AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

THE ELECTRIC SYSTEM OF THE GREAT NORTHERN RAILWAY COMPANY AT CASCADE TUNNEL.

The two-hundred-and-fortieth meeting of the American Institute of Electrical Engineers was held on Friday evening, November 12, at the Engineering Societies Building, New York city, with President Stillwell in the chair. After the meeting was called to order Secretary Pope announced that at the meeting of the board of directors held in the afternoon, twenty-eight associates were elected and one associate transferred to grade of member.

The president then made a few introductory remarks prior to introducing the speaker of the evening, Dr. Cary T. Hutchinson, of the Great Northern Railway, who was to read a paper on "The Electric System of the Great Northern Railway Company at Cascade Tunnel." He said that it is certainly a fact of great interest that in this year 1909 a three-phase railway installation of magnitude had been completed and put into commercial operation in the United States. Polyphase motors were brought to this country in 1888. Those which arrived in that year were at about one-quarter horsepower, but none of them ever succeeded in producing that amount of power. Serious efforts were made at that time by American engineers, connected with one of our manufacturing companies, to adapt this motor to railway purposes, but the conclusion reached was that the constant-speed characteristic of the motor rendered it unsuitable for that purpose. He reviewed the development of the electric traction problems in Europe, and continuing, said that in the United States but little attention was paid from 1890 until recently to the practical application of the polyphase motor to railway purposes. It received during that period, it is true, very serious and careful study, but the conclusions reached were negative, and it was not introduced in commercial service in this country. In the United States today, there are three different electric systems operating electric traction of the heaviest kind, direct-current system, the single-phase alternating, and the three-phase alternating-current systems. All of these are doing their work not only successfully, but in a manner that shows a marked improvement, as compared with the steam locomotives which they superseded. The railroad managements of the country are beginning to awake, and are asking the question—which is the best system for general railway work? and that question, Mr. Stillwell said, is going to be answered by the electrical engineers. He then introduced Doctor Hutchinson, who made a few introductory remarks before beginning the reading of his paper, an abstract of which follows:

The first three-phase installation on a trunk line railway in the United States was put into operation early in June of this year at the Cascade Mountain Tunnel on the Great Northern Railway in Washington, about one hundred miles east of Seattle. In general the plant supplying current for this system comprises a hydroelectic generating station operating under a head of one hundred feet, having a capacity of approximately 5,000 kilowatts in generators at 6,600 volts and twenty-five cycles; a transmission system at 33,000 volts delivering energy to the substation, where it is transformed to 6,000 volts, at which pressure it is supplied to the overhead conductors and to the locomotive by way of an overhead trolley; on the locomotive the pressure is reduced by three-phase transformers to 500 volts for the supply of the four three-phase motors with which each locomotive is equipped.

The Great Northern Railway crosses the Cascade Mountains through a tunnel 13,873 feet long. The operation of this tunnel with steam locomotives was at all times difficult and frequently very dangerous on account of the heat and smoke from the locomotives. The temperature in the locomotive cab was almost unbearable. The tunnel is lined with concrete throughout its length and is in good condition. The entire tunnel drips more or less from condensed steam just after the passage of a train, but is comparatively dry at other times. The temperature changes at the top of the tunnel are very rapid, varying the atmospheric temperature several hundred degrees from the heat of the locomotive exhaust. For many reasons this tunnel is a limiting feature to the capacity of the Great Northern Railway for hauling freight across the mountains. The plant described is designed for use over the entire mountain division by extending the system of conductors and building additional stations.

