AMONG THE MEMBER COMPANIES

ABOUT THE C., M. & ST. P. ELECTRIFICATION

REGENERATIVE BRAKING EFFECTS SAVING—DESCRIPTION OF EQUIPMENT, OVERHEAD AND SUBSTATION FROM FORTHCOMING PAMPHLET OF THE GENERAL ELECTRIC CO.

Through the courtesy of F. H. Gale, of the General Electric Company, AERA is able to present to its readers the following extracts from a pamphlet entitled "An Epoch in Railway Electrification," shortly to be issued by his company, in which the astounding development upon the Chicago, Milwaukee and St. Paul railroad is described:

The tracks of the mountain district of the Chicago, Milwaukee & St. Paul Railway, in surmounting the obstacles imposed by the Rocky Mountain and coastwise ranges, represent the solution of one of the most difficult problems ever mastered by railway engineers. Out of this section of rugged mountain railway, including many long grades and short radius curves, four steam engine divisions were selected for electrification, aggregating 440 miles in length. Steam engines were first abandoned on the Three Forks-Deer Lodge Division, 115 miles long, and crossing the main Continental Divide, thus giving the electrical equipment its initial tryout under the severest service conditions of the entire system. The first electric locomotives were placed in regular service on December 9, 1915, and during the month of April, 1916, service was extended to Harlowton, making a total of 220 miles of electrically operated road. By the first of November, 1916, it is expected that steam engines will be superseded over the entire distance of 440 miles from Harlowton, Montana, to Avery, Idaho.

This project is the most extensive steam railway electrification in the world, the length of haul being nearly six times as great as any trunk line now operating with electric locomotives. The length of track between Harlowton, Montana, and Avery, Idaho, is approximately equal to that from New York to Buffalo or from Boston to Washington.

Grades Heavy and Long

In crossing the three mountain ranges included in the electric zone, there are several grades of one per cent or more, the most difficult of which is the 21-mile two per cent grade between Piedmont and Donald, and the longest the 49-mile one per cent grade on the west slope of the Belt Mountains.

The curvature is necessarily heavy, the maximum being 10 degrees. There are also numerous tunnels in the electric zone, 36 in all, of which the longest is the St. Paul Pass tunnel, over a mile and a half in length, through the ridge of the Bitter Root Mountains.

The passenger service consists of two all-steel finely equipped trancontinental trains in each direction, the "Olympian" and "Columbian," and a local passenger train in each direction daily between Deer Lodge and Harlowton.

Freight traffic through the electric zone comprises from four to six trains daily in each direction. Westbound, the tonnage is made up of manufactured products and merchandise for Pacific Coast points and foreign shipment. Eastbound tonnage includes grain, lumber, products of the mines and some live stock.

As a larger part of the traffic is *through* freight, trains are made up of an assortment of foreign cars, including box and flat cars, coal and ore hoppers, stock cars, refrigerators, etc., varying in weight from 11 to 25 tons empty and as high as 70 tons loaded. These cars being owned by many different railway systems are equipped with air brakes adjusted for different conditions of operation, and in accordance with different standards as to braking power and type of equipment, thus making the problem of holding the long trains on the heavy down grades by air brakes, a most difficult one.

INTERIOR OF VOLTA PLANT, MONTANA POWER COMPANY, GREAT FALLS, MONT., SHOWING FOUR TYPE ATB. 36–10,000 (8,000-KW.–8 P. F.) 200–6,600-VOLT GENERATORS AND TWO TYPE MPC 8–500–450–240-VOLT EXCITERS.

Running Time Cut Down

Electrification promises a material reduction in running time. It has been found, for example, that on the 21-mile two per cent grade from Piedmont to Donald, the electric locomotive can reduce the running time of passenger trains from an hour and five minutes to approximately 40 minutes. On the run from Deer Lodge to Butte which, under the steam locomotive schedule, required an hour and 20 minutes, a saving of approximately 30 minutes can be made.

