THE CONSTRUCTION OF THE TELEPHONE AND FREIGHT TUNNELS IN CHICAGO

BY

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This is to certify that the thesis prepared under the immediate supervision of Assistant Professor F. G. Frink by ERNEST EDWARD MEIER

entitled THE CONSTRUCTION OF TELEPHONE AND FREIGHT TUNNELS IN CHICAGO

is approved by me as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering

[Signature]

Head of Department of Civil Engineering
THE CONSTRUCTION OF THE TELEPHONE & FREIGHT TUNNELS IN CHICAGO.

On Feb. 20, 1899, the City council of the City of Chicago, passed an ordinance, permitting the Illinois Telephone and Telegraph Co. to build conduits and put up poles for the wires of a new telephone company. These wires could be carried on poles or put in conduits at first, with the understanding that all wires would be underground in fifteen (15) years after the passing of the ordinance.

The permit was granted for a term of thirty years and it contained several clauses which took care of the city's interest. Some of these clauses were: (1) City may regulate rates. (2) City may purchase property at the end of thirty years if notification is given three years before permit expires. (3) The telephone system must furnish 2,000 subscribers in five years or forfeit $50,000 to the city. (4) For a term of ten years after permit is given, the company pays the city 3% of the annual receipts; for the next five years 5%; and for the remaining five years, 7% of the annual receipts. The ordinance said nothing about the size of the conduits. The method of construction as described in this permit was to have manholes, 3 feet in diameter, run from the surface of the street diagonally down to the conduit, as shown in Fig. 1.

When the telephone company was about ready to begin construction, they were notified that the city would not allow
them to proceed according to the original plans, the contention being that the great number of manholes which would be necessary would be obstructions to a subway which it is thought the city will build some day, also, that the tunnels are placed too near the surface of the street.

The company's engineer, Mr. Geo. W. Jackson, then formulated new plans for construction, by which manholes were not necessary. These plans, Mr. Jackson said were accepted by the city, and work was started on the 3rd. of September, 1901. The construction was being done by the Illinois Telephone Construction Co., which was the Illinois Telephone and Telegraph Co. plus an engineering corps.

At about this time the City of Chicago was having an investigation made, for the purpose of finding a space underground, where the city, if it ever wanted to, could build a tunnel or subway for the transportation of passengers. Mr. Bion J. Arnold made the report of the investigation and in his report, nothing was said pertaining to the Illinois Telephone and Telegraph Co.'s conduit, so that its location, is presumably entirely satisfactory to the city.

The size for the conduits was six feet by seven feet six inches, in the shape of a horse-shoe. This size for a conduit which was simply to hold wires for telegraph and telephone service, was enough to arouse the suspicion of the city authorities, but as the ordinance gave no size, this was allowable. It was then said that the size six feet by seven feet six inches was not large enough to accommodate 100,000 subscribers, so, early in
1902 the company started the construction of a tunnel, whose dimensions were double the first, they were twelve feet nine inches by fourteen feet. The City council, through one of its members, found out that the company was building the tunnel twelve feet nine inches by fourteen feet in cross section, which was not permitted by the ordinance. The company was immediately enjoined from going on with the work. It was clear that the authority given in the ordinance had been exceeded. After that there was no work done on the tunnel for a period of about one year. During this time the company was trying to get a new ordinance.

On July 15, 1903 the Illinois Tunnel Co. received an ordinance from the city, which was to entirely supersede the ordinance of Feb. 20, 1899, given the Illinois Telephone and Telegraph Co. This ordinance gave permission to construct two systems of tunnels; (1) the lateral system, which was the original size six feet by seven feet six inches high with ten inch walls and fifteen inch bottoms, and, (2) the trunk system, which was the larger section, twelve feet nine inches by fourteen feet with eighteen inch walls and twenty-one inch bottoms. The ordinance also said that the conduits could be used "for the transmission of newspapers, mail matter, parcels, or merchandise". The ordinance made further stipulations that: (1) The tunnel is to become the property of the city on Feb. 20, 1929 unless permission is then given the company to continue in operation. (2) Under no circumstances can there be any transportation of passengers, neither by this company, nor by any concern to whom
they may lease space in the tunnel.

(3) Highest portion or top of crown of tunnel must not be closer than nineteen feet to the surface of the street.

(4) Trunk lines (twelve feet nine inches by fourteen feet) to be constructed only on streets specified in the ordinance.

(5) Entire trunk system to be constructed in ten years.

(6) All tunnel already constructed must be lowered until required nineteen feet is obtained, if this is necessary.

(7) Space must be allowed in the tunnels for the city's telegraph, electric light and telephone wires, without any cost to the city.

(8) All construction is subject to the approval of the Commissioner of Public Works.

(9) There shall be no manholes used, as were permitted in the ordinance of Feb. 20, 1899.

(10) The city retains the right to purchase, at the end of twenty years, everything, except wires and other appliances necessary to carry on the telephone business. This is to be a cash sale; the price to be determined by three appraisers.

(11) The company must pay into the city treasury; 5% of annual receipts for the first ten years, eight % for the second ten years, and for the remaining seven years, 12%. This permit granted for a period of twenty seven years, or for a term of thirty years dating from the time of the original permit, of Feb. 20, '99.

