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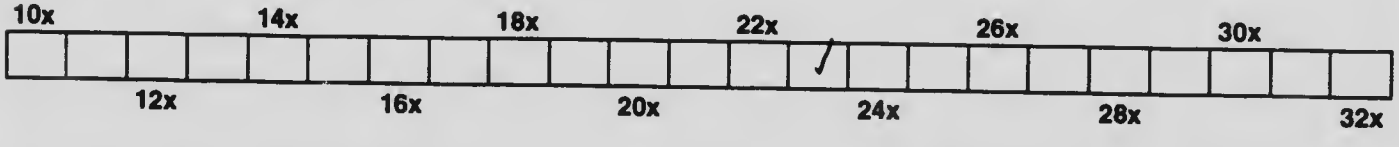

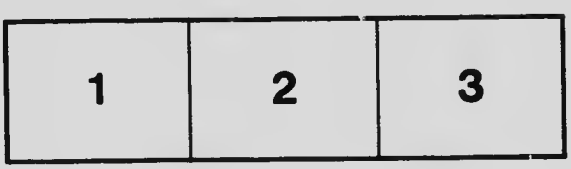

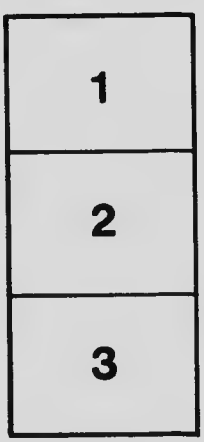

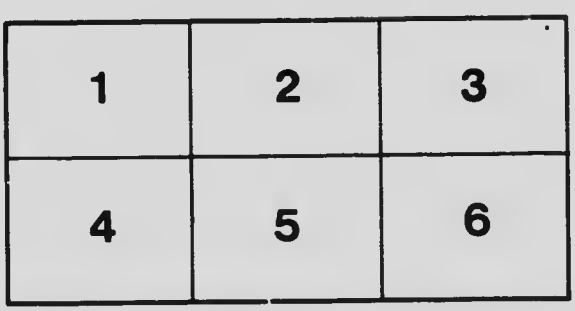

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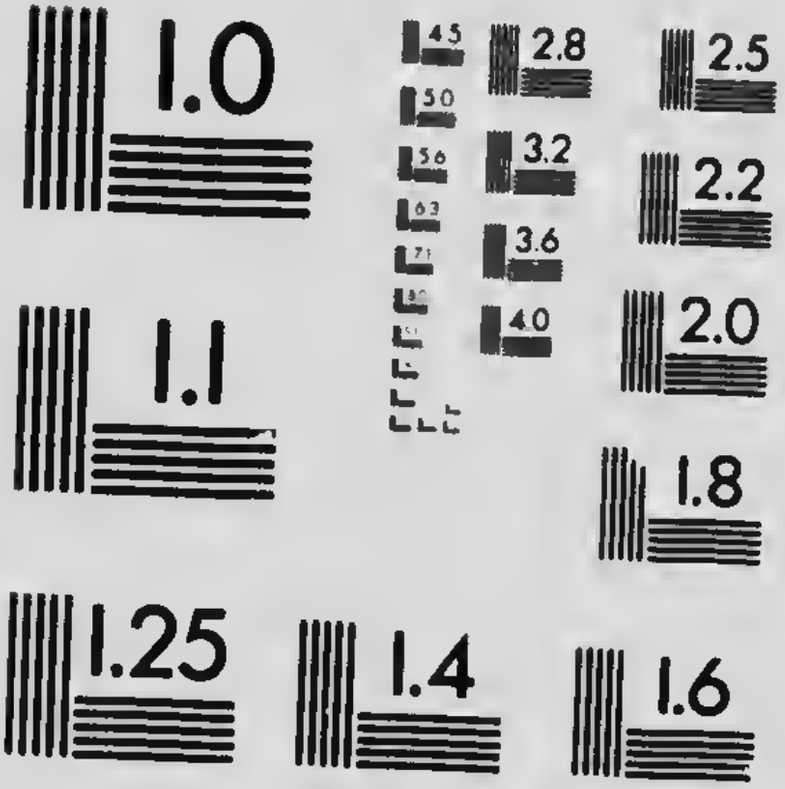

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Electrolysis

in the

City of Winnipeg

BY

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Consulting Electrical Engineer

ELECTROLYSIS IN THE CITY OF WINNIPEG.

