The Future of Electricity

By
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MR. GEORGE J. COX, Supervising Director of the New York Electrical School, introduced the presiding officer, Mr. John E. Wallace, Attorney-at-Law.

MR. WALLACE: The introductory remarks of the director, when he stated that orators are born, etc., may lead you into a mistake, for I make no pretence whatever to being an orator; plain, simple speech is mine.

It is a pleasant duty to preside at this meeting. The rules governing the meeting are few and very simple. The lecturer of the afternoon will have as much time as he desires to treat his subject, after which those present may ask questions touching any point of the discourse, or, if they object to any statement of his, they may state their views briefly. This is the procedure for this meeting.

I stated it was a pleasant duty to preside. For two reasons I hold to that: One is that the lecture—the subject of the lecture—the future of electricity, and the fact that this lecture is held under the auspices of your New York Electrical School, bring to my mind a very nice point. The educators of the country, as they admit to-day, recognize the fact that our public school systems are in want of something; that there is no thoroughness or practicability there, or, in other words, that there is a breach between that period when we leave off from the course and take a hold of the great wheel which is revolving in the economic and commercial world. Right there we find the next admission, and that is that they must turn to the practical men of life—to those who have been fortunate in the past in securing knowledge and applying it, and that those men are to be the ones to govern and control the future order of things. And along with this movement, there is going on on behalf of, unfortunately, a few philanthropists throughout our country, who, seeing the needs of society, and seeing also that, in order at the present time to get all the advantages from modern development of science and mechanics, it is necessary to have those who are thoroughly familiar with them, upon whom they can depend when those things are applied.

And so we find these gentlemen selecting those who have had experience, and placing them in the direction of the youth of the country. Branching throughout the country, taking root, are such institutions as the New York Electrical School, differing, of course, in this regard, that, under the experienced management of those having charge of your school they are attempting to give you the practical side of it, so that the period of your connection or apprenticeship will be short.

It is a pleasant duty for me at this time to bring your attention to the lecturer of the afternoon. By those of the scientific world he is regarded for his knowledge and learning; but from the section of the country where I come from, there is a deeper feeling. While they have the same respect and admiration for his high station, they have a regard for him because of that true humility that he displays, that kindness and gentleness for those of our station in life. We have found on many occasions when we have sought for advice that we have been met upon what we would call a democratic station.

There has been no reason why the youth of Schenectady should have lost the advantage of the advice of the lecturer of the afternoon, for we feel for him the deepest feeling, and I state it with all the emphatic words that I can command and reach that there is no man in our section who can strike the popular chord as much as the lecturer of the afternoon, Dr. Charles P. Steinmetz, of Schenectady. (Applause.)

THE FUTURE OF ELECTRICITY

The subject of the lecture is the prospective future development of electrical engineering.

On a subject like this it obviously is not possible to make any very definite statements. We do not know what the future will bring. A single year's development may reverse the trend of progress and turn it into an entirely different direction. All we can do is to see what is going on at the present time, and study the development of electrical engineering, to understand in which direction it trends at present, and estimate whereto it will lead when progressing in the way it progresses at present.

We can, however, see a number of problems before our nation and the world at large—problems which have no immediate connection with electricity, but which the electrical engineer will have to take up and solve. I also desire to speak on the personal relations of all of us here assembled, and its change with the advance and progress in electrical engineering.

The first and oldest applications of electricity was for the communication of intelligence; that, the telegraph and telephone, and the simple bell, which latter, after all, is one of the most useful and important of electrical apparatus, whether it is the bell announcing the arrival of a visitor at the house door, or an annunciator system in a hotel, or a railway signal system on whose perfection and reliability the safety of passengers and trains depends.

The second field of application is to electric lighting. Then we have the development of electricity to railroading, to power distribution; we also have a field least generally known, although not the least important—electro-chemistry. Looming up also in the future are the applications of electricity to heating, cooking and many other purposes.

