generating plant and extending over the entire route. In most cases the wires are carried overhead on poles, but where the street traffic is heavy, as in large cities, this causes some encumbrance and danger to the public, especially in case of fire, so that it may be found necessary to carry the feeders and mains underground, a matter which entails considerable difficulty and extra expense; the wires must be better covered and good insulation is much more troublesome to maintain. Since a good conducting path is offered from the trolley to the earth, lightning will be more apt to do injury to the line, though the risk of damage to the station machinery should not be so great as in the case of an entirely overhead line.

A variety of conduit systems were early proposed, but the difficulty of properly insulating a bare wire lying below the surface, or of providing other suitable means of contact, was found to be so great that they received little attention. Lately, however, a number of conduit roads have been constructed on plans which seem to promise better success. The Love system has undergone a series of experiments in Chicago, and a short line was also installed in Washington, D.C., last fall. The conduit used at the latter place is 17 inches deep by 14 inches wide, very similar in general construction to that of cable roads, and connected to the sewer at frequent intervals to secure proper drainage. A complete metallic circuit is used that leakage may be easier detected and kept as low as possible. Full descriptions of this, as well as several other new conduit systems, have appeared in the engineering journals and need not be repeated here. We are informed by one of the engineers of the Washington Road that it has so far given good satisfaction, and that during the severe wet weather of the past winter no trouble was caused by water, the leakage being quite small.

In the European cities there are a number of conduit roads in operation, which we believe are showing good results, the one at Budapest being perhaps the best example.

Induction systems in which primary coils are to be imbedded just below the surface at regular and short intervals along the track, while a secondary is carried low down on the car, have also been proposed; this would overcome the difficulty of moving connections between car and line, but it carries with it other sources of trouble, and we have as yet no suitable alternate current railway motor.

As to the construction of the line for trolley service, we want, of course, to secure as nearly as possible the same potential difference between trolley wire and ground at all points, and to obtain this we must run feeders from the station to different points on the line. We may run out one continuous feeder and connect it to the trolley wire whenever necessary.

The trolley or main may or may not be connected directly to the station.

In this case the diameter of the feeder is decreased as its distance from station increases; a better method is to run out separate feeders.

To determine the location and sizes of feeders we must find the amount of current required at certain parts of the route, and to do this we need of course to know the particulars of the case. Given then :

The profile of the road,

Car speed and time intervals between successive cars,

Total weight of car and number of passengers it is intended to carry,

we can determine the horse-power required by any car at any part of the road from which, assuming a certain efficiency for each of the different parts of the plant, we deduct the current required on any portion of the line *for the given case* and the mechanical horse-power required at the station.

The proper calculation of feeders is nevertheless a difficult problem, as the alteration of any one of the given data will change the result. Take, *e.g.*, cars A, B, and C running at such intervals that their distance from each other is 2,000 feet, drawing respectively 40, 50 and 60 amperes. If now another car D, drawing also 60 amperes, were to follow closely after C, the current required on that section would be doubled, and the line loss increased four-fold; *i.e.*, the available pressure and efficiency would both be materially lessened. Where the feeders had been calculated just to accommodate a certain service, a change in the running schedule of a road might thus entail rather unexpected results in efficiency of operation. The necessity of having a properly constructed ground return is sometimes overlooked, and complaints of corrosion of lead or iron pipes by electrolytic action are not uncommon. Rails should always be properly bonded and grounded at regular intervals by a wire running into permanently moist earth; in some cases it is advisable to put down a return wire.

In the case of roads of the second type, the accumulators must be considered as the transmitting plant, and these have been the one weak point in storage traction. The barriers mostly used have been the lead and acid cells, of the types originally devised by Plante and by Faure, or modifications thereof. The difficulties in their operation are many and well known; the positive plates do still warp and form a short circuit in spite of all efforts put forth to keep them in line, and grid plugs still continue to swell and drop out. The Waddell-Entz Electric Co., of New York, have been experimenting on a French alkaline battery which shows considerable probability of success. The metallic elements used are copper and zinc and the electrolyte caustic potash. The electromotive force of such a couple is quite small, being only eight-tenths to nine-tenths of a volt, while that of the lead cells is 2· to 2·4, but its chemical action is almost completely reversible, and its weight is only about 60 pounds per horse-power hour, stored, while that of the lead type is about 100 pounds; its efficiency is claimed to be fully equal to that of the best lead battery. The motor used in connection therewith is especially designed for low voltage, and has a Gramme ring armature of large diameter with internal field, thus securing a longer power arm and better ventilation. It is wound to take heavy currents so that a powerful torque may be exerted to make up for its slower speed.

MOTORS AND CAR EQUIPMENTS.

The style of motor employed for electric traction work is substantially the same for all of the different systems now in use. In the earliest forms it was carried above the car floor and connected to the car axle by means of belts or chains, but this method was soon abandoned. Link connection between armature shaft and car axle, like that of railway locomotives, was used to some extent, and the method may yet in a modified form come into use, though at present spur gearing is