(12) There must be fifty miles of tunnel constructed in ten years.

(13) The company must have installed within five years, a tel-
ephone service, adequate for serving 20,000 subscribers. 

(14) This ordinance subject to modification by the city council as from time to time it may see fit to make a change.

It is under this very flexible ordinance that the tunnel is now being constructed and operated.

Primarily the tunnels were constructed for the purpose of carrying the wires of the Illinois Telephone and Telegraph Co., which operating the Stowger Automatic System, already serves about 6,000 subscribers. This automatic system does away with the "central exchange operator" and forms the connection automatically. Under the latter ordinance, the Illinois Tunnel Co., while continuing the telephone business already does considerable business in the transportation of freight.

It has been estimated that about 4,000,000 tons of coal are burned annually by the buildings inside the "loop". Already the company has contracted to haul the coal to, and the ashes and other rubbish away from about seventy of these buildings. The company will also haul freight to and from depots and business houses. One can vaguely imagine the volume of business this offers, when it is considered that no less than twenty five trunk lines of railroads radiate from Chicago. Another use of the tunnel was discovered recently. The Heyworth building on the corner of Madison and Wabash Ave. made a connection with the tunnel and all the dirt excavated was taken away through the tunnel. This building has a sub-basement, forty feet below the street grade, which is used as a storeroom for freight going in and coming out through the tunnel. The tunnel company also
has a proposition to furnish concrete already mixed, at a price cheaper than if concrete was made at the place. They will also deliver building material through the tunnel.

The company now has facilities for hauling 50,000 tons of freight per day, having recently given an order for 150 new electric locomotives and 3,000 freight cars, the weight capacity of each car being 30,000 pounds. The cars and locomotives are so constructed as to be able to turn on a radius of fifteen feet, this being the radius of curvature of the by-passes.

These facts show that there is absolutely no limit to the amount of work which these tunnels may yet do.

These tunnels are now to be found under the center line of all the down-town streets and extend from Michigan Ave. on the east to Clinton St. west of the Chicago River, and from Kinzie St. north of the River, south the fourteenth St. There is a network of tunnel under all streets included in the area bounded by South Water, Michigan Ave., West Harrison and Orleans Sts. This area takes in the entire business district of Chicago. Now there are nearly thirty miles of tunnels completed, while the entire system contemplated is sixty miles long reaching from Seventy First St. on the south to Fullerton Ave. on the north and from Kedzie Ave. on the west to Michigan Ave. on the east, as shown by Plate 1.

The grade in the tunnel varies on the different streets. The grades usually are between -27.0 and -31.0 except in places where the tunnel goes under the River, in which place the lowest grade is -51.320. The tunnel is not on a level for any distance
at any place. There is usually a grade up or down of a fraction of one percent. All grade readings in the tunnel are kept to the nearest thousandth of a foot.

The tunnel is lighted by electric lights placed thirty feet apart. During construction they were placed at an interval of one hundred feet, but it was nothing uncommon to be compelled to walk several blocks in total darkness.

The method with which this work was carried on, deserves the highest commendation. For over a year the general public of Chicago knew nothing of the tunnel. They would daily see a corrugated iron structure, projecting up from the sidewalks, on prominent business streets, without having any idea of what they meant or for what purpose they were being used. It was through these little houses that all the dirt was being taken out of the tunnels and loaded into wagons, this work being done after dark, so as not to interfere with the regular traffic.

The entire work was done by the Illinois Telephone Construction Co. which was the constructing company for the Illinois Telephone and Telegraph Co. at first and then for the Illinois Tunnel Co. The whole work was done by day labor and not by contract. At one time there were 850 men actually engaged in tunnel construction work and 600 more in the office work and in handling cement, stone, gravel and dirt. Before actual construction could begin, the telephone company had to have an accurate map of the streets of Chicago. This work had to be done between ten o'clock at night and five in the morning. This made it a very difficult piece of work. This map had to be a very accur-
Thickness of Arch

Trautwine's formula: \( d = \sqrt{\frac{P + \frac{1}{4}S}{4}} + 2 \)

in which,
- \( d = \) depth at crown, in feet
- \( P = \) radius of curvature, in feet
- \( S = \) span in feet

Substituting values:
\[ d = \sqrt{\frac{4.4 + 3}{4}} + 2 = 0.875 \text{ or } 10.5" \]

4.4 was taken as the average radius of curvature of the intrados.

Rankine's Formula.

For Tunnel Arches, where ground is firm and safe,
\[ d = \sqrt{\frac{12}{5}} \]

For soft and slipping material,
\[ d = \sqrt{\frac{48}{5}} \]

For medium soft, blue clay, as encountered in Chicago Tunnel,
\[ d = \sqrt{\frac{2}{5}} \]

in which, \( r = \) rise.
- \( s = \) span.

\[ d = \sqrt{\frac{2}{5}} \cdot \frac{35}{6} \]
\[ = 0.902' = 10.8" \]

Considering these values as found, the thickness will be considered as correct.
ate one, for the angles and distances found in this survey had to be reproduced down below.