By L. A. Herdt, E.E., M.A.E.
Consulting Electrical Engineer.

In January, 1909, the writer was instructed by the Council of the City of Winnipeg to report upon the danger to the watermains and telephone cable system that might exist in the city, due to the return currents of the Winnipeg Street Railway Co., and to submit recommendations dealing with improvements of the present street railway system, so that electrolysis, if it existed, would be eliminated. A report was made following the above instructions, and was published in the *Canadian Engineer*, August 20th, 1909, *Canadian Electrical News*, September, 1909, and in other technical periodicals.

There has been a demand for this report from different quarters, and it is reprinted with some additions, hoping that it will prove serviceable to those who have to consider similar problems in connection with the grounded returns of electrical railway companies.

THE AUTHOR.

Montreal, March, 1910.

Preliminary.—The Winnipeg Electric Railway Company, in operating their street railway system, use the rails as a return for the current operating the cars. In order to make the rails a continuous conductor, and thus secure a good return path for the current, the rails are bonded at the rail joints with copper bonds. Besides this the rails are connected to the station negative busbars by return copper feeders, bonded to the track at different points of the system.

This is the usual method of street railway return construction, but electric railway companies using this system, that is, using the rails as the return circuit for the returning currents, are a serious menace to piping and cable systems in proximity to the tracks, if the methods of constructing the above described rail return are such that the railway companies are unable to control their own currents, but use the piping and lead-covered cables as part of their return circuit.

Cause of Electrolysis.—Currents from the railway system, if the track returns are in bad condition, having to find their way back to the power house, will flow from the rails which are in contact with the ground, through the ground, and such metallic constructions in it that offer the least resistance to the flow, and after flowing through these (gas pipes, water mains, lead covered cables, etc.) towards the station, will return through the ground back to the rails or to return conductors in the vicinity of the

power house. These stray currents cause electrolytic action, that is, whenever current passes from a pipe or cable to ground, or to another pipe or cable, corrosion of the metal is set up; holes and pittings are produced, causing bursting and leaking of pipes, eating away of the lead covering on telephone and other cables, rendering them useless. This corrosion may be very rapid, and depends on the intensity of the stray currents passing through.

If the rails in a track system were continuous and the current density in the rails kept low, with rails well connected to the power house, the rails would offer such a good return path for the current that street piping, cables and other metallic structures would be practically immune from electrolytic damage due to stray currents. However, as the rails are not continuous, but are made up in lengths, they must be joined by copper bonds possessing such mechanical and electrical properties as will secure permanent and efficient continuity of the rails between sections. If such bonding does not exist, and if return feeders connecting the rails to the power house are inadequate for the purpose, the amount of leakage current must be great and electrolysis is bound to exist.

The immunity of street piping and other metallic structure from electrolytic damage, due to stray currents, demands that electric railway companies adopt such method of construction for their track returns as will minimize the danger, and the railway companies must maintain the efficiency of such construction through systematic inspection and repair.

In view of the above and in order to arrive at correct and definite conclusions regarding the conditions existing in the city of Winnipeg, a survey for electrolysis and examination of the tracks was made.

Plans.—Drawings were made showing

1. Electric railway tracks.
2. High pressure water mains.
3. Domestic water mains.
4. Telephone cable runs.

(Of the above, only those close to or paralleling the railway tracks, were shown on the plans.)

A plan was also made, showing layout of overhead feeders and sections, the railway tracks, weight of rails, return feeders, bonds, etc.

(These plans are not inserted in this reprint.)

Plan No. 1 shows localities in the city of Winnipeg where damage to water pipes has taken place. This plan also gives the location of the terminal station feeding the whole railway system, the type of bonds used, and return feeders used.

Description of System.—The Winnipeg Street Railway Company

Fig. 1.

