foot pole—six feet in the ground.
45 foot pole—six and one-half feet in the ground.
50 foot pole—seven feet in the ground.

In cable work it is necessary to step only poles on which terminals are placed.

Construction Details.

The paper telephone cable is a delicate structure which the slightest moisture will render unserviceable. For this reason, great care must be taken to see that all construction details will insure against moisture entering the cable.

The cable is hung on messenger strand fastened to poles or to cable crossarms with suspension clamps. Three kinds of this strand are used, according to the following rules where the spans are less than 150 feet.

For 50-pair No. 19 gauge cable or 100-pair No. 22 gauge cable and smaller, messenger strand having a minimum breaking weight of 6,000 pounds should be used. This strand is composed of seven No. 12 galvanized steel wires twisted together.

For 100-pair No. 19 gauge cable, or 200-pair No. 22 gauge cable, messenger strand having a minimum breaking weight of 10,000 pounds should be used. This strand is composed of seven No. 13 B. W. G. galvanized steel wires twisted together.

All cable larger than this should be strung on messenger strand having a minimum breaking weight of 16,500 pounds. This messenger strand is composed of seven No. 11 B. W. G. galvanized steel wires twisted together.

Where more than two cables are to be placed on one pole, steel cable crossarms having a capacity of six cables are ordinarily used.

The amount of sag in feet to be used in placing cable is as follows:

Spans 100 feet or less—2 foot sag.
Spans 115 feet—2½ foot sag.
Spans 130 feet—3 foot sag.
Spans 145 feet—4 foot sag.

Where cable is liable to either electrical or mechanical injury from foreign conductors or from trees, it must be protected by substantial moulding. A boxing of wood is generally used, although metal tubing is used in some cases.

As a rule the marlin cable hanger is used for attaching cable to the messenger strand. The hook of this hanger is made of galvanized steel wire of not less than 0.144 inch in diameter (No. 9 B. W. G.) and must not open when subjected to a load of 100 pounds. The marlin or houseline must stand a strain of 330 pounds without breaking when looped around a one-inch rod. Different sized loops are used for the different sized cables.

Cable hangers are placed 15 inches apart on 200-pair No. 22 gauge cables and on 100-pair No. 19 gauge cables and larger, and 20 inches apart on all smaller cables.

In special cases, such as at railway crossings, in the vicinity of chemical works and with certain atmospheric conditions, an all metal cable hanger is used. All metal cable hangers would be used universally if they could be manufactured as cheaply as the marlin hanger, and devised so as not to hold the cable rigidly to the messenger strand.

It is considered good practice to bond aerial cable sheaths together and ground the same at frequent intervals.

Splices in cable must be made with great care. At each splice in a 400-pair cable 800 wires must be joined together electrically and the joint insulated from every other wire.

The joint is made by removing the paper insulation from the ends of the wires and twisting the bared wires together. Solder is never used in paper cable and, strange to say, open wires in splices made this way are rare.

The splices in the wire are insulated by enclosing them in small paper sleeves.

"Multiple" splices are more complicated than "straight" splices, especially where more than two branch cables lead from the same splice.

With a community "cabled" for a telephone to each family, one feels that Goethe must have had a premonition of such a condition when he wrote:

"Truly the fabric of mental fleece,
Resembles a weaver's masterpiece,
Where a thousand threads one treadle throws,
Where fly the shuttles hither and thither,
Unseen the threads are knit together,
And an infinite combination grows."

THE STEPHENSONS AND THE DEVELOPMENT OF THE LOCOMOTIVE.

H. J. THORKELSON, U. W., '98.

[Read before the U. W. Engineer's Club, Oct. 29, 1906.]

The locomotive is, no doubt, one of the most fascinating types of the steam engine. Ever since its inception, it has attracted to it many of the brightest intellects of the engineering profession. There are, no doubt, few men present this evening who have not at some time in their lives felt the attraction of this great field of work and, perhaps when younger, the desire to become a locomotive engineer.

We very seldom stop to reflect on the importance of this branch of engineering; its effects upon the commercial industries of the world, and the very great changes that have been made in our economic conditions during the past century, due to the development of the steam railroad.

In no country does it rank higher than in the United States, where it has played an important part in the opening of our great western territories and in bringing all parts of our land closer together. The truth of the statement made by Mr. Seward at the time of the Civil War is evident to all. He said, "Physical bonds, such as highways, railroads, rivers and canals are vastly more powerful for holding civil communities together than any mere covenants, though written on parchments or engraved on iron." The railroad might very justly be placed at the head of this list of forces for good.

The development of the railroad has been so closely allied with the development of the locomotive that it is almost impossible to separate the two; and in dealing with the early history of the ralroad or of the locomotive, the work of the Stephensons should take first rank.

Just as it has surprised many to hear that Watt did not invent the steam engine, so it may surprise some to hear that Stephenson did not invent the locomotive. However, great honor is due and is very justly given these men because of the very important improvements made by each, the one in the use of steam as a means of changing the latent heat energy stored in coal, wood, etc., into a useful form of mechanical energy, and the other in applying the steam engine to the field of land transportation.

As Robert Stephenson himself says, "The locomotive is not the invention of one man, but of a nation of mechanical engineers."

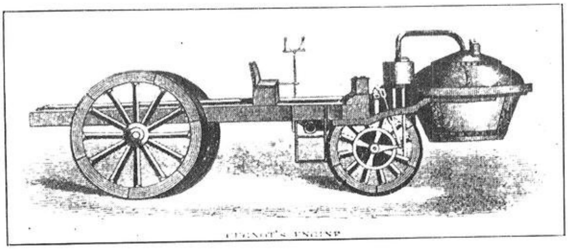
To better appreciate the importance of the work done by the Stephensons, let us very briefly trace the development of the locomotive before their time.

The earliest record of any suggestion of the use of steam for the purpose of propelling vessels on sea and carriages on land is found in a letter written by a Marion Delorme at Paris in 1641 and suggested to Dumas one of the best scenes in his romance "The Count of Monte Cristo." In this letter, which is written to a friend, she describes a visit of the Marquis of Worcester, who, as her guest, was taken to see points of interest in Paris, among which was a mad house where one Solomon de Caus was confined. The reason for his confinement was the fact that he had presented a statement to the king of the wonderful effects that might be produced from the use of boiling water. His importunities so annoyed the cardinal that he had him confined for his folly. To listen to him, as the letter states, you would imagine that with steam you could navigate ships, move carriages,—in fact there is no end to the miracles which *he* insists could be performed. The Marquis of Worcester, taking the suggestion of the confined insane man, made what was probably the first *useful* steam engine soon after he had returned to England.

One of the earliest attempts to make use of steam for the purposes of locomotion occured in 1771 when Cugnot, a

Frenchman, designed the locomotive shown in Fig. 1. Many of you will doubtless recognize a few points of similarity between this early attempt at steam locomotion and a modern automobile.

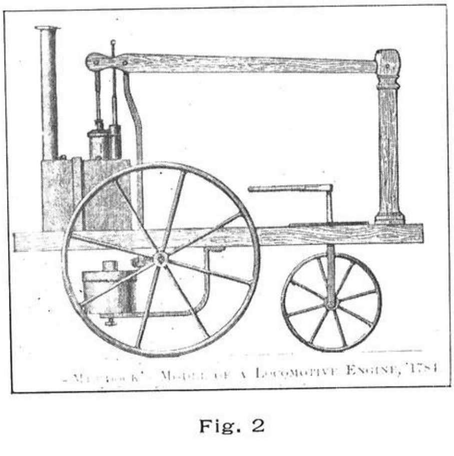
This locomotive was designed to run on common roads, had a single front wheel, ran at a speed of four miles per hour and carried four persons. Unfortunately, the boiler was so small that after running for about a quarter of an hour, it was necessary to stop the machine in order to again get up steam. A second engine of this type, built by the same designer, came to grief in a rather tragic manner. When running on the street in Paris, it overturned with such a great crash that the city authorities condemned it as dangerous and locked it in the arsenal.



CUGNOT'S ENGINE

Fig. 1

Next in order should be mentioned the small model locomotive (Fig. 2) made by Murdock, Watt's distinguished as-



MURDOCK'S MODEL OF A LOCOMOTIVE ENGINE, 1784

Fig. 2

sistant who invented the slide valve. Many features of this small toy, for such it really was, were adopted in the first successful locomotives built some thirty years later.

Necessity is surely the mother of invention, and the needs of the mines of England led ultimately to the production of both the steam engine and the railroad. When wood for fuel became scarce, and the forests of southern England totally inadequate to supply the demands, attention was called to the great supplies of coal in the earth, and coal mines began to increase in size and number. With the increasing trade in this commodity and the greater demand came the need for better methods of transporting the coal from the mines to the seaports, to be hauled by boats to the larger cities and foreign ports.

As early as 1630 wooden rails were laid for the wheels of the coal wagons, enabling horses to pull much larger quantities. Some of these early wagon roads were nine to ten miles in length, and it was not long before thin plates of iron were fastened to the top of the wooden rails as protection. From this it was but a step to the cast iron rail that did not rot. These "plate roads," as they were called, were next equipped with a flange to better keep the coal wagons on the track, and later the flange was put on the wheel and the track was made with a smooth flat top for the same purpose. In this way, step by step, the modern railroad has gone through a process of evolution to the modern comparatively high state of perfection.

In 1803, Richard Trevithick, a Cornish miner, made a wager of a thousand guineas that he could carry a load of iron a distance of nine miles by means of steam power. He won the wager in 1804 by constructing the locomotive shown in Fig. 3. This, the first actual steam locomotive, had a speed of five miles per hour and possessed many interesting features. The cylinder, 8 inches in diameter by 54 inches long, was placed in the boiler, and the exhaust entered the stack, thus increasing the draft. The large fly wheel shown is also of interest. The engine, however, was rather poorly constructed and, soon getting out of order, was abandoned by the builder.

Trevithick, the year before this, built a steam locomotive for use on dirt roads, which attracted a great deal of attention, and many at this time prophesied wonderful achievements for Capt. Trevithick's dragons, as they were called.

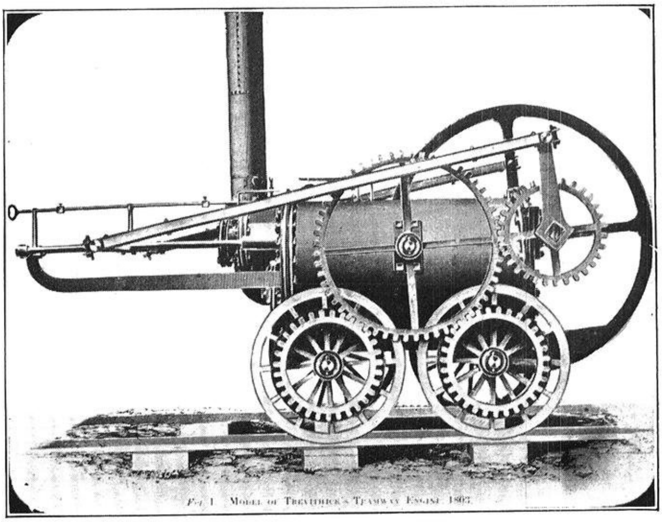


Fig. 3

Trevithick is often called the father of the locomotive and the automobile because of the pioneer work he did in both these fields.

One of the imaginary difficulties which existed at this time was that of getting enough adhesion between a smooth wheel and the rail. This was thought impossible, and in order to get the desired adhesion the gear and rack type of locomotive was introduced. Blenkinsop, in 1811, brought out the first locomotive of this type, and many similar locomotives were used for a number of years in hauling coal from the Middleton collieries to Leeds, a distance of three and one-half miles.

One very interesting device for surmounting the supposed difficulty of frictional contact between a smooth wheel and

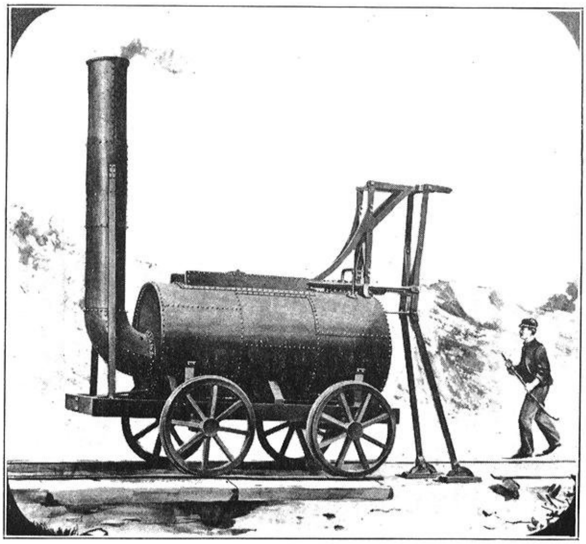


Fig. 4

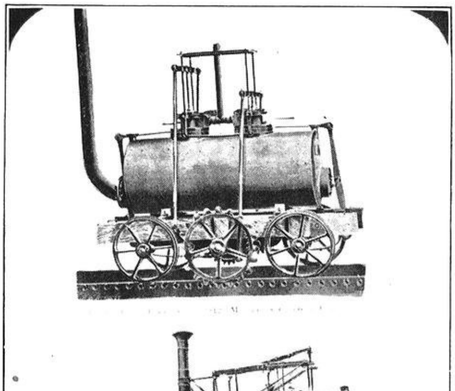


Fig. 5

rail was the "Mechanical Traveler," invented by Brunton in 1813 (Fig. 4). The levers were so arranged that the legs were alternately lifted from the ground, swung forward, and then pressed down and pushed against, thus forcing the locomotive ahead. This locomotive, however, never ran. At the first trial, the engineer, in order to make sure of a good start, fastened the safety lever down, and the locomotive exploded.

The early development of the locomotive owes much to Mr. Blackett, who spent a great deal of time and money in an endeavor to perfect the locomotive. His experiments accomplished more negative than positive results. The first blew up and the second was so heavy that it broke the rails of his road. The engineers experienced a great deal of difficulty in keeping the locomotive on the track. It is said that on one occasion the driver of one of Blackett's locomotives was asked how he got on, to which he replied: "Get on! We don't get on. We only get off."

The upper locomotive of Fig. 5 gives some idea of one of the early Blenkinsop locomotives of the rack and pinion type, built by Blackett for hauling coal. It is entitled to credit as being the first locomotive that may, without a serious stretch of the imagination, be called a commercial success.

Mr. Blackett's colliery viewer, Wm. Hedley, built next the locomotive shown in the lower part of Fig. 5. This you will notice has no rack along the track, but depends for its adhesion solely upon the weight of the locomotive. Mr. Hedley is entitled to a great deal of credit for the experimental work he performed before building the locomotive shown, in order to demonstrate that the rack and gear were entirely unnecessary.

From the time of Blackett and Hedley, the progress of the locomotive was continuous, although at times very slow indeed. Some of the early locomotives built by Hedley were in use for a number of years for hauling coal from the collieries to the loading docks. These early locomotives are very interesting in many ways. They were all named, and many names indicate that the owners possessed a sense of humor.

The locomotive shown in Fig. 6 is said to be the oldest locomotive in existence. It was built by Hedley and was called the "Puffing Billy." The cylinders, as you will notice, are vertical and connected by means of a walking beam to the driving wheels inside the frame, and in this way the power was communicated to the drivers. The cast iron track for the locomotive is also of interest, as is the lagging about the boiler.

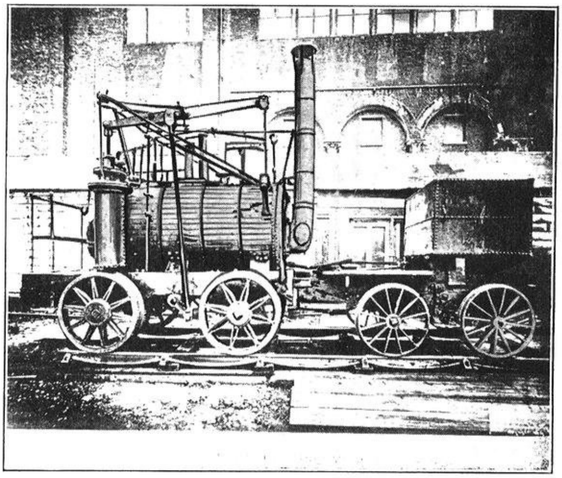


Fig. 6

We have traced thus far the development of the locomotive up to the time of Stephenson, and it must be evident to all that a great deal of work had been done upon it. It still lacked, however, many desirable features and was not economical. The great improvements made by Stephenson will be all the better appreciated when we understand the conditions under which he lived. To read his biography is certainly an inspiration. We will have time, however, for only a very hasty summary of the life history of this truly remarkable man.

*George Stephenson was born June 9, 1781, at Wylam, a small colliery village on the north bank of the Tyne, about eight miles west of Newcastle. His father, Robert, was a Scotchman who came into England as a gentleman's servant, married the daughter of a dyer and shortly after came to Wylam where he secured employment as fireman of the old pumping engine at the colliery. Robert, the father, was very fond of children and birds, characteristics which were equally pronounced in his son George. "Bob's engine fire" was a favorite resort for the children of the village, and George was early entrusted with the duty of carrying his father's dinner and of seeing that the children were kept out of the way of the large coal wagons which were dragged by horses on the wooden tram road in front of the cottage door.

The family were in very straightened circumstances indeed, occupying the lower room at the west end of the cottage shown in Fig. 7. As the mines could not be worked successfully to great depths because of the expense of handling the fuel, the family were often compelled to move to new works as the old mines became run out. George was early called upon to assist in the family's maintenance. His first position was

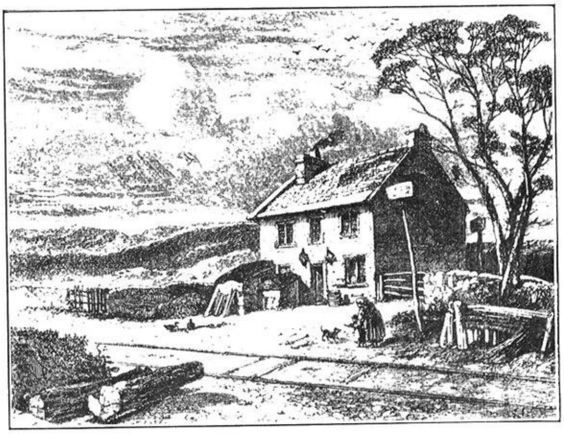


Fig. 7

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*Smiles' "Lives of Great Engineers."

herding cows, keeping them out of the way of passing wagons, for which he received two pence per day. As he grew older, he was set to work leading plow horses and soon was able to satisfy his highest ambition by securing employment at the colliery as "Corfbitter," or picker, cleaning the coal by picking out the stones, etc. Shortly after this he was set to drive the gin horse used for raising the coal from the mines and after some time secured a position assisting his father as fireman.