In the freight service, it has been found that on the first division where the steam locomotives have required 10 to 12 hours to make 115 miles, electric locomotives can meet a schedule of from seven to eight hours for the same distance. The heavy grades and frequent curves at certain points offer serious obstacles to steam locomotive operation even in the summer time, but with winter temperatures as low as 40 degrees Fahrenheit, and heavy snowfalls in the Bitter Root Mountains, serious delays have occurred, owing to engine failures or to inability to make steam. The capabilities of the electric locomotives are in no way impaired by cold weather or by inability to obtain fuel or water in case of snow blockades. During a series of record-breaking temperatures in December, 1915, Mallet engines were frozen up at different points on the system and the new electric equipment was rapidly pressed into service to replace them. On several occasions electric locomotives hauled in disabled steam engines and trains which would otherwise have tied up the line.

Longer Trains Possible

During initial operation on the Rocky Mountain Division, the capacity of the new locomotives has been thoroughly tested. Trains of 3,000 tons trailing have been hauled east and 2,800 tons west, using a helper on the heavy grades. From the operating data obtained on the first division, it is evident that much heavier trains can be hauled with the electric locomotives than with steam engines, and all passing tracks are being lengthened to take advantage of longer trains. On some of the runs where the grades are less than one per cent trains of as many as 130 cars and as heavy as 4,000 tons have been hauled with a single locomotive.

The four through passenger trains, "Olympian" and "Columbian," are taken across the two mountain ranges by a single passenger locomotive. These trains at present consist of eight full vestibuled steel coaches, weighing approximately 650 tons. Instead of changing locomotives at Three Forks, as has been the practice under steam operation, the same locomotive is run through the 220 miles from Deer Lodge to Harlowton, changing crews midway. Passenger trains will travel over the entire electrified division in approximately 15 hours, including all stops, and the tourist thus will have an opportunity of traversing by daylight some of the most beautiful scenic regions in the United States and without suffering the annoyance of cinders and smoke incident to the use of steam locomotives. The local passenger train, operating in the electric zone between Deer Lodge and Harlowton, is handled by a half unit weighing about 150 tons with equipment similar to the main line locomotives.

Regeneration, or Energy Recovery

Regeneration, or the recovery of energy on the descending grades, by reversing the function of the electric motors reduces the cost of operation and furnishes a ready solution of the difficult braking problem. On the long sustained grades encountered in crossing the three mountain ranges, great skill is required to handle either the heavy and varied freight or the high speed passenger trains with the usual air brakes. The entire energy of the descending train must be dissipated by the friction of the

GENERAL VIEW OF GREAT FALLS DAM AND POWER HOUSE AT VOLTA

brake shoes on the wheels, and it approximates 3,500 kilowatts or 4,700 horse power for a 2,500 ton train running at 17 miles per hour on a two per cent grade, thus explaining why brake shoes frequently become red-hot and other serious damage is done.

With regenerative braking, the motors become generators which absorb the energy of the descending train and convert it into electricity, thus restricting the train to a safe speed down the grade and at the same time returning electric power to the trolley for use by other trains. The strain on draw bars and couplings is reduced to a minimum since the entire train is bunched behind the locomotive and held to a uniform speed. The electric-braking mechanism automatically controls the speed by regulating the amount of energy fed back to the line. This smooth and easy descent is in marked contrast to the periodical slowing down and speeding up of a train controlled by air brakes.

The usual speed of the electrically hauled freight train is 15 miles per hour ascending and 17 miles per hour descending the maximum grade, but half these speeds can easily be maintained with series connections of the motors should conditions require it.

In case there are no other trains between the substations to absorb the power generated by a descending train, this power passes through the substation machinery, is converted from direct to alternating current and fed into the distribution system connecting all substations. The power company's lines are so extensive and the load of such a diversified character that any surplus power returned by regenerating locomotives can readily be absorbed by the system; credit is given for all energy returned.

Advantages Claimed

The advantages of regenerative braking may be summarized as follows:

Elimination of difficulties incident to the use of air brakes on heavy freight trains when descending mountain grades.

Elimination of brake shoe and wheel wear with resultant reduction in maintenance.

Reduced wear on tracks, especially on severe curves.

A probable saving of approximately 15 per cent in the total power consumption.

Maximum safety in operation assured by a duplicate braking system relieving the air brakes.

The entire absence of grinding of the brakes which is especially disagreeable on a heavy passenger train.

Increased comfort to passengers and reduced wear and tear on freight equipment, owing to uniform speed on grades.

