STREET RAILWAY NEGATIVE RETURN SYSTEM FOR THE MITIGATION OF ELECTROLYSIS.*

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WITH the rapid growth in the extent of electric railway lines and the traffic carried by them, the importance of providing a proper return of the current from the cars to the power houses and sub-stations and thus protecting piping systems, cables and other underground structures, against electrolysis, should be recognized by electrical railway engineers.

Serious corrosion of pipes, with attending damages, has occurred in various cities, as is well known, and efforts in certain instances have been made to eliminate the danger. However, it is a fact that as engineers are only human and liable to the error of advocacy, namely, seeing only one side of the question, the engineers of both interests, that is, the engineer of the company owning and operating the electric railway, and those of the company owning the underground structures, are still earnestly debating where to place the responsibility for damage done by stray currents. The often recurring result is that lawyers are brought into the debate and the courts become the stage of action. Judgment obtained after long delay is usually a legal compromise with orders for certain measures for the alleviation of the nuisance.

Such measures are rarely far-reaching or fundamental enough to do more than remove the particular cause of complaint for a time. The merry-go-round of suit, judgments, expenditure on measures of alleviation and legal costs, and then recurrence of the trouble continues ad infinitum.

But as times change the street railway systems serving growing urban districts themselves include underground structures consisting of lead-sheathed cables liable to destruction by currents straying from returns.

Thus a community of interest in the proper methods to avoid damage occurs, and the interest of all parties becomes the same. Engineers alive to the necessity of avoiding damage at the minimum cost may then be asked to apply the solution of the problem that will remove the trouble.

Various Methods of Electrolysis Mitigation.—The various methods of electrolysis mitigation which have been for years the subject of discussion can be divided into two groups:—

(1) Those methods applicable to underground pipes and cable systems.

(2) Those applicable to the railway negative returns.

Of the various methods under the first heading, namely, chemical protection of pipes, cement coatings of pipes, insulating joints in piping systems, pipe drainage and cable drainage, none are entirely suitable for general use and cannot be considered as primary means of preventing electrolysis damage. These methods have their usefulness, but they are suitable only to special conditions and cannot be considered as important factors in any general plan for electrolysis mitigation.

Of the various methods covered under the second heading, that is, those applicable to the railway negative returns, such methods are suitable as will keep the track voltage gradient, that is, the voltage drop per 1,000 feet of track within certain limits, and will reduce the overall maximum difference of potential between any two points of the return system, also within limits, as well as those which will increase the resistance from tracks to earth. These methods are fundamental, as they control the causes of the straying of current from the tracks. Experience has shown what limits of track voltage gradient and overall potential differences can be allowed. Some ordinances grade the allowable limits to the density of the traffic, allowing greater latitude in the suburban districts than in the urban ones; for in fixing voltage limitations, the voltage limit prescribed should evidently be largely determined by the degree of development of the underground utilities in that district.

A track construction which results in a relatively high resistance of leakage path from rail to earth is eminently desirable but difficult to provide in city streets with flush rails and paved streets.

In Great Britain, where the operation of electric railways is governed by regulations of the Board of Trade, regulation No. 3 requires that the maximum difference of potential between any two points on the track return shall not be more than 7 volts, and also prescribes current densities in rails equivalent to a voltage gradient limit in the tracks to about one volt per 1,000 ft. at peak load.

That is, it is sufficient to say, that if the voltage gradient nowhere exceeds one volt per 1,000 ft. and the maximum difference of potential between any two points (reasonably remote from one another) on the returns, is not more than 7 volts—these readings taken at peak load—almost complete immunity from electrolysis damage will result. (The peak load is here considered to be the average of the readings for twenty minutes at peak load.)

Under the conditions cited above, any residual current leakage, or electrolysis effect that may occur, can conveniently, properly and equitably be taken care of by the party owning the structures affected, by methods cited above under Class (1).

To reduce the track voltage drop in an electric railway system various methods are in use:—

(*a*) Improvement of condition of bonding of rail joints.

(*b*) Subdivision of load amongst substations properly located.

(*c*) Installation of negative return feeders with the negative bus grounded at the station.

(*d*) Installation of negative return feeders insulated throughout their length and connected to the negative bus which is not grounded but is maintained at a potential lower than ground.

These methods have been applied in various ways.

In general, methods (*a*) should be applied in all cases to the maximum practical degree of perfection.

Methods (*b*), (*c*) and (*d*) all aim at the same result—namely, the taking of current from the tracks at an increased number of points.

Methods (*c*) and (*d*), however, are radically different from one another inasmuch as method (*d*) divides the system into a network of mains with separate feeders, whilst method (*c*) shuts the mains by so-called feeders.

It will be found in general that method (*c*) will require a prohibitive amount of copper to reduce the track voltage gradient and overall difference of potential within the limits stated previously. A glance at appendix A will show that the current density in the return path through the track is so low, when calculated for the equivalent copper section of the rails, that any attempt to shunt the current will require excessively large copper conductors. For example, the conductance of a single track 100-lb.

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