The entire tunnel is a concrete construction in the shape of a horse shoe, as best shown by Fig. 2. The smaller section shown in the picture is the lateral system — six feet wide in its widest part and seven feet six inches high, having ten inch walls and fifteen inch bottom. The larger section is the trunk system. It is twelve feet nine inches wide and fourteen feet high, having eighteen inch walls and twenty one inch bottom. (The section shown in Figure Two is the section of the larger tunnel which was built without permission, under the first ordinance.) The height of the tunnel is increased somewhat at intersections, the cause being, that special forms were used in the construction of intersections.

The excavation of the tunnel was started on Madison St. between Fifth Ave. and La Salle St. at Shaft No. 1. Here a shaft was dug straight down and from there a section of tunnel was mined. These shafts are round holes about six feet in diameter.

There were eight of these shafts located at various points along the tunnel. These shafts were so spaced that the distance to haul dirt was minimum.

There was some difficulty encountered in locating these shafts as property owners were suspicious and thought there was danger. Each shaft had a superintendent, an engineer and a timekeeper and foreman for each shift.

As soon as a shaft was dug and a section of the tunnel, say one hundred feet, had been mined, line was gotten down, that is,
Cross Section of Street showing the space below the pavement—occupied by Sewers, Water and Gas Pipes and Conduits—also showing the Lateral Conduit and Manhole Connection.

**Figure 1.**

Shaft No. 3 Looking North.

**Figure 2.**
the proper direction was transferred from the street to the tunnel below. There were several methods used in "getting line down" in the tunnel. One method and it was possibly the best, was as follows:- Two holes about five inches in diameter were dug in the street at approximately the same distance from an established base line. Then five inch cast iron pipes were driven down into these holes, the pipes being driven as nearly plumb as possible. Then tripods, (with 8 ft. legs) were set up over each hole. On these tripods were placed a special apparatus. The apparatus consisted of a target, in the center of which was a grooved pulley. The target was placed perpendicular to the head of the tripod and was free to move around in the plane of the tripod head. It had a fine motion screw for adjustment. The plumb bob string was fastened into the ground and then run over the grooved pulley, then down into the pipe.

A transit was then set up over a point on the base line, directly opposite the pipe. Sight was taken along the base line and an angle of ninety degrees was turned. The plumb bob string was then moved until it was covered by the cross hair in the transit. The exact distance from the plumb bob string to the transit bob string was measured. Then the same operation was repeated on the other side or end of the line, opposite the other pipe. In the tunnel below, the exact points of the plumb bobs were marked on the floor. The transit was then taken down in the tunnel, and the permanent points were placed on the
ceiling of the tunnel. In this way the line was established below.

Grade was gotten down by measuring down through the pipe with a steel tape. The elevation of the top of the pipe was known and by subtracting the length of the pipe the elevation of the bottom of the pipe was found out. From this, the elevation below was gotten. City datum was used throughout the tunnel. These pipes in the street were protected by putting a cap on them and then putting a ten inch pipe around all and capping the ten inch pipe. The top of the cap of the ten inch pipe came to the level of the street as shown in the sketch.

The tunnel was under compressed air during construction. The pneumatic system was used more as a protection against labor troubles, than for any other reason. Mr Jackson said, "with that system, if the men should go on strike, there would be no danger even if the work was left in an incomplete state for a time."

In installing the pneumatic system, air locks were placed near the shafts. These air locks were from about twenty to forty feet in length, varying at the different shafts. They have a capacity of from four to fourteen cars at the different shafts. At each end of these air locks, are placed iron doors with frames imbedded in the concrete.

The concrete at the doors is about twenty inches thick. Sketch shows a section of concrete at lock at shaft No. 8.
The lock at shaft No. 8 was poorly constructed and it leaked air in several places. There seemed to be an error in the design of these locks, as the size of the supply pipes for the compressed air was the same at all the locks, even though they varied greatly in size.

It was necessary to pass through these air locks in going in and out of the tunnel. The "locking in" process was effected by allowing the air under pressure to come into the lock from the tunnel, through one or two, two and one half inch pipes. "Locking out" process is effected by allowing air under pressure to escape to the outside air, through two and one half inch pipes. There was usually from five to nine pounds pressure in the tunnel.

The construction was done by three shifts of men. The first was the mining shift composed of several mining gangs. They worked from four in the afternoon till twelve at night; the second was the trimming shift composed of the same number of trimming gangs, who worked from twelve till eight in the morning; the third shift was made up of concreting gangs, they worked from eight in the morning till they were finished.

The Mining Gang. - Mining is done by a hoop shaped drag knife as shown in sketch. It is a steel knife, tempered to a straw-blue and is made at the company's machines shop. They are used in the soft clay found in most places in the tunnel, but in the excavating under the River, where there is a very hard clay, the miners used
grubbing-axes, as shown in the sketch on the preceding page. The knife is used by two men, each man having one hand on the handle and the other hand on the steel near the handle, as indicated in the sketch on the preceding page. They insert the knife in the clay as far up as they can conveniently reach and then grab it down through the clay, cutting a "slab" of clay about four to six inches in diameter and two to three inches deep and two or three feet long. This piece falls to the floor, and they raise knife to repeat the process. The pieces are picked up as they fall to the floor, by two men called "muckers". They put the clay into a small car which they have in the headings. These cars run on a small track and when there are three or four cars full they are pushed out of the heading by a man called the "car-pusher", and then hauled away by mules. The mules are driven by men called "skimmers". The skinner hauls the clay to the air lock and returns to the heading with a load of empty cars. There are usually two or four miners, one or two muckers, one car-pusher, and one skinner, in a mining gang. One of the miners is foremen of the gang.

