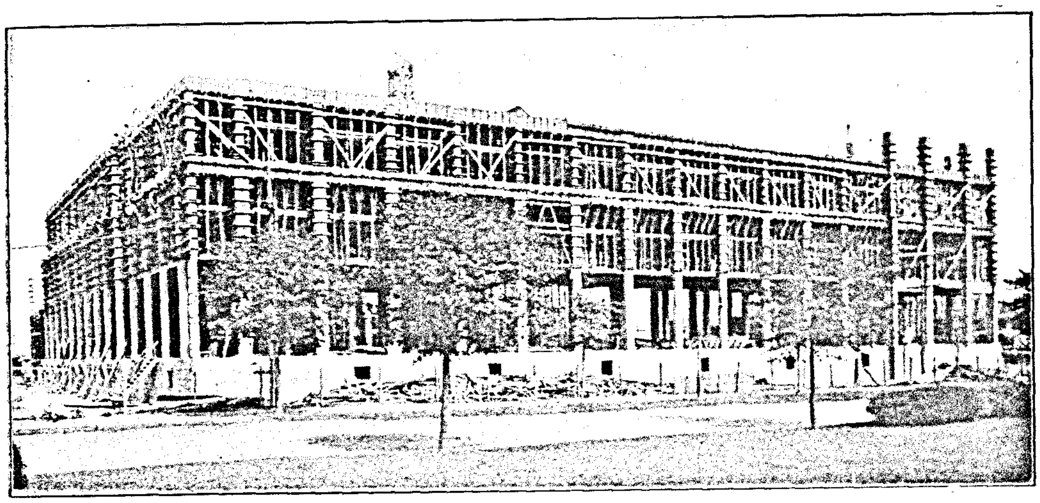
in., the test specimens are 6 x 6 x 12-in. prisms.

Each specimen is tamped in the molds with a 6-in. flat iron tamp, and only the same precautions are taken as are employed in the regular course for the work. Where it is not possible to take the samples directly from place, the concrete is taken from the buggies just before they are dumped. Each specimen is tamped once on each face and four times in the center, the tamp being held each time at an angle of 90 deg. to its position in the preceding operations.

TIME PERIODS

The whole operation of dumping from the pails into the molds and the tamping does not exceed 5 min., and just previous to the time the initial set is expected to take place the tops of the specimens are carefully troweled with an ordinary plaster trowel in order to provide a uniform bearing for testing. At the expiration of 48 hr. the molds are taken out of the wet sand, the specimens removed from the mold and reburied in moist sand, where they are left until the morning previous to the day arranged for the test. At this time they are removed and sent to the laboratory of the Massachusetts Institute of Technology for testing.

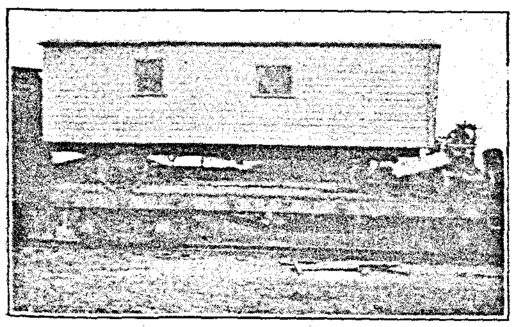
The construction of the new technology buildings is being carried out by the Stone & Webster Engineering Corporation of Boston.



ONE CORNER OF THE TECHNOLOGY BUILDING GROUP ON CHARLES RIVER ROAD

Bunk Wagon Used by Iowa Contractor

IN order to facilitate moving his construction camp outfit, a contractor of Iowa Falls, Iowa, has constructed a bunk wagon which can be loaded on a flat car for long journeys. The accompanying photograph portrays one of the contractor's two-bunk wagons, together with other equipment ready for travel.



BUNK WAGON LOADED ON CAR

Contract for Equipment for Chicago, Milwaukee & St. Paul Electrification

Twelve Electric Locomotives of Heaviest Type Ordered, Together with Line Material and Equipment for Four Substations

AS announced in the "Current News" of last week, the contract for the electrical equipment for the proposed electrified division of the Chicago, Milwaukee & St. Paul Railway in Montana was placed Nov. 13 with the General Electric Company. This covers twelve electric locomotives of the heaviest type, the overhead line material and the equipment for four substations.