Electrolytic Action on Water Mains.

have two plants in the city of Winnipeg one, the old steam plant, at the foot of Main Street, corner of Assiniboine Avenue; the other a substation on Mill Street. The first plant is kept as a steam reserve; the second plant, which furnishes the whole of the electric current for the street railway system, receives its electrical energy from the hydro-electric plant at the Pinawa channel of the Winnipeg river. The average current for the railway service fed out from this plant approximates 6,000 amperes, but reaches as high as 9,000 amperes at times of heavy load in the winter months.

The street railway tracks are bonded at the corner of Main Street and Portage Avenue to return feeders connected to the negative bus bars at the station. Other return feeders connected at different points to the track are also used (see Plan No. 1.)

It was apprehended at once from a study of the geographical location of the power station, its distance from the street railway tracks, the large volume of current that required to be returned to it, the run of the underground piping system and telephone cables, and the proximity of the river, that unless the track returns were of the very best, and unless there was a very generous amount of copper used for the negative feeders, the conditions were such as to point to great possibilities for stray currents.

Electrolysis Investigation and Survey.—The electrolysis survey, which was carried out, involved not only mere readings of potential difference between the rails, the piping system and telephone cables, but it embraced an examination of the feeder circuits, the general condition of the roadbed and the sizes and efficiency of the returns. A complete and thorough examination of the points where the City Electrician had reported damage to pipes through electrolysis was also made.

The following summary states concisely the conditions existing in the city.

District Affected by Stray Currents.—The report of your City Electrician, giving location of pipes damaged dating from January, 1905, to June 4, 1909, shows that electrolytic action has mainly taken place in the following districts:

1st. Princess Street, from Logan Avenue to Notre Dame Avenue.

2nd. Portage Avenue, from Hargrave Street to Fort Street.

3rd. District enclosed by Main, Broadway, Hargrave and the river.

4th.—Notre Dame Avenue, from Main Street to Winnipeg Electric Railway Company's substation.

5th.—Ellen Street, from Notre Dame Avenue to McDermot Avenue.

6th.—Langside Street, from Portage Avenue to Ellice Avenue.

(These districts are shown shaded in Plan No. 1.)

Pieces of water pipe and lead covered cables taken from these districts by Mr. Cambridge were examined, and showed without doubt that holes and breaks in them had been caused by electrolytic action.

Photos of a few of the destroyed piping are shown.

The damage reported in districts Nos. 1, 2, 5 and 6 is caused by the very bad condition of the bonding on Portage, Notre Dame, and William Avenue, and Sherbrooke Street tracks. On Portage Avenue, from Hargrave Street towards Sherbrooke, where the roadbed is unpaved, the bond wires, which are Nos. O, B, and S, soft copper wire with bonding cap terminal, give readings in equivalent feet of rail of 20 to 60 feet—this shows very bad condition of bonding.

At several places the bonds are uncovered, and many broken bonds were noticed. Current is leaving the tracks in Sherbrooke Street, South Portage, and Notre Dame west of Sherbrooke, (rails are positive to pipes), entering the pipes, flowing down these until close to Main Street is reached (along Main Street from river to C. P. R. subway, pipes are positive to rails), the current leaves the pipes to rails, telephone cables on other pipes causing the damage reported—it accounts also for the trouble reported in the T. Eaton Company's store. (Report of City Engineer, March 2, 1909.)

In connection with district No. 3, that is, in the district around the car barns on Main Street close to the river, the rails on Main Street are bonded to the water pipes. The heavy water mains on this street carry a large part of the railway current till it reaches Water Street, Notre Dame Avenue, and Portage Avenue East, that is, district No. 4, the stray currents are here given back to the telephone cables, which are bonded to the negative bus bars of the substation on Mill Street, and also to the intricate network of high pressure mains and service pipes lying in this district. This accounts for the trouble reported in the McIntyre block. In this connection, the writer desires to state that on May 26, in company with the city electrician, this building was visited. In the basement a recording amperemeter was connected between a water main and a telephone cable. Charts of current readings were kept. At the time of the visit 50 amperes were recorded, and the water pipe was positive to the telephone cables. With the statement reported by our city electrician, that such a condition involves danger of fire, the writer does not agree, although the conditions there are remarkable enough that conditions might be assumed under which fire could be possible. The remedial scheme referred to above, that of bonding the tracks with water and gas pipes, although it may afford local protection, and was considered good practice some time ago, will greatly increase the amount of stray currents and should not be encouraged.