The principal data of the locomotives are as follows: Total weight, 230,000 pounds, all on drivers; two trucks connected by a coupling, each truck having two driving axles; a three-phase motor connected by twin gears to each axle; synchronous speed of motor 375 revolutions per minute, giving a speed of 15.7 miles per hour at no load and dropping to fifteen miles per hour for a load corresponding to a one-hour rating. The motors are wound for 500 volts and are completely enclosed and air cooled. The specifications of the motor required an output of 250 horsepower continuously for three hours, with seventy-five degrees Centigrade temperature elevation when supplied with not more than 2,000 cubic feet of air per minute. Each locomotive is equipped with four three-phase induction motors wound for 500 volts at the primary or stator; the motors are completely enclosed and air cooled by forced air circulation from a large blower. They are suspended from the axles in the standard manner, except that they are geared at both ends of the armature shafts, this being made necessary by the low speed and high torque required, as it was not considered safe to use a single pair of gears. The locomotive carries two three-phase air blast transformers, having a nominal rating of 400 kilowatts each, transforming from 6,000 volts to 500 volts normal, or to 625 volts by the use of taps. The continuous capacity of the transformer is not as great as that of the motors, although it is fully up to the specifications, and it may be that the quantity of air to the transformer will have to be increased when the locomotives are put in continuous service. The control system of each motor is separate; the circuits branch from the transformer and are independent from the resistances. There are fourteen conductors in each motor circuit, fifty-six in all. The pilot control is in duplicate and there is one switch at each end of the locomotive. There is a clear aisle on each side of the locomotive from end to end, all of the apparatus being assembled in the center of the cab.

The locomotive is of the articulated or hinged type, having four driving wheels on each half of the running gear, and is without guiding wheels. The running gear is comparable to the Mallet type of steam locomotive, in that the hinge sections are so connected that they tend to support each other vertically and guide each other in taking the curves. The cab is carried on the trucks through center pins on each bolster, the center pin on one end having a slight longitudinal sliding motion to allow for variation in the distance between truck center pins in taking curves. The cab extends the entire length of the platform.

The energy supply for the locomotive is derived from the Wenatchie River, which flows along the line of the railway for a distance of some twenty miles. The power house is designed for three main units and two exciter units. There are now installed in the power house two main units, each being a turbine rated at 4,000 horsepower directly connected to a three-phase generator of a capacity of 2,500 kilo-volt-amperes, at 6,600 volts and twenty-five cycles. These machines are designed to have very large overload capacity and operate at a low flux density. There are two exciter units, each having a nominal capacity of 125 kilowatts. These units also have a large overload capacity. The power house contains four transformers for raising the pressure to 33,000 volts, each of nominal capacity of 833 kilowatts and guaranteed to operate 100 per cent overload for one hour with a low rise in the temperature. The switching apparatus is of the usual type.

The transmission line extends to the substation, approximately thirty miles away, following the railroad all the way. In the design of the line, as in other features of the work, the aim was to secure apparatus and types of construction giving promise of the greatest reliability, in order that there should be as few links as possible in the chain from the power house to the locomotive that would be liable to derangement. The overhead construction in the yards consists of wires supported at intervals of one hundred feet. Multiple track supports consist, for each phase, of a steady span supported by and insulated from the cross catenary span, both spans being secured to cross arms on the poles by means of porcelain petticoat strain insulators. The wires for the two respective phases are three feet apart. The wires of the same phase for the different tracks are insulated from each other by means of a wood breaks and porcelain link insulators in series. The lighting system installed in the tunnel consists of five transformers of four kilowatts capacity, each placed in refuge chambers. Incandescent lights are spaced at intervals of fifty feet and are connected in sets of five in series across the 500-volt system.

The electric service was started on July 10 last, although one or two trains had been handled previously. From that time to August 11 practically the entire east-bound service of the company had been handled by electric locomotives. During this period there were 221 train movements, of which eighty-two were freight, ninety-eight passenger and thirty-two special. In each case the steam locomotive was hauled through with the train. The total tonnage hauled was 275,000 tons.