One of the most important applications of electricity still is the telegraph and telephone and, in general, signal systems. In this line, the progress has extended over half a century, and is still continuing, mainly, however, in the increase and extension of the systems, and no less startling than in some other fields of electricity. Yet we have seen in the very last years one of the most startling developments in the wireless telegraph, in the elimination of the conductor which connected the receiving with the sending station, whether as submarine cable under the Atlantic or Pacific oceans or as the telephone line reaching to Chicago or yet farther. In the wireless telegraph we have now eliminated that conductor altogether, and send out the message into empty space, and collect it again a hundred or a thousand miles away. When wireless telegraphy first arrived and was still in its beginning, it exceeded all expectations. Instead of only a few miles we very soon reached hundreds of miles, thousands of miles, and enthusiasm ran high. Hopes were held that very soon the cable would be supplanted, that transatlantic messages would be flashed across space. So far this has not yet been realized—at least not commercially to any great extent. We have crossed the Atlantic by wireless, but still the submarine cables hold the field, and I do not think the cable companies need be very much afraid that their shares will lose their value for a long time to come.

However, there is one thing that the wireless telegraph has done: There is no place on earth, whether in the middle of the ocean or in the polar regions, or in the interior of a besieged fortress, that the rest of the world cannot reach, if it so desires. Even such a thing as warfare, which, after all, as human society is organized now, is an essential feature, has been greatly modified by the wireless. There is no more possibility of cutting a fortress off, for at Port Arthur communication was kept up to the last day because you can reach across thousands of miles of empty space. A ship can always communicate on the ocean if supplied with wireless telegraph. A polar expedition, no matter where in the vast polar regions, can communicate with the rescuing party, which, after all, seems to be an essential part of a polar expedition.

In this direction still greater progress will be made. There is one great difficulty at present. We can send out the message into space, we can collect it from space, but we cannot efficiently direct it, cannot send it just in one direction from the sending wire as we send a beam of searchlight in one direction. We also cannot take up just the message of the sending station that we want to. The receiving wire will take up everything in the space, some better than others, depending on how the receiving station is fitted up; but there is no complete selection yet where we can send out just to one other station and take up from just one other station. In that direction, then, future progress must lie.

The next application of electrical power is for lighting. Electric lighting has become useful in everyday life. But, after all, electric light is still a luxury. Its use may be very far extended, very general, but in economy it is more expensive than gas and still more expensive than kerosene, and whatever may be said in favor of electric lighting, the majority of American homes still rely on the kerosene lamp for illumination. Not so much in the large cities; but, after all, the large cities are not the country, and most of the nation does not live in the large cities. So we see that although electric lighting has reached far, and has been extended to a very great extent, is extending still farther by its superior convenience, it has not yet been able to compete in economy, in cheapness, with the kerosene lamp, and that is the development which the future has to bring. That is, we must reduce the cost of electric light. Now, that can be done, and we can see in which direction it will be accomplished. At the present time, we find the electric current used for lighting and other purposes. We measure it by the kilowatt hour—a certain quantity of electricity as much as can supply one and one-third horsepower running for an hour. The cost of the kilowatt hour when sold for lighting varies in different places, between five and twenty cents. The average may possibly be about ten cents. Then, again, we use the electric power for other purposes, as, for instance, for driving the pumps which feed a city water supply or for running a copper refining plant. For these purposes we frequently get the cost down to one cent a kilowatt hour, or one-tenth of what we have to pay for electric light. From water-power stations, when buying electric power in large bulk, over transmission lines, we may even get it very much below one cent a kilowatt hour. So we see the enormous advance there is still possible to cut down the cost of electric power for lighting to the same rate at which we can get it for other purposes. We have to realize that the cost of electric power varies with its use. It is not like, for instance, sugar or any other commodity for which we have to pay so much a pound, whether used for one purpose or another—we may get it a little cheaper wholesale, but the difference is not very great. It is entirely different with electric power. When we want it for lighting its production may cost ten or more times what it costs to produce electricity to supply a copper refining plant or a city water system, or a large plant running day and night at full load. Hence the cost of electric power depends on its use, as we shall see.

We want not only to reduce the cost of electric lighting, but also to get more light from the same power. At the present time from one kilowatt hour we can get something like three hundred candlepower—as much light as three hundred candles give during one hour. In the last few years improvements have been made in the electric incandescent light. Heretofore Edison's carbon filament has been used—a modification of coal—as the glower of the incandescent lamp. Now other materials have been found which give much more light for the same power. One of these materials was tantulum, the last tungsten. With the tungsten filament an incandescent lamp gives three times as much light for the same power, so it will reduce the cost of lighting about one-third of what it is now. That will be an enormous advance. At present this is what has been accomplished—to get three times as much light for the same power, but we have not yet been able to get the same light for one-third the power. You see, for the power which you had to use to get sixteen candlepower in lighting you can