In order that the miners may mine in about the right direction, the engineers give them the line before they start work in the afternoon. This is done by setting the transit up over a point previously established, then sighting back on an old point, then revolving telescope and lining in two points in the ceiling near the heading. These points are put in about ten or fifteen feet apart. Common horse shoe nails with the heads flattened and a 3/32 inch hole drilled in the head,
were used as points. The engineers usually put strings through
the holes in the points and put clay on the end of the string
so that the miners had a plumb bob and string along which
they could sight and in that way maintain about the proper
direction. The headings were usually lighted with two of four
lights run into the heading with movable extentions.

The mining gang usually does
the upper part of the tunnel and
the trimming gang which follows,
digs out the lower part to the
proper depth, and if they have
time they dig ahead. Trimming the newly mined section consists
of cutting the tunnel to about the proper shape and size which
is ten inches larger all around and fifteen inches deeper on
the bottom than the finished section, making the size mined out
seven feet eight inches by nine feet seven inches.

The miners usually leave their work in a very rough shape
and trimming is absolutely necessary. The trimmers also dig out
the bottom to the proper depth. The miners and the trimmers
often change places for a week at a time, the one gang will mine
for one week and the other the next. Both receive the same
wages. The trimming gang works till eight in the morning when
the concrete gang comes in.

The distance mined by both gangs varies with the kind of
clay and the men. It varies from nine feet to thirty six feet
in soft clay and from three to nine feet in hard brown clay.
The average length mined is twenty one feet in soft clay. Some
of the examples have been noted:— (1) Two miners, two muckers
drive twelve feet in rather hard clay in eight hours, four men in the next eight hours drive three feet more and trim all fifteen feet.

(2) Five men - sixteen hours, dig and trim twenty one feet.
(3) Ten men - Sixteen hours, dig and trim thirty six feet.
(4) In hard clay - six men - six feet in sixteen hours.

It can be seen that there is nothing constant about the length mined by any special number of men. Of course it increases as the number of men in the gang increases. Fig. 3 shows the section after trimming.

The clay that was encountered in digging the tunnel did not vary much except for the amount of stones found in it. It was nearly all soft blue clay except in the River tunnel. Quite often pockets of sand mixed with black dirt were found, sometimes as much as several cubic yards, one pocket. It was necessary to brace this before concreting. In the River drift the clay contained more stones and most of them angular, and looked like granite. The clay got harder, the lower the drift went. At -45, a solid brown clay was found mixed with stones, this continued until -48, when a somewhat purer but harder brown clay was struck. This extended down below -52.

At eight o'clock in the morning the concreting gang would come in, but before they could start work, the engineers had to give them grade for the newly mined section. This is done by setting a level between the heading and some previous bench mark whose elevation is known. A rod (five feet Philadelphia) is held upside-down on the bench mark on the ceiling, and a rod reading taken. This gives the height of instrument.
**Figure 3.** Lateral Conduit Under Construction

**Figure 3A.** Four-Way Intersection completed.

**Figure 3B.** View of 6x7\(\frac{1}{2}\) ft. Lateral Conduit Completed and Ready for Inspection.
rise or fall of grade is known, also the distance mined; from this can be computed the correct elevation for the grade at the end of the mined section. The rod is set to give this point and is then held in the heading and set. A nail is put in at the bottom of the rod and marked with a crow-foot. This nail gives the elevation of the top surface of the floor. All bench marks are on nails driven into wooden blocks, which are concreted into the ceiling. It is necessary to carry candles to illuminate the target while getting the rod set, also while setting the rod in the heading. While giving line an extention, which the engineer always carries with him, is used. It is screwed into a socket somewhere along the drift. In that way the point of the plumb bob is illuminated. Tissue paper is wrapped around the electric light globes to give a softer light. The length of line, elevation of nail, of and kind, a bench mark, permanent or temporary, are written on a common tag.

