cars, the brake should be cleaned, which would avoid the necessity of putting the car on repair track again in so short a time, and when it might possibly contain an important load. If more attention be given to the empty car, putting the brakes in working condition while it is empty, we will have few cases of delays to the loaded cars. Cars have been tested for leaky roofs and thoroughly inspected for important shipments, while at the time of this inspection the brake was inoperative and no attention was given it.

Now, along these lines, we will be confronted with the argument of delays arising from necessary inspection to disclose inoperative brakes and switching. If we wait until the trains are made up in the yard to make this inspection, we will have delays and bad cars, but if we require the men on all incoming trains to have the train fully charged and then make the required application of brakes before cutting off, the air brake inspection can be made at the same time of usual train inspection and any cars "bad ordered" can be switched out in the usual switching time. In doing this, the air brake inspectors go immediately over the train as soon as the application is made, marking cars that did not apply or that leaked off, also marking cars that have piston travel too long or too short, paying no attention to cleaning dates. The car inspectors in coming over the train watch the cleaning dates and place bad order tags on any old dates found and also on cars marked as having inoperative brakes by the air men.

A map is presented of a railroad on which certain terminals are designated as 100 per cent points, and all other terminals where facilities are available instructions are in effect to "bad order" all dead freight loads and empties. Referring to the map, the places marked by the squares are points at which no cars, regardless of lading, are permitted to pass in the direction of the arrows with inoperative brakes; the places marked with crosses are terminals at which dead freight loads and empties are stopped, but through which manifest or important loads of any kind are allowed to pass providing the percentage of operative brakes is above 85 per cent. The divisions on which mountain grades are located are shown also. In these localities the retainer test is made and sufficient good retainers are provided to handle the train.

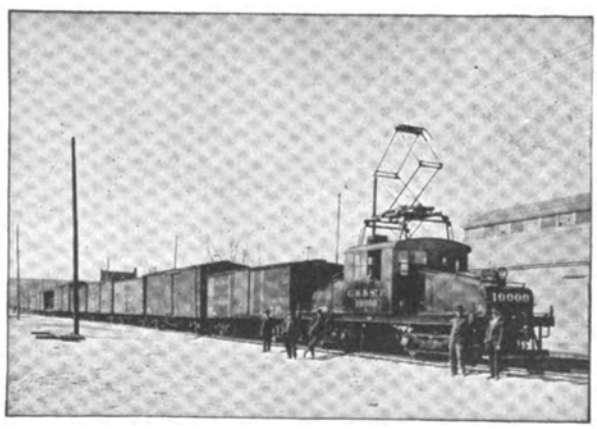
When the 100 per cent rule, as above carried out, was put in effect it caused considerable annoyance due to the large number of cars that were found in trains with brakes inoperative, but as the general conditions were gradually improved, by this means, the troubles lessened until now we hardly know that the 100 per cent points exist. We would be confronted with the argument that this does not constitute 100 per cent as cars are allowed to pass many terminals inoperative, which is a fact; but it is certainly a long stride in that direction and about as near to 100 per cent as can practically be obtained under the present order of general conditions throughout the country, and like the one terminal referred to in the beginning of the paper, help must come from other sources; and, we believe, that any road now trying to run 100 per cent will find itself in this predicament and that all the roads throughout the country will have to set their goal on this line to get the ideal.

In drawing conclusions it is believed that if every railroad would adopt the means outlined, flexibly at first, and gradually drawing the lines tighter, that in time we would have a practical working 100 per cent and after that point is reached, would have little more trouble in maintaining it at that standard than now obtains with the 85 per cent standard. The question arises as to what is to be gained by increasing the number of operative brakes. One reason is to provide a wider margin of safety from the ability to stop in a shorter distance in cases of emergency. The reason more frequently encountered, however, is the resultant reduction of slack action in long trains, which contributes largely to troubles arising from break-in-twos. There are many obstacles to be overcome, and due to conditions in the United States at least, over which our companies have no control, it is hard to get financial aid for betterments of this kind, but every move that can be made along this line is a step in the right direction.

Electrification of Terminal Line at Great Falls, Mont., Chicago Milwaukee & St. Paul Ry.