In conclusion, the following advantages and disadvantages of the three-phase system for traction use are given: (1) Maximum electrical and mechanical simplicity. This point is of great importance and was one of a number of reasons for using three-phase system. The motors will stand any amount of abuse and rough use. (2) Greater continuous output within a given space than can be obtained from any other form of motor. This is shown by comparison with other electric locomotives, which is due to the fact that the losses can be kept lower in the three-phase motor than in any other type. (3) Uniform torque. This is important, particularly at starting. The three-phase motor will work to a three or four per cent greater coefficience of adhesion than a single-phase motor of fifteen cycles. (4) The possibility of using twenty-five cycles. This is important, as it leads to a less cost and a better transformation of power-station apparatus; moreover, it is standard and the power supply can readily be used for other purposes as well as for traction; a commercial supply can be provided. (5) Constant speed. This is ordinarily stated as a disadvantage of the three-phase motor, but it is a distinct advantage in mountain service, particularly the limitation of the speed on down grades. It has also an advantage on up grades—meeting points can be arranged with greater definiteness. It is generally believed that the impossibility of making up lost time with a three-phase motor will be a decided drawback to its use. This would be true if there were the same liability to lose time with three-phase motors, but when a train can be counted on to make a distinct speed without regard to conditions of track or of its load, there is less liability to lose time. (6) Regeneration on down grades. This matter has been discussed since the earliest days of electric traction, but has not been, up to the present time, put into practice. Although this result can be attained with other forms of motors, yet it is most perfectly attained by three-phase motors, there being no complications involved. This is of importance in reducing the power-house capacity required for a given space, although no doubt the saving in power-house capacity will not be as great as indicated by theory, owing to the various emergencies that must be provided for; nevertheless, there will be a material saving. (7) Excessive short-circuit current is impossible, and consequently destructive torque on the gears and driving rigging is eliminated. There will be no necessity for the complication of the friction connection between the armature and driving wheels, as in the recent large direct-current locomotives. (8) Impossibility of excessive speed. Even when the wheel slips the speed remains constant. Therefore, the maximum stresses put on the motor are less and are more accurately known than with any other form of motor.

On the other hand, the principal disadvantages of three-phase motors for traction use are commonly stated to be: (1) The constant speed. This is rather an advantage for this class of service. (2) Constant power. The fact is that the motor is a constant power motor, and, therefore, requires the same power at starting and accelerating as at full speed. (3) Small mechanical clearance. In this particular motor the clearance is one-eighth of an inch, which is ample for all practical purposes. (4) Inequality of load on several motors of a locomotive due to differences in diameter of driving-wheels. To meet this an adjustable resistance is included in the rotor of each motor. The motors are then balanced up and no further attention is required as long as the wear on the driving-wheels is approximately the same. (5) Low-power factor of the system. This does not seem to be borne out by practice. The power factor, as shown by the switchboard instruments in the power house, is eighty-five per cent. (6) Two overhead wires. There is no doubt that two wires will cause more trouble than one, and in case of complicated yard structure, it might not be practicable to use two overhead wires.

The president then called upon W. S. Murray to open the discussion.

Mr. Murray said that he was a "single-phase man;" but as far as the Cascade tunnel is concerned, he was hearitly in agreement with Doctor Hutchinson, because the physical conditions of the road required a three-phase system. The reasons for the application of three-phase are exceedingly simple. Any piece of trackage, be it one mile or three hundred miles, be it zero grade, up to a percentage of grade that admits of adhesion of the locomotive, only with trains upon it, with no stops, and even with conditions of stops where the acceleration is exceedingly low, under such conditions most of the engineers in this country would adopt three-phase. The single-phase motor is admittedly heavier than the three-phase motor for the same output. Therefore, three or four per cent greater adhesion is not important. Now, the single-phase motor is admittedly heavier than the three-phase, for a certain amount of capacity, and therefore this lack of adhesion, if that fact exists, is taken care of by its excess weight. It is unfortunate that the single-phase motor weighs more, but it does, and takes care of that case. The twenty-five-cycle on single-phase can be used, but the three-phase secures less costly generators. This is offset, however, by less complicated switchboards. It is not greatly more expensive to use three-phase rather than single-phase generators for single-phase distribution, and the dampened field rather cuts down the rising voltage on the idle phase, making it perfectly possible to develop three-phase current for commercial requirements.