After the grade is given, the concreting gang goes ahead with its work. They first remove the bulk head which was put in at the end of the previous day's work, then prepare to put in floor of the tunnel. They first put two wooden "horses" in the heading and run the rail out on these horses, as per sketch. The cars full of concrete are pushed out onto these tracks and the concrete is then dumped until there is enough for the floor. The concrete is then leveled
off and tamped until it comes to the right grade, a trough is then made along the middle of the floor and a 1/2 round wood, which forms the gutter is put in. The wood is six inches wide and three inches deep. On the concrete floor is put a temporary wooden floor made of ten by one and three fourth inch boards. On these boards are put the forms. They are set every three feet, and are made of five inch by six and one half inch channel iron bent into shape, as shown in Fig. 4. These forms were at first made of four pieces bolted together at the top, bottom and on each side, but it was found that in tamping the sides, they sprang up in the center. They were after that made of two pieces, both alike, bolted at the top and the bottom, as shown in sketch opposite. These forms are gotten from old work, where the concrete has set and are used again. When they have gotten enough forms they are lined up, in the following manner; the form nearest the heading is lined in so that its center is directly under the point given by the engineers. This form is then set plumb and braced, so that, when the plumb bob string is held on the lug at the top of the form, the plumb bob strikes the center of the form at the bottom. If it does not, pieces are put under the low side. This is called "shimming". A line is then strung from the last form of the previous days work to this form and all the intermediate forms are lined in and braced as was the first. A strip of
Frame and Form for Lagging of Lateral Conduits

**Figure 4**

- All connecting Angles 3" x 4" x 3/8"
- Bolts —— 3/4"
- Rivets —— 5/8"
- " countersunk outside

5" 6.5" Channel

7'1" Rad

3'10" Rad

6'0"

7'2" Rad

2 1/2" x 2 1/2" x 1/2" Filler
lagging is then nailed across the forms to hold them in place. There were two 3/16 inch holes drilled in the channel for this purpose. When there was an angle to be turned in the tunnel the lagging was so arranged, that a joint in the lagging came on the form nearest the angle point. The carpenters did not like to put in these braces, especially the ceiling braces as these were hard to get at. They would shirk this work whenever given a chance.

After the forms were set, the trimming was investigated, to see that there was twelve inches from form to clay or ten inches from lagging to clay. If there was not the required distance there, the concrete men would have to trim it out to size. Here is another place where the work was shirked.

Just before starting to concrete the sides there is a plastic mortar of cement and water in a one to one mixture, made. This is smeared on old concrete so that new concrete will adhere and make a good joint.

There are then three inch by four inch ties laid between the forms on the floor, and the rails are spiked to these. On these ties another floor is laid but not spiked. There is also a bulk head put in back of the last form, against which the concrete is placed. This bulk head is braced against the clay in the heading.

After this is done the sides are concreted. This is done
by putting "lagging" up against the forms and throwing concrete in between the lagging and the clay. These "lagging" are two by six inch pine boards planed on three sides and are in three six and twelve foot lengths. They, of course, are used over and over again just as forms are. They are usually wet and coated with concrete, and are therefore very heavy. Care must be taken that they do not fall while walking through the tunnel. They sometimes left sticking to the walls after the forms are taken away. The lagging for the trunk system or conduits was made of sheet steel. Fig. 5 shows the details of this lagging.

The tamping should be done after six inches of concrete is put in but this work is shirked worse than any in the tunnel. The sides of the tunnel are built up in this way, until only three lagging remains to be put in at the top or crown of the tunnel. The remainder of the work is called "keying". In keying, one section, of three feet, between forms, is worked at a time, as it would be almost impossible to throw concrete farther and tamp it well. The lagging is put in at the top and the concrete filled in. It is then tamped with a piece of lagging cut into the shape of a tamper. The men preferred this to the regular floor tamper as that was too heavy. The last key in each days work was left and put in the next day, thus joining the work better than if the whole was put in at once. This is shown in Fig. 3.

It is considered that two car loads of dirt make a section of the tunnel one foot in length. When old and new concrete are
joined, the method at first was to put the bulk head square across at right angles to the direction of the wall, then when new concrete was to be joined, to remove the bulk head and smear the old surface with this mixture of cement and water (one to one) called "dope". This was not at all effective, as it was often noticed that in breaking out old concrete to form by-passes or for other purposes, the concrete would split down this plastered joint. The method used latter was to put the bulk head diagonally across the concrete and plaster it the same as before.

In joining old concrete and new concrete, the forms were put in right up to the old work in the usual manner, but, of course, it would never be an exact multiple of three, so that the lagging had to be sawed to the proper length. The walls and crown were constructed in the usual manner, except the crown of the last section. Here it was necessary to fill in by hand, until it would no longer stick. The carpenter would then saw the last two lagging in two parts, one part a little longer than the other. These two half laggings were nailed together and put in and braced in place. The concrete, made somewhat richer, was then put in here and filled in until it would no longer stick. Then the other two half laggings would be filled up with concrete and pushed up into the hole and rammed. This was then nailed in place. This process was called "pigeon holeing" and was a good way of joining new and old work. See next page for drawing of pigeon holeing.
Whenever a street was carried as far as was necessary and did not connect with a cross-street a six inch concrete bulk head was put in across the heading.

When one street crosses another in the tunnel there is an intersection put in. There are three common forms of cross-section, two-way, three-way, and four-way intersections, besides the special intersections necessary in several cases. Figures 6 and 8 show the position of frames in three and four way intersections. Figures 7 and 3 A show the intersections complete.

The by-passes at the intersections were built on a fifteen foot radius and it is thought that they were built to accomod-
Location of Frames to Support the Loging
Three-Way Intersection.

Figure 6

Three-Way Intersection - Completed.

Figure 7
ate pneumatic tube mail service, but there were never any pneumatic tubes installed, and there probably never will as the Government recently gave the contract for pneumatic-mail service to another company, who underbid a supposed representative of the Illinois Tunnel Co.