This electrification is the first step in a scheme which when completed will greatly exceed in route mileage anything that has heretofore been attempted. The immediate program, as stated in an article in the Engineering Record of Jan. 3, page 29, calls for the electrification of 113 mi. of line between Three Forks and Deer Lodge, Mont., which, with sidings, make a total single-track mileage of 168. The final plans, however, include the extension of the electrified zone to cover the 440 mi. between Harlowtown, Mont., and Avery, Idaho, the whole foreshadowing the ultimate electrification of the main line to the Pacific Coast, a distance of 865 mi.

In authorizing the statement that the final contract for the work had been closed, C. A. Goodnow, assistant to the president of the Chicago, Milwaukee & St. Paul Railway, in charge of construction, said that field work on the overhead line would be started as soon as forces could be organized. Practically all of the poles are on the ground at the present time, and the overhead line material will be available when required. The contract calls for the delivery of the first substation equipment May 1, 1915, and the first locomotive Oct. 1, 1915. On receipt of the first locomotive it is planned to run an operating test, and if this is satisfactory the electrified division will be in full operation by Jan. 1, 1916.

The estimated cost of electrifying the 113-mi. section is $3,000,000 and that for the full 440 mi. is $12,000,000.

OVERHEAD CONSTRUCTION

Power for propulsion will be furnished at 3000 volts, direct current, instead of at 2400 volts as stated in the article referred to, and there will be four instead of five substations. The overhead construction, on which work has already been begun by the railroad company, is exactly similar to that used on the Butte, Anaconda & Pacific Railway, except that a double trolley wire will be used in order to provide greater collection area for the pantograph shoes. The contact wires will be supported by a flexible catenary construction that will be hung from mast arms on wooden poles, the single-pole bracket construction having been adopted because it affords a minimum obstruction to the view and also is less expensive than the use of span wires. Double poles with span wire, however, will be employed where there are two or more tracks as well as at the sharper curves.

A limited amount of feeder copper will be placed on the poles at the present time to minimize the voltage drop between substations. A high-tension transmission line will also be installed along the right of way, tying the substations together. This line will be erected and maintained by the railroad company, independently of the transmission lines from the hydroelectric company which is to supply the power, and will form a ring system to protect against shutdowns through line failures.

The prime power will be purchased from various hydroelectric plants of the Montana Power Company, and will be transmitted to the railway company's substations at 110,000 volts, three phase, sixty cycles. The price at which it will be furnished approximates ½ cent per kilowatt-hour, the power factor being limited to a variation of 20 per cent from unity and the monthly load factor being the equivalent of 60 per cent when based on the contract load. As planned at present, the load factor will easily be maintained by requiring the dispatcher to adjust train movements so as not to exceed the maximum amount of power covered by the power contract.

LOCOMOTIVES

The locomotives, of which twelve are to be included in the initial installation, will each consist of two half-units permanently coupled together to make an engine 112 ft. 8 in. long that weighs 260 tons and has 200 tons on drivers. The prominent feature of the design is the use of a separate motor twin-geared to each of the eight pairs of driving wheels. In the design the principle of "stretching out" the locomotive has been followed, minimizing the localization of vertical and horizontal blows on the track. The same principle was followed, although on a much smaller scale, in the case of the latest type of high-speed electric locomotive built by the General Electric Company for the New York Central & Hudson River Railroad, these engines having made a remarkably successful record for the past year in hauling the extremely heavy through passenger trains on that road.