The mine, however, was soon worked out, and the family were again compelled to move to new fields, and George, who at this time was only fifteen, secured a position as fireman at a new colliery, working twelve hours a day at the rate of a shilling a day. This position he held for two years, working until the mine was run out, and then secured a similar position at another colliery, where his wages were soon raised to twelve shillings a week. Shortly after this he was promoted to the position of engineman, or "plugman," at a mine where his father was fireman, his duties being to keep the pump in working order, and when the level of the water in the mine was lowered, he had to descend to the bottom and plug the holes in the pump cylinder to prevent the pump from losing its suction.

While working as plugman, he formed the habit of taking his engine to pieces in his leisure hours for the purpose of cleaning and understanding its various parts, a habit which he kept up in later years when occupying more responsible positions and one which enabled him to gain a very practical knowledge of the construction of his engines.

Although eighteen years of age at this time, he was unable to read or write. He was, however, anxious to learn more of the engines of Watt, and, being told that they were fully described in books, he determined to learn to read. Soon after, he began taking lessons in reading and spelling three nights in a week. By dint of perseverance, he learned to read and, as an extra accomplishment, practiced "pothooks," so that at the age of nineteen he felt very proud in being able to write his own name.

Shortly after this, through the good offices of a friend and in spite of rather strenuous opposition from one of the miners, he secured a position as brakesman. His duties in this position were to start, stop and reverse the hoisting engine used for raising coal and men from the mine, duties considered so responsible that this position was one of the best paid in mining work.

At the age of twenty-one, Stephenson married and settled at Willington Quay. An incident happened at this time which, though apparently trivial, had quite an influence on his future life. The chimney of his cottage caught fire and, though soon extinguished, many of his household things were damaged, among them a clock which was so filled with soot that it could not run. Stephenson was urged to send it to a clockmaker, but instead he took it to pieces, cleaned and had it running very soon. In a short time he acquired quite a reputation as a clockmaker and was able to earn many a spare penny by repairing his neighbors' time pieces.

While living in this village, his only son, Robert, was born, and on him he lavished a great deal of affection and care which increased in succeeding years The two were unusually intimate and in later years worked a great deal together. His wife died when the boy was three years old, and this event, no doubt, drew father and son closer together.

Shortly after his wife's death, he received a call to a position as engineer at a new spinning works near Montrose, Scotland, to take charge of a new Boulton & Watt engine, and while here he secured quite a reputation as an "engine doctor" because of the remarkable success he had in repairing engines and pumps.

Missing the companionship of his friends, he soon returned to England and secured the contract of operating a hoisting engine at a mine. His attention was attracted to the excessive friction developed in the rope wheels, and after a little work, he reduced this and placed the engine in such good condition that the cost of operation was materially decreased and the contract made quite profitable. He gained considerable fame because of his skill and ingenuity in repairing engines and in increasing their economy. While doing work of this kind, he was frequently called to mines at a distance. These demands upon his time increased to such an extent that he left his position as engineman to devote his entire time to the repairing and altering of engines, and while engaged in this work did his first work with the locomotive.

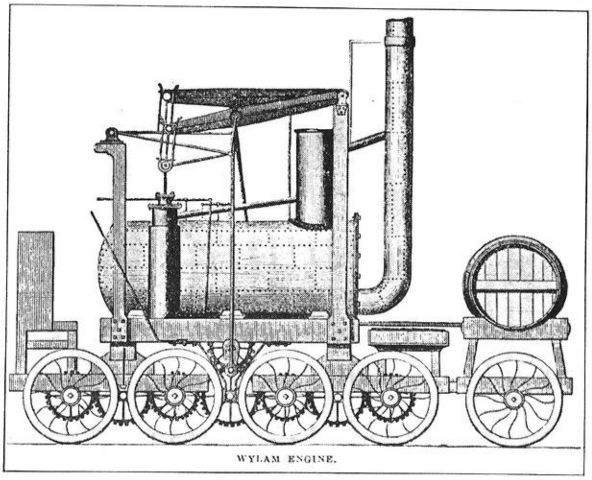


Fig. 8

He was often called upon to install and start new hoisting and pumping engines, and among other duties, laid out portions of the tram road over which the cars pulled by horses carried coal from the mines near Willington. The grades of part of this road were so planned that the loaded wagons descending a slight grade would pull up the empties, this being one of the first "self-acting inclines" built in this district.

While working upon the problem of a more economical transportation of coal from the mines, he made himself acquainted with the engines of Mr. Blackett, which were used on the road that passed in front of the cottage in which he was born. He also became familiar with the experiments of

Mr. Blenkinsop and seems to have thoroughly appreciated the defects of these "traveling engines," as they were called, and also the wonderful possibilities of this type of steam engine. After satisfying himself as to their adaptability for hauling coal, he persuaded some of his employers to furnish money for the building of an experimental locomotive.

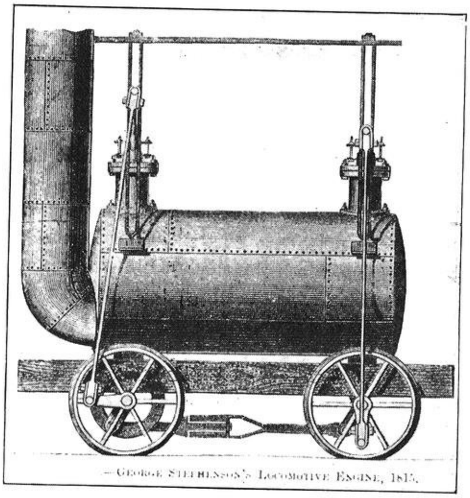
In this work Stephenson had to contend with difficulties similar to those which assailed Watt in his early work. Good materials and skilled labor were not available, and because of this the early locomotives were necessarily crude. However, after much labor, the locomotive shown in Fig. 8 was finally completed and placed on the rails July 26, 1814.

The boiler was cylindrical and of wrought iron, 8 feet long and 34 inches in diameter, with an internal flue containing the furnace or grate 20 inches in width. Two cylinders, 8 inches in diameter by 2-foot stroke, were placed on the side of the boiler. In order to couple the drivers to the engine the crank shaft was geared to spur wheels engaging with the driving axle in a manner similar to Blackett's locomotive.

Although this engine represented an advance over previous types, it was not an unqualified success. Very careful records were kept, and it was found to be no more economical than horses. The fate of Stephenson's first effort hung in the balance until he conceived the idea (probably original with him, although first used by Trevithick ten years before) of sending the exhaust from the engine into the stack and in this way increasing combustion and the power of the locomotive.

The success of the first locomotive being assured, Stephenson set about to improve its defects, and in 1815 brought out the locomotive shown in Fig. 9. This was the first locomotive to have the connecting rod connected directly to the wheels and also the first to use a coupling or side rod between the wheels. These rods were fastened to cranks on the axles between the rails, but, not proving very satisfactory, a sprocket and chain was substituted, to be replaced shortly after by the outside rod, as used in the modern locomotive.

Stephenson, as enginewright for the Killingworth colliery, achieved an enviable reputation because of the many improvements he introduced above and below ground. His locomotives, however, were looked upon with derision by many, although they continued daily their work of hauling coal. Some of them were used for this purpose for over sixty years, an unusual life for any locomotive.



—George Stephenson's Locomotive Engine, 1815.

Fig. 9

About 1818, Stephenson's attention was called to the possibilities of the locomotive for hauling passengers as well as freight, but he was soon convinced that the locomotive could not at this time be made a success for carrying passengers on dirt roads. His experiments impressed him with the advisability of avoiding grades if economical operation was to be secured, and the roads afterwards constructed by father and son were characterized by this particular.

It was not until 1819 that any other steam roads were introduced, probably because of the immense amount of capital required for these enterprises. In that year, the owners of the Hetton colliery decided to introduce steam traction and engaged Stephenson as their engineer. Their line was some eight miles in length and lay over a rather hilly country. He can certainly not be regarded as a visionary and impractical enthusiast of the locomotive, for he here installed five self-acting inclines and used stationary engines with cables for two others. The rest of the line was operated by locomotives running at a speed of four miles per hour and drawing a train of approximately 64 tons.

In 1817 a railroad was projected between Darlington and Stockton by Edward Pease for the use of the coal industry. After many disappointments, and in spite of opposition from almost all of the land owners concerned, a charter was granted by Parliament.

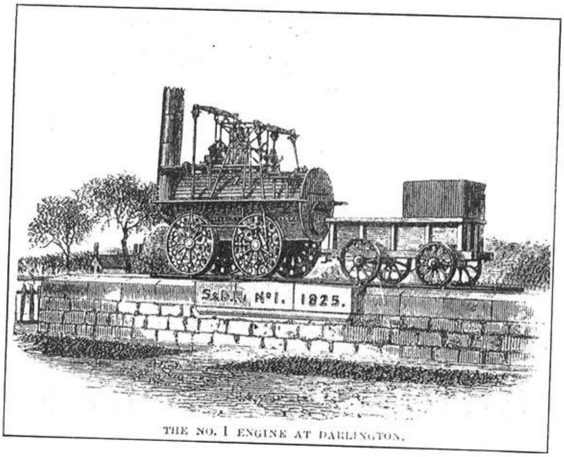
Stephenson interviewed Pease while he was formulating plans, and, acting on Stephenson's urgent advice, the charter which originally contemplated the use of horses was so altered that steam could be used if desired, and passengers as well as freight carried.

Some difficulty was met in trying to convince Mr. Pease of the advisability of this change until he was finally induced to make a visit to the Killingworth colliery and see the engines there used. After this visit, Pease became the firm supporter of Stephenson, and when in 1813 the long sought charter was finally granted, Stephenson was made the company's engineer, at a salary of $1,500 per year.

It is interesting to note that in his first estimates for this road, an item was included for several stationary engines to be used for hauling the cars up the heavy grades. At one point on the road, such an engine was installed when the road was finally built.

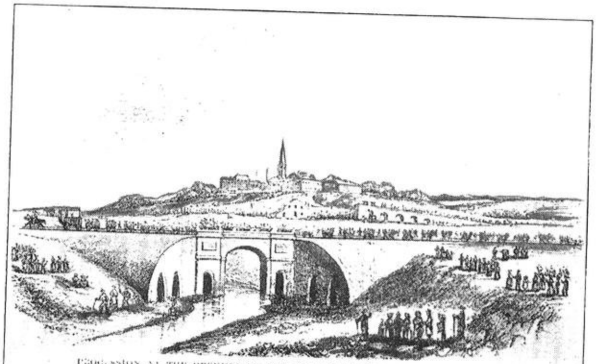
Among the important questions raised in constructing this railroad were the use of cast or wrought iron rails, the gauge of the track and the motive power.

Stephenson recommended malleable rails, but because of the expense, half of the rails were of malleable, the remainder being of cast iron. The gauge selected was that of



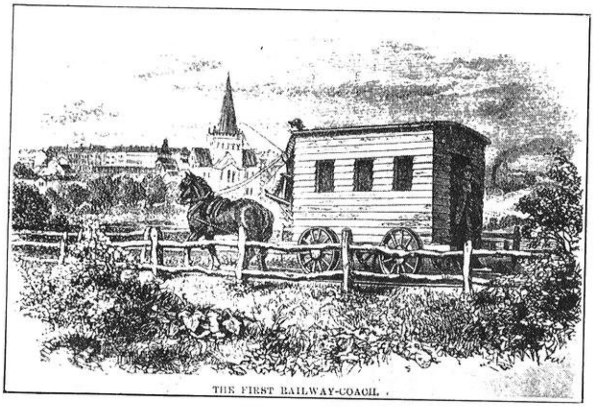
THE NO. 1 ENGINE AT DARLINGTON.

Fig. 10



PROCESSION AT THE OPENING OF THE STOCKTON AND DARLINGTON RAILWAY.

Fig. 11



THE FIRST RAILWAY-COACH.

Fig. 12

the wagons used at that time. The company wished to use many of these both for construction and for hauling coal after the line was completed. For this reason a 4-foot 8½ inch gauge, which is now standard, was selected.

The motive power to be used was open to debate for a long time. Arrangements were even made for the purchase of horses, but finally it was decided to give the locomotive at least a trial.

Stephenson, with the help of Pease and other friends, organized in 1823 a company for the manufacture of locomotives, and the railroad company purchased three of these. Engine No. 1, the first locomotive built at this factory, is shown in Fig. 10. It had 9-inch x 24-inch cylinders, with driving wheels 4 feet in diameter and could attain a maximum speed of twelve miles per hour, although usually operated at a much lower speed.

September 27, 1825, the Stockton & Darlington road was opened for traffic with considerable ceremony. (Fig. 11.) Many came, as they said, to see the bubble burst; others were there who did not want to miss the blowing up of the much vaunted traveling engine. A train of loaded wagons was hauled up an incline near Darlington and then lowered on the other side to where a locomotive was waiting.

The train consisted of six wagons, as they are still called in England, of coal and flour, then passenger coaches for the directors and their friends and, lastly, twenty-one wagons fitted up with temporary seats for passengers, followed by six wagons of coal.

Great attention was attracted by the very successful opening of this the first public railroad and the actual working of the line soon started.

The company had looked largely for its profits in the sale of coal lands rendered more valuable because of the road and were very much surprised at the extent and character of the traffic, which soon grew to such a degree that the sale of lands became a subordinate part of the operations.

The company did not anticipate any passenger traffic, but, just before starting the road, had Stephenson construct a coach for this purpose, to be drawn by horses and called "The Experiment." (Fig. 12.) This was not run by the company, but was rented to a contractor who paid toll for its use.

Other contractors soon secured the same privilege, for the charter specified that the road was to be free to those who chose to use it at prescribed rates. As there were only four sidings on the line, many amusing pugilistic encounters took place between the various contractors, until finally a post was placed midway between the sidings, and it was agreed that he who passed the post must go on and the coming man, back. From this very small beginning, the great passenger traffic of England and other countries has developed.

About this time, 1828, merchants and manufacturers of Manchester became indignant and provoked at the Canal Company because of the time required to transport cotton and other merchandise between Liverpool and Manchester, often requiring a longer time between these points than from the United States to Liverpool.

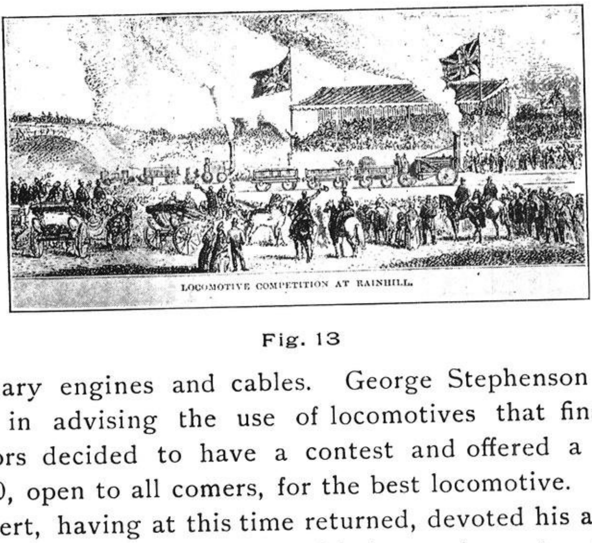
The canal company was rather dictatorial and opposed all efforts to introduce other methods of transportation. Finally, after almost endless bickerings, petitions and refusals, Parment granted a charter to the Liverpool and Manchester railroad.

Stephenson was selected as engineer of this company at a salary of $5,000 per year, and the survey was started. The opposition to the road was at times serious. The lives of the engineers were threatened, and only after the most arduous labors, often at night, was the survey completed.

An editorial written at this time in an English paper concerning a proposed railroad is of interest. It says: "What can be more palpably absurd and ridiculous than the prospect held of locomotives traveling twice as fast as stage coaches? We would as soon expect the people of Woolrich to suffer themselves to be fired off upon a rocket as to trust themselves to the mercy of such a machine going at such a rate. We will back old Father Thames against the Woolrich Railway for any sum. We trust that Parliament will, in all railways it may sanction, limit the speed to eight or nine miles an hour, which is certainly as great as can be ventured on with safety."

Time will not permit even a brief discussion of the difficulties met in constructing the road. Robert Stephenson, the son, at this time was in South America as engineer for a mining company, and the assistance the engineer of the road had was very meagre indeed. However, he persevered in spite of the discouragements and pushed the road to a successful completion.

The directors could not decide on the motive power to be used and received so many suggestions that they were confused. Finally they called in two eminent consulting engineers who, after due deliberation, recommended the use of stationary engines and cables. George Stephenson so persisted in advising the use of locomotives that finally the directors decided to have a contest and offered a prize of $2,500, open to all comers, for the best locomotive.



LOCOMOTIVE COMPETITION AT RAINHILL.

Fig. 13

Robert, having at this time returned, devoted his attention to their locomotive factory, and father and son together designed the famous "Rocket," to be entered at the contest. (Fig. 13.)

"On the first of October, 1829, the day appointed, four locomotive steam engines were nearly ready, but to give additional time to the various makers, the contest was postponed until the sixth of the same month.

"Mr. Geo. Stephenson entered the 'Rocket' in the name of his son, Robert; Timothy Hackworth entered 'The Sanspareil'; Messrs. John Braithwaite and John Ericsson brought forward 'The Novelty', and Mr. Burstall sent 'The Perseverance'. The last named engine was found unfit to take part and was withdrawn.

"The trials did not finally commence until the eighth of October. The length of the run adopted was one and one-half miles only, on a level part of the line at Rainfall, near Liverpool.

"The 'Rocket' was tried first on the eighth, the 'Novelty' on the tenth, and the 'Sanspareil' on the thirteenth.

"The whole of the experiments with the "Rocket' were performed without accident of any kind and with no delay inseparable from the circumstances under which the trials were conducted. The engine made a speed of twenty-eight miles an hour.

The experiments with the 'Novelty' were put to a stop after only two runs of one and one-half miles were made, owing to some part of the machinery giving way. Subsequently, on the same day, the engine, having been repaired, was again tried, and the highest rate of speed attained was twenty-one and one-sixth miles per hour.