Bion J. Arnold said that his difficulty for the last five years had been, not in handling single-phase or three-phase, direct-current or alternating-current systems, but rather in handling men and other elements, which enter, not into the construction of railways or in the operation of them, but in the continuance of them in financial existence, or endeavoring to point out ways whereby they could remain in existence and prevent them from being financially eliminated. He said that last summer, while on a trip, he found he was only a few miles from the Cascade tunnel, so went over and rode through the tunnel several times on the locomotives. The system operated as successfully as any direct-current or single-phase installation he had ever seen. It had the objection of the double overhead conductor, and the yard was necessarily somewhat complicated on that account. That was one of the principal reasons why Mr. Arnold chose the single-phase for the tunnel between Detroit, Mich., and Sarnia, Ont. That element, and others, which seemed to show an economy in favor of the adoption of the single-phase system, together with the saving in investment which seemed to be made under the circumstances, caused him to adopt the single-phase installation for that system, and at a time when single-phase installation had not been tried on heavy traction work.

F. N. Waterman said that, as one who has advocated the consideration of three-phase motors for railway work, he is particularly gratified by the evidence of its advantageous application as set forth in the paper of the evening. He called attention to one property of induction motors not exhibited in the present instance, because only one train is operated, namely, the action of moving trains as flywheels to keep down the peaks or minimize the fluctuations on output of the central station. The present system operates only one train at a time, and therefore it is impossible to realize that unique feature of induction motors.

J. H. Davis, electrical engineer, Baltimore & Ohio Railroad, said that the plant described by the author makes an epoch in the history of heavy railroad electrifications in the United States. It is the first attempt in this country to use the three-phase induction motor for handling heavy passenger and freight trains on a trunk-line railroad. The paper is replete with interest, as it covers, in a general way, all of the principal features of the plant from the utilization of an available waterpower to the locomotives and their operation. We are especially impressed with the importance of the electrical engineer's decision in recommending the adoption of a certain system of electrification. His decision is second in importance only to that of the engineer locating the railroad. A decision to use this or that system of electrification for a certain purpose, as, for instance, handling heavy traffic over a mountain division, will, of necessity, have great weight in determining the system of electrification to be used when other divisions of the road are electrified. The system thus adopted may or may not be that which is best suited for the desired extension. If the entire road is eventually electrified, one system of electrification should be used throughout, although this system may not be best adapted to all of the various conditions to be met. Therefore, the system adopted should be that which is best adapted to the requirements of the road as a whole. The necessity for interchange of equipment from one division to another is well known, and in meeting this requirement the electrical engineer can best secure simplicity of equipment by confining himself to one system of electrification. The gain in this direction will be more than sufficient to offset the loss due to the adopted system not meeting in the best way some of the conditions.

L. R. Pomeroy, of the American Locomotive Company, in the discussion stated that he made an examination of the Cascade Tunnel situation to determine the possibilities of electrification, and subsequently has been furnished with road tests of locomotives over the road described, which were presented. From these figures Mr. Pomeroy presented the deduction that the percentage of difference in favor of electricity was fifty-eight per cent. Also that the total amount saved by using electricity over this section is $268,769, and this amount capitalized at five per cent, represents $5,375,380. This amount alone, and not figuring on other savings, such as train crews, reduction in train mileage with the same tonnage, the advantage of a great increase in capacity, would go to show that such a mountain section comes very near being a situation where we can accomplish by electricity what is now impossible under steam conditions.

