lutely necessary to forestall capillarity by elevating the roadbed above the level of the adjacent fields."

Obvious and platitudinous as this may seem, there is no elementary principle of road building that is oftener violated. Anyone who has traveled over some of the infamous roads of Kansas, Nebraska, Missouri and some of the other agricultural prairie states can vouch for the fact that a great part, if not all, of their troubles is caused by the fact that the roadbeds are troughs in cultivated fields. No amount or kind of surfacing on such roads will cure their real weakness.

It is strange that a practice so universally followed in railway grading should be so often ignored in the parallel practice of highway grading, although behind this neglect of course is the desire to save expense. To raise a 21-ft. roadbed 1 ft. above the level of the surrounding land requires about 4,500 cu.yd. of fill per mile, making an allowance of 10% for shrinkage. Made with wheel scrapers from roadside borrow pits at 20c. per cu.yd., this extra cost would be $900 per mi.—a liberal estimate.

Suppose we go a little farther than Mr. Bilger and suggest a nearer approach to railway practice—an 18-in. fill—making the additional cost not over $1,500 per mi., or 10% of the probable pavement cost, which is not an extravagant expense when the permanency of a $15,000-per-mi. investment is under consideration.

American Concrete Institute Placed on a Sound Basis

Those connected with the concrete industry who are aware of the difficulties through which the American Concrete Institute has traveled in the recent past will be pleased to learn, in connection with the announcement of the annual convention to be held next February, that the Institute is now in a financially sound condition. Back numbers of the Institute's Proceedings, which have long been withheld from publication for lack of funds, are shortly to be printed and placed in the hands of the members. The delayed volumes Nos. 9 and 10, containing the Proceedings of the conventions of 1913 and 1914, will be printed and distributed to the members before the end of the year. The Proceedings of the convention of 1915 were printed during that year in the form of a monthly journal. Vol. 12, which contains the Proceedings of the convention of last February, has been printed, and is now in the hands of the binders. The cash necessary for publishing all these volumes is already in hand.

The concrete industry owes a debt to the officers of the Institute, headed by President Leonard C. Wason, for the energetic manner in which they have discharged the responsibilities laid upon them. There can be no dissent from the proposition that the Institute has in the past done a very important work for the sound, technical development of the concrete industry. It is the record of that past work, doubtless, which has made possible the campaign that has placed the Institute on a sound financial basis.

The rapid growth of the industry ought to make possible a large accession of membership to the Institute now that it is firmly established as a successful going concern. The President announces that fourteen committees are at work upon subjects in connection with the concrete industry in order to have their reports ready for presentation at the February convention. Under these conditions many new members should join the Institute at the present time so that they may be either able to attend and take part in the February meeting or entitled to receive the report of its proceedings.

Successful Train-Braking with Electric Motors

Saving the power generated when a train runs down a grade and utilizing that power to help the train up another grade has been a dream of inventors ever since the early days of the railway era. The invention of the electric motor and its application to railway service seemed to open the way for the possible realization of this dream, since the electric motor is capable of acting both as a motor and as a generator.

In the November "General Electric Review," J. J. Linebaugh, of the General Electric Co.'s railway and traction engineering department, reviews the progress of regenerative electric braking. The problem may seem easy to the engineer unfamiliar with electrical design; but while a great many different combinations of fields, armatures, motors and control have been invented to make possible regenerative electric braking, none of these combinations have until recently been found practicable with the direct-current railway motor.

With the three-phase alternating current the induction motor used can very readily be adapted to electric braking on steep grade lines, and such a system has been in operation for many years on some of the Alpine lines of the Italian state railways. The three-phase system has been strongly urged as preferable to the direct-current system in the electrification of steam railways on account of this advantage.

The principal installations of electric braking in this country on alternating-current installations have been in connection with the electrification of the western division of the Norfolk & Western Ry. and on the electrified section of the Great Northern Ry. through the Cascades tunnel, the former on the split-phase and the latter on the three-phase system.

One of the most notable features in connection with the Chicago, Milwaukee & St. Paul's electrification of its main line through Montana and Idaho is that electric braking has been adopted and made successful with the 3,000-volt direct-current system. In fact, the braking system is claimed to be superior to that used with the induction motor on alternating-current railways. With this latter type of motor as used on the Norfolk & Western Ry., for example, electric braking is only operative at one uniform speed. In other words, when the train is running down grade and the motors are acting as generators, the train is held to one uniform speed regardless of changes in the profile and alignment.

In practical railway operation, however, it is often desirable to make large variations in speed when running down grade, and the direct-current motor employed as a generator permits this. The control adopted on the St. Paul lines allows the motors when used as generators to be operated either in series or parallel. With the flexibility thus secured it is possible to do effective electric braking over a wide range of speeds. Mr. Linebaugh submits cards of braking effect from a freight locomotive at speeds of 8 to 35 mi. per hr. and from a passenger locomotive at speeds of 15 to 65 mi. per hr.