The Chicago Milwaukee & St. Paul Ry. is proceeding with electrification of 116 miles of its main line between Three Forks and Deer Lodge, Mont. Before embarking in this undertaking the road had put into successful operation 92 miles of heavy ore-handling railroad of the Butte Anaconda & Pacific. The present account describes another related project, consisting in the electrification of a short terminal line in the city of Great Falls, Mont., connecting a branch which comes into that place, with the terminal yard. While this undertaking presents no unusual features, either as to weight of traffic or physical features of the road, it possesses a certain interest in connection with the larger project of which it is a part.

As an undertaking related to the forthcoming electrification of its main line between Three Forks and Deer Lodge, Mont., the Chicago Milwaukee & St. Paul Ry. has recently installed electric motive power on its terminal line in the city of Great Falls, Mont. This city is at present the terminal of the new 138-mile branch line from Lewistown, Mont., connecting with the main line transcontinental division at Harlowton. The latter city is the eastern terminus of the 3000-volt electrification now under construction. The Great Falls and the terminal yards are connected by a crosstown line, about 4 miles in length, known as the



Electric Locomotive Hauling Freight Train on Electrified Terminal Line at Great Falls, Mont., Chicago Milwaukee & St. Paul Ry.

Valeria Way line. There are about 3 miles of additional electrified trackage, making a total of 7 miles. The terminal buildings include a large freight house, roundhouse, power plant and passenger station.

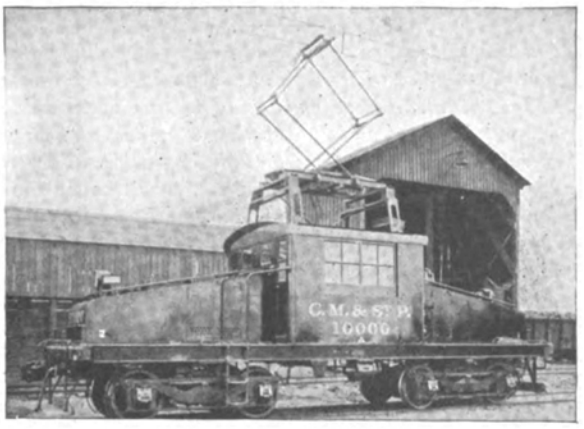
The tracks connecting the Falls yards and the terminal yard pass through the business part of the city; and it is expected that considerable benefit will be derived from the elimination of steam locomotive smoke from the center of the city, as well as a reduction in the cost of train haulage. The traffic includes the transfer of both freight and passenger trains from the Falls yards to the terminal station, as well as switching service in the terminals.

The electrical equipment is of sufficient capacity to take care of 580-ton freight trains operating at about 9½ miles per hour on the maximum grades of 0.65 per cent. Electric

power is supplied by the Great Falls Power Co. from the hydroelectric plant at Rainbow Falls, about 6 miles from the substation. Energy is transmitted at 6600 volts, 3 phase, 60 cycles, as generated at the power station.

Substation.

The substation equipment is located in the power station operated by the railway for heating the terminal buildings. It includes a 2-unit, synchronous motor-generator set with a two-panel switchboard for controlling the alternating and direct current units. The motor is rated 435 kva. (0.8



Electric Locomotive, 1500-Volt, Direct Current, Electrified Terminal Line at Great Falls, Mont., C. M. & St. P. Ry.

power factor), 6600 volts, and operates at 900 revolutions per minute. Provision is made for starting as an induction motor through a compensator, which is operated from the alternating current panel. The generator is the commutating pole type, rated 300 kw. at 1500 volts. The set is capable of carrying 200 per cent overload, or 900 kw. momentarily. Excitation for the alternating current motor fields and for the shunt fields of the direct current generator is furnished by a 10-kw., 125-volt, direct-connected exciter.

The switchboard consists of two natural black slate panels, one controlling the sychronous motor and the other the direct current generator and feeder. The direct-current panel is a standard 1500-volt type, carrying remote control, hand-operated switch and circuit breaker mounted between slate barriers at the top of the panel. The motor panel contains the usual instruments and starting and operating switches for controlling the motor. An aluminum cell lightning arrester is also installed in the station as a protection against electrical storms.