F. S. Denneen, of the Ohio Brass Company, said that he had quite a little to do in laying out the detail of the overhead construction, and in that capacity was acting for the manufacturers who supplied the materials. The trolley construction is what is generally termed a direct suspension type, that is, the trolley wire is not supported by any auxiliary overhead wire, and the reason for selecting this direct suspension instead of going into the more elaborate catenary types now so popular, was that there is a necessity for providing two wires over each track, with a voltage of 6,600 between the wires, and the same voltage between either wire and ground, and therefore the installation of auxiliary supporting wires would greatly complicate the problem of insulation, not only that, but the danger of cutting down the road and interrupting service for any of a great many possible causes, would be greatly increased, and therefore he decided to go to this self-supporting type of trolley. The overhead structure on the single track yard consists of a bracket, each phase is supported by an independent span, and auxiliary insulation is provided in every case, that is, the major insulation may be said to consist of two heavy porcelain strain insulators. The porcelain strains are rated for 10,000 volts, while wood break strains might be rated at 3,200 volts, or more. In certain parts of the yard it was necessary to provide overhead construction for as many as six tracks. Wires of the same phase are carried upon one cross catenary, while those of the opposite phase are carried upon another one; there is insulation between the wires of the same phase over different tracks. This was done in order to maintain the tracks entirely independent, and make it possible to cut out any one track or any set of tracks. Dr. Hutchinson refers to the trouble experienced at the intersection of lines due to the trolley leaving the wire, this trouble occurring as the trolley wheel crosses the pan casting. At the time the layout was originally made a scheme was considered for turning a tongued portion in the pan so as to carry the wheel across in the proper direction, but this complicated the arrangement and was not followed. When the original tunnel was made the trolley wires were set five feet apart, but after the whole layout had been worked out and approved by the railway engineers, the officials of the road decided that they wanted the entire central part of the tunnel, or the entire overhead, in the center, clear, so it was necessary to set the trolley wires out to a separation of eight feet within the tunnel, which made it rather bad in a great many ways. The clearance between the side wall and the trolley on either side was only fourteen inches, and it was desirable to prevent the trolley from swinging, and it was necessary to provide double insulation throughout, so the problem was not an easy one.

W. I. Slichter, of the General Electric Company, contributes a written discussion wherein he stated that the principal characteristic which differentiates American from European railway installations is size. In the locomotives under consideration it was necessary that there should be developed a tractive effort about three times as great as that developed by the foreign locomotives and the practice of pushing a 2,000-ton train up a two per cent grade required that that tractive effort should be applied gradually, steadily and continuously, as any sudden variations in a tractive effort of this large value would almost certainly result in breaking a train in two and possibly in causing a wreck. Thus, the control system of such a locomotive is a very vital feature. There can be no reduction in the tractive effort after it is once applied, and there must be sufficient control steps so that successive increments of tractive effort are not so great as to slip the wheels or strain the draw-bars to a dangerous extent. In this particular case the character of the service and the low speed of the locomotive eliminated the necessity of having more than one running speed. The problem was then to provide a control system which would give a steady acceleration and yet provide for running at fractional speeds for short intervals of time such as fifteen minutes as contrasted with continuous running. This is accomplished by using plain rheostatic control in the secondaries of the motors, varying the resistance by contactors and providing sufficient capacity in the rheostats to permit of running for fifteen minutes at full load. The control system consists of fourteen contactors per motor, five of which are in the primary, there being one contactor on one phase and two on each of the other two phases to provide for reversing the motors. This leaves nine contactors in the secondary to give thirteen steps, which is accomplished by a scheme of dividing the resistances into two or three groups, each having its contactor, and these groups are brought into different combinations so that each group is used over and over again, some times in series, some times in multiple with the others, and not left idle after being used once. A separate and independent set of resistances is provided for the secondary of each motor to avoid the tendency of the motors to exchange current and "buck" when they are all connected in multiple to one set of resistances. The advantage of the induction motor, due to its peculiar adaptability to regeneration, is best illustrated by considering the amount of energy which is regenerated and which would have to be dissipated in rheostats otherwise. To hold a train having a gross weight of 600 tons on a 2.2 per cent grade would require a resistance capable of absorbing 650 kilowatts per locomotive for the time during which the braking occurred. This corresponds in size of rheostats, to the condition of running continuously at a speed of four miles per hour with an input of 460 amperes per motor and a tractive effort per locomotive of 37,500 pounds.

C. L. de Muralt, after commending Dr. Hutchinson's paper and the three-phase system in general, said that a point emphasized particularly in the paper of Dr. Hutchinson is that the efficiency of the three-phase system is extremely high. The second point is that the recuperative feature has also been rather underestimated. The paper shows conclusively that the regeneration of the train on a down grade is fully up to the calculated results. There is no reason why actual experience should disagree with calculations on this subject. The paper does not bring out the full value of the recuperation, it cannot, because it is too limited an application. When the road is extended and operates over a long distance it will bring out the full value of the recuperation.