The success of this electric-braking system is claimed to be due to the commutating pole motor used, which, with its thorough internal ventilation, can stand without injury the heavy overloads due to fluctuating line voltage, and also to the simple form of control that was worked out by the General Electric engineers just before the St. Paul contract was let.

It is evident that if regeneration is used, all the apparatus on the locomotives and in the substations, etc., must be capable of operating inverted. Not only must the motors on the locomotives act as generators, but the generating equipment in the substations must invert; and if motor-generators sets are used, the direct-current generators must operate as motors and the synchronous motors as generators. They must be capable of doing this instantly and as often as required without affecting reliability or successful operation in any way.

The electrical machinery installed on the St. Paul system has been designed to meet these requirements. When a train is descending a heavy grade and feeding current back into the line, that current is utilized in the propulsion of trains on other portions of the line. Under the rare conditions when more power is being returned to the line than is required by other trains, the surplus power is available for other demands over the wide network of lines fed from the power houses that supply current to the railway. This returned power is in fact credited to the railway company.

On the electric-braking system used on the Norfolk & Western Ry. the power house supplies current to the railway alone, and it was necessary to install large water rheostats to turn excess current into heat, when the railway is returning energy to the power house instead of drawing from it.

The profile of the electrically operated line of the St. Paul shows grades of 2% as a maximum, while there are long stretches of 1.7% grades, and three mountain summits are crossed at elevations of 5,678 ft., 6,350 ft. and 4,200 ft. The electric motors are used as brakes only in descending the steeper grades. On a grade of less than ½% there is little or no surplus of power over that required to overcome the train resistance. On grades of 0.6% one-half the locomotive is used to generate power. It will be understood that the air brakes are regularly used for stopping and holding trains and as an auxiliary for regulating speed when the electric motors are acting as generators.

The great advantage of the electric-braking system in securing the safe handling of trains on long heavy grades will be obvious to every railway man who is familiar with the precautions necessary for the safety of trains on such grades with air brakes alone. The St. Paul is sending trains of 3,000 to 3,500 tons' weight behind the tender down these mountain grades, often with a single locomotive.

It will be readily understood that, with electric braking, the train is bunched against the locomotive in descending a grade, and the common difficulty with broken draft gear due to unequal action of air brakes, varying profile, etc., is eliminated. Of equal importance is the elimination of overheated wheels and brake shoes, with the resultant liability to accident.

These practical advantages in the operation of trains on mountain grades are probably more important than the saving in power by the use of the motors as generators although the power saving is considerable. Mr. Linebaugh states that in descending a long 2% grade a train will return to the line about 60% of the current that would be required to haul it up the same grade. In actual service the power saving varies of course with the grades operated over. On eastbound St. Paul trains between Deer Lodge and Three Forks the power returned to the line is about 25% of the power drawn from it. On trains in the reverse direction over the same division 7% is the proportion returned. On the entire 220 mi. between Deer Lodge and Harlowton the power returned by all trains both ways is about 14% of the total current consumption.

The foregoing summary of what has been actually accomplished with electric braking presents facts of interest and importance to every railway engineer. Numerous problems of economic railway location may require revision in the light of these facts. Just as the application of mechanical power to road vehicles has radically revised standards of road construction, so the introduction of electric motive power and regenerative braking may cause a new answer to be given to old problems.

To take a concrete example, engineers are generally familiar with the extensive line revision carried out by the Delaware, Lackawanna & Western R.R. a few years ago, west of Scranton, Penn., at a cost of about $12,000,000, by which 40 mi. of new railway were built to save 327 ft. of total rise and fall with a reduction also of maximum grades and of curvature. It is at least within the possibilities that the introduction of electric motive power over this division might have been a much more economical solution of the problem, since it would also have improved operating conditions on the long and heavy grade that still remains on the line west of Scranton.

This is only a typical example of the problems in railway location and relocation where the engineer will need hereafter to take into consideration the fact that the use of electric motive power with electric braking has materially reduced the difficulties and losses in the operation of railways with heavy grades.

How To Use Your Old Canals

For many years a number of American cities have suffered from the nuisance of abandoned canals in their midsts—canals that not only were obnoxious as open sewers, but were worse than useless because their boatless waters took up useful ground in the busy areas of the town. Now several of these communities are finding, or hope to find, a use for these deep water-filled cuts by draining the canal and using the bed for rapid transit or railway lines. In Cincinnati the proposed interurban entrance is on the Miami and Erie Canal there; in Syracuse the old Erie Canal bed will certainly in time become the route of the New York Central through the city to replace the tracks which now are the most disgraceful example of municipal disfigurement in the country; in Rochester the Erie Canal will soon be turned into new channels, permitting the use of its bed for a street railway route. The combined advantages of ridding the city of a nuisance and of obtaining ready made a depressed railway terminal or rapid transit route are of such commanding importance as to recommend the procedure to any city now saddled with an unused canal.