Fig 2

Waterpipes Pitted and Burst on Account of Electrolysis.

The bonding of the tracks on Main Street, from the river to the C. P. R. subway, is good. In addition to the rails, which are heavy (70 and 95 lbs. to the yard), a 500,000 c.m. cable runs between the rails and is cross bonded to the track. On account of the bad condition of the track returns in the other parts of the city causing stray currents everywhere, the tracks on Main Street connected to the bus bars through heavy copper returns, draw the currents from the piping along this street. This is shown by the electrolysis survey, as readings taken along this street between the high pressure hydrants and domestic water pipes show these positive to the rails. As a matter of fact throughout the whole centre of the city this condition is met.

Damage is Widespread.—It can, therefore, be stated that electrolysis is taking place through the entire centre of the city.

The tracks are bonded, at the corner of Main Street and Portage Avenue, to the return feeders of a total sectional area equal to 6,848,000 circular mills. The drop of potential between this point and the negative bus bars, if these carried the railway current altogether, would reach 12 volts at times. The distance is approximately 1,200 feet, that is, the drop of potential from these tracks to the station is one volt per 100 feet. This is altogether excessive; a voltage drop of one-half volt per 300 feet is usually considered large enough. The above condition is responsible for the trouble reported in district No. 4.

Tracks in Very Bad Shape.—Return feeders, besides the one stated above, are also used (see Plan); they are bonded to the tracks at different points of the system, but they are of comparatively small section and little current can be carried by them. To sum up it will suffice to say:

1. With the exception of Main Street from the Assiniboine River to the C. P. R. subway, Portage Avenue from Main Street to Hargrave Street, Notre Dame Avenue from Main Street to Charlotte, Corydon Avenue from Pembina Street to Lilac Street, Lilac Street from Corydon Avenue to Woodlaw Avenue, and the tracks which are being now bonded with electrically brazed bonds (i.e. Dufferin Avenue and Logan Avenue), the track returns of the Winnipeg Street Railway Company are in very bad shape.

2. The load on the Mill Street substation, and its location are such that it is not possible to return through the rails and return feeders only the large volume of current required for the Street Railway service.

Electrolytic troubles and damage to the piping system and cables result from these two conditions, and is spread out over the whole of the centre of the city, although it has appeared only so far in certain districts.

Recommendations.—The cure for the electrolytic trouble should come from the electric railway company, as the city cannot do anything to protect its piping system from stray currents.

Remedial means are mainly those which I have already stated in my preliminary report, dated April 1, 1909, and addressed to your secretary, namely:

1. Installation of substations at different points of the system—this with a view of diminishing the amount of current to be returned through the rails in the centre of the city.

2. Proper rebonding of all tracks that show defect.

3. Special bonding and cross bonding work at intersections.

4. A system of inspection of track returns by the railway company.

Substations.—A substation system of power distribution will greatly help do away with the electrolytic trouble. At present the whole current for the railway service being fed from one station, gives rise to a concentration of current in the tracks situated in the heart of the city. The current density in the rail returns must be kept low. The soil in this city shows a very low resistance, and only very small difference of potential in rail returns can be allowed.

Rebonding of Tracks.—This must be assisted by a rebonding of the tracks which now show defects, that is, which indicates excessive drop. All bonds showing a reading of more than 4.5, that is, whose resistance is greater than 4.5 feet of rail, should receive attention and be made good. Track intersections should also receive careful attention, ground plates at sides of bridges to carry return currents from one side of the river bank to the other, must be done away with and insulated feeders placed instead.

Action by Company.—I am pleased to state that the Winnipeg Electric Railway Company is carrying its work along these lines. Following recommendations made by William B. Boyd, Chief Engineer Toronto Railway Company and Toronto Power Company, Toronto, and approved by the writer, the Winnipeg Railway Company have placed orders for electrical machinery, which will be installed in three new substations, located as follows: One substation near the car barns at Fort Rouge, another on the line running to the County Club, approximately 17,000 feet from the Mill Street substation, and the third in the north end of the city near the car barns. This will reduce very largely the amount of current returning through the rails on Main Street. These rails are now very much overloaded with current.