"The experiments with the 'Sanspareil' had hardly commenced when one of the cylinders cracked through the bore into the steam port extending along its side, the thickness of metal having been reduced there by imperfect moulding and boring to hardly more than one-sixteenth of an inch.

"This failure lead to a considerable waste of steam at each stroke of the piston, notwithstanding which, however, the engine was kept at work until, twenty-two and one-half miles having been run at full speed, the feed pump stopped working, thus preventing the supply of water to the boiler necessary to continue the experiment. The mean rate of speed for twenty-two and one-half miles, exclusive of the ends of the stages, was thirteen and eighty-eight hundredths miles an hour. The first run of one and one-half miles was made at the rate of seventeen and forty-seven hundredths miles per hour, which was the highest speed attained by this locomotive.

"The 'Rocket,' as the only engine which had completed the stipulated distance, received the 500 pound prize, and the results fixed general attention upon the mechanical and commercial practicability of locomotive conveyance."

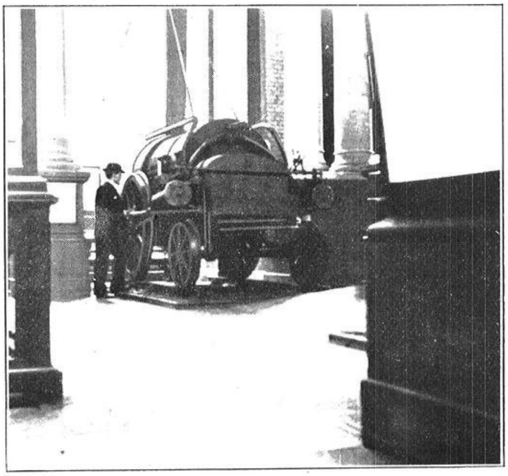


Fig. 14

Because of the results of this trial, "The Rocket" is considered of historic interest and is now kept in the Kensington Museum (Fig. 14).

"The boiler of this engine was cylindrical in form, with flat ends; it was six feet in length and three feet in diameter; the upper part of the boiler was used as a reservoir for steam, the lower half being filled with water; through this lower part twenty-five copper tubes, three inches in diameter, extended the full length, opening at one end into the fire box and at the other into the chimney.

"The fire box, two feet long and three feet high, attached mmediately behind the boiler, was also surrounded with water. The cylinders, two in number, were placed one on each side of the boiler in an oblique position, one end nearly level with the top of the boiler and the other end pointed to the center of the foremost pair of driving wheels, with which connection was made with the piston rod by a pin to the outside of the wheel.

"The Rocket" with its load of water weighed only four and one-fourth tons, and was supported by four wheels not coupled.

The position of the cylinders was later changed and brought nearer to the horizontal, as shown in Fig. 14, before the engine was put in actual service.

The Liverpool and Manchester Railway did not open until eleven months after the Rainhill contest, and during this time the design of Stephenson's "Rocket" was materially changed. When the road was first opened George Stephenson himself acted as engineer, and his son Robert as fireman.

The development of the locomotive from this time on was very rapid indeed. As early as 1830, locomotives capable of making a speed of fifty miles per hour were built and in use. Many types and designs were constructed and many costly experiments made before the present type, which represents the survival of the fittest, was produced.

In the design of locomotives it seems true that although many are called, but few are chosen. The problems are so different from the problems met by the designer of stationary engines that the field of locomotive engineering constitutes a separate branch of mechanical engineering.

As an illustration of this fact, the experience of Mr. Corliss, the renowned inventor of the Corliss engine, may be of interest. The account of his experience is given not to disparage the fame of that great engineer, but merely to illustrate how difficult the problem of locomotive engine designing really is.

Mr. Corliss, not content with the application of his four valve gear to the stationary engine, attempted to apply it to the locomotive in the early 50's. The result of this attempt can best be told in the words of Alexander Lyman Holly, in an after-dinner speech before the American Society of Mechanical Engineers at Hartford. He said:

"'The idea began to obtain that science should be pursued not in books but in things, and I commenced the pursuit of science in and on and under one of the awfullest things this world ever saw. It was Corliss' original locomotive, euphoniously called 'The Old Jigger.' This locomotive was possessed of a certain inborn cussedness which could hardly be an attribute of a mere machine. Her spiritual nature was a sort of Mephistophelian cross with a Colorado mule; and as to her physical constitution and membership, a cotton factory mule was simple in comparison. The 'Old Jigger' had, as nearly as I can remember, 365 valves, one to break down every day in the year. And as to valve motion, well, nobody ever counted the number of its pieces. They were as the sands of the seashore. Most of them used to jar off the first few trips of the week, after which it took all the men of the shop to keep track of them. I will say for the 'Old Jigger' that she made the best indicator card I ever saw from a locomotive; clean cut-off, almost a theoretical expansion curve, and an exhaust as if she had knocked out a cylinder head.

"'Well, once in a while, after she had been careening over the road about four hours behind time, and we had pinch-barred her into a round-house, we used to pull out those indicator cards of hers and talk them over right before her, and we would look at her and ask one another why in thunder an engine that could make a card like that, would act as if the old mischief were in her. She was an inconsistent old girl and lazy too—used to prefer to work with one side, and always made some plausible excuse for breaking down the other. I remember, one March morning when nobody was looking, she kicked off about two dozen pieces of her starboard valve-gear and brought up all standing over a culvert about ten feet wide and full of ice water. As I was standing in this culvert up to my middle, disconnecting her eccentric straps, a college professor came along, rammed his umbrella into me and asked me to explain to him the difference between this locomotive and any other locomotive. I then delivered my first scientific lecture; and I am now of the opinion that its diction would have been modified by a divinity student."

The valve gear of the locomotive was one of the most difficult of the problems to be met in the design, and many very ingenious devices were brought forward. None, however, were better adapted to its needs than that brought out by Stephenson's factory, and which still bears the name of the Stephenson link motion. It is probably one of the most wonderful pieces of mechanism ever designed. The gear, while quite simple, has an almost human control of the valve, and therefore of the engine, and permits the designer to accomplish almost any required result to meet the different requirements of freight, passenger service, etc.

Fig. 15

Fig. 16

The improvements made by Stephenson on the locomotive, its construction, design and possible speed are so fundamental that it is no more than just that to him should be accorded great praise for the work done in perfecting this powerful agent of civilization.

Smiles, in his work on the lives of great engineers, says of Stephenson (Fig. 15): "His fair, clear countenance was ruddy and seemingly glowing with health. The forehead was large and high, projecting over the eyes, and there was that massive breadth across the lower part which is observed in men of eminent constructive skill. The mouth was firmly marked, and shrewdness and humor lurked there as well as in the keen gray eyes. His frame was compact, well knit and rather spare. His hair became gray at a rather early age, and towards the close of his life was of pure silky whiteness. He dressed neatly in black, wearing a white neckcloth; and his face, his person and his deportment at once arrested attention and marked the gentleman.

"So great was his reputation as an engineer that he was called to Belgium to advise the king on the matter of railways and was also called to Spain as consulting engineer for a railway that was being promoted for that country. He became very active in the opening of new roads and was in great demand because of the skill that characterized his work. Near the close of his life he retired from the active performance of his profession and devoted his attention to agricultural pursuits. Even here his engineering training was manifest. He was constantly endeavoring to perfect the vegetables grown on his place and was at one time annoyed by the fact that his cucumbers could not be induced to grow straight, until he hit upon the expedient of growing them in glass bottles, which compelled them to grow perfectly straight. It is said that no one was more minutely acquainted with the habits of the British birds, and there was not a bird's nest on the grounds of which he was not acquainted. He died, 1848, in the 67th year of his life and was buried in Trinity church, at Chesterfield."

(Fig. 16.) Robert Stephenson, the son, worked with his father for many years and secured an enviable reputation for the character of his engineering work, particularly in the construction of bridges for railroads. He has perhaps received more fame because of the so-called tubular bridges which he built than for any other particular work. These were essentially box girders, through which and, in some cases, on top of which the track was laid.

The Brittania bridge (Fig. 17) consisted of two of these tubular girders, each 1,511 feet long and weighing 4,680 tons. The problem of erecting and placing these immense tubes was a most serious one, but was solved satisfactorily by first building the tubes, and then floating them into position, a process requiring extreme care and skill.

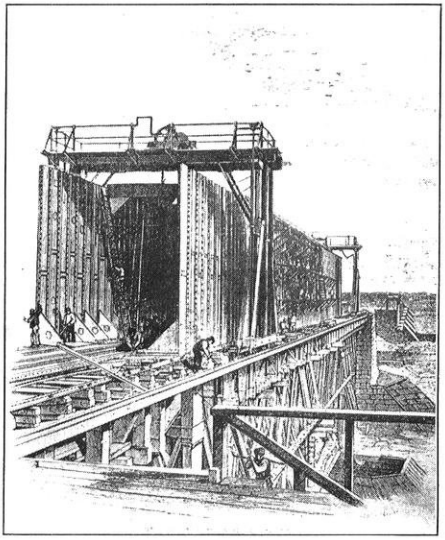


Fig. 17

Of him, Smiles states: "Robert Stephenson inherited his father's kindly spirit and benevolent disposition. He almost worshipped his father's memory and was ever ready to attribute to him the chief merit of his own achievements as an engineer. Like his father, he was eminently practical and yet always open to the influence and guidance of correct theory. His main consideration in laying out his lines of railway was what would best answer the intended purpose, or, to use his own words, 'to secure the maximum of result with the minimum of means.' He was pre-eminently a safe man because cautious, tentative and experimental, following closely the lines of conduct trodden by his father.... His great wealth enabled him to perform many generous acts in a right noble, and yet modest, manner.... Both father and son were offered knighthood, and both declined. He died October 12, 1859 and was buried in Westminster Abbey.

"As respects the immense advantages of railways to mankind, there cannot be two opinions.... As tending to multiply and spread abroad the conveniences of life, opening up new fields of industry, bringing nations nearer together and thus promoting the great ends of civilization, the founding of the railway system by George Stephenson and his son must be regarded as one of the most important events, if not the very greatest, of the first half of the nineteenth century."

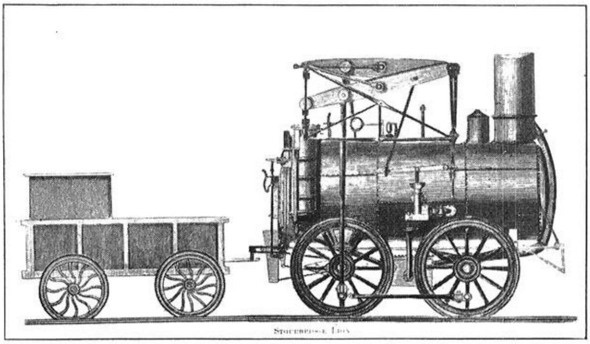


Fig. 18

The development of the locomotive in this country dates from the year before the "Rainhill Contest," when Mr. Horatio Allen was sent to England to select three or four locomotives for the Delaware & Hudson Canal Company. As a result, he contracted with the Stephenson Company for the "America" which was patterned after the "Rocket" and was the first locomotive to arrive here.

The "Stourbridge Lion," Fig. 18, built by another company was the first locomotive to run, while an American built locomotive, "The Best Friend," Fig. 19, has the honor of drawing the first train of cars. It was a four-wheeled engine having two inclined cylinders, 6 inches in diameter by 16-inch stroke. The drivers were $4\frac{1}{2}$ feet in diameter, and the weight was only $4\frac{1}{2}$ tons. The boiler was vertical, placed between the wheels, a little to the back. Unfortunately, the boiler exploded, caused by the negro fireman placing his weight on the safety valve to prevent the steam escaping, this being, as far as known, the first of many similar disastrous accidents marking the development of boiler construction in this country.

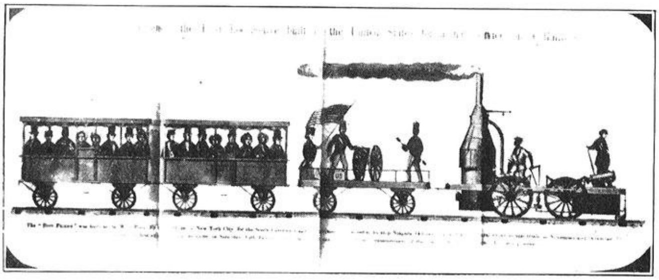


Fig. 19

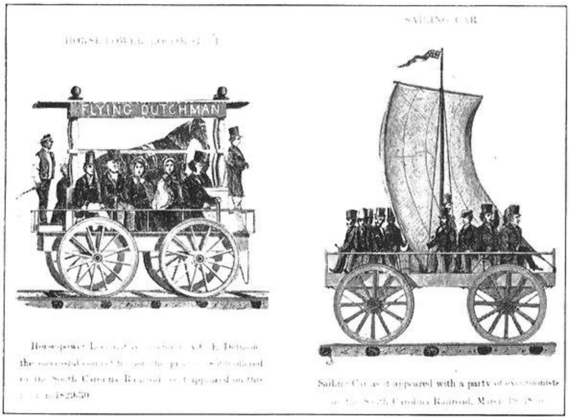


Fig. 20

The South Carolina Road, in 1830, offered a prize for the best type of motive power for their road, and Fig. 20 shows two of the different types submitted.

The third locomotive built by the West Point Foundry Association, the first company to manufacture locomotives in this country, was the "DeWitt Clinton," Fig. 21. This engine pulled the first railway train on the New York Central attaining a speed of 15 miles per hour. The cut also illustrates the early form of passenger coach used on these roads and their similarity to the old stage coach, from which the present form has been gradually developed.

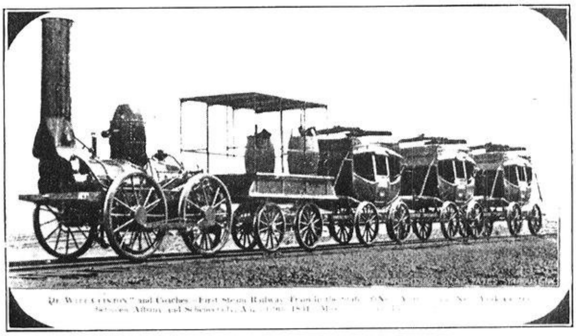

"DeWitt Clinton" and Coaches—First Steam Railway Train in the State of New York [illegible] New York Central [illegible] between Albany and Schenectady, Aug. [illegible] 1831 [illegible]

Fig. 21

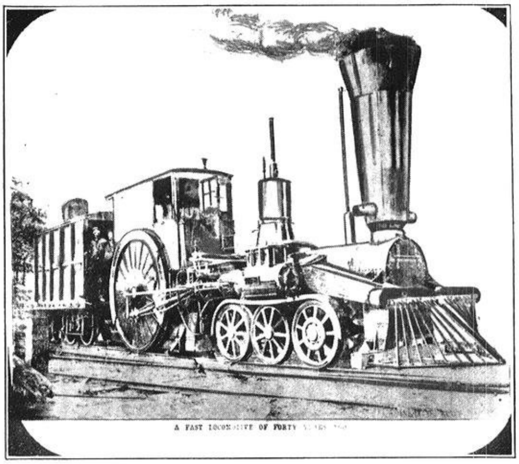

A FAST LOCOMOTIVE OF FORTY YEARS AGO

Fig. 22

Within the last half century, the changes wrought in the appearance, construction and speed of American locomotives are marvelous. A high speed locomotive built in 1855 is shown in Fig. 22, while a modern four cylinder compound is shown in Fig. 23.

This locomotive has two compound engines, one for each rail. The H. P. cylinder is placed inside the rail and is connected to the front axle drivers by a cranked axle. The L. P. cylinder is on the outside and is connected to the second pair of drivers. This locomotive is used on the N. Y. C. and H. R. R. R. for such fast heavy trains as "The Lake Shore Limited," "Fast Mail," etc. It can develope 1,631 Indicated Horse Power and maintain a continuous speed of about 60 miles per hour.

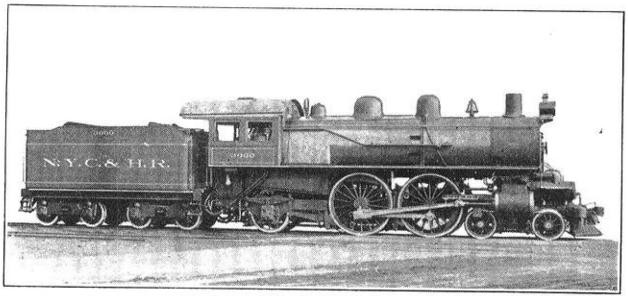


Fig. 23

Fig. 24 shows the largest locomotive ever built. It is a Mallet Articulated Compound Freight Locomotive with Walschaert Valve Gear and was exhibited at the St. Louis Exposition. It is about 80 feet long, exclusive of the tender, and weighs some 125 tons. It consists practically of two

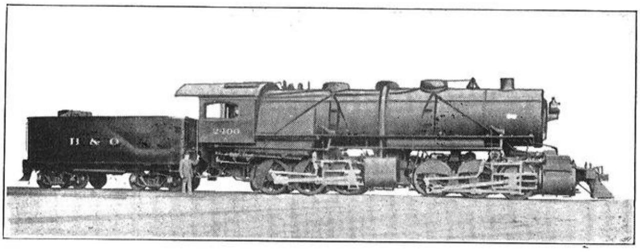


Fig. 24

compound locomotives connected to a single boiler. This locomotive was built for use on heavy mountain service of the B. & O. R. R., where the grades are steep and the curves sharp, and is giving very satisfactory results.

Recent tests of some compound locomotives show a steam consumption of from 19 to 27 pounds of steam per I. H. P., results that are certainly remarkable. The same tests show the normal consumption of coal per dynamometer H. P. is, for simple engines, from 3½ to 4½ pounds while for compounds it may be as low as 2 pounds.

The locomotive is essentially a steam engine, and, as Thurston has well said, "It stands today as a nobler monument, a higher tribute to the genius of man than any other product of his many and mighty powers the world has yet seen."

THE AVAILABILITY OF CORRESPONDENCE SCHOOLS AS TRADE SCHOOLS.

BY DUGALD C. JACKSON.

A half dozen years ago, the writer was chairman of a committee of the Northwestern Electrical Association, which drew up a somewhat extended report on the subject of the usefulness of correspondence schools to the employes of electric light companies. This report reviewed the work then being done by a number of correspondence schools, including the International Correspondence Schools of Scranton, Pennsylvania, and the American School of Correspondence, now of Chicago, Illinois.

