venture will be watched with considerable interest by the Metropolitan Street Railway Company, to whom the development of a really satisfactory independent motor for their crosstown lines seems to be almost an imperative necessity.

LIMITS OF ELECTRIC TRANSMISSION.

BY ALTON D. ADAMS.

The electric transmission of power at pressures that render the conducting wires luminous, cause hissing sounds, and produce a certain sensation in the observer at several feet distant, is being ably exploited. Referring to the subject, a recent writer has said: "The most fundamental present question is the limit of practicable voltage." Again it is stated that, referring to experiments with electric transmission at high pressures, "The carrying out of such experiments has a vital interest far beyond the mere utilization of distant water powers. It may, and very possibly will, open up the way for the wholesale transmission and distribution of power from coal." To fairly consider this question, the clear distinction between the long distance transmission of power and its distribution should be held clearly in mind.

It may, for example, be shown that a cheap and distant power is, or can be, transmitted to a center of population and there distributed to consumers at a profit; but this is not the question at issue. The real problem is whether the cheap and distant energy can be delivered at one or more convenient points, in or near the center of population, at a cost per unit that shows a saving over energy there generated from coal. It is a well-known and demonstrated fact that a central electric generating station in or near a town or city can supply power to a great number of small consumers on a sound economic basis for all concerned, because the generating station can develop power from fuel at a much less cost per unit than can the small user. It remains, however, to be proved that energy from a cheap source, 100 or 200 miles distant, can be transmitted to this central station and there used to drive the dynamos for the local service, thus displacing their engines, at a profit. If the transmitted power is to be used in a great manufacturing establishment, the question remains about the same as when it is destined for a distributing plant, since in either case power can be economically developed from coal at the point of delivery.

When a source of cheap fuel invites the transmission of power there developed to great centers of distribution or consumption, the saving in the cost of fuel per unit of energy delivered over that produced at that center is the chief economic reason for the transmission. The real question of electric power transmission, in large units, over great distances, is whether the saving in fuel warrants the investment in line and machinery and their attendant losses. In power production, the cost of fuel is neither the only nor in most cases the largest expense, and a part of the fuel cost is all that can be saved by the electric transmission. The long distance transmission of power is an undertaking that involves a large investment, and it is only fair that when the cost of power generated near the point of use is to be compared with that of the transmitted power, figures should be based on first-class results in a local plant conducted on a large scale. Considering two steam plants, one at a long distance, where fuel is cheap, and the other at the center of use or distribution, an equal economy in the weight of fuel consumed per unit of energy developed should be assumed, the cost of fuel in each case per unit of delivered energy computed, and the difference found. The price of steam coal that will develop a horse power hour at the engine shaft, in a first-class steam plant, on a consumption of 2·5 pounds, is not more than $3 per ton of 2,000 pounds in most cities of the Central and Eastern States.

Allowing 3,000 working hours per year, the cost of coal per horse power per year is $(2·5 \times 3000 \times 3) \div 2000 =$ 11·25 dollars. If the steam generating plant is moved to the vicinity of the mine, this same quality of coal can be had at a much lower figure, say $1 per ton, and the fuel cost per brake horse power hour will then be $(2·5 \times 3000 \times 1) \div 2000 = 3·75$ dollars. The apparent saving in fuel by this change of location for the generating plant cannot all be realized, because, to deliver one horse power at the point of use or center of distribution, more than this rate of work must be maintained at the shaft of generating engines to make up for transmission losses. To determine these losses, the elements of the electric transmission system must be considered. To take power in the form of mechanical motion at one point and deliver it as mechanical motion at another point a long distance from the first, by electric means, requires at the generating station dynamos and step-up transformers; at the receiving station, step-down transformers and electric motors; also a line of conductors connecting the two stations. A good average efficiency under the varying conditions of load for the dynamos and motors is 90 per cent each, and for the transformers 95 per cent each. The efficiency of the line will vary inversely with the outlay for conductors, but would seldom be more than 85 per cent for a very long distance transmission.