In connection with the rebonding of the tracks, the railway company have now in the city, and in operation, a bonding car for electrically brazing copper bonds on the rail joints. This type of bond, carefully installed, will secure an effective system of rail return. It can be easily applied on old work with very little disturbance of

Fig. 3.

Destruction of Waterpipes by Electrolytic Action.

pavement. Tests made on Logan Avenue, where this type of bond is in place, show very low readings of voltage drop. The work being carried out now by the railway company on Dufferin Avenue shows construction work of a very substantial nature, and plans for special work at intersections submitted by the railway company to your city electrician, and approved by the writer, will give intersections with very small drop of potential.

Besides the above, the railway company have advised me, through Mr. Boyd, that it is the intention of the company to carry out the following work of reconstruction of their tracks:

1. New rails on Broadway, from Main Street to Osborne Street.
2. New rails on River Avenue, from Main Street to Osborne Street.
3. New rails on Osborne, from Assiniboine River to Spadina Avenue.
4. New rails on Academy Road, from Wellington Crescent to Stafford Street.
5. New rails on Notre Dame Avenue, from Nena to Arlington Avenue.

The Winnipeg Railway Company must be instructed to proceed with this rebonding work, and with the installation of the sub-stations without delay. The rebonding of the tracks must proceed at maximum speed, night and day, until the whole system is in proper condition. After this is done, all bonding of the rails to the telephone cables and pipes should be removed, as well as the ground plates at bridges. The amount of copper in the feeder returns from Main Street, corner of Portage Avenue, to the substation, must be increased to at least 10,000,000 c.m., and the railway company should be instructed to place these wires in the ground in approved conduit.

The writer also desires to recommend that following the termination of the work above outlined, that is, sometime in the fall, a survey be made to see results accomplished.

The third recommendation made, namely, that the railway company should maintain its plant in a high state of efficiency, through a rigid inspection of the track returns, is of the greatest importance to the city, and should be enforced. The track returns should be under test at all times, in order to remedy at once any faulty bonds as they appear.

Accurate records of the drop of potential at different points of the railway system should be kept by the railway company, and be open to inspection of the city electrician.

If the above recommendations are carried out with a desire to obtain best results, troubles due to electrolysis will be practically eliminated. In conclusion, the writer desires to acknowledge his indebtedness to Mr. Boyd for his assistance in this investigation.

The electrolysis tests were carried out with the assistance of Mr. Beaubien, electrical engineer, Montreal, and Mr. McGinnis, of the Winnipeg Electrical Department. Respectfully submitted,

L. A. HERDT.

Winnipeg, June 22, 1909.

As stated in the above report, the Winnipeg Railway Company took immediate steps to remedy the conditions existing, and proceeded to erect substations at different points.