A resume of the committee report was presented to the Society for the Promotion of Engineering Education at the Buffalo meeting of 1901. As the University of Wisconsin is now proposing to go into correspondence instruction, it will probably be interesting to some of the students and alumni if I review the latter paper, remodeling it somewhat, so as to give in brief scope the views of the committee on the trade education of central station employes. It is to be remembered that the deductions of the committee may be applied equally as well to other trades attempted to be taught by the correspondence schools as to the trades involved in the operation of electric central stations.

Among other characteristic propositions, the committee particularly considered the three following inquiries, giving special consideration, on account of the purpose of their appointment, to the conditions in electric central stations:

1. Can correspondence instruction be relied upon to increase the usefulness of employes to the employers?
2. Are existing courses of correspondence schools properly adapted to be of the greatest use to employes and through them to their employers?

3. What provisions may employers reasonably supply for the purpose of encouraging their employes to study the requirements of their business, and how may those provisions be executed?

Manifestly, these three branches of inquiry are thoroughly pertinent to the solution of the problem that the University has taken upon itself. Five schools which advertised correpondence courses that entered the field of the committee were considered.

It is not necessary here to enter upon the methods of enrollment, corporation forms, or capital invested in the several schools that the committee examined, and these questions will be passed over. The committee was dependent, to a considerable extent, upon the correspondence schools themselves in the effort to get information with respect to the schools, and considerable time and money was expended in interviewing managers at the various headquarters of the several schools, and in personal examinations of the arrangements for dispatching business.

All of the schools courteously responded to requests for information, and all of them, with one exception, gave fairly complete information upon points inquired about. The exceptional school courteously declined to lay bare its methods of business management and the results obtained by the school, but this school has since gone out of existence, and so cuts no figure in this article. The management of one school responded faithfully to the requests for information, but were unwilling to allow correspondence to be carried on with its scholars except through the home office.

In arriving at a conclusion in respect to the first query set forth above, we carried on a considerable correspondence with various scholars of two of the schools and received through the principal office of the third school answers to a series of questions which the scholars wrote out in reply to a request. A universal feeling amongst the subscribers of the schools, of either reasonable or enthusiastic satisfaction with the courses pursued, the methods of instruction and the results accruing in the way of bettered situations, was brought to light by this correspondence. The scholars were almost universally from classes of society to whom a common school education above the grammar grade has been an impossibility, but in a few cases, correspondence was carried on with men who can be properly classed as educated and skilled workmen.

On the whole, this correspondence confirmed the expectations which may reasonably be gained through abstract reasoning on the advantages of a special education for skilled employes or for apprentices who are expected to become skilled workmen. But it must be remembered that only a small proportion of the committee's correspondence was carried on with such men.

An illustration of such reasoning pertains to the affairs of electric generating stations and distributing circuits where the work requires skilled labor and is of such a nature that inefficient employes may cause wastes of greater or less magnitude in almost every operation, from the stoking of the furnaces to the testing of the meters. Not the least proportion of the losses in a central station are to be laid to inferior work in the boiler room. A fireman who has been well informed in regard to the combustion of the fuel and the relation between fuel combustion and admission of air to the furnaces, may every week save a sum comparable to his wages, as compared with an uninformed or careless fireman. Each fireman with a hand shovel may handle coal which has a value exceeding many times his wages. The difference between judicious and injudicious handling of this coal makes a marked difference in the earnings of a station.

A properly planned correspondence course may put the fireman upon a proper footing with respect to his handling of the coal. The engine runner, the dynamo tender, and the machinery oiler may each likewise be made more efficient through a proper understanding of his business, with a resulting considerable increase in the net earnings of a station. It is particularly important that the chief operating engineer of a station and the superintendent of the company shall be well trained in matters relating to the economical combustion of fuel for the raising of steam, the economical operation of steam engines and auxiliaries, as well as the economical handling of electrical machinery and devices, and that they shall be competent to properly instruct all the station employes.

In all of these matters, and many more, properly planned and administered correspondence courses may be relied upon to increase the usefulness of employes. The experience of the gas light companies may be looked upon as a precedent. Correspondence instruction of employes has been of such value to these companies that various corporation members of the American Gas Light Association at one time contributed liberal sums to a fund called the "Gas Educational Fund" which was used in carrying on correspondence courses for especially designated employes of the contributors.

Correspondence instruction alone, however, cannot be relied upon to bring the greatest results, but to it must be added practical demonstrations of the proper methods of handicraft. These supplementary demonstrations may be conveniently supplied by the correspondence schools themselves for some trades, as is proven by the marked success of the instruction of railroad train hands by one of the correspondence schools through correspondence instruction which is supplemented by the liberal use of well equipped "instruction cars" for practical demonstrations. The same school has also fitted up in the local headquarters at Chicago and elsewhere very complete demonstration equipments for additional air-brake instruction and special instruction in other features of train running.

A demonstration car cannot be so readily brought to the employes in most trades, nor can the employes in most trades be so readily brought to the local headquarters of a correspondence school. Consequently, some other plan must be devised. A practicable plan is to depend on the state (whose welfare and wealth depend upon industrial progress) to establish special trade schools for the several trades. Complete trades courses may be obtained in the trade schools by those who live in the immediate vicinity or who are able to remain in the vicinity for a considerable period, and in addition thereto correspondence scholars may here obtain the requisite practical demonstrations that are essential to their trades.

In another practicable plan, the existing engineering colleges may enter to a certain degree the field of the trade schools. Much of the laboratory apparatus and appliances used in the professional engineering courses may be readily adapted to trades instruction, to which purpose it may be put for a few weeks at a time in the summer or other periods when it is not under requisition for the professional work. By a proper arrangement of this equipment, it may be brought into use for trades instruction under the conditions named without in any way trespassing upon its use in its regular service in the professional engineering courses. This is the plan that has for several years been tried at the University of Wisconsin, in the Summer School for Artisans and Apprentices. It was a unique experiment, but one which was bound to succeed. In this plan which has heretofore been in operation at Wisconsin, instruction is given to all comers in the scientific applications pertaining to various trades, and it is my understanding that many subscribers to the correspondence schools have embraced this opportunity to round out the character of the instruction received by correspondence. Certain of the correspondence schools early approved this plan.

The trade intruction of the correspondence schools as it now exists is at fault in another direction. The books of several schools are well written and reasonably accurate and up-to-date, but the courses should contain much less of design and of matters verging on professional engineering and much more of the trades details before they may be of the greatest usefulness to skilled workmen and apprentices. It, again, justly creates a favorable impression of the correspondence schools that they themselves appreciate the conditions and are doing much work to improve their courses in the direction here outlined.

The results of the careful study of the situation by the committee may be briefly epitomized as follows: The idea of correspondence instruction in the trades as they are situated in this country is an excellent one, and good is coming from the correspondence schools. The administrative methods of the schools, as far as the treatment of enrolled scholars is concerned, are good, as a rule; but the sensational methods resorted to in advertising, and the jealousy of the schools for each other, are to be deplored. It is not easy to inspire to study by correspondence, but valuable instruction in facts, which is exactly what is required in trades instruction, may be given. To make this most useful, auxiliary physical demonstrations must be added to the correspondence instruction in a manner analagous to that in which demonstrations are made to railroad trainmen through the traveling instruction cars, which carry complete outfits of air-brakes or other train devices.

The experience of many railroads, gas companies, electric light companies and other industrial concerns all goes to substantiate the natural inference that proper instruction may be relied upon to increase the usefulness of skilled employes, and that this increase of usefulness will result in advantage to both employed and employers. There is a demand for such proper instruction which has not been filled. The correspondence schools have tried to fill it and have done good. After their courses of instruction are more closely adjusted to the requirements they will do more good; but adequate *practical demonstrations in handicraftsmanship* must be added to supplement the correspondence instruction before the courses can reasonably fulfill the demand for trades instruction. And, however much the correspondence schools may do, there will still be a large opportunity to be filled by fixed trades schools in all large communities.

It must be remembered, also, that the engineering schools have no organic connection with the sphere of the trades schools, and that the two spheres are so little in contact that there is no necessity for affiliation between them, but that the faculties of the engineering schools can do much to guide trades education in the right direction by the mere weight of influence and suggestion.

It is an interesting and notable fact that all of the plans which are being made by the University of Wisconsin, as I understand them, for carrying on correspondence instruction in the industrial trades, include actual practical demonstrations in the laboratory, such as those referred to in the report of the committee. It is now suggested that these laboratories may not only be located at the University and at proper centers in the larger cities of the states (of course, under University supervision), but that traveling laboratories, made up of a railway locomotive with one or more laboratory cars which may be moved by rail from place to place, may be usefully added to the equipment for the purpose of bringing laboratory advantages, at appropriate or needed intervals, into the smaller cities, where the location of permanent laboratory centers could not be afforded.

Every student of the industrial situation, who sympathizes with the idea that the workmen must be afforded adequate training in their trades, cannot but take deep interest in this move on the part of the University of Wisconsin and give it his heartiest encouragement.

DISTRIBUTION LOSSES.

JOHN C. POTTER, U. W. '04.

In every central station system there are losses from the time the coal is used in the boilers to the time the generated current is delivered to the consumer. Some of these losses are very large and some are small, some have been reduced to a minimum, while others are far greater than they ought to be. But whatever the nature of these losses, it is the duty of every good manager to know as much as possible about them. In these days, when competition is so keen, it is the person who takes care of the details of his business, no matter how small they may seem, who is successful.

The chance for losses from the time the generated current leaves the station to the time it is used by the consumer may not appear very great, but if the power house meters be checked with those of the consumer, it will be found that the losses vary from a small per cent in small D. C. stations to as much as forty or even fifty per cent of the station's output in some A. C. stations where individual tranformers are used. Some of this current may have been stolen, which is not an uncommon occurrence. The wires may have been tapped outside the meter, or the meter shunted, or other similar things done for part or all of the time. Or it is possible that there is a ground or short of some kind which gives a more or less constant loss, depending upon its nature. In other cases there might be an excessive copper loss in the feeders, or the transformers may be of poor design. But whatever the losses are, they must be known before they can be corrected.

During the summer of '05 the distribution losses of the A. C. lighting system of Milwaukee were very carefully determined. Before this a rough estimate had been made which showed that about 33 per cent of the power generated was lost. Now if this was so, where did it all go? That was the question to be answered.

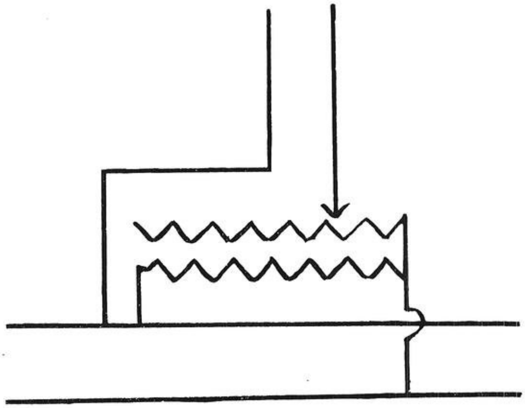
The T. M. E. R. & L. Co. has two main stations in Milwaukee, the Oneida St. station and the Commerce St. station. The Oneida St. station generates current for D. C. incandescent lighting, D. C. railway current and current for D. C. series arcs. The Commerce St. station is considerably larger than the Oneida St. station and at the time the tests were made contained the following machines: four 1,500 K. W., 13,000 V., 25 cycle, 3 phase alternators; four 2,000 K. W., 600 V., D. C. railway generators; and two 1,000 K. W., 2,300 V., 60 cycle, three phase turbo alternators of the Curtis type for A. C. lighting. The last two as well as one of the 600 V., D. C. machines were being installed and were, therefore, not in use.

The 2,300 V. lighting current at that time was obtained from two 500 K. W. motor generators which transformed the 13,000 volts to 2,300 volts, and changed the cycles from 25 to 60. The A. C. series arcs in the outlying districts of the city were also run from these converters, there being between 550 and 600 lamps in all. The power from the 13,000 V. machines which was not used in this way, and which was by far the larger part, was sent out to the substations at West Allis, Farwell Ave., Kinnickinnic and South Milwaukee and at these places was converted into 600 V. direct current for railway work.

The A. C. lighting current was distributed by means of fifteen feeder panels and their corresponding feeders to all parts of the city and to Wauwatosa, except a part of the business district which was near the Oneida St. station and which was supplied with D. C. current from the same.

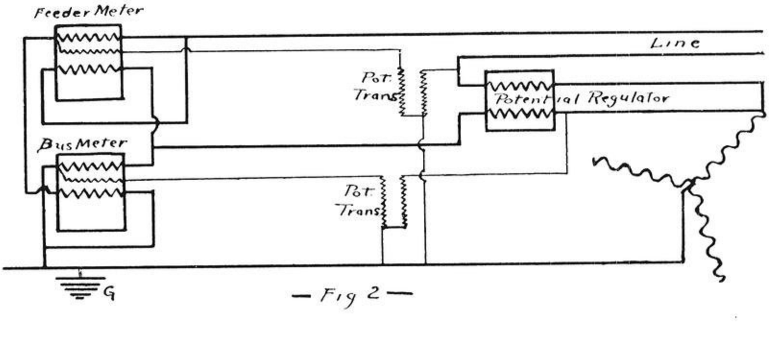
Each feeder, before it left the station, ran through a potential regulator of 17½ K. W. capacity. (Fig. 1.) These regulators were simply transformers which could either boost or crush the voltage. They were operated by small D. C. motors which were controlled by switches on the feeder panels.

In order to know what the total distribution loss amounted to, it was necessary that wattmeters be placed upon each feeder at the power house. The readings as given by these meters, less the sum of the readings of the various consumers' meters, was the total amount of power lost. Ordinary G. E. induction meters, the same as were installed for consumers, were used. Of course they were carefully regulated for both heavy and light loads.



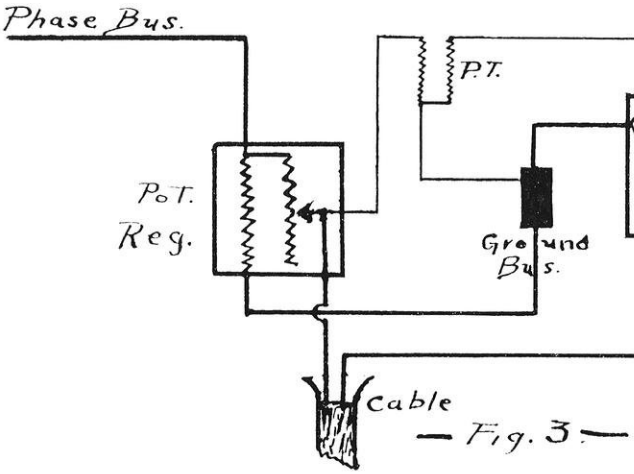
— Fig I —

On one of the feeders two meters were placed, one on each side of the potential regulator. This was done in order to measure the loss which occurred in the regulator (Fig. 2). The meters on the feeders, with the exception of the one already mentioned, were connected either as in Fig. 3 or Fig.

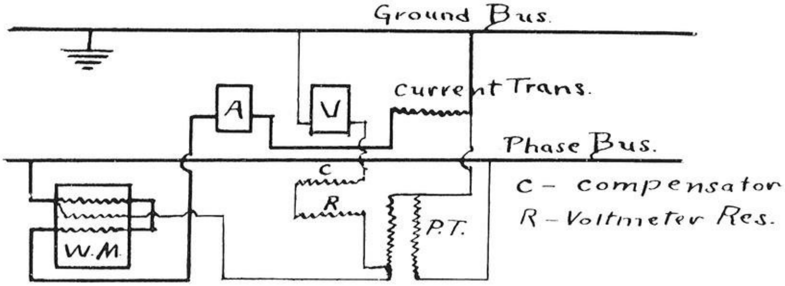


— Fig 2 —

4. In the first case the ground line was cut and the current coil of the wattmeter placed in series with it. It was also necessary to run a wire to the potential transformer to which the voltmeter was connected. In the second case a three-wire instrument with the current coils in series was used. It was put in the ammeter circuit which was supplied by a 20–1 current transformer. The potential lead in this case was connected the same as before. The multiplying factor using the connections of Fig. 3 was 20, in the case of Fig. 4 it was 200.



— Fig. 3 —



— Fig. 4 —

The distribution losses were divided as follows:

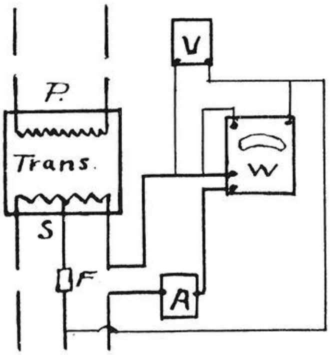
1. Transformer iron loss.
2. Transformer copper loss.

3. Feeder or primary C^2R line loss.
4. Main or secondary C^2R line loss.
5. Meter shunt loss.
6. Lost and unaccounted for electric power.

Each feeder must be considered by itself in order to facilitate the tracing of the various losses.

The transformer iron losses were obtained by multiplying the iron loss per transformer by the number of transformers on the circuit and this product by the number of hours in use. Of course this had to be done for each size of transformer used.

All transformers, before being placed in service, should be tested for both iron and copper losses, and a careful record of these tests kept. A check on the iron losses should be made whenever a transformer is brought in for any reason, or, if changes are infrequent, certain pilot transformers should be selected and periodic tests made upon them.

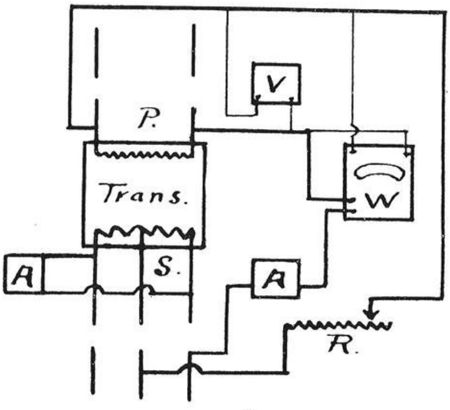


— Fig 5—

The only data which was obtainable in this case was the losses of each transformer as given by the manufacturer. This made it necessary to test as many of the transformers as possible.