The eight pairs of drivers for each complete locomotive are equally spaced at about 10-ft. intervals. Each half-unit has two articulated trucks with frames outside of the driving wheels, and this arrangement, together with the connection between the half-units themselves, provides a chassis composed of four trucks linked together by three permanent couplings. The driving-wheel trucks at the extreme ends of the com-

MAIN DIMENSIONS AND WEIGHTS OF LOCOMOTIVES

Length face to face of couplers	112 ft. 8 in.
Total wheel base	103 ft. 4 in.
Wheel base each half unit	46 ft. 7 in.
Minimum driving wheel base	5 ft. 0 in.
Total weight	260 tons
Weight on drivers	200 tons
Weight on each pair of driving wheels	25 tons
Weight on each bogie truck	30 tons
Diameter of driving wheels	52 in.
Capacity of locomotive—continuous rating	3000 hp
Capacity of locomotive—one-hour rating	3440 hp

plete unit have their frames extended to provide center-pin castings for four-wheeled bogie trucks, the extended framing carrying also the bumper beams and coupler at each end of the locomotive.

A summary of the general dimensions and weights of the locomotive is given in the accompanying table.

The drivers are 52 in. in diameter and are equalized in pairs on each side, so that each of the four driving-wheel trucks is independent. The drivers on the end trucks are not excepted, so that there is no cross equalization anywhere in the structure. The bogie trucks at the ends of the complete unit are of the standard locomotive type with 36-in. wheels on 6-ft. centers. Each one will transmit a 30-ton load to the truck wheels for guiding purposes, the truck center pin being 13 ft. 5 in. ahead of the nearest driving axle.

The cab extends practically the full length of the locomotive, the space between the two half-units being minimized to provide easy passageway from one end of the locomotive to the other. The height of the cab roof is only 13 ft. 10 in. above the rail exclusive of the housings for the ventilators, but the pantograph bases extend about 5 ft. above this, owing to the great height of the trolley wire, which will be maintained at an elevation of about 24 ft. above the rail. The cab for each half-unit will be supported at two points, one permitting rotation and the other a sliding movement, so that the chassis can weave about in accordance with the requirements of the track without affecting the cab.

MOTORS AND CONTROL

The eight motors for the complete locomotive will be of the General Electric 253-A type, and each will have a continuous rating of 375 hp and a one-hour rating of 430 hp. This will give the locomotive a continuous rating of 3000 hp and an hourly rating of 3440 hp. The drawbar pull effective for starting trains will approximate 80,000 lb. As previously mentioned, the motors will be twin-geared to the driving axles, that is to say, each armature shaft will carry a pinion on each end, and it is only in the matter of gear ratio that the passenger locomotives will differ from those used for hauling freight.

The motors will be insulated for 3000 volts, but permanently connected in pairs in series so that the voltage across each one will be 1500 when the locomotive is operating in full parallel on the 3000-volt trolley. The control will provide three running positions with the four pairs of motors connected in series, series-parallel or full-parallel, but the control system will include the novelty (for this country) of using regenerative braking control for holding trains on down grades. This will provide also for regenerative return of energy to the trolley wire on long down grades so that the presence of a train going down a mountain grade will be of assistance to another train coming up. This obviously will improve the load factor of the electrified division to a marked degree.

The motor equipment will enable locomotives in freight service to pull 2500-ton trains up 1-per cent grades at a speed of 16 mi. per hour, or, when two locomotives are used on a train, will provide power enough to pull 2500 tons up a 2-per cent grade. However, the plan of operation includes the general use of a locomotive at each end of trains on ascending grades, there being one 2-per cent grade 20 mi. long and two 1-per cent grades approximately 35 mi. long on the electrified section. On descending grades only the locomotive at the head end will do the regenerative braking. The locomotives in passenger service will be called upon to haul trailing loads of 800 tons at a speed of 60 mi. per hour on the level.

Collection of the large drafts of current (ranging from 1500 to 2000 amp at 3000 volts) that will be required for the service at times will be effected through the use of two pantographs of the "pan" type on each complete locomotive. As a provision against the possibility of injurious arcing, however, and to supply an ample factor of surplus capacity the previously mentioned use of a double trolley wire was considered desirable. This secures flexibility and gives a greater area of collection, the maximum draft of current per pantograph contact being thus reduced to something in the vicinity of 500 amp.