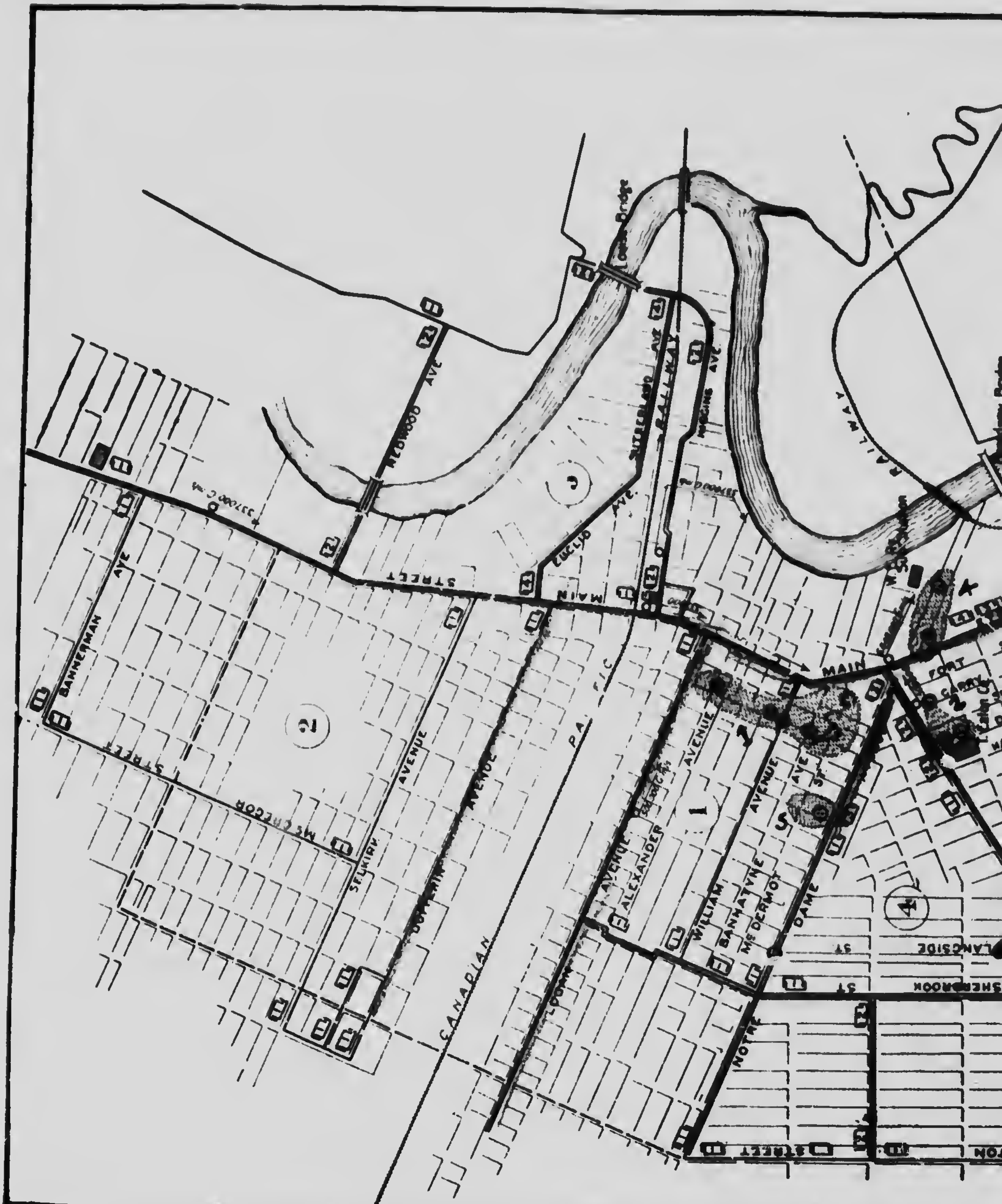
Due to the fact that the high pressure mains for fire purposes, working under 300 lbs. pressure, were situated in the district where electrolysis was found at its worst, the situation was indeed a very serious one, and radical improvements in the system were necessarily called for. The rebonding of the tracks and the installation of the substation proceeded during the summer of 1909.

In November a second electrolysis survey was made to show improvements accomplished.

A comparison of a plan showing the danger district from this survey to that made after the original survey of June, left no doubt to the very great improvements that had been obtained. The danger district was then limited to a comparatively small area around the main terminal station.

The railway company has not yet increased the feeder returns to the terminal station (as recommended), but when this is done and the bonding of all the tracks made good, the danger of electrolysis will practically disappear.

Montreal, March, 1910.