Calvert Townley, in the discussion, stated that he wanted to mention one point which seems not to have had as much emphasis as it really should have had. The various advantages of electric traction over steam have been considered for a long time, and predictions made of possibilities when the water powers of the western mountains were used to supply power for the electrification of our mountain roads, but here is a case where the installation has actually been made, where a large steam railroad system, backed by abundant capital and officered by men standing high in their profession has gone to work and electrified a section of their line at a very heavy expense. He said that question of the type of apparatus, its performance, etc., in which electrical engineers are naturally very much interested, important though it may be, is really a secondary matter in this particular case. It seems that the greatest importance attaches to the making of this installation. It means more than any mere question of the design of the machinery, because this installation will be successful, it will be extended, the road putting it in will find that it has been to their advantage to substitute electricity for steam, that entirely aside from the questions of economy of operation on which we have had some interesting figures, on other and broader questions in operation that will be shown to be of such importance that this installation will mark a distinct advance towards the electrification of these important trunk lines.

C. P. Steinmetz said that it is now something over fifteen years since the first three-phase induction motors were applied to railway circuits. At that time the single-phase commutator motor had been designed for railway work, had been designed some years previously, but had not been carried through, because no frequency then existed low enough to make this type of motor suitable. Very much work was done on three-phase induction motors, a number of equipments filled, and very high hopes were entertained in those early days. At the same time, however, the rotary converter was successfully developed and introduced into the industry and gave the direct-current railway motor such an extension in the distance to which it could be used, that the direct-current railway motor was capable of taking care of all the railway work for practically unlimited distances, and in view of this the three-phase induction motor development in this country did not progress as we hoped it would. Ultimately the three-phase induction motor also has reappeared and found successful application. The advantage of the three-phase induction motor is the simplicity and resulting reliability, the uniformity of current and the greater output. These are the characteristics of polyphase machinery in the polyphase generator, motors, etc.—the main characteristic of the three-phase induction motor, however, is that it is a constant feed motor. All other characteristics result from the constant speed, and that follows that its efficiency of acceleration is relatively low, it consumes the same amount of power in turning around slowly as it consumes when running at full speed at the same given current. The result of the constant speed feature is also the regenerative feature, that above synchronism it goes into regeneration automatically. The constant speed feature limits to a certain extent the present application of the three-phase motor in railway work. It is well suited for mountain divisions, for running continuously with heavy torque, positive or negative. For general railway work, however, as it is at present carried out in our country, the three-phase induction motor locomotive is not as well suited as the direct-current locomotive or the single-phase commutating machine, for the reason that the direct-current series motor or the alternating current commutating motor can replace the steam locomotive in our present railway operation, while the three-phase induction motor locomotive can at best efficiency replace the steam locomotive and operate the railway system in the same manner as it is operated now, but it requires a rearrangement of the method of operating to a constant speed service. When considering the method of operation, we have to investigate whether this particular method is really inherent in the problem, is a necessary feature of the desired results, or whether it is an incidental feature of the particular apparatus we use. The steam locomotive is a constant power motor. It gives the same power irrespective of the speed—the power is limited by the steaming capacity of the boiler, and whether you climb a heavy grade or run on a level track, you have that particular power limit, and that has fixed the present method of railway operation. It was not the anticipation of making up for lost time, it was merely that the locomotive had to slow down on the up-grade, because it could not keep up steam and could run faster on a level track. As regards the shunt motor limitation, Mr. Steinmetz called attention to one particular curiosity—when speaking of the shunt motor, the induction motor, we always specifically exclude from its field of operation, the rapid transit service—rapid transit is that operation where the series characteristic is especially necessary and where the shunt motor is especially unsuited. The most extreme case of this constant acceleration of heavy torque and never doing anything else, the most extreme case of rapid transit, is the high-speed passenger elevator operated by the shunt motor and induction motor for the sake of reliability and capacity of operation.