The Electrical Equipment

The scheme of electrification includes the generation of electricity from the several water power plants of the Montana Power Company; transmission at 100,000 volts, three-phase, 60 cycles; conversion in substations to 3,000 volts direct current and distribution over catenary overhead construction to electric locomotives.

The development of the electric locomotive is primarily the achievement which has made electrification of trunk lines

WHERE TWO GREAT ELECTRIFICATIONS MEET—ORE TRAIN ON BUTTE, ANACONDA & PACIFIC, HAULED BY TWO 80-TON 2,400-VOLT D. C. LOCOMOTIVES PASSING OVER A FREIGHT TRAIN ON THE CHICAGO, MILWAUKEE & ST. PAUL, HAULED BY 3,000-VOLT D. C. LOCOMOTIVE.

feasible. The main line Chicago, Milwaukee & St. Paul electric locomotives are constructed in two units permanently coupled together, the halves being duplicates and each capable of independent operation. The enormous tractive effort of these electrical giants will be appreciated when it is stated that the wood-burning locomotive of 50 years ago weighed 20 tons and had a tractive effort of only 5,000 pounds. The modern Mallet steam locomotive weighing 278 tons with tender, which has been released, has a tractive force of 76,200 pounds, while the electric locomotive, weighing 282 tons, has a running tractive force of 85,000 pounds or a starting tractive force of 136,000 pounds.

C., M. & St. P. Freight Train Descending Two Per Cent Grade on Eastern Slope of the Rocky Mountains.

Operate With 3,000 Volts, D. C.

There are 42 of these main line locomotives (30 freight and 12 passenger) and two switching locomotives. The locomotives are the first to be used for railroad service with direct current motors operating at a potential as high as *3,000 volts and the first to use direct current regeneration. The passenger locomotives are equipped with a gear ratio permitting the operation of 800-ton trailing trains at speeds of approximately 60 miles per hour on tangent level track. The average passenger train weighs from 650 to 700 tons and is hauled over the two per cent grade without a helper. The freight locomotives are designed to haul a 2,500-ton trailing train at approximately 16 miles per hour on all grades up to and including one per cent. On two per cent grades the trailing load was limited to 1,250 tons, although this figure has been exceeded in actual operation.

Each locomotive is equipped with eight Type GE-253-A, 1,500-volt motors, insulated for 3,000 volts to ground. This motor has a normal one hour rating of 430 horse power and a continuous rating of 375 horse power, so that the locomotive power plant has a normal one hour rating of 3,440 horse power and a continuous rating of 3,000 horse power. Each motor is twin geared to its driving axle in the same manner as on the Butte, Anaconda & Pacific, the Detroit River Tunnel, and the Baltimore & Ohio locomotives, a pinion being mounted on each end of the armature shaft. Additional flexibility is obtained by the use of a spring gear and a spring nose suspension which minimize the effect of all shocks and also reduce gear wear to a minimum. The motor is of the commutating-pole type and is constructed with longitudinal ventilating ducts in the armature for forced ventilation from a blower in the cab.

The control equipment is the well-known Sprague General Electric Type M., arranged for multiple unit operation. The main control switches are mounted in steel compartments inside the locomotive cab with convenient aisles for inspection and repairs. A motor-generator set in each half of the locomotive furnishes low-voltage current for the control circuits, headlights, cab lighting and for charging the storage batteries on the passenger coaches. Under steam operation, the charging current for these batteries is furnished by a steam turbo-generator set located on the locomotive. The blower for ventilating the traction motors is also direct connected to one end of this set.

The pantograph collectors, one of which is mounted on each half of the locomotive, are of the double pan type with a working range of from 17 feet to 25 feet above the rail. The contact elements are of the same metal as the trolley wire, so that current passes from copper to copper.

The air brake equipment is practically the same as that used on steam locomotives, except that motor driven air compressors are used to furnish compressed air. Aside from the air brakes, compressed air is also used for signals, whistles, bellringers, sanders, flange oilers, pantograph trolleys, part of the control equipment, and on the passenger locomotives for the oil-fired steam boilers.