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REDWOOD AVE
RAILWAY
ALEXANDER AVENUE
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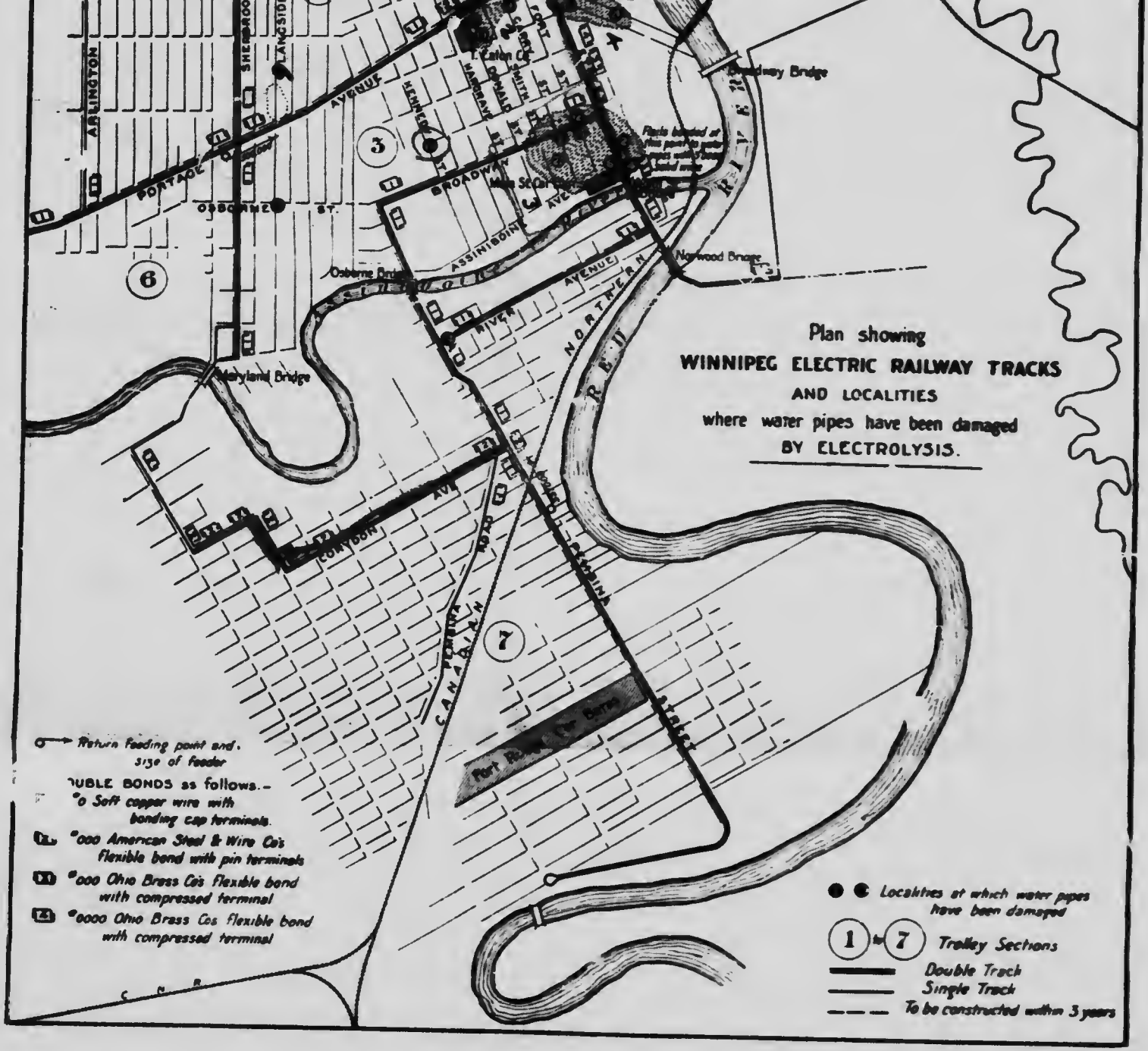
Plan showing
WINNIPEG ELECTRIC RAILWAY TRACKS
AND LOCALITIES
where water pipes have been damaged
BY ELECTROLYSIS.
Broadway Bridge
Osborne Bridge
Norwood Bridge
Maryland Bridge
Return feeding point and size of feeder
DOUBLE BONDS as follows.–
0 Soft copper wire with bonding cap terminals.
0000 American Steel & Wire Co's flexible bond with pin terminals
0000 Ohio Brass Co's Flexible bond with compressed terminal
0000 Ohio Brass Co's Flexible bond with compressed terminal
Localities at which water pipes have been damaged
1 to 7 Trolley Sections
Double Track
Single Track
To be constructed within 3 years