These intersections require special forms as shown in more Figures 6 and 8. They also require much work and more men. It takes between three and four weeks to entirely construct a four-way intersection. It requires the entire time of two carpenters most of the time. The number of intersections built and their length, is given below. This is for the time from Sept. 1, 1901 to Sept. 1, 1902.

Seven, two-way intersections -----------@--- 4 feet ----28
Twenty nine, three-way intersections -----@-- 24 feet ----696
Twenty five, four-way intersections ----@--- 40 feet ---1000

Below is given a table which shows, the work done and rate of progress, also the material used. This table is one compiled by Geo. W. Jackson, Engineer, and appeared in the October number of the "Western Society Of Engineers Journal". It is also for the time Sept. 1, 1901 to Sept. 1, 1902.

Total No. of Feet constructed — 61,726

<table>
<thead>
<tr>
<th>Shaft</th>
<th>No. Feet</th>
<th>Working Days</th>
<th>Av. Feet per Working Day</th>
</tr>
</thead>
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<tr>
<td>No. 1</td>
<td>18,730</td>
<td>247</td>
<td>75.1</td>
</tr>
<tr>
<td>No. 2</td>
<td>14,595</td>
<td>118</td>
<td>125.4</td>
</tr>
<tr>
<td>No. 3</td>
<td>2,454</td>
<td>63</td>
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<td>No. 4</td>
<td>17,510</td>
<td>176</td>
<td>99.4</td>
</tr>
<tr>
<td>No. 7</td>
<td>1,244</td>
<td>53</td>
<td>23.6</td>
</tr>
</tbody>
</table>
| No. 8 | 7,183    | 40.1         | 175,000 cu. yds.
The construction of the tunnel under the Chicago River at Van Buren St. was somewhat different than at the other parts of the tunnel. The excavated material varied there more than at the other drifts in the tunnel.

The material was so very hard that it could not be mined with drag knives but had to be mined with grubbing axes. The miners choped into the clay but never got very large pieces out.

There were numerous piles stuck in mining here. They were said to be the piles of the left abutment of the Van Buren St. bridge. There was no official record kept of these piles, as it seems there should have been. The ends of the piles were cut off and were concreted as fast as possible.

The ends of the piles were in very good shape showing that iron points are unnecessary, even through this hard clay. Water leaked down the side of the piles, but not enough to cause any trouble. Troughs were made out of cement bags, which took the water into the heading.

There was another lock put in at the river drift for safety. The pressure was increased to about twenty three pounds but there was no trouble encountered.

After a section of the tunnel is completed the temporary floor and tracks are removed and the whole is then plastered, so that there is a fairly smooth surface. After the plaster is dry, the entire surface is washed with a cement wash, which gives it a very clean and finished appearance.

The small cars used in carrying away the excavated mat-
31.

Orizontal, had a capacity of about one half a cubic yard. There were two kinds; (1) those with wooden sides which measured twenty one inches by forty eight inches by twenty four inches deep - inside measurements, and, (2) iron cars containing 13.5 cubic feet.

They run on a narrow gage track (14 inches). Mr Jackson says he believes that "it is because of the smallness of these cars that the work was so successfully carried on". These cars when full could be managed by one man, if a car jumped the track as they often did, one man could set it back on the track. The moving of the excavated material was kept up continuously, without an interruption.

The smallness of the cars was also a very good thing for the concrete, because it could be handled speedily, thus obviating any chance of its becoming set. These cars were driven to the lock by the skinners, they were then taken through the air lock in the small house on the sidewalk, and from there dumped directly into wagons. There were 900 of these cars in use.

Hauling away the excavated material was done between five P.M. and seven A.M. so as not to interfere with street traffic. The management of this part of the work was excellent, as at no time was there any delay, no matter what the weather conditions were.

The concrete was mixed in the basement of the buildings used and taken down into the tunnel through the air lock. From the air lock it was taken to the headings. It was mixed above, just as it was used. The skinners reported how many more cars they wanted and these were mixed. The cement used was American
Portland (Atlas and Chicago A A). All cement was tested by the company before being used. It was subjected to a fourteen day test before being accepted and was under very rigid specifications. Most concrete was made with a mixture of mixed gravel and sand in the proportions of five parts of gravel to one of cement. Some of the concrete, that at shaft No. 8, was made with crushed stone, unscreened, and cement in the same proportions. The mixing of the concrete was done in a very careless manner, the proportions while given were hardly ever thought of. This was particularly true of the amount of water. This was dependent upon how long the foreman cared to stand at the faucet before being called away. There was a layer of one fourth to one half inch of water on some of the concrete while other concrete could hardly be called a dry mixture. More attention should have been paid to the mixing of the concrete. Drake concrete mixers were used.

The condition of the atmosphere in the tunnel was anything but healthful. The whole tunnel was a decided unsanitary condition as can be imagined when one considers the degree of intelligence of the laborers. There was comparatively no drought or air-current in the tunnel except that created by opening and closing the air lock doors. It was nothing uncommon to find for a distance of one or two blocks, a heavy vapor hanging from the ceiling, which was impossible to inhale. It was necessary to either stoop and walk under the cloud of vapor or take a deep breath before walking through it. The tunnel was always damp and chilly, often being cold enough to see one's breath.