Switching Locomotives

The switching locomotives are of the swivel truck type, weighing 70 tons each, and equipped with four geared motors. A single pantograph of construction, similar to that used on the main line locomotives, is mounted on the cab and in other ways the locomotives represent the standard

* "It is of interest to note that this is the first direct current installation to use a potential as high as 3,000 volts, and this equipment was adopted after a careful investigation of all systems available for electrification. The Butte, Anaconda & Pacific Railway, in the immediate vicinity of the Chicago, Milwaukee & St. Paul electrification, has been in operation with 2,400-volt direct current locomotives since May, 1913, and has furnished an excellent demonstration of the entire practicability of high-voltage direct current operation.

construction commonly used with the steeple cab type of switcher. The motors (known as Type GE-255) are of box frame, commutating-pole, single-geared type designed for 1,500 volts with an insulation of 3,000 volts to the ground. Many of the switching locomotive parts are interchangeable with those used on the main line locomotives; for example, the air compressors, small switches, headlights and cab heaters.

Utmost precautions were taken by the railway company in making plans for this electrification to insure a reliable source of power. The Montana Power Company, with whom the contract was closed for electric power, operates a network of transmission lines covering a large part of Montana, which are fed from a main plant at Great Falls, and a number of other widely separated water power plants of adequate capacity at all seasons of the year. A notable feature of this pioneer electrification is, therefore, the conservation of fuel consequent upon the utilization of water powers.

The Montana Power Company's transmission lines, which are carried in some cases on steel towers and in others on wooden poles, tap into the railway system at seven different points where the power is most needed. The railway company's transmission line extends the entire length of the system on wood poles. In most cases this line is built on the Company's right of way, although at several points there are cutoffs which make a considerable saving in the length of line.

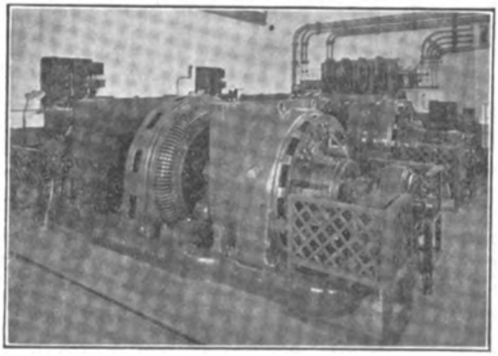
With this completely inter-connected transmission system, each substation may be fed from either direction and also at the tie-in points from a third source of power.

Fourteen Substations

Fourteen substations are equipped for converting the 100,000-volt alternating current to 3,000 volts direct current. They are distributed along the route at average intervals of 32 miles. Each station contains step-down transformers, motor-generator sets, switchboard and the necessary controlling and switching equipment. The transformers receive the line current at 100,000 volts and supply the synchronous motors at 2,300 volts. Each synchronous motor drives two 1,500-volt, direct current generators connected permanently in series, thus supplying 3,000-volt current for the locomotives. The fields of both the synchronous motors and the direct current generators are separately excited by small direct current generators direct connected to each end of the motor-generator shafts.

The overhead construction is of the modified flexible catenary type designed by the General Electric Company and installed under the direction of the railway company's engineers. With this quite novel, but remarkably successful construction, the current is collected in both high speed passenger service and heavy freight service without any sparking.

The construction comprises two 4/0 copper wires flexibly suspended side by side



TWO 2,000-KW. 3,000-VOLT DIRECT CURRENT, 2,300-VOLT ALTERNATING CURRENT SYNCHRONOUS MOTOR GENERATOR SETS IN MOREL SUBSTATION

from the same steel messenger by independent hangers alternately connected to each wire. Bracket construction is used wherever the track alignment will permit, and cross span construction on passing tracks and in the switching yards. All of this work is supported on 40-foot wooden poles suitably guyed and spaced.

Reason for Change

Electric locomotion has been adopted by the Chicago, Milwaukee & St. Paul Railway as "a newer, better foundation on which builders shall rear the structure of railroading to undreamed-of efficiency and comfort." The enterprise has been undertaken with the expectation of effecting a sufficient reduction in the cost of operation to return an attractive percentage on the investment required, as well as to benefit by all the operating advantages of electric locomotives. According to statements made by the railroad officials, about $12,-000,000 will be expended, and with the work more than half completed there is every reason to believe that the cost of construction will come inside the estimates.