Frank J. Sprague was present and entered into the discussion by saying that he is not the advocate of any particular system, or the disparager of any particular system. He mentioned the three main electric installations on trunk lines in this country, and said that at each of these places the steam locomotive was under the maximum disadvantage, under the vilest possible conditions of operation. Electricity offered a remedy, and according either to the beliefs of the designers or the ambitions of the various manufacturing companies, or the engineers of the railroad companies, the three distinct systems were adopted. In each of these operation continues successfully. There are higher speeds, higher capacity, greater safety and greater cleanliness, which are the characteristics of operation, and he thinks engineers have every reason to have hope, and feel gratified, because each system of these three particular installations has overcome many difficulties incident to steam operation, and are giving creditable results, but neither of these is a complete trunk line, the Cascade, not more than the others.

Dr. Hutchinson concluded the discussion by saying that most of the criticisms that have been made can be answered in the general statement that he was not describing this as a system applicable to any condition other than that to which it was applied. This system has been put in for a particular purpose, to meet a particular situation. It may or may not be good for other conditions. He said that he believed it would be good for the entire mountain, but that has not been tried. As to whether, generally speaking, it is better or worse than other systems, that is immaterial.

Newly Elected Associates, American Institute of Electrical Engineers.

At the directors' meeting, held in New York on Friday, November 12, twenty-eight applicants were elected to membership in the American Institute of Electrical Engineers, as Associates. The list of Associates so elected is as follows:

Anderson, Gustave Emil, assistant installer, Automatic Electric Company, Morgan and Van Buren streets, Chicago, Ill.

Bailey, Edgar Lawrence, electrical expert, General Electric Company; residence, 119 East Erie street, Chicago, Ill.

Beal, Henry M., superintendent, Citizens' Light, Heat and Power Company., Montgomery, Ala.

Bell, Robert James, electrical engineer, Chicago & Southern Traction Company, Chicago; residence, 91 154th street, Harvey, Ill.

Campbell, George, electrical superintendent, R. Simpson Department Store; residence, 108 Emerson avenue, Toronto, Ont.

Cline, William Hamlen, motor engineer, General Electric Company; residence, 101 North Common street, Lynn, Mass.

Condon, Casimir C., superintendent of construction, Condon Construction Company, 1531 Unity Building, Chicago, Ill.

Cox, John William, chief engineer, Columbus & Hocking Coal and Iron Company, Kachelmacher, Ohio.

Coxey, Albert Childs, electrician, Pittsburgh Plate Glass Company, Crystal City, Mo.

Frickey, Royal Evarol, electrical engineer, Northern California Power Company, Redding Cal.

Garnier, Edward Jacob, electric section foreman, Indiana Steel Company; residence, 767 Madison street, Gary, Ind.

Hillebrand, Phillip Henry, division foreman, Marysville Power Division, Pacific Gas and Electric Company, Marysville, Cal.

Karow, Edward, Jr., designing engineer, General Electric Company, Schnectady, N. Y.

Knapp, Martin Vale, superintendent of electrical department, The Union Utilities Company, Morgantown, W. Va.

Marcell, Lawrence Powell, electrical engineer, The National Railways of Mexico, Aguascalientes, Mexico.

Murray, William Wallace, superintendent, Dreamland, Coney Island; residence, 92 Montrose avenue, Brooklyn, N. Y.

Myers, Laurence Joseph, consulting electrical engineer, 228 West Borden avenue, Syracuse, N. Y.

Neel, Blanton, enginner, Chattanooga Electric Company; residence, 215½ Vine street, Chattanooga, Tenn.

Nichols, Charles Hart, consulting engineer, 11 East 24th street; residence, 63 West 127th street, New York city.

Nipper, Ainsworth M., superintendent electric light and power, Board of Public Works, Hannibal, Mo.

Orr, John, professor of engineering, Transvaal University College, Johannesburg, S. A.

Rice, Homer Coke, sales engineer, Westinghouse Electric and Manufacturing Company, 209 Central Building, Seattle, Wash.

Rutledge, Henry Benson, construction foreman, General Eelctric Company, Union Trust Building, San Francisco, Cal.