Every night the mining gangs would get strong hot coffee.
They seemed to enjoy this very much and it was a good stimulant for them even though it was not the favorite drink of most of the laborers.

On account of the compressed air, sound traveled much farther than it ordinarily would. Talking nearly a half a mile away could be heard distinctly. The rumbling noise of the cars and the shouting of the skimmers could be heard so plainly that the mule seemed at one's back, when several blocks away. Taking altogether the tunnel was, unavoidably, a very unhealthy place.

Fig. 9 shows the machinery and its arrangement at shaft No. 1. The arrangement at the other shafts was, in general, the same, except at shaft No. 8. At each shaft they have a horizontal tubular boiler, a horizontal steam engine driving the concrete mixer; a ten horse power motor driving the belt conveyor, which conveys the material from the chute in the side walk to the bin for the material; an air compressor with a capacity of about 400 cubic feet per minute; a steam hoist at the elevator; and a motor furnishing the lights which are eight candle power, 110 volt incandescent lamps. There usually are a few dressing rooms for the workmen, a wash-room, tool room, oil room and a small office. At shaft No. 8 the arrangement was somewhat different. Instead of an elevator, they there had a long incline. This was necessary here because the mule barn was at this shaft and all mules were taken up and down this incline in going to and coming from the tunnel. The excavated material was conveyed by an endless chain. On this chain were "dogs" like sketch. These "dogs" caught the cars at the axle and
conveyed them up to the ground. They were then pushed out onto the platforms, extending over scows, which were moored to the dock below.

These platforms can be raised or lowered so as not to interfere with boats in the river. This method of handling material was very economical and did away with any chance of delay, because of its increasing the capacity to such a great extent. Fig. 10 shows the platforms. There was another method used at the Lake Front (Shaft No. 7) as shown by figure 11. The dirt was hauled to this place by wagons. The sides were lifted off the wagon here by a ten ton stiff-leg derrick. The derrick then took the bottom with its load and dumped it. They now have a new and better arrangement. The clay is brought up an incline in cars holding about one cubic yard each, the cars are hauled by an electric motor-car. These cars run out onto a framework, built in the form of a loop as shown by Fig. 13. The cars are run out to the place where the dirt is to be dumped. Two men are stationed at this place. These men loosen the sides of the car and the dirt is dumped down. The electric motors used at the Lake Front are eighty horse power motors manufactured by the Morgan Electric Machinery Co. They run by third rail up the incline and by both trolley and third rail in the tunnel as can be seen by Fig. 14.

The system of narrow gauge track used in the tunnel was as follows: - Double track in all the completed drifts, except when the heading is finished, when the track is torn up and used in some other place. At all crossings and switches only single track is laid, which saves complication. In changing from double
Elevator House, to lift the excavated clay that it may be dumped into wagons to be hauled away to the Lake Front.

Tracks and Movable Platforms for dumping the excavated clay into scows in the river.

**Figure 10**

**Figure 11.**
Showing method of Dumping at Lake Front.

**Figure 12.**
Elevator House, to lift the excavated clay that it may be dumped into wagons to be hauled away to the Lake Front.
DUMP IN LAKE FRONT PARK WHERE DIRT FROM NEW DOWNTOWN BUILDINGS IS DISPOSED OF.

FIGURE 13

FREIGHT TRAINS AT STREET INTERSECTION.

FIGURE 14
to single track, a standard cast iron switch is used. Fig.3 shows rails.

In the angles of the frog and switches two inch wooden strips were placed to prevent the mules from slipping and getting their hoofs caught.

The track was two or three inches high. The gauge was fourteen or fourteen and one half inches. There were also three-way switches used. A simple rail bending machine was also used in the tunnel.

There were turntables used in some places instead of switches, but there were not many of them.

Connections to buildings for telephone service are made by building a lateral out from the tunnel as shown in sketch. The lateral is round, three feet in diameter and has walls of concrete, eight inches thick.

For freight service, laterals of the same size as the tunnel are run down the alley to the building and from there a shaft is run into the building, and an elevator put in the building, which runs from the tunnel level, to the level of the basement of the building. The tunnel company does all this work, when it makes a connection, without cost to the subscriber.
In all the new buildings in Chicago, the architects have planned a sub-basement on about the level of the tunnel. This sub-basement is used for storage of freight passing through the tunnel.

The sensation of passing through the air lock is certainly a peculiar one, especially the first time.

When "locking in" or going into tunnel, the outer door is closed and the air under pressure is admitted from the tunnel. It is necessary to take a deep breath, then do as if you were blowing your nose, but hold nostrils shut, also take deep breath and exhale. This is done to equalize the air pressure on both sides of the tympanum in the ear. If the pressure is not the same on both sides of the tympanum, it cannot vibrate and you therefore cannot hear. The lock becomes very warm while pressure is increasing more so at the end opposite to where the cold air is being admitted than at that end. The lock tender is in his glory, if he can get a "tenderfoot" in the lock and put the pressure on real fast. It is said that some of the workmen wanted to know if there wasn't a ladder somewhere so they could climb up and get out of the tunnel. They dreaded the lock. If a person did not take care of his ears while being "locked in" he would receive a sharp pain. This was called being "blocked". A person suffering with a cold or catarrh would always have trouble when "locking in".