These figures give the complete transmission system, from engine shaft to motor shaft, an efficiency of $0·90 \times 0·95 \times 0·85 \times 0·95 \times 90 = 0·62$. For each horse power delivered at the motor shaft, the engine must, therefore, supply $1 \div 0·62 = 1·61$ brake horse power, costing for fuel alone $3·75 \times 1·61 = 6·03$ dollars. As the plant located in a large city consumed fuel to a value of 11·25 dollars per brake horse power year, the saving as to fuel by the power transmission is $11·25 - 6·03 = 5·22$ dollars per horse power year delivered by the motor. To effect this saving in the cost of fuel, the capacity of the steam plant has been increased 61 per cent and the entire electrical equipment added. The items of interest, depreciation, and repairs should now be computed for these additional investments. As the idea seems to prevail, in some quarters, that electrical transmission on a grand and general plan will be commercially practical, if only a sufficiently high working voltage can be employed to hold in bounds the weight and cost of line conductors, the cost of connecting wires and supports is entirely omitted from the following estimate, this being more favorable to the long distance electric transmission than any increase in pressure can possibly be. This omission is made with confidence that the necessary investments and losses, aside from the line, are so heavy as to forbid the delivery of electric power, from a great distance, in competition with that from coal at ordinary prices. Counting the brake horse power capacity of the motor at the point of delivery as one, the capacities of the several other elements in the electrical transmission are as follows: Step-down transformer, $1 \div 0·90 = 1·11$; step-up transformer, $1·11 \div (0·98 \times 0·85) = 1·38$; dynamo, $1·38 \div 0·95 = 1·45$; and engine, $1·45 \div 0·90 = 1·61$, as found above. The combined capacity of the dynamo and motor in terms of the brake horse power delivered by the latter is, therefore, $1·45 + 1 = 2·45$, and the combined capacity of the transformers in the same terms is $1·38 + 1·11 = 2·49$, so that $2·45 + 2·49 = 4·94$ times the rate of power delivery must be installed in capacity of electrical apparatus. A moderate price for the dynamos and motors installed with necessary attachments is $25 per horse power capacity, and on this basis their cost per brake horse power delivered at the motor shaft is $2·45 \times 25 = 61·25$ dollars. Allowing $10 per horse power capacity of transformers, installed, their total cost per delivered horse power at the motor shaft is $2·49 \times 10 = 24·90$ dollars, making the total investment for electrical equipment, apart from the line, $61·25 + 24·90 = 86·15$ dollars per available horse power at the point of use or center of distribution. But the engine at the generating plant is shown above to require a capacity 1·61 times that necessary if it is located where the power is used or distributed to local lines, and the investment in steam plant is, therefore, increased 61 per cent to make up for losses in the electrical transmission. A fair price for a first-class steam power plant may be taken at $60 per brake horse power capacity, exclusive of buildings, making the value of 0·61 horse power capacity $0·61 \times 60 = 36·60$ dollars. The total additional investment for machinery equipment in a long distance electric transmission system, over that for a local plant, making no charge for line conductors or buildings, is $86·15 + 36·60 = 122·75$ dollars per each horse power delivery capacity at the receiving station. To compensate for this great increase of investment, there is a yearly saving of 5·22 dollars per delivered horse power. Assuming the very low figure of 16 per cent on the investment, to cover depreciation, repairs, insurance, taxes, and interest, makes the annual charge for these items $122·75 \times 0·16 = 19·64$ dollars for each horse power delivered at the point of use or distribution. As the amount saved in the value of coal consumed is only 5·22 dollars per delivered horse power, the yearly outlay of 19·64 is nearly four times the saving.

This comparison is very favorable to the transmission system, because no charge is made for the additional buildings necessary with it or for the line. It should also be noted that, while the labor of operation for the generating and receiving stations and the care of the line will no doubt require more expense than the labor of operation in a steam plant at the place of use, no charge has been made for this increase. As the total cost per brake horse power in a first-class steam plant, using a fair grade of steam coal at $3 per ton, about its cost in many cities, was found to be only 11·25 dollars per year, the extra expense resulting from the equipment for long distance transmission from free fuel is $19·64 - 11·25 = 8·39$ dollars per delivered horse power per year. That is, if absolutely free fuel could be had at a point 100 miles from some of our great cities, the electric transmission of steam generated power from this fuel to the cities would involve a yearly loss per delivered horse power of more than 8·39 dollars. So much for long distance transmission from the coal mines to great cities.