Summary

Marked reduction in cost of electricity as compared with cost of coal.

Reduction in maintenance cost of locomotives.

Elimination of delays due to coaling, taking water, oil, etc.

Elimination of delays due to natural causes, such as freezing of locomotives, loss of steam in cold weather, bucking snow drifts.

Elimination of non-revenue trains hauling coal and water for steam locomotives.

Increased tonnage per train.

Increased train speed on grades.

Greater reliability and certainty of maintaining schedules.

Reduction in train crew hours per ton mile.

Reduction in damage to rolling stock due to rough handling by steam engines.

Greatly increased safety of operation on grades due to regenerative braking.

Saving in power and reduction in wheel and track wear by use of regenerative braking.

Improvement of tunnel conditions due to smoke and gas, absence of smoke and cinders which obscure scenic attractions, uniform speed and absence of grinding brake shoes on grades, all of which accrue to the benefit of the traveler on the transcontinental passenger trains.

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"ELECTRIC RAILWAY SERVICE" STARTS ITS FOURTH YEAR WITH RESTATEMENT OF ITS POLICY

With its issue of June 16, *Electric Railway Service*, the publication of the Detroit United Railways, began the fourth year of its existence. This periodical is unique among public utility publications, in its aggressive, combative policy towards misrepresentations of the company's affairs. For this reason it is interesting to learn of the results which have been obtained by the consistent carrying out of such policy.

Electric Railway Service says of its past and future activities:

> It has been in the past and will continue to be our bounden duty to speak the truth, of which we have nothing to fear. If, hereafter as it has been heretofore, it is necessary to correct misstatements of ignorance or to expose deliberate falsehoods we shall continue to so do irrespective of whose heads we hit within or without the press.
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> > "It sometimes happens that in a public discussion one side seems to have all the strength because it is the only side able to make itself heard and THEN IT SUDDENLY SINKS INTO INSIGNIFICANCE AS SOON AS THE OPPOSITE SIDE HAS FOUND A MEDIUM OF SPEECH."
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> The emphasis is ours, but the words are not. We simply quote in this the opening sentence of editorial expression from the Detroit *Evening News* of a few weeks ago. We quote the words as most splendidly expressing the situation as applied to these properties operated by the Detroit United Lines.
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> The medium of speech of these properties is *Electric Railway Service* and the FACTS we have uttered have caused to sink into insignificance much of the noisy mouthings of those who have attempted to gain either financial or political preference by knocking the Detroit United Railway.

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FOUR INDICTED FOR PERJURY IN CONNECTION WITH ACCIDENT CASES IN PORTLAND, OREGON

The Sunday Oregonian of Portland, Ore., tells of a band of accident fakirs who have recently come to grief in that city. The *Oregonian* says:

> Conscience-stricken, three persons have appeared before District Attorney Evans in the course of a month desirous of cleansing themselves from the stain of perjury, and confessed to lying testimony that won damage verdicts against the Portland Railway, Light & Power Company.
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> As a result of voluntary confessions, Edson K. Carr was indicted by the Multnomah County grand jury for perjury yesterday, and Thomas S. Molesworth, Mrs. Selma L. Wallace and Clyde E. Wallace were indicted for subornation of perjury in connection with the suit of Mrs. Wallace against the Portland Railway, Light & Power Company, in which a $5,000 verdict was won.
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> The indictment of several persons connected with a similar damage suit against the railway company will be considered by the June grand jury, which will be drawn to-morrow. District Attorney Evans will lay the facts gleaned from one perjured witness before the jury as soon as it is organized.
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> ### Witness Not Near Spot, He says
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> Edson Carr, who swore on the witness stand to a set of incidents which he said came under his observation, in connection with injuries to Mrs. Selma L. Wallace, May 8, 1915, in a fall from a street car on Eleventh street, between Hall and Montgomery streets, has confessed, it is said by the district attorney's office, he was not near the scene at the time of the accident he described as an eye-witness.
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> Mrs. Wallace sued the Portland Railway, Light & Power Company for $25,600. She said a car from which she was alighting had started before she had stepped to the ground, throwing her and inflicting severe injuries. The case went to trial before Circuit Judge Kavanaugh, September 15, 1915, and two days later a verdict of $5,000 for the plaintiff was returned.