"Locking out" was just the reverse, that is reducing the pressure from nine pounds above atmospheric pressure to atmospheric pressure. In locking out the air became very cool and as there was considerable moisture in the air, a very dense fog
always appeared. This fog would rise from the floor in clouds and quickly envelop everything. The entire spectrum could be seen around the electric light when this fog was in the lock. There is nothing to be done to the ears when looking out. There was no trouble in taking the mules through the lock. New mules would kick a little at first but they soon became accustomed to it.

Below is given the scale of wages in effect June 4, 1902.

<table>
<thead>
<tr>
<th>Position</th>
<th>Wage</th>
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</thead>
<tbody>
<tr>
<td>Working foreman Miners</td>
<td>$3.85</td>
</tr>
<tr>
<td>Miners</td>
<td>$3.50</td>
</tr>
<tr>
<td>Labor &quot;Muckers&quot;</td>
<td>$2.70</td>
</tr>
<tr>
<td>Skinners</td>
<td>$2.50</td>
</tr>
<tr>
<td>Laborers (At drift)</td>
<td>$2.70</td>
</tr>
<tr>
<td>Laborers (Common)</td>
<td>$2.25</td>
</tr>
<tr>
<td>Laborers (Cleaning up and hauling)</td>
<td>$1.75</td>
</tr>
<tr>
<td>Concrete men (Drift)</td>
<td>$2.70</td>
</tr>
<tr>
<td>Concrete Foreman (Working)</td>
<td>$3.25</td>
</tr>
<tr>
<td>Concrete Mixers</td>
<td>$2.35</td>
</tr>
<tr>
<td>Air Lock Tenders</td>
<td>$2.75</td>
</tr>
<tr>
<td>Elevator Men</td>
<td>$2.35</td>
</tr>
<tr>
<td>Dump Men</td>
<td>$2.35</td>
</tr>
</tbody>
</table>

It is rather difficult to try to get at the cost of the tunnel. To get the cost consider the length mined as twenty feet. In mining, trimming, and concreting the twenty feet there will be:

- 2 Mining foremen $\times$ $3.85 = 3.85$ per day
- 2 Miners $\times$ $3.50 = 3.50$
- 4 Muckers $\times$ $2.70 = 2.70$
<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
<th>Rate per Day</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Car Pushers</td>
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<tr>
<td>Concrete Foreman</td>
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<td>3.25</td>
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<tr>
<td>Concrete Men</td>
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<tr>
<td>Dump Men</td>
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<td>2.35</td>
</tr>
<tr>
<td>Laborers</td>
<td>2</td>
<td>2.25</td>
</tr>
</tbody>
</table>

Figuring the time of the above gangs and the cost of the material, haulage, superintendence, engineering and profit, the cost per foot of the tunnel comes to about $10.00. This of course is very rough, it being necessary to suppose so many of the conditions.

However accurate this price per foot may or may not be, the fact that the company, has actually spent about $10,000,000 already and has completed about thirty miles bringing the price per foot to about $90.00 shows in itself the great cost of an undertaking of this kind, other than the cost of construction. This is especially true of this company as it had to get two ordinances and there is always an expense about that.

The construction of the tunnel was comparatively free from accidents. There were no lives lost. The most serious accident was a cave in on Plymouth Place. A section of newly concreted tunnel about twenty-five feet long was broken down. The weight of the clay above settled on the concrete and it broke down.
Another small cave-in took place at Fifth Ave. and Monroe St. This was not serious. Both of these accidents were quickly remedied. While piles were being driven for the new Rock Island Depot, cracks appeared in the tunnel along Pacific Ave. Although the piles were thirty or forty feet away, the force exerted itself on the tunnel walls and they were slightly damaged. A laborer had his leg crushed between two loads of concrete, another laborer had his foot crushed by a load of concrete. These accidents while bad in themselves can not be considered bad when one thinks of the enormous amount of work done.

Recently the Chicago Subway Co. was organized in Trenton, N.J. with a capital stock of fifty million dollars. They purchased the entire stock of the Illinois Telephone and Telegraph Co., and 66 2/3 % of the stock of the Illinois Tunnel Co. While both these organizations will remain intact, the Chicago Subway Co. will be the owners. The new owners are all railway men and represent 90 % of all the railroads having Chicago terminals. The Illinois Tunnel Co. will remain as the operating company and the Illinois Telephone Construction Co. will still be the constructing company, but doubtless with the exception of Pres. Wheeler the other officers will be replaced by representatives of the new financial interests. There is not much known about the deal, but in short it means the use of the tunnel for an enormous amount of business.

A Chicago paper, rightly expressed it, when it said, "The Wheeler Enterprise, after a stormy career, had finally won notable triumph in the financial world".
First Section of Tunnel Mined Cor. Madison & LaSalle.

Typical Four Way Intersection.