The connections used for determining the iron loss of a transformer are shown in Fig. 5. In order to test in this way it was necessary to have at least two transformers connected to the same network of secondary lines. The primary fuses of the transformers to be tested were pulled, as well as were two of the three fuses of the three-wire secondary. In place of one of these secondary fuses the wattmeter current coil and the ammeter were placed. The losses obtained were slightly more than those given by the manufacturer.

The tests which were necessary in order to obtain the copper losses of the transformers were made at the same time the iron losses were found. The connections used are given in Fig. 6. The three fuses in the secondary side and the two in the primary of the transformer to be tested were all pulled. Current was taken from the secondary network through a variable resistance, the transformer primary, a wattmeter and an ammeter. The potential coil of the wattmeter and the voltmeter were both connected across the transformer primary. The variable resistance consisted of a pail of salt or slightly acid water in which was placed electrodes made from four lighting carbons fastened side by side. The secondary of the transformer was short circuited through an ammeter. The current in the transformer was varied by means of the resistance. Readings were taken for $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and full load, and from these, what was called a loss curve was plotted.



— Fig 6 —

In order to find out just how the load on the different transformers varied, load readings were taken in the central station for each feeder. This was done twice a month. The load curves for Saturday and Monday were similar, Sunday had a curve of its own and the other four days of the week had still a different curve. So the readings in the central station were taken for Friday, Saturday and Sunday, thus getting a curve for each of the three conditions. In figuring the copper loss in the transformers, it was assumed that each transformer took as much of the load as its rating bore to the sum of the ratings of the transformers upon that feeder, except in cases where peculiar conditions existed, such as a large store, factory, or church, which facts were taken into consideration. From the above data it was possible to calculate the losses for all the transformers on the line. The potential regulators were treated as transformers.

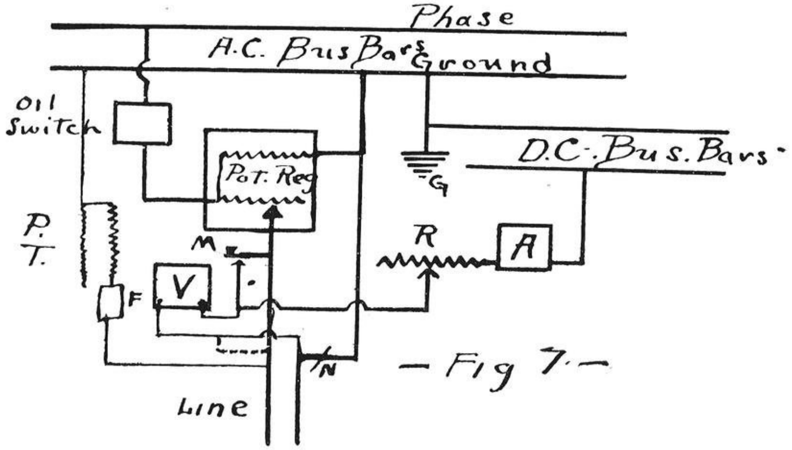
In order to obtain the primary resistance losses, the size and length of the feeders must be known, as well as the variation of the load. As has already been said, if more than one transformer or group of transformers were on a feeder, the load was assumed to divide in proportion to the connected load of each branch, unless there was some known variation of this rule. The total C^2 R loss for each feeder can now be calculated with the aid of the same load curves that were used above. It might be mentioned that the accuracy of these sample load curves may be checked by comparing them with the total output of the station for the month.

In order to see if the resistances of the cables as determined from the data at hand—*i. e.* the size and length—are the actual resistances, measurements were made. The instruments were connected as shown in Fig. 7. The oil switch was first opened, and fuse "F" was pulled. Connections were made from the 500-volt D. C. phase bus through an ammeter, water resistance, switch M, down through the cable and back to the ground bus. The voltmeter was placed across the cable terminals. The calculated resistance and the actual resistance as found from the test checked very closely.

Just after the resistance test, a test for insulation resistance was made. The circuit was opened at M, and also at N (Fig. 7). R was short circuited. The total D. C. voltage was measured. The terminal of the voltmeter which had been connected to the A. C. grounded cable was transferred to the A. C. phase bus (Fig. 7). The leakage voltage was then measured. The insulation resistance could now be determined from the formula

$$R=\frac{r\,(E-e)}{e}$$

where R is the insulation resistance, E the total voltage, e the leakage voltage and r the voltmeter resistance. The total time necessary for the circuit breaker to be open in order to perform the above two tests was about three minutes.



— Fig 7. —

The secondary resistance loss was figured in much the same way as was the primary, only it was necessary to use more judgment in the distribution of the current. It was necessary to know whether the secondary lines supplied stores, offices, or residences, and also upon what part of the secondary network these loads were connected. From this data centers of load were determined, at which places the entire load was supposed to be concentrated, thus making it possible to find the C^2R loss.

As an aid in determining the above, a number of tests were made with a small current transformer so constructed that it could be clamped around any conductor in which it was desired to know the current. These measurements also showed whether the loads in the three-wire secondaries were properly balanced.

The next loss to be considered was the meter shunt loss. A record had been kept of all meters sent out, their make, size and type, and also a record of their tests. These tests showed practically the same loss as that given by the manufacturer.

One would naturally think that the meter shunt loss would be small and not be worth considering, but table IV shows it to be about the same as the transformer copper loss or the feeder losses. Of course the percentage of this loss to the total output is greater in summer than it is in winter when more current is used.

A record of the power used by each consumer was kept on accounting cards. But on these cards, only the watts to the nearest thousand were recorded. Of course this did not make any difference in the amount a consumer would pay, for if his bill was large one month, it was just that much less the next. This method, however, made it necessary to make what was called a "last dial correction." In the meter reader's books was a fac simile of the dials of each meter, upon which were marked the positions of the hands as they were at the time the reading was taken. From these books the actual amount used by each consumer was readily obtained.

As the meters were not always read upon the same day of each month, a correction had to be made because of this in the amount of power used by each consumer.

Still another correction was due to the fact that when a meter was tested the hand of the last dial was set back one space. This was done to differentiate between a tested meter and one which had not been tested. Whenever a new meter was installed, or an old one replaced, the meter put in had to make up this last unit before it registered. Of course this had to be taken into account.

After all of the above data has been collected for each circuit, it is an easy matter to determine where the trouble lies, if there is any trouble. Such information will show at a glance whether or not line losses are excessive, or core loses too high, or whether all transformers are properly loaded, and in fact will enable changes to be made so that the lines may be operated at the highest possible efficiency.

There is a further side to this question, however. It may be economical to waste energy as long as interest has to be paid on borrowed money. It is, of course, possible to reduce C^2R losses to a negligable amount by putting in enough copper in the lines, but it may not be economical to do so. It is the duty of the engineer to design a system which shall give the best results for the least annual expenditure; he must avoid losses in transmission up to the point where the expense of avoiding the losses becomes greater than the cost of the energy lost.

I. SUMMARY OF TRANSFORMER IRON LOSSES. K. W. Hrs.

Month.	3 K. W.		5 K. W.		7½ K. W.		10 K. W.		15 K. W.		17½ K. W.		25 K. W.		Total.	
	No.	Loss.	No.	Loss.	No.	Loss.	No.	Loss.	No.	Loss.	No.	Loss.	No.	Loss.	No.	Loss, K. W. Hrs.
July........	10	360.0	24	1123.2	12	864.0	11	949.6	9	1035.9	11	1518.0	22	3770.8	98	9,621.5
August	10	372.0	25	1210.0	12	892.8	11	982.3	9	1071.0	12	1716.0	22	3897.0	101	10,140.1

II. SUMMARY OF METER SHUNT LOSSES. K. W. Hrs.

Month.	Induction 2½ Watts.			T. R. W. 5 Watts.			T. R. W. 10 Watts.			Total No. Meters.	Losses.		
	Prev. Inst.	Ins. dur. Mo.	Total.	Prev. Inst.	Ins. dur. Mo.	Total.	Prev. Inst.	Ins. dur. Mo.	Total.		Induction.	T. R. W.	Total K.W. Hrs.
July	392	47	439	481	12	493	4	....	4	936	790.2	1,792.8	2,583.0
August	442	29	471	490	5	495	4	...	4	970	897.8	1,814.4	2,662.2

III. CORRECTIONS APPLIED TO SALES. K. W. Hrs.

Month.	Total Sales Uncorrected.	Total Sales Corrected.	Difference.	% Corrected Sales.	New Meters.	−9 Correction.	% Difference.	% Corrected Sales.	Last Dial Correction.	% Difference.	% Corrected Sales.	Correction to Even Month.	% Difference.	% Sales.
July........	95,134.3	96,861.3	+1727.0	+1.78	59	+48.2	+2.8	+.05	+1678.1	+97.2	+1.73	Included in last dial correction		
August.....	111,496.9	111,009.0	+1512.1	+1.3	35	+30.5	+2.0		− 46.2	−14.3	− .1	+1697.8	+ 112.3	+ 1.4

IV. SUMMARY OF FEEDER LOSSES. K. W. Hrs.

Month.	Total Output.	Total Sales.	% Output.	Trans. Iron Loss.	% Output.	Trans. Copper Loss.	% Output.	Prim. C²R. Loss.	% Output.	Sec. C²R. Loss.	% Output.	Meter Shunt Loss.	% Output.	Known Losses.	% Output.	Unknown Losses.	% Output.	Total. Losses.	% Output.
July...	121,261.0	96,861.3	79.9	9,621.5	7.9	2,138.6	1.8	2,859.9	2.4	1,341.8	1.1	2,583.0	2.1	18,544.8	15.3	5,854.9	4.8	24,399.7	20.1
Aug ..	139,556.6	113,009.0	81.0	10,138.5	7.2	3,016.4	2.2	3,303.7	2.4	1,544.6	1.1	2,662.2	1.9	20,665.4	14.8	5,882.2	4.2	26,547.6	19.0

MOTORGODILLES AND HYDROPLANES.

By W. B. Homan.

Motor boat manufacturers believe Thomas A. Edison's discovery of large deposits of cobalt during his recent prospecting trip through North Carolina will have an important bearing on the motor boat races to be held at the Jamestown Exposition at Hampton Roads in 1907. For the past five years manufacturers of motor boats have been hoping Mr. Edison would be able to put on the market his new storage battery, which would be not only cheaper, but would also combine greater power with less weight and bulk than the existing style of batteries. This metal is one of the essentials of the new battery. Deposits of cobalt have hitherto been scattered and of small extent. This, of course, made the price high. In an interview given out a few days ago, at the conclusion of his prospecting trip, Mr. Edison said he had found large deposits of cobalt all through the northwestern part of North Carolina, and hoped to go forward with plans that had been held in abeyance by reason of not being able to get cobalt in sufficient quantities.

The motor boat appliances that will most benefit by this new discovery are the hydroplane and the motorgodille. Both are new inventions.

The hydroplane consists of a series of thin plates fixed to the boat below the water line and tilted at such an angle that when the boat is set in motion the hydroplanes lift it out of the water in the same manner that a kite or æoplane is lifted. This makes the boat skim over the surface of the water rather than plow through, and by lessening the water friction increases the speed. A small boat, weighing with two men 550 pounds, was lifted clear from the water while going at the moderate speed of fifteen miles an hour. Larger boats have been lifted from the water at higher speed, and the discoverers of this principle claim boats can make from forty-five to fifty miles an hour when equipped with them. They believe that with a battery of small compass and great power records so far never attempted can be made.

The motorgodille is an invention recently brought out in France by G. Trouche & Company and manufactured near Paris. It, like the hydroplane, requires a light and powerful battery for the best results. It consists of a screw propeller fixed upon a shaft and fastened to a socket in the stern of the boat. The power of the storage batteries is conveyed to the propeller shaft through a small portable motor. Like a sculling oar, it can be used to either steer or propel the craft to which it is attached. The principle of sculling with a single oar thrust through a rowlock in the stern of boat is, in fact, responsible for the invention of the motorgodille. It can be fastened to or removed from any rowboat in a few minutes and requires no alterations in the boat to which it is fastened. With a motorgodille an ordinary skiff can be converted into a motor boat in a few minutes. The inventors believe that with powerful batteries, of small size and great power, such an improvised motor boat can beat most of the swift white racers equipped with ordinary engines.

Owners of motor boats of the existing styles, on the other hand, are looking forward to the time when they will, by means of Mr. Edison's new battery, store tremendous power in small space, and not only smash all existing records, but protect the new ones from all comers.

If the great inventor puts on the market the long awaited storage battery, there will be a battle royal at Hampton Roads next summer for the honor of being the speediest craft afloat.

THE JUNIOR ENGINEERS' EASTERN TRIP APRIL, 1906.

WM. K. WINKLER.

The first two and one-half years of an engineering course are almost entirely devoted to theoretical studies. The average student has had little practical experience up to the middle of his junior year, and cannot see the value of this long term of mathematics, physics, mechanics, etc. It is for this reason that the engineering trips are planned. They give an opportunity to see the theory of engineering studies applied to actual practice, and give a chance for travel which is always of a broadening influence.

The party of junior engineers, of which I was a member, who took the eastern trip, left Madison for Chicago the morning of April 6th, over the Illinois Central railroad. Although this is only a small branch line as far as Freeport, it goes through interesting country of very rocky and hilly formation. At one place it passes through a tunnel about one-third of a mile long cut through solid rock. From Freeport to Chicago it is a main line, the roadbed being very good. We left Chicago in the middle of the afternoon on the Michigan Central road for Buffalo, stopping off at Niagara Falls all day Saturday for sightseeing and visiting plants, and resuming our trip to Buffalo in the evening.

The first plant visited was the Niagara Falls Power Co., an immense electrical installation which utilizes power from the falls to operate water turbines, which are directly connected to electric generators. The water is taken from the Niagara river about a mile and a quarter above the falls by an in-take canal 1,250 feet long and varying in breadth from 100 to 200 feet. Two power developments, one on either side of the canal and running parallel to it, make up the complete installation of this company. The plant constructed first is called Power Plant No. 1, and the newer one, Power Plant No. 2. In the No. 1 plant there are ten 5,000 H. P. turbines, and in the other, eleven of 5,500 H. P. Water is distributed from the canal to each one of the twenty-one turbines through separate steel penstocks of seven and one-half feet diameter. The turbines are located at the bottom of two immense wheel pits, that of plant No. 1 being 424.7 feet long, 18 feet wide and 178.5 feet deep; that of plant No. 2 being 466 feet long, 17.5 feet wide and 177.43 feet deep. The discharge from the turbines is carried to the river below the falls by a tunnel 7,000 feet long, 200 feet below the surface, and having a horseshoe shaped section, 21 feet high by 18 feet 10 inches in maxinum width.

The equipment of the No. 1 plant consists of ten Fourneyson inverted twin turbines, each of 5,000 H. P., working under a head of 136 feet. They were designed by Faesch and Piccard of Geneva, Switzerland, and built by the I. P. Morris Co. of Philadelphia. Governors control the flow of water at the turbine wheels, keeping a constant speed no matter what changes occur in the load. Faesch and Piccard designed three of these governors which operate mechanically, and Dr. Coleman Sellers, chief engineer of the company, designed the other seven which are operated electrically. They were all built by William Sellers and Co. of Philadelphia. Ten 5,000 H. P. A. C. generators are directly connected to the turbines by a 38-inch hollow shaft built in three sections. Each section is joined to the next one by a short solid shaft 11 inches in diameter and revolving in a bearing. The generators are about 140 feet above the turbine wheels. They were designed and constructed by the Westinghouse Electric and Manufacturing Co., and are of the vertical type, making 250 R. P. M. The weight of the revolving parts of the turbine and generators is 150,000 pounds for each unit, and is supported by the hydrostatic upward pressure of the water in the turbine wheel case upon a disc fastened to the shaft.

The equipment of Power Plant No. 2 consists of eleven Francis single turbines, equipped with draft tubes, each of

5,500 H. P. The wheels are 5.33 feet in diameter, and work under an average head of 141 feet. These wheels were designed by Escher, Wyss and Co. of Zurich, Switzerland, and were built by the I. P. Morris Co. High pressure oil governors, designed by the designers of the turbines and built by the Falkman-Sinclair Machine Co., of Philadelphia, control their speed. The generators are 5,500 H. P., built by the General Electric Co., and are very similar to those in Power Plant No. 1, with the exception that six have revolving fields. The output of the eleven generators is controlled and distributed from a single operating switch-board, through two groups of electro-magnetically operated oil break generator and feeder switches, designed and installed by the General Electric Co., under specifications of the Power Co.'s engineers.

Two step-up transformer stations are located at the plant. From these the power is distributed to nearby factories, and to their terminal station in Buffalo, twenty-two and one-half miles away. Here it is taken by an overhead transmission, and is distributed to consumers in Buffalo. The company owns a great deal of property in its immediate vicinity, some of which is occupied by factories using their power, but a great deal can still be had by companies looking for an ideal location with available electrical power. It is interesting to know that the power produced by the installation of the Niagara Falls Power Co., to be produced by steam, would require the consumption of 1,750 tons of coal per day. The grounds and buildings of the plant are remarkably neat; the latter are all solid stone structures of very pleasing architecture. This was the second installation to develop electric power from the falls.

The Cliff Paper Co.'s plant was the next place we visited. This factory is located below the falls on the high bluff at the edge of the river. Water power operates the plant and is developed at the bottom of the bluff by water taken from above the falls in a canal across the city of Niagara Falls to the Paper Co. The product of the factory is coarse newspaper stock. The raw material is spruce, most of which is imported from Canada. A short summary of the process is as follows: The spruce logs are first cut into short lengths of about one foot, barked, and then ground to a pulp by being held by hydraulic pressure against large revolving grindstones. The pulp is washed away from the grinders by running water and is carried in a conveyor to an agitator. The pulp is then run over brass screens which remove dirt and water, and is then passed on to felt rolls where most of the remaining moisture is absorbed. This completes the first process, the product taken from the felt being called ground wood pulp. To continue the process the pulp is put into a large tank called a beater. The inside of the beater is lined with wooden teeth and a large wheel having teeth extending radially revolves in it so that the teeth just pass each other and grind the pulp to a fine paste. Sulphite and white clay are added at this point in the process, to give the substance weight. Alum is added to size, and coloring matter to get the desired color, otherwise the paper would be yellow. After being thoroughly mixed in the beater for several hours, the mixture is run into another agitator and from there pumped into a cylinder where the fibres are brushed, lengthened and sized to suit the quality of paper to be turned out. From this cylinder the pulp is pumped into a suction screen, a brass plate containing many narrow slits, with a suction box below it; then it runs on a wire roll where any dirt still remaining in it is removed and the substance is further dried. A dandy roll above the wire lays the paper to a uniform thickness. From here it is run over more felt-drying rolls and then to the hot steam drying rolls, called calendar rolls. These last rolls have a polished steel surface and are kept hot by steam in the interior. They give the finish to the paper, and from them it is collected on a reel where it is cut by slitters to correct width and length. The process is continuous, and the plant is in operation day and night without interruption, as any stop would break the pulp on the rolls and cause a waste of material and time.