THE CHEMISTRY OF SOOT.

The impression generally prevails that soot is simply carbon, but although carbon is its chief constituent, there are present many other elements among which are hydrogen and nitrogen. Soot may be considered as an impure hydrocarbon, containing a very large proportion of carbon relatively to the amount of hydrogen. The smell of soot suggests ammoniacal compounds, and The London Lancet states that a recent analysis has shown that soot contains no less than 7·4 per cent of ammonium salts. This fact amply accounts for the value placed on soot for agricultural purposes. Soot on burning in a confined area, as in a chimney on fire, evolves a characteristically persistent and nauseous smell. This characteristic is probably due to the presence of nitrogenous organic compounds.

PARIS EXPOSITION NOTES.

The United States Publishers' Building, which has been erected in the grounds adjoining the main buildings of the Esplanade des Invalides, contains a number of exhibits which characterize the printing and other industries of this country. The building itself presents a handsome exterior; it is of square form, and the different facades are constructed of a series of arches resting upon columns. Two doors at each end give access to the interior. A number of exhibits are grouped in the center, surrounded by a passageway, leaving space for a considerable number of exhibits around the walls. The center is occupied by the Publishers' Headquarters, containing a number of desks and chairs for the use of publishers and others; the building is under the immediate charge of Mr. Charles Simms, Assistant Director of the Liberal Arts Section; Mr. A. S. Capehart is Director of this department. Nearby is the installation of The New York Times, which prints a Paris edition on the large Goss printing press, driven by an electric motor in the basement; a model printing office is shown in actual operation, the most interesting feature of which is the series of Morgenthaler linotype machines; there are five of these in actual operation, each being driven by an electric motor mounted directly upon the machine. To the right of the entrance is the exhibit of the Mutual Life Insurance Company of New York; the cases are finished in hard wood and ornamented with reliefs and statuary; the walls are lined with framed charts showing either by figures or graphically the different statistics relative to insurance and kindred subjects, with charts showing the growth of the United States in its various resources. Near it is the exhibit of the Equitable Life Insurance Company, which also shows a number of charts, besides photographs of its various office buildings. A number of typewriters, including the Yost, Remington, Smith Premier and Century, are shown in actual operation. A number of printing presses are also shown, most of which are running; among these are the Campbell, Babcock, the Mickle, which prints in colors, and others. Among the phonographs the American graphophone and the Columbia Phonograph Companies are represented, with a number of machines. The United States Express Company has an exhibit showing the system by a number of photographs or charts. Outside the main building is a model stereotyping pavilion, containing the melting furnaces, presses and all the necessary appliances. Another small building contains the reading room; most of the principal American newspapers are on file, and the cases contain bound volumes of illustrated journals. All of the SCIENTIFIC AMERICAN publications are to be found here.

EXPERIMENTS WITH X-RAYS IN ELECTROSTATIC FIELD.

The well-known fact that light movable bodies, when placed in a Crookes tube, enter in movement under the action of the cathode rays, is used to support the hypothesis that these rays are formed of material particles moving with a certain velocity. Nevertheless, it is remarked that the presence of cathode rays is not necessarily connected with the production of the movements, for these are observed to commence before the rays appear, and to cease when the rarefaction is pushed to a certain point, even though the cathode rays are still very intense. It is more probable that the movements are due to electrostatic action, especially if they are compared with those which have been studied by Groety in the case of Roentgen rays. This experimenter disposes a very light movable body, carried on the point of a needle, between the two plates of a charged condenser. In this constant field the body remains at rest, but when Roentgen rays are brought into the field, it enters into rotation, which lasts as long as the rays continue to act. With condensers of small dimensions and a movable arrangement formed by two disks of coppor foil united by an insulating cross-piece, the direction of rotation is found to change with the direction of the electrostatic field. The position of the tube emitting the rays also affects the sense of rotation. The two plates of the condenser are not indispensable in the experiment; they may be replaced by a small sphere, or even suppressed altogether, and the vanes placed in the air in the neighborhood of a Crookes tube. The rotation is not a direct effect of the Roentgen rays, for it ceases when a sheet of ebonite or aluminium is placed between the tube and vanes, the rays still passing through this screen.