Locomotive.

All trains are handled by a standard, 50-ton electric locomotive of the steeple cab type, designed for slow speed freight and switching service. The running gear consists of two swivel equalized trucks, carried on semi-elliptic equalizer springs. The driving wheels are of solid rolled steel, 36 ins. in diameter. The motor equipment includes four GE-207, 750-volt, box-frame, commutating pole motors insulated for 1500 volts. Each motor has a normal one-hour rating of 79 h. p. at 750 volts, and two motors are connected permanently in series. All motors are ventilated by a blower direct-connected to the dynamotor in the cab of the locomotive. The gear reduction is 64 to 17.

The control equipment is Sprague General Electric type M, arranged for operation from either end of the cab. There are ten steps with the motors in series and seven steps in series-parallel. Control current for operating the contactors, lighting and other auxiliary circuits is furnished by a type CDM-19, 1500/600-volt dynamotor. A multivane fan carried on an extension of the shaft furnishes air for ventilating the motors.

The current collector is a sliding pantograph, similar to that being installed on the main line 3000-volt locomotives. The slider is lifted into position by air pressure and is held against the wire by steel coil springs. Provision is made for operating at trolley heights varying from 17 to 25½ ft. above the top of the rail.

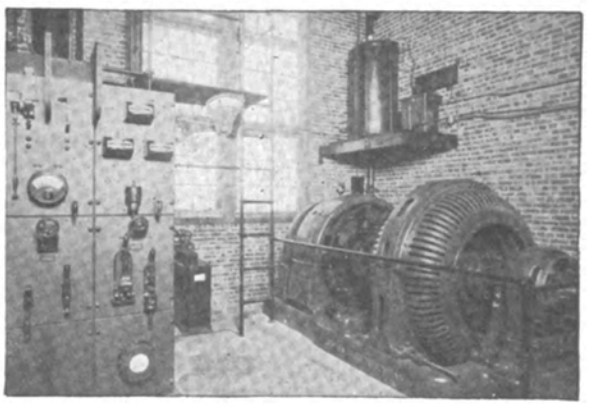
Compressed air for operating the air brakes, whistles and sanders is supplied by two CP-29, 1500-volt, motor-driven air compressors. Each of these units has a displacement of 27 cu. ft. of air per minute at 90 lbs. pressure. The compressors are located in the cab of the locomotive convenient for inspection.

A headlight, provided with a concentrated filament type Mazda lamp of about 100 c. p., is mounted on each end of the locomotive.

As a safety precaution, no trolley wire is installed inside of the round house. A connection is made in the cab of the locomotive for applying power to the locomotive through a length of special flexible cable insulated for 2400 volts. A double-throw switch in the locomotive cab allows connection to be made either to the trolley or cable circuit.

Line Construction.

The overhead line construction is of the catenary type, similar in a general way to that installed on the Butte Anaconda & Pacific 2400-volt railroad, which latter was described and illustrated in the Railway Review, April 25, 1914. Both span and bracket construction are used, depending on local conditions. Poles are spaced approximately 150 ft. apart on tangent track, supporting a 4/0 grooved



Interior of Substation at Great Falls, Mont., Delivering 1500 Volts Direct Current to Electrified Terminal Line of the Chicago Milwaukee & St. Paul Ry.

trolley from a 3-point suspension. There is no feeder copper installed.

The work was done by the electrification department of the Chicago Milwaukee & St, Paul Ry., R. Beeuwkes, engineer-in-charge, under direction of C. A. Goodnow, assistant to the president. All of the electrical apparatus, including locomotive, substation equipment and line material, was furnished by the General Electric Co., Schenectady, N. Y.

The General Electric Co., Schenectady, N. Y., has issued bulletin No. 42552, entitled Motor-Generator Sets. It is an attractive publication of 28 pages.

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The Newport Rolling Mill Co., Newport, Ky., has issued a pamphlet devoted to describing the uses and superiorities of the firm's trade marked brand of "genuine open hearth" iron. This is a rust-resisting sheet metal building material. It is especially recommended for such work as roofing, siding, eaves trough, conductor pipe, roof gutter, cornices,