An inclined elevator for carrying freight and passengers down to the power plant and grinders on the river's edge, 100 feet below the factory proper, is an interesting feature. The elevator consists of a platform built up on a truck, running on inclined rails, so that the platform is horizontal. A cable the length of the incline is fastened at one end to the car and at the other to a cylindrical tank which slides in a groove at the center of the rails and below them. Water pipes are arranged so that when the car is up and the tank down the water can be removed to make the tank lighter than the car and cause it to descend. When the tank is up it can be filled with water in order to bring the car up. The elevator is operated by levers at the top of the incline where the operator can observe the movement of the car.

Next door to the Cliff Paper Co. is the Niagara Falls Hydraulic & Power Co., the oldest installation to develop electric power from the falls. The canal running across the city, from which the paper company receives its power, is the head-race for this plant. From the canal three vertical steel penstocks carry the water to the turbines at the river's level below the bluff. The wheels are horizontal, water entering from the bottom and being discharged at the sides, a wheel being on each side of the entrance pipe. Each turbine operates two generators, one on either side of it, and directly connected, the units being of 1,300 H. P. The pressure on the two wheels of each turbine is equalized by a pipe connecting the case on the outside of one wheel to the outside of the other. The plant is old and is not using all the power supplied to it by the canal, so plans are being made to improve it as to arrangement and capacity.

On the afternoon of this same day we visited the Ontario Power Co., on the Canadian side of the river. On that side the problem of installing a water power is very different, as there is no city, but a large open park extends along the river. This company has erected an extensive construction as a protection against ice, in taking water from above the falls. They have built a concrete dam diagonally out into the river with gates below the surface. Another dam connects the outer end of the first one with the shore and keeps the water high between the two. The water to get between the dams must enter through the gates below the surface, thus ice and other floating substance is excluded. The in-take is from between these two dams, and runs through a gate-house where the supply is controlled. From the gate-house the water is carried in three mains, laid just below the surface, one of 18 feet and two of 20 feet diameter, only the first one being fully installed at present.

The turbines are in the power house built on the river's edge just below the falls. An extensive system of tunnels is built in the solid rock bluff just behind this building, an elevator shaft connecting the different levels. In one of the levels, 38 feet from the surface, is a valve room, where the speed of the turbines is controlled by valves operated electrically in the main office building of the company, almost half a mile away, back on the bluff. The three generators, installed and running at the time of our visit, were supplied with power from the 18-foot main, 1½ miles long and sloping 34 feet in its length, each unit being on a branch 9 feet in diameter. The turbines were made by J. M. Voith of Heidenheim, Germany, and are arranged two on a shaft, the generators being on one end and directly connected. The Westinghouse Electric and Manufacturing Co. built the generators. They are of 10,000 H. P. each, with revolving fields, 7,500 K. W., A. C., and 12,000 volts. One unit of 12,000 H. P. was almost complete at the time of our visit. The total plant when finished is expected to develop about 210,000 H. P.

The visit to the falls at this time was particularly interesting as there was a bill up in the House of Representatives to revoke the water rights given to utilize the falls power, because of the destruction thus caused to their natural beauty and grandeur. About one-third of the water available has been sold by water rights, but so far only a small portion of that is being used, and little difference is noticed in the flow of water over the falls. The American side is several feet higher than the Horse Shoe Falls on the Canadian side and would therefore be affected more by this encroachment on the water supply. To revoke the water rights of the companies now installed seems impossible, and so far the beauty of the falls is not noticeably marred; but as to further demand on the water supply, it is a question whether or not their aesthetic value as one of the seven wonders of the world will win out over their great commercial value as a power producer.

Monday morning we visited the Buffalo City Water Works Station, one of the largest single pumping plants in the country. It has a capacity of about 225,000,000 gallons of water per day. The equipment consists of four old tandem compound engines of about 500 H. P. each, three modern tandem compound engines of 700 H. P. each, pumping 930 gallons per revolution into a 36-inch discharge pipe, two very large modern vertical triple expansion engines of 1,200 H. P. each, pumping 30,000,000 gallons per day into a 48-inch discharge pipe, and one induction motor operating a turbine as a centrifugal pump, discharging 25,000,000 gallons per day. The latter was built by the General Electric Co. and had been installed very recently. This installation was the exact opposite of the power developments at Niagara Falls, using electricity developed there by turbines and generators to operate a motor which in turn operates a turbine as a centrifugal pump. This unit furnishes almost as much water as the largest steam pump in the plant, but occupies about one-eighth of the space. The water furnished by the different pumps is measured by Venturi water meters, a typical meter being one with a 48-inch tube and a 24-inch throat and having a measuring capacity of 20,000,000 gallons per day.

On leaving the Water Works plant we crossed the city and visited the Snow Steam Pump Works. This is a very complete plant, manufacturing pumps of either steam or gas power. Their foundry is very complete and equipped to handle the heaviest of castings. Two large horizontal gas engine pumps were in course of construction for water works service at Oakland, California, each of 5,400 H. P., making them the largest gas engines ever built. Two very large vertical, triple expansion steam pumps were being erected, very similar to the ones we had just seen at the Buffalo Water Works. When complete a pump of this type stands over eighty feet in height.

In the afternoon we visited the Lackawanna Steel Company's plant, south of Buffalo. This is one of the largest concerns of its kind and is independent of any trust. It is located on the Buffalo River, and most of the ore is brought to it by boat. A very complete unloading system of cranes and conveyors is used to exchange the ore from the vessels to cars used in taking it to the reducing furnaces. One whole mill is devoted to the Bessemer process, which takes eleven minutes from one pour to the next, and another mill to the open hearth process. In the rolling mill, rails, channels, I beams and plates are rolled, straightened and cut off to length. Some of the machines for operating rollers and cutters are very interesting, especially the large reversing engine used for the rollers. The air compressor plant is immense; a long row of compressors run by direct connected 1,000 H. P. gas engines, using furnace gas, extends from one end of a very long building to the other, in fact, to see them all going at once it really seemed impossible to count them. Besides the gas engines there were two large vertical steam compressors, built by the E. P. Allis Co., installed at one end of the building.

Tuesday morning we left Buffalo and stopped off three hours at Dunkirk, N. Y., on our way to Pittsburg. Dunkirk is purely a manufacturering town, built up around the large Brooks Works of the American Locomotive Company, which turns out two locomotives a day. In the boiler shop the entire locomotive boiler is built from the plate, using some interesting riveting tools. The front end and fire box ends are made separately, a large crane handling them over the riveters, and then the two parts are riveted together by hand. The locomotive wheels are built up by being pressed on to their axles cold, and the rim pressed onto the wheels hot. The rims are heated in an oil furnace and taken out black, when they fit loosely over the wheels; upon sudden cooling they contract, fitting perfectly tight, so that when they are machined it is difficult to find the division of the metal. The frame of the locomotive is made of long forged pieces, with cross braces welded between them. After going through each department, we had our dinner in the employee's restaurant, where a good meal is served very reasonably. This was the first place we had been thus served.

Tuesday night we reached Pittsburg and early next morning left for the Westinghouse Works, located in a suburb about twenty miles out from the city. The Westinghouse Electric and Manufacturlng Company was the first plant visited. It is an immense concern, employing ten thousand men and eight hundred girls, one thousand men being in the offices. The lay out of the buildings is a good feature here; the different shops are parallel and are all connected across one end by the office building. As the business of the company has increased, the number of shops perpendicular to the office building has been increased, or they have been lengthened at the outer end. We went through the following departments: winding of commutators and amatures, street car motors, circuit breakers, switch boards, and the testing rack where generators and motors are tested. In the the last department most of the employees are college men, taking a two year apprentice course, which the company offers to graduates.

After dinner we went through the Westinghouse Machine Company, across the street. Here we saw the usual line of machine shop work, but on a large scale, some machines making cuts taking five or six days. They were building, principally, large vertical gas engines and steam turbines. The latter were especially interesting to see in all stages of construction. Both of these plants received their castings from foundries belonging to Westinghouse interests, but some distance away.

The Westinghouse Air Brake Company, in another suburb, was our next place to visit. This plant is very complete and different from those we had seen before, as most of the work is with comparatively small parts. The foundry is said to be one of the best equipped in the world; compressed air is used for tamping and making molds, greatly increasing the rapidity of the process. In the machine shop a great number of automatic machines are used for turning out small parts, especially in the brass work. Steam turbines directly connected to dynamos in the power house make that a neat plant and furnish electric power to the different buildings. The completed air brakes are tested for defects on a rack, sixty at a time, to see how quickly they respond to the opening of an air valve, it taking just three seconds for the air pressure to go around the rack affecting them all.

Thursday the entire day was spent at Scott Haven in visiting a coal mine. In this section of Pennsylvania there are four veins of coal, the first one too poor a grade to mine, the second one being the one worked now. This vein is from five to six feet thick, and produces a high grade bituminous coal. A tunnel entering the side of a hill goes in for over two miles, and is equipped with an electric railroad. From this main tunnel cuts are run off perpendicularly, enough coal being left between each one to support the earth above. Electric tools are used for undercutting and drilling. Mules haul the loaded cars from the cuts to the electric road in the main tunnel. The mules when first impressed into the service are taken into the mine in one of the cars. A cut not being worked is fitted up for stabling them, and they never see daylight again. The mine is ventilated by air blowers, partitions, made of heavy cloth, running along the sides of the cuts, conduct the air to the ends of the tunnels.

The Nernst Lamp Company and the R. D. Nuttal Gear Company, both of which are Westinghouse interests among the forty-three other concerns, were visited next morning. The Nernst lamp is one of the rare earth illuminants used with electric power for lighting. A great deal of the work is very fine, and only girls are able to do it profitably, as they are so much more deft with their hands than men or boys. The process of manufacturing the lamps is interesting, but too deep and complicated to go into description of here.

The Gear company makes all sorts of gears for heavy work, and some of the machine tools for cutting the different shaped gears are clever and interesting. This concern also makes trolleys for electric cars, probably to accompany the electric car motors made at the electric company, that we saw being constructed two days before.

In the afternoon we visited the Brashaer Optical Works, where lenses, telescopes and optical instruments are made for commercial use and for the government. This is by far the most accurate work done in any line of manufacturing. Some of the grinding and polishing processes take days to remove the smallest fraction of an inch of material. Most of the machinery is built on masonary piers anchored in the ground and free from the building to avoid vibrations.

This concluded our list of plants to visit in the east, and in the evening the party left Pittsburg. Saturday morning we reached Chicago and joined the members of the class taking the western trip to visit points of interest along the Chicago Drainage Canal and at Joliet. At Lockport we stopped to see the Bear Trap dam which controls the flow of water in the drainage canal. This is a hollow dam fixed on a pivot and rollers so that it may rise and fall. The opening of a gate on the up stream side of the dam allows water to enter inside of it and raise it because of the upward hydraulic pressure, and thus stops the flow of water in the canal. Another gate in the lower side of the dam allows the water to flow out of this chamber and does away with the upward hydraulic pressure, allowing the dam to lower and water to flow over it. It is an ingenious contrivance to control the water in the channel, operating so simply and by the power of the water it controls.

At Joliet we visited the hydraulic-electric plant of the Economy Light and Power Company. Here is quite a different proposition from the developing of power at Niagara Falls. The water is supplied by the Chicago Drainage Canal, the Desplaines River and the old Illinois and Michigan Canal. A head varying from nine to fifteen feet is caused by a dam built across this water way. The entire plant is built on a concrete foundation, built on the solid limestone rock at the bottom of the river bed. The water wheels are set vertically in concrete bags below the power house. The equipment of the plant is forty turbines, built by the S. Morgan Smith Company. There are two 48-inch wheels of 125 H. P. each directly connected to a 75 K. W. 125 volt direct current exciter, and thirty-eight 66-inch wheels rated at 500 H. P., each under a 14-foot head. Thirty-six of these latter are connected in units of six wheels each, operating by gears a 750 K. W. generator. These units are so arranged that in time of high water three wheels may be disengaged, the power being furnished by the other three. The other two turbines drive a 375 K. W. generator. All of the generators were built by the General Electric Company and are of the revolving field type. This plant is probably the largest electric hydraulic installation in the country working under so small a head.

Upon returning to Chicago the parties broke up, most of their members leaving for their respective homes, to be there over Easter Sunday. All felt, I am sure, that the many practical benefits derived from the trip could not have been obtained in any other manner.

REPORT OF THE JUNIOR M. E. AND E. E. INSPECTION TRIP.

The Western Trip.

In the spring of 1906 the faculty of the College of Engineering decided that the annual inspection trip was of enough practical value to the students in engineering to warrant making that trip compulsory. Heretofore the trip had been taken during the Senior year and it had been left to the choice of the student whether he went on this inspection tour or not. The faculty, therefore, arranged to have the trip during the week preceding the Easter vacation and to have all members of the Junior class excused from University work during that time.

Two trips were arranged for, one to visit Niagara Falls, Buffalo, Pittsburg and the surrounding districts, and the other to take in Milwaukee, Chicago, Lockport and Joliet.

Our party, those who took the Western trip, left Madison early Monday morning for Milwaukee. Two days were spent there and the remainder of the week in Chicago and the outlying districts.

The first place visited in Milwaukee was the West Milwaukee Car Shops, owned by the Chicago, Milwakee & St. Paul railroad. The entire morning was spent here; and it was one of the most interesting places, probably because of the large number of good guides furnished for our party by the company.

There are two roundhouses here; one, of quite recent construction, will probably have to be widened to permit the storing of larger engines. For lifting the engines off the track, to permit inspection and facilitate repairs, an hydraulic lift is used. As we were passing through, one of the locomotives was being cleaned by water. That is, water was being forced through a pipe, which was moved through the flues by hand. Cleaning is performed every six or eight days on each engine.

The power plant has two air compressors, two Corliss engines, and a Nordberg engine with patent cut-off device. The boilers are of the Babcock and Wilcox type.

In the foundry the most interesting feature was the Barr contracting chill molds, and the annealing pits for the car wheels. The blacksmith shop was more spectacular. There are a number of machines for pressing the bolt heads when the iron is hot. Bulldozers for bending the iron into shape by means of dies and a number of small steam hammers were being operated.

None of the iron is allowed to waste. A number of men are kept employed in sorting the scrap iron, such as is obtained from box cars, etc. The iron, so separated, is stored in bins and piled up in the yard. If the bolt is broken so that a smaller one can still be made out of it, this is done; but if not, the iron is remelted, a number of pieces together, and re-rolled. Economy is practiced to the fullest extent possible.

In the machine shop an unusual type of traveling crane was seen. It consists of a jib crane supported above and below by rollers and operated, of course, by electricity. On account of the shape of the building, being low in structure, this design was probably necessary. The tires of the locomotive wheels are shrunk on by first being heated by a gas flame. Further along in the shop these wheels are driven on or taken off from axles by hydraulic presses working under a pressure of one thousand pounds per square inch.

In the boiler shop the number of pneumatic tools in use is noticeable. All the riveting and chipping is done in this manner. Of course the work is easier, therefore, and the capacity of the shop is increased without changing the number of men.

In the works about 3,000 men are employed. Every part of the locomotive is numbered, so that it is possible to tell who made it and what its capabilities are. The cost of manufacture of a locomotive for them is about the same as what they could buy one for, but material contained therein is under a closer inspection.

The arrangement of the different departments, as machine shop, wood shop, etc., is not the best, as the plant was built and rebuilt as demand made necessary. The buildings are of brick and steel construction, but are low in structure. In the roundhouses trouble is experienced by the hot gases from the locomotives attacking the steel structure. The lighting and ventilation is not very good. A very much better plan could have been laid out with what is there, if a complete plan could have been made in the very beginning.

In the afternoon the National Electric Co. was visited. The building is much neater in appearance on the inside and outside than the one visited in the morning. In the foundry oil is applied as a fuel in the open hearth furnace. The oil is burned in a system of pans. On account of the strong light the men in charge wear blue glasses. The company manufactures a large number of air brakes for use on the street railways.

From here the car was taken to the Schlitz Brewery Co. Probably the greatest interest was manifested in the ice machines. A number of De La Vergne machines are here used in securing the desired low temperatures.

In the Commerce St. station of T. M. E. R. and L. Co. there is a novel method of handling coal. An electric traveling crane lifts the wagon-box off from its trucks and carries it inside. On the box being emptied it is replaced on the trucks without a human hand touching it.

The plant consists of Allis compound condensing engines of the vertical type. Each engine is about 1,500 H. P. So far there are also two Curtis steam turbines here, of about 1,200 H. P. each.

The type of boiler is the Edge Moore water tubular, with 18-foot tubes, equipped with under-fed stokers. A forced draft is created by fans operated by motors.

The arrangement of the entire plant is good. Everything is placed, as far as possible, to the best advantage. Just as much care was taken in looking after the small details as the large parts. For example, this was well illustrated in the method of handling the lubricating oil.

Tuesday morning the shops of the Allis-Chalmers Co. were visited. In the foundry the mold for the bed plate of a rolling mill engine was being constructed. This casting when made was to weigh 110 tons. The engine was 18,000 H. P. A few moulding machines were seen in operation. The molds on the large castings were held together, to prevent washing, by nails; and all large molds were painted over with what appeared to be filling.

In the machine shop the fact that the tool is brought to casting, instead of the reverse, was noticeable. This, of course, is necessary on account of the size of casting. On the erecting floor a steam turbine was being erected. This turbine differs from the Westinghouse-Parsons in the manner of holding the blades in place.

In the power plant a Nurnberg engine is installed. This was the only gas engine of any size which was in operation in any of the plants inspected. As far as could be ascertained the engine had proved satisfactory.

In the blacksmith shop a 40-ton and 25-ton hammer were working. The connecting rods which were being worked were heated in furnaces near by to the correct heat. To handle rods, grips were strapped on.