Tillson, Percy E., assistant engineering department, Bell Telephone Company of Pennsylvania, Philadelphia, Pa.

Wadsworth, George Reed, consulting engineer, 19 Congress Street, Boston; residence, Brington Road, Brookline, Mass.

Wall, Samuel Smith, superintendent, Town of Pulaski Light and Water Department, Pulaski, Va.

Warren, William Douglas, president and manager, Warren Electric Company; residence, 117 South Water Street, Trinidad, Colo.

Wyrick, Byron M., superintendent construction and equipment, Postal Telegraph and Cable Company, of Texas, 243 Main Street, Dallas, Tex.

At the same meeting Robert Dale McCarter, consulting engineer, London, England, was transferred to the grade of Member.

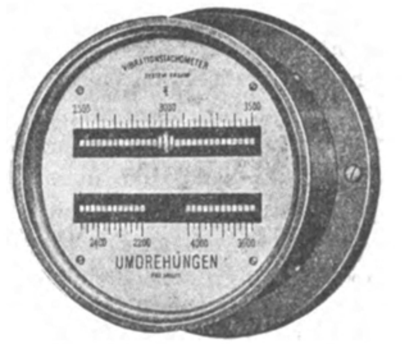
Inductance in Resistance Coils.

In an article by S. Leroy Brown in *The Physical Review* for October, on "The Residual of Inductance and Capacity in Residual Coils," the author arrives at the following conclusions: (1) A parallel wire standard of resistance can be constructed which is free from residual inductance when used with interrupted, steady current, or with alternating current of moderate frequency. (2) The outstanding difference between inductance and capacity in resistance coils can be measured by comparison with this parallel wire standard. (3) A standard coil, made by twisting the wires together and separating consecutive turns, is not completely compensated for inductance and capacity when capacities of a few hundred micro-microfarads are to be measured. (4) Capacities and inductances of small or large values can be measured with alternating current and an alternating-current galvanometer. The values are calculated from formulas which involve only the resistance, inductance and capacity of a single circuit and the frequency of the applied electromotive-force.

The new electric-railroad mileage built in 1908 in the United States, Canada and Mexico was 1,258 miles, computed as single-track road. New York state takes the lead in mileage, with 184 miles, closely followed by Ohio, with 171 miles.

A Vibrating Speed Indicator.

This device, which is manufactured by the Siemens & Halske Company, under the Frahm patents, is based on the resonance principle and utilizes the balancing defect existing in the rotating mass of all machines on account of the fact that the center of gravity of rotating systems can never be placed exactly in the center of the axis. The small, often scarcely perceptible, shocks are a direct function of the number of revolutions of the shaft and



VIBRATING SPEED INDICATOR.

are perfectly sufficient to set the apparatus in action. If a tuning fork is mounted on a machine, it will receive a small impulse at each revolution, but will respond to these impulses only when they coincide exactly with its natural period of vibration. If several tuning forks of different notes are mounted together it will be possible to make the number of revolutions correspond to their known notes. The construction of the practical apparatus is shown in Fig. 1. The tuning forks are replaced by thin, flat steel strips bent at right angle at their heads and painted

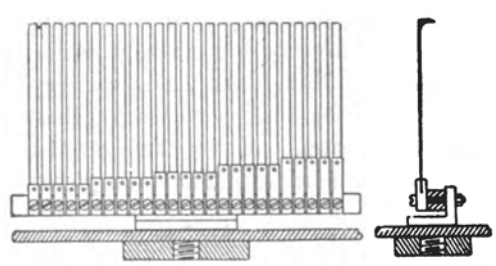


FIG. 1.—VIBRATING ELEMENTS OF SPEED INDICATOR.

white in order to render them more visible. These so-called resonance tongues are roughly tuned by varying their lengths, the finer adjustment being made by a quantity of tin solder under the bent heads. The apparatus receives a larger or smaller number of such resonant tongues according to the limits of speed which it is desired to measure. On the basis of practical experience a maximum vibrating scale is made about seventeen millimetres wide with tongues of a width of about three millimetres.