All of the plans for the electrification project have been in charge of C. A. Goodnow, assistant to the president, Chicago, Milwaukee & St. Paul Railroad, and R. Beeuwkes, electrical engineer, and the work of construction that is soon to begin will be under their direction. In general, all of the erection will be done by the railroad company, including the installation of the overhead lines, the construction of the substations, and the preliminary operation during the future period of transition from the use of steam to that of electricity.

Relation of Road Maintenance to Traffic

Abstract of Paper Read at Fourth American Road Congress at Atlanta, Georgia, Nov. 11 by Col. William D. Sohier, Chairman, Massachusetts Highway Commission

STUDIES in road maintenance in Massachusetts have attracted much attention in recent years. In an address before the Fourth American Road Congress, held in Atlanta, Ga., Nov. 9-14, Col. William D. Sohier, chairman of the Massachusetts State Highway Commission, dealt at length with these studies, comparing them with observations of English and French practice. His remarks at the preceding Congress, held in Detroit in 1913, included many of these European impressions and were published in part in the Engineering Record of Oct. 11, 1913, page 405. What Colonel Sohier had to say at the Atlanta meeting with regard to the influence of the characteristics of traffic—volume, weight of units, relative number of rubber-tired and steel-tired vehicles, and the like—on the cost of maintenance, is abstracted in the following. The remarks cover comprehensive traffic and repair studies completed since 1894, when the Massachusetts commission began building roads.

H. T. Wakeland, engineer of the County of Middlesex, just out of London, has given some very careful figures showing damage caused to roads by motorbuses weighing about 6 tons loaded. He took certain roads which had heavy traffic and gave the cost of maintenance, not including watering or cleaning, for macadam roads for three years previous to the motorbus traffic, and the cost per square yard for the year 1912-13. These are given in Table 1.

The average cost of maintenance for three years before the motorbus came in was about 12 cents per square yard per annum. Since then the cost has increased to more than 25 cents. The maintenance cost to carry 1 ton 1 mi. in 1911-12 was 1.2 cents. When the motorbus was put on, the maintenance cost was raised to 1.8 cents per ton-mile. Mr. Wakeland's opinion is that this increase was practically all due to the motorbus. The increased cost of upkeep has been found to be about 4 cents per car-mile, or 2/3 cent per ton-mile in the case of a rubber-tired motorbus. In many cases the macadam surface has been practically destroyed by bus traffic on hard rubber tires. These macadam roads were in standard condition prior to the inauguration of the motorbus traffic, fully able to carry ordinary traffic. Road authorities, Mr. Wakeland believes, should be authorized to direct which roads shall and which shall not be used by motor vehicles. He states, as do the other county engineers in England, that a license fee of $50 a year for motor trucks is entirely insufficient to pay for the increased cost of maintenance caused by the use of the trucks on the roads.

TABLE 1—INFLUENCE OF MOTORBUS TRAFFIC ON MAINTENANCE COST OF ENGLISH ROADS

Cost in cents per yard per annum for each of ten roads for three years previous to motorbus traffic.	Cost in cents per yard for 1912-13.
13.5	25.8
11.2	33.1
14.1	41.9
15.6	16.9
9.1	15.4
8.7	15.1
5.9	16.8
5.1	11.1
21.5	36.4
16.9	42.9

DOMINANT TRAFFIC ELEMENTS

A very useful paper on construction and maintenance was published in connection with the International Road Congress in 1913, presenting the experiences of five of the most competent road engineers in England. It gives the weight in traffic in tons carried 1 mi. for 1 cent of maintenance cost, and appears here in Table 2, which also includes data for two Massachusetts roads. All roads named are waterbound macadam, with or without surface tar.

The English ton is used, but the pennies are changed to cents. The table shows that the maintenance cost on waterbound macadam roads to carry 1 ton 1 mi. varied from about ¼ cent to 1½ cents, illustrating very well the necessity of the traffic census showing the class and character of the vehicles which use the road rather than any formula which merely uses an assumed weight for each class of vehicle.

We have found in Massachusetts that the largest cost of upkeep on macadam roads