All the work is performed on a large scale. In almost all the plants visited, the name of Allis-Chalmers is seen on some or many of the engines installed.

In the afternoon the Pauling & Harnischfeger Co. was inspected. The buildings of this plant were the best in appearance of any shops visited. Although things are not performed on as large a scale as at Allis, yet it was very interesting. The building is of brick and steel construction. The lighting area is large and the work is all on one floor. The floor itself is cement and gives a good foundation for the machines.

Among the different kinds of machines there the method of cutting gears attracted attention. A gear cutter of the form of the tooth is automatically fed through a previously roughed blank. The machine was made by the Gould & Eberhardt Co. The armature rings are stamped out tooth by tooth intead of all at once as at the National Electric Company.

In the draughting room a blue printing machine of 300 print capacity was shown. The draughting room is large, airy and well lighted.

The Johnson Service Co., the next plant visited, have a re-inforced concrete building. The building itself is fine in structure. The work is of a large variety. Everything from a thermopile to an automobile is being manufactured here. Nothing is wasted. If material can not be used for one thing, it is made into something else.

Tuesday evening our party went to Chicago via the Goodrich line steamer. In this city, where we stayed for the remainder of the week, we made the Victoria hotel, on Michigan Ave., our headquarters.

In Chicago the first plant visited was the down town part of the Western Electric Co. Here is manufactured the smaller parts in which they are interested, as telelphones and telephone switchboards. They manufacture all the apparatus for the Bell Telephone Co. The capacity of the plant is 5,000 telephones per day; and 7,000 people are employed in this business.

The applications of automatic machinery are numerous: in wrapping the paper and tin foil together. making coverings for wires, winding cables, turning small screws, etc. However, some time, apparently, is lost in testing the different parts, as condensers, bells, etc., because these parts are handled by hand a number of times. The testing is, however, a necessity. Quite a number of presses are used in stamping out small parts.

Some of the men running automatic lathes are able to take care of two or three machines. As these automatic machines are very complicated in mechanism, a few men are employed to see that the machines are kept in good working order. By this means expensive help is done away with to a certain extent.

The Western Electric Co. also manufacture their own rubber. This part of the work is situated in a suburb of Chicago. Here, also, the larger machines are manufactured. In the machine shops and foundry nothing radically different from other shops and foundries which we had inspected was seen.

Near the blacksmith shop a gas producer is installed, and is said to have proved satisfactory. In the power plant an economizer is employed to heat the feed water. A continuous test is run in their boiler room, so that a record is made of the work performed.

The cable-making department was visited and some interesting automatic machines were seen. One machine twisted 300 strands into a cable, each strand being insulated by paper. Cables of this type are covered with lead. This is performed by means of machines which are partly operated by hydraulic pressure. The cable runs in at one end, lead being forced around the cable by means of a hydraulic press, and comes out at the other end a finished product. For operating the presses a number of machines are used which are situated across an aisle.

The plant is of recent construction, and there is space for further building in the future. This could not be done very well in the case of the down-town shops, except by increasing the number of stories.

Near St. Louis Ave. one of the city pumping stations was seen. Inside, glazed brick was used and the windows were made of what is called fire-proof glass. This consists of a wire netting placed in the glass when in molten condition. The result is that in case of fire the whole pane does not crack and fall out.

The capacity of the pumping station is 20,000,000 gallons per day. In order to have constant pressure and a reserve the water is pumped into a tank under pressure of a weight acting by gravity.

The new plant of the Sears-Roebuck Co. was next visited, the power plant being the principal object of interest. It contained, besides a number of air compressors, three 750 H. P. and one 500 H. P. horizontal compound condensing engines. Although it is not necessary to use all of these engines at once, yet they are installed so as to be able to replace one by the other for repairs or cleaning. Underneath this building a tunnel runs to the main building.

Probably the most instructive plant visited on this trip was the Illinois Steel Co. at South Chicago. The plant, of course, is very extensive, so much so that small dummy engines are used to transfer the products from one part to another. Because of the number of these engines death by being run over is a frequent and almost daily occurrence.

The Bessemer plant was visited first. This contains three converters, with a capacity of twelve tons. The shells are made after Holley's design. The double pouring process is used in casting the ingots, which are about 4,500 to 5,000 pounds in weight. In handling the shell and bottom hydraulic power is applied. These hydraulic lifts are operated by men at considerable distance away. A Wellman jib crane, operated by water power, conveys the ladle.

After being stripped of their molds, while still hot, the ingots are carried to soaking pits, fired with oil. Electric traveling cranes are employed to lift ingots out of the pits and place them on tilting cable cars, to transfer to rolling mills, three rollers high. After going through a number of mills the rails while still hot are sawed to correct length and inspected. Then they pass through straighteners and drill presses.

The building of the Open Hearth Mill is of steel and brick construction. The ten furnaces are arranged on one side along the length of the building. The other half is used for making and handling the castings. The charging floor is back of the furnaces, about 12 feet above the yard level. The cranes are 40, 30, and 75 tons.

The blast furnaces are divided into two sections, each of four stacks. Each blast furnace, 1, 2, 3, and 4, has in connection four Whitewell–Foote hot blast stoves. Steam is generated by 40 horizontal tubular boilers, heated by waste blast-furnace gas not used in stoves. Ten vertical blowing engines, manufactured by Cuyahoga Engine Co. of Cleveland, generate the air blast.

Blast furnaces 5, 6, 7 and 8 have four Massick & Crookes hot blast stoves. Here 48 horizontal tubular boilers generate steam to drive 10 Southwark Foundry and Machine Co. Porter Allen vertical engines. Two engines are used with each furnace, and two are held in reserve for the four furnaces.

The iron ore is brought to South Chicago from their own mines by barges owned by the company. Shovels of immense dimensions unload the barges. The iron is hoisted to the furnaces in cars; the structure for this purpose is of steel.

The Fiske Street Station, of the Commonwealth Co., one of the most modern of power houses, was next visited. The situation is such that there is water on three sides of the building. The result is that water can be taken in at one side and emptied out on the other side, taking care of the water question very adequately.

The plant is arranged with view to further improvement and extensions. The ultimate capacity is 14 units; at present only four units are installed. These four have a capacity of 5,000 K. W. each, while the new units are to have a capacity of 8,000 K. W. each.

Eight Babcock & Wilcox boilers represent one battery. Each battery has its own coal conveying apparatus; and the piping of each battery is independent, so that any one can be idle without shutting down the others. The boilers operate under 175 pounds pressure and 150° superheat. Babcock & Wilcox grate stokers feed the coal. The stacks are of steel, being 250 feet high and 18 feet in diameter.

The Curtis steam turbine has been installed here; in this respect the station is an experiment. To keep the turbine shaft off from the bearing, a system of relaying pumps are employed. If one fails to work another is automatically called into play. The pressure of the oil required is 1400 pounds per square inch.

If an attempt is made to stop the turbine without its carrying a load, five hours would be required to bring this about. A water rheostat, placed in a canal nearby, accomplishes this end in twenty minutes, as the load which could be applied is almost unlimited.

The building is furnished with glazed brick. The main room is very high and wide enough to permit the installation of steam engines if necessary.

The current is carried from the generating station to substations situated in different parts of the city. One is placed at 22d and Fiske streets. The result is that of a central power station.

Besides the above mentioned plants, the Libby, MacNeal & Libby packing house, Swift & Co.'s stock yards and soap works, and the South Chicago ship yards were visited. On the ships in the South Chicago ship yards, a number of compressed air riveters and drills are employed. In the shops rolls are installed for bending the steel plates into shape.

At Lockport the Bear Trap dam was seen in operation. Leaving here, the power plant at Joliet was inspected. Nineteen water wheels are installed here and the head of water is 9 feet. The company furnishes power for the interurban systems between Joliet and Chicago, and Joliet and Aurora; the city power is also supplied, together with that of a few other industries. A steam turbine has been installed which could in time of an emergency furnish the necessary power for lighting the city.

What most impresses one on such a trip are the great and varied uses of air, the number of electric cranes employed to assist the workmen, the great chance for the steam turbine, and the broad field for mechanical and electrical engineers.

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EDITORIALS.

The opening of the present school year and the beginning of Vol. XI of THE WISCONSIN ENGINEER are witnesses of great activity in all departments. College work is progressing at the usual engineering pace. New equipment is being secured, changes are being made in the courses of study and new courses are being added. Everywhere are signs of progress, typical of the successful engineer and of the up to date engineering college.

Among the improvements in the way of additional equipment a few of the most important should be mentioned.

The Hydraulic Laboratory, which last year was only partially built, is rapidly nearing completion. The Chemical Engineering Building has been remodeled and is now fitted up to supply considerable of the much needed room for the work in electrochemistry and electrical installations. An addition is being built to the Mechanical Laboratory and an entirely new building, the Agricultural Engineering Building, is being erected for the exclusive use of agricultural students. Lastly, we must not fail to mention the installation of the University Telephone Exchange. With a local central in Science Hall and ample trunk facilities to both the Bell and Standard city exchanges, any city or long distance call may be had from the office desk. One other long felt want is thus relegated to the past.

The principal addition to the course of study is that of the Correspondence Course. It is the object of this course to make it possible for those who so desire, to take the theoretical part of their college work at home and take the laboratory work here during the summer.

But the changes in the Engineering College are not confined alone to those cited above. They affect our faculty as well. Prof. W. D. Pence, former Professor of Railway Engineering at Purdue, Indiana, has come to take charge of the work in Railway Engineering, the position formerly occupied by Prof. W. D. Taylor. We are glad to have Prof. Pence with us and extend to him a cordial welcome. In the Electrical Department we have the loss of two excellent men to regret. These are Prof. D. C. Jackson and Assistant Prof. Shaad. Both have accepted positions in the Faculty of the Massachusetts Institute of Technology, Prof. Jackson as head and Assistant Prof. Shaad as Associate Professor in the Electrical Engineering Department. We all feel keenly the loss of these men, and although we would like to have them remain, we know they are advancing in their profession and our best wishes for continued success go with them.

The total registration for this year shows a slight increase in numbers over last year, although the Freshman Class shows a decrease of about ten per cent. This decrease is probably due to the more rigid entrance requirements.

On the whole, the College of Engineering is moving rapidly ahead and easily maintains the rank it has always held among Engineering Schools.

The alumni of the College of Engineering are showing more and more of a tendency to have some regular time to get together, to renew acquaintances made during their college days, and to form new friends among those who have graduated in later years. In Chicago, for example, all who are able meet at the Grand Pacific Hotel for luncheon on Friday noon. Any alumni from outside the city who may happen in at that time are always made welcome, and are made to feel that their college days are not so very far past, after all.

THE ENGINEER would suggest that, in all places where there has been no regular times fixed for the alumni to meet together, steps be taken toward such an arrangement. Everyone will feel repaid for the effort by the friendships which he is thus able to renew.

The board of editors of THE ENGINEER wishes to make an appeal to the alumni of the College of Engineering. For the past two or three years the alumni have been withdrawing their support, without which it is wellnigh impossible for the journal to exist. For every one word of encouragement from one alumnus, we receive whole sentences of discouragement or else absolute silence from the others. Conditions should not be thus, the relations between the alumni and THE ENGINEER should be of the closest. We realize that our graduates, as a rule, are very busy after they go out into practical work, but the college and its publications need their support, and they should be willing to give some of their time to help these interests along.

If any of the alumni have suggestions to offer to the board of editors, we would be very glad to hear them.

On Friday, Nov. 9th, Mr. Charles F. Scott, of the Westinghouse Electric and Manufacturing Company, of Pittsburg, spoke to the students of the College of Engineering, on the subject "The Relations of a College Graduate to a Large Manufacturing Plant." Mr. Scott discussed the question from the standpoint of the business man and left the students many points to think about.

He said that most college graduates are well informed on the theoretical part of manufacturing, but lacked the practical experience which is necessary to make a successful engineer. For this reason a large manufacturing establishment must take a graduate as an apprentice and teach him the practical side of the work before he is of any financial value to his employers.

Mr. Scott said that the two points which he would like to leave with the students were "To be broader," and "To be more self-reliant." By being broader he meant to have a knowledge of other things beside engineering subjects, to pay attention to what is going on around us and to be interested in everything that is for our improvement. With regard to self-reliance, he mentioned the fact that all through our college course we are under direction, while, on the other hand, when we start out into the world, we have to think and act for ourselves. The more we rely upon ourselves while in school, the better able we shall be to cope with the problems which we will meet in practical work.

On Friday, Nov. 2d, the students of the College of Engineering had the privilege of listening to an instructive lecture by Prof. Breckenridge, of the University of Illinois. Prof. Breckenridge is a very entertaining speaker, and the question which he discussed, that of the burning of bituminous coals in boiler furnaces, is one of such vital importance to the engineer that it made the talk doubly worth hearing.

Prof. Breckenridge is in charge of the government tests of the heating values of coals, which are being carried on in St. Louis. The government has appropriated $200,000 for this purpose, and, since the work was started, 450–10 hour tests have been made on one boiler, besides numerous other tests. With the data from these tests at hand, Prof. Breckenridge was prepared to make known some very interesting facts.

The essential features for burning bituminous coal with the best results are boiler capacity, good draft, automatic stokers and intelligent direction in the boiler-room. The speaker emphasized the fact that even if we have the first three requisites, we cannot accomplish much without the last, the intelligent direction in the boiler-room.

To get the best efficiency from the fuel, the burning divides into two parts, first, the slow distillation of the coal, and secondly, the complete burning of the gases in a hot chamber. Prof. Breckenridge said that this part of the lecture could be summed up in the words: "Give the furnace just enough hot air to run it."

With hand stoking it is impossible to get the best results from the fuel, because the burning is not carried on according to the processes mentioned above. Of the various types of mechanical stokers, the chain grate seems to bring more nearly perfect combustion than any other.

The report of these fuel tests is to be published by the government in about six months, and every one who is at all interested in the subject should procure a copy. With it an engineer, after determining the grade of coal which is to be burned, may design his boiler and grates to burn that fuel.

A new lean-to is being built at the Engineering Building, as an addition to the Mechanical Laboratory. This addition is of a temporary nature, erected to protect the student during the winter while working with the new gas producers. In addition to the Wile gas producer, installed last spring, there is now being installed a Fairbanks Morse gas producer and a producer gas engine of twenty-one horse-power capacity.

A new gasoline engine will soon be received and installed for special tests, the results of which will be embodied in a thesis.

At the semi-annual election to Tau Beta Pi, the following members of the class of '07 were elected to membership: F. C. Schroeder, C. E., Madison; C. P. Barker, G. E., Chippewa Falls; G. E. Wagner, E. E., Fond du Lac; F. J. Derge, E. E., Eau Claire; A. J. Goedjen, E. E., Manitowoc; B. E. Pease, C. E., Richland Center; Louis Sherman, Jr., G. E., Milwaukee; F. M. Warner, M. E., Fountain City and R. B. Anthony, E. E., Kewaunee. As the highest Junior, J. W. Cunningham, C. E., Madison, was elected. These men were initiated Oct. 25th, and given a smoker Oct. 27th.

The U. W. Engineers' Club.

According to present indications this promises to be a banner year for the U. W. Engineer's Club. Of course the loss of our thirteen seniors hits us pretty hard, but the return of many of the old members, together with the initiation of an exceptionally strong bunch of new men is gradually putting the club back on its old basis. Excellent programs have been rendered this year. A number of innovations will be tried. In the first place open meetings will be held once a month at which lectures will be delivered by some faculty member or visiting engineer. The numbers on the programs will be shorter than has been the rule, but there will be more of them so as to give every member a chance to participate. Musical numbers and short debates will be made a feature. On Oct. 26th the first open meeting was held in the auditorium and voted a success by everybody. Professors Mack and Thorkelson addressed the club, and B. Rahn '07 rendered a violin solo. The officers are: F. M. Warner '07, Pres.;

W. J. Platten '08, Vice Pres.; H. G. Kislingbury '08, Sec. and Treas.; F. W. Derby '09, Censor; and J. H. Lokke '08, Asst. Censor.

Among the old members who have returned to school are A. J. Luick '07 and R. Sutherland '09. The following men have been elected to membership this fall: W. Lindeman '08, H. J. Newman '10, F. M. Blackburn '07, L. G. Matthews '09, C. G. Weber '08, J. R. Shea '09, F. Neubauer '08, C. R. Osgood '07, F. Mahoney '10, C. H. Shepherd '08, E. E. Huntington '09, I. T. Thompson '07, R. P. Watke '10, C. A. Scribner '08, W. F. Lent '10, G. Wagner '07, and F. Paesler '07.

The A. L. A. M. Standard Screw is a new standard evolved from the old U. S. Stardard as a basis. It is nothing revolutionary in any sense of the word, but, on the contrary, it conforms to the general practice of many machine tool and automobile builders.

A finer thread than that of the U. S. Standard has been found necessary, and this new standard is intended to fill this want.

Like any new standard, it can not be hoped that it will be adopted immediately or universally, but it is believed that it will gradually creep into use.

Considerable study was put on the dimensions of the nuts and heads; careful destructive tests were made before the Standard was adopted, to make it absolutely certain that the nuts and heads were large enough and that the threads would not strip.

Tests were made with ordinary material and with the material it is proposed to use for automobile work. The results were the same in both cases; that is, the screw broke at the base of the thread inside the nut, which was to be expected.

The material to be used for the screws in automobile work (and which can be easily worked in automatic screw machines) is about twice as strong as ordinary screw stock. Not only is it strong, but very much tougher, being lower in the impurities and showing a very fine fracture, characteristic of a tough steel.

As time goes on, it is probable that these screws will be found in stock just as the ordinary U. S. Standard is now found. This can not be done immediately; it must be accomplished by merit, that is, merit in this standard.

CHANGES AND ADDITIONS IN THE FACULTY.

Upon the resignation last year of Professor W. D. Taylor, Professor of Railway Engineering, it was felt that the college had lost one of the strongest men of its faculty, and one whom it would be difficult to replace. The position remained vacant during the second semester, but in April Professor W. D. Pence, Professor of Civil Engineering at Purdue University, was appointed to the place, his duties to begin at the opening of the present college year. Professor Pence has had a wide experience, both as an engineer and as a teacher, having occupied the position of Professor of Civil Engineering at Purdue University since 1899; and it is felt that the college is very fortunate in securing his services.

Professor Pence graduated from the University of Illinois in 1886, but previous to this time he had spent some three or four years in engineering practice. After graduation he entered the engineering corps of the Santa Fe system, serving in succession as assistant engineer, roadmaster, and resident engineer in charge of track, bridges, buildings and water service of the southern division. In 1892 he entered the instructional staff of the University of Illinois, serving as instructor, assistant professor and associate professor, teaching chiefly railway engineering subjects. From his appointment at Purdue in 1899 until his resignation the number of students in civil engineering increased from about 100 to about 400.

Aside from his work as a teacher, Professor Pence has maintained an active interest in engineering practice and has taken a prominent part in various engineering societies. For some years he has done special work on the subject of drainage in the State of Indiana, being appointed in 1905 by Secretary Wilson as a member of a special commission to report upon the drainage of the Kankakee marsh. His general engineering practice has included work along the lines of railway, bridge and electric railway engineering, and appraisal work. He has contributed largely to engineering literature and is author of "Standpipe Accidents and Failures in the United States," and joint author of a "Surveying Manual," which is widely used in technical schools. For several years he has served as editor of the publications of the American Railway Engineering and Maintenance of Way Association. Besides this association he is a member of the American Society of Civil Engineers, Society for the Promotion of Engineering Education, Western Society of Engineers, Western Railway Club and the Indiana Engineering Society, of which he was president during the years 1903-04.

In the Electrical Engineering department four new instructors and assistants have been appointed. These men take the places of Asst. Prof. Shaad and Messrs. Petura and Post who have resigned.

Mr. William E. Wickenden is a graduate of Denison University of 1904. During the year 1904–05 he was instructor in physics and electrical engineering in Mechanics' Institute at Rochester, N. Y., and during the past year has been an assistant in physics and graduate student in electrical engineering in this University. For several years his summers have been spent in various engineering works.

Mr. John R. Price is a graduate of this college of 1905. Since graduation he has been in the testing department of the General Electric Company until appointed as instructor last September.

Mr. Edgar A. Loew is a graduate of Oshkosh Normal School of 1901 and of this college of engineering in 1906. During his summer vacations he has been in the employment of various telephone companies.

Mr. Lewis Fussel received his B. S. and M. S. degrees at Swarthmore College, and for the two years, 1903–05, was instructor in phyics in that institution. During the year 1905–06 he was a graduate student in the University of Wisconsin.

In the department of Drawing instructor Boynton has resigned, and his place has been filled by Mr. Dean E. Foster, who graduated from the mechanical engineering course last year. Before entering this college Mr. Foster had attended Grinnell College, Iowa.

In the department of Railway Engineering the instructional force has been increased by the addtion of an assistant. Mr. Jerome G. Van Zandt, who has been appointed to this position, is a graduate of Purdue University of 1904. Previous to graduation he was employed for a time in the office of the Allis-Chalmers Company, and also in the bridge department of the Illinois Central Railway Company. During the two years since graduation he has been engineer of the Southern Steel Company at Gadsen, Alabama, until coming here last July. During the past summer he has been in the service of the Wisconsin Central Railway Company.

In the department of Chemical Engineering, Dr. Oliver P. Watts, P. H. D., University of Wisconsin, 1905, has been appointed instructor in applied electro-chemistry, to fill the vacancy caused by the resignation of Oliver W. Brown. Dr. Watts has been engaged during the past year upon research on electrolytic iron under a grant of funds to Professor Burgess from the Carnegie Institute.

Otto L. Kowalke, class of 1906, has been appointed assistant in chemical engineering. In addition to his instructional work he has charge this year of research work in iron.

ALUMNI NEWS.

The great activity in all lines of engineering work has made the demand for technical graduates much greater than usual. There were more positions open for last year's Seniors than there were men to fill them. Every man of the class of '06 had his position assured before commencement in June. Below is a list of the members of that class and the companies for which they are working:

'06.

General Engineering.

Bush, J. I., Racine, Wis., J. I. Case T. M. Co.

Davis, R. E., Butte, Mont., with Pittsburgh-Montana Copper Co.

Dunlap, G. L., New York City, Instrumentman, Penn. & Long Island R. R.

Falk, H. S., Milwaukee, Falk Manufacturing Co.

Haertel, C. F., Madison, Wis.

Hart, J. G., Racine, Wis., Racine Gas Light Co.

La Dow, C. V., Sandusky, Ohio.

Larkin, F. V., Provo, Utah, Telluride Power Co.

Marks, F. R., Chicago, Engineering Dept., Chicago Telephone Co.

McCoy, L. B., Milwaukee, Wis.

Mead, W. J., Madison, Assistant in Geology, U. of Wisconsin.

Miller, E. B., Schenectady, N. Y., Testing Dept., General Electric Co.

Miller, W. B., Pittsburg, Penn., Pennsylvania R. R.

Moser, A. L. B., Cripple Creek, Wis.

Smith, W. H., Pittsburg, Penn.

Wheeler, R. A., Milwaukee, Inspector, Wisconsin Telephone Co.

Civil Engineers.

Allen, M. E., W. Lafayette, Ind., Inst. in C. E., Purdue University.

Bates, W. E., Hibbings, Minn., Oliver Iron Mining Co.

Buchanan, J. W., Madison, Wis.

Calvin, C. J., Hibbings, Minn., Oliver Iron Mining Co.

Conway, W. M., New York City, Instrumentman, Penn. & Long Island R. R.

Gormley, J. H., Madison, Building Inspector, U. of W.

Harza, L. F., Madison, Instructor in Hyd. Engineering, U. of Wisconsin.

Howson, E. T., Waverly, Ill., Asst. Engineer, C. B. & Q. R. R.

Hunt, H. J., Madison, Draughtsman, D. W. Mead.

Johnson, F. M., Western Coast Extension, C. M. & St. P. R. R.

Lawrence, F. W., Madison, Assistant in Hyd. Engineering, U. of Wisconsin.

Lawrence, F. H., Chicago, Engineering Dept., Chicago Telephone Co.

Parker, H. A., Cincinnati, care of Cincinnati Water Works Commission.

Parker, W. C., Hibbings, Minn., Asst. to Consulting Mining Engineer.

Rath, W. C., Milwaukee, Fire & Rust Proof Construction Co.

Reid, J. W., Bridge Dept., C. M. St. P. R. R.

Rossing, A. H., Argyle, Wis.

Sacket, W. H., Coast Extension, C. M. & St. P. R. R.

Stock, Harry, Madison, Draughtsman, D. W. Mead.

Thorne, J. G., Superior, Wis., Resident Engineer, Wisconsin Central R. R.

Trestler, A. M., Madison, Draughtsman, D. W. Mead.

Van Hook, W. A., Instrumentman, Construction Dept., C. & A. R. R.

Wild, E. C., Madison, Draughtsman, D. W. Mead.

Wright, A. E., Detroit, Mich., U. S. L. S.

Youngblutt, F. C., Middleton, Wis.

Wetzler, W. W., Madison, Draughtsman, D. W. Mead.

Electrical Engineers.

Balsom, A. P., Chicago, Ill., Chicago Telephone Co.

Bertke, W. A., Denver, Col., Apprentice, Denver Gas & Electric Co.

Bradshaw, J. W., Chicago, Operating Dept., Chicago Telephone Co.

Byers, V. C., New York City, J. G. White & Co., 56 Wall St.

Cade, O. B., Chicago, Woods Electric Vehicle Co.

Davidson, P. E., Chicago, Apprentice, Western Electric Co.

Delgado, A. E., Schenectady, N. Y., Testing Dept., General Electric Co.

Delgado, A., Schenectady, N. Y., Testing Dept., General Electric Co.

Derge, M. L., Denver, Col., Denver Gas & Electric Co.

Elmore, S. E., Pittsburg, Penn., Westinghouse Machine Co.

Feige, H., Chicago, Engineering Dept., Chicago Telephone Co.

Fisher, F. E., Madison, Northern Electric Co.

Flagg, W. H., Chicago, Traffic Dept., Chicago Telephone Co.

Ford, R. H., Chicago, Apprentice, Western Electric Co.

Hardaker, R. J., Chicago, Apprentice, Western Electric Co.

Heller, H. L., Milwaukee, Wisconsin Telephone Co.

Herdegen, R. F., Cincinnati, O., Bullock Works, Allis Chalmers Co.

Hoelz, J. G., Burlington, Wis.

Hull, I. W., Chicago, Inspector of Materials, Chicago Telephone Co.

Jacobson, Ernst, St. Louis, Mo., LaClede Gas Co.

Jenista, G. J., Chicago, Traffic Dept., Chicago Telephone Co.

Keyes, D. H., Chicago, Engineering Dept., Chicago Telephone Co.

Kohn, A. J., Chicago, Apprentice, Western Electric Co.

Kommers, J. B., Chicago, Construction Dept., Chicago Telephone Co.

Loew, E. A., Madison, Instructor in Electrical Engineering, U. of W.

Noe, E. J., Schenectady, N. Y., Testing Dept., General Electric Co,

Parker, F. I., Milwaukee, Cutler-Hammer Clutch Co.

Peck, B. H., Chicago, Engineering Dept., Chicago Telephone Co.

Reynolds, I. A., Chicago, Apprentice, Western Electric Co.

Rickerman, F. H., Madison, Testing Dept., Northern Electric Co.

Rosier, F. B., Chicago, Operating Dept., Chicago Telephone Co.

Smith, L. L., Madison, Graduate Scholar, U. of W

Sorem, A. J., Madison, Testing Dept., Northern Electric Co.

Strait, E. N., Milwaukee, Testing Dept., National Electric Co.

Sustins, W. A., Chicago, Apprentice, Western Electric Co.

Terhorst, Steve, Milwaukee, Engineering Dept., Wisconsin Telephone Co.

Thwing, C. C., Chicago, Suburban Construction Dept., Chicago Tel. Co.

Van Hagen, A. E., Chicago, Engineering Dept., Chicago Tel. Co.

Walsh, A. J., Des Moines, Ia., Des Moines Gas & Electric Co.

Warren, W. E., Chicago, Operating Dept., Chicago Tel. Co.

Shadboldt, L. J., La Crosse, Wis., Vogt Telephone Co.

Chemical Engineers.

Burling, B. B., Depew, N. Y., Gould Storage Battery Co.

Kowalke, O. L., Madison, Asst. in Chem. Eng., U. of Wisconsin.

Legreid, H. N., Madison, Madison Gas & Electric Co.

Mechanical Engineers.

Biersach, Rudolph, Milwaukee, Wis., 265—10th St.

Eskuche, O. A., Milwaukee, Four Wheel Drive Motor Co.

Foster, D. E., Madison, Inst. in Mech. Drawing, U. of Wisconsin.

Hoefer, A. U., Chicago, Engineering Dept., Chicago Telephone Co.

Johnson, G. M., West Salem, Wis.

Kearney, Edgar, Springfield, Mo., 125 Benton Ave.

Kirk, A. T., Joliet, Ill., Illinois Steel Co.

Manchester, T. H., Beloit, Fairbanks, Morse & Co.

Manegold, R. A., Madison, Madison Gas & Electric Co.

Read, B. K., Chicago, Draftsman, The Arnold Co.

Ripley, R. R., St. Louis, La Clede Gas Co.

Robertson, L. B., Joliet, Ill., Illinois Steel Co.

Russell, W. S., Schenectady, N. Y., American Locomotive Works.

Saubert, H. M., St. Louis, La Clede Gas Co.

Wachtman, E. L., Chicago, Western Electric Co.

The following letter from W. M. Conway, C. E., '06, and G. L. Dunlap, C. E., '06, was received by Dean Turneaure some time since. These gentlemen are located with the Pennsylvania and Long Island R. R. Co., in the tunnel department:

"We came here immediately after graduation, June, 1906, and like the work very much; there is an unlimited amount of experience to be gained in almost every branch of civil engineering and promotion comes very rapidly to the majority of men. The work under compressed air is not nearly as bad as reported. The engineers are not required to go into it more than every other day for a period of two hours.

They have begun to put in the reinforced concrete in the tunnels under the city, and the engineers have complete charge of the work. Thus it can be seen that a vast amount of experience can be gained along this new field of engineering.

The wages here are probably better than most places. They pay to inexperienced men $60.00 for the first month, $70.00 for the second and $90.00 for the next, which is rodmen's wages. Instrument men get $120.00 and chief of party $150.00. We are in need of more men, and in case there are any Wisconsin graduates looking for a change, write J. H. Brace, 345 E. 33d St., N. Y. Mr. Brace is Resident Engineer and a Wisconsin graduate."

W. M. CONWAY '06.
G. L. DUNLAP, '06.

The following is part of a letter received from O. B. Zimmerman, formerly Asst. Professor of Machine Design at U. of W.:

CHARLES CITY, IOWA.

"You will of course note that I am not in Milwaukee, as I have taken up work as a Mechanical Engineering with the above named firm (Hart-Parr Co.). It might be of interest to you to know that C. W. Hart, president, U. W., '96; C. H. Parr, secretary, U. W., '96; W. H. Williams, sales manager, U. W., '96; O. B. Zimmerman, engineer and chief draftsman, U. W., '96 and R. P. Howard, superintendent, ex-U. W., '91, are all together here and things are 'doing.' Regards to boys.

Yours truly,
OLIVER B. ZIMMERMAN.

Arthur H. West (Eng., '87) is now fourth vice-president and chief engineer of the Westinghouse Machine Co., at East Pittsburg, Penn.

Harry B. Sturtevant (Eng., '80) is now a mining engineer in Tucson, Arizona. He went to Tucson from Duluth, Minn., where he was manager of mines for Rogers, Brown & Co.

F. C. Weber, '03, who is now in electrical work in Omaha, Neb., was seen on the campus Nov. 22, '06. Mr. Weber had been in the city for a week on business, and took the opportunity to look up old friends at the College of Engineering.

Mr. Claud Berry, '01, has been transferred from Minneapolis to San Francisco, at which place he is in charge of a branch office of the Minneapolis Steel and Machinery Co.

Mr. C. F. Graff, '04, has left the employ of the G. N. R. R. and has opened offices in Seattle, Wash., as a Consulting Engineer, with Reinforced Concrete as a specialty.

Mr. Harry Gardner, '05, who has a position as instructor in C. E. at the University of Illinois, spent the summer in the office of the City Engineer at Grand Forks, N. D.

Mr. G. N. Whitby, '04, is now Assistant Engineer of the Great Northern R. R., and is located at Grand Forks, N. D.

Mr. J. H. Griffith, '93, has accepted a position as engineer in the bridge department of the Pennsylvania R. R.

Mr. W. A. Hoyt, '00, is now with the Schillinger Bros. Co., Chicago, as engineer in charge of Steel Concrete Construction.

Mr. G. G. Post, who was last year an instructor in Electrical Engineering at U. of W., has accepted a position with the Milwaukee Electric Railway and Lighting Co., Milwaukee, Wis.

Mr. F. J. Petura has resigned his position as instructor in Electrical Engineering, U. of W., and has accpted a position with the Denver Gas and Electric Co.

Mr. J. E. Boynton, '05, last year an instructor in Mechanical Drawing, U. of W., has accepted a responsible position with the Western Electric Co., in Chicago.

On August 16 occurred the marriage of Miss Bernice Quin, of Madison, and Mr. William N. Jones, '05. Mr. and Mrs. Jones will make their home at Cincinnati, where Mr. Jones has a position as civil engineer for the Board of Water Commissioners.

Miss Elsie Dillon and Mr. S. W. Cheney, '04, were married on June 27th at the home of the bride's parents in

Madison. Mr. and Mrs. Cheney will make their home in Lincoln, Nebraska, Mr. Cheney having a position in the Lincoln Gas & Electric Co.

On July 18th Miss Julia Field and Mr. Arthur W. Scheiber, '99, were married at the home of the bride's parents in Chicago. Mr. and Mrs. Scheiber will reside at Oran, Mo., where Mr. Scheiber is operating engineer of the telephone exchange.

Miss Theo Pickford and Mr. Ray S. Owen, '04, were married August 1st, at the home of the bride's parents in Madison. Mr. and Mrs. Owen will make their home in Madison, where Mr. Owen is an instructor in C. E. in the University of Wisconsin.

Miss Norma Nebel and Mr. T. Harris Manchester, '06, were married in Madison, at the home of the bride's parents, on October 14th. Mr. and Mrs. Manchester will make their home at Beloit, where Mr. Manchester is employed by Fairbanks, Morse & Co.

On Oct. 20th occurred the marriage of Miss Elsie Duerr of Madison and Mr. Edgar A. Goetz, '03. Mr. and Mrs. Goetz have made their home at Minneapolis, where Mr. Goetz is engaged in engineering work.

On Oct. 24th Miss Marion Van Velzer and Mr. Lancaster D. Burling, '05, were married at the home of the bride's parents, Prof. and Mrs. C. A. Van Velzer, in Madison. Mr. and Mrs. Burling will make their home in Washington, D. C., where Mr. Burling is employed by the U. S. G. S.

On Saturday evening, Nov. 10th, at St. Raphael's parsonage, Madison, Miss Josephine Harrington and Mr. Irving Hull, '06, were married. Mr. and Mrs. Hull will be at home after Nov. 25th at 1706 W. 15th street, Chicago. Mr. Hull has a position as inspector of materials with the Chicago Telephone Co.

BOOK REVIEW.

Experimental Electrochemistry, by N. Monroe Hopkins, Ph. D. D. Van Nostrand Co. 1906. $3.00.

The book is written in a simple and interesting manner and has many good illustrations. In discussing the theoretical and applied phases of electrochemistry, the author lays much stress on the historical side. The chapters on electrolytic preparation of inorganic and organic compounds, the isolation of the alkali metals, electric furnace products, and fixation of atmospheric nitrogen are very clear and entertaining, because of the many cuts of apparatus. Since methods of teaching electrochemistry differ so widely, it is difficult to criticize the author's method of presenting the subject. However, there are some points where criticism could be made. These points are inaccuracies and misleading statements, for instance, in the chapter on isolation of aluminum there is an evident error in balancing a chemical equation as well as a wrong equation, in the chapter on single potentials the use of "a sensitive voltmeter" in series with the normal electrode and the metal to be tested is unusual and misleading. A voltmeter of the standard type would not measure accurately the drop of potential across the long column of electrolyte. In his attempt to carry the historical phase together with theoretic and applied phases, the author gives undue prominence to the "fireworks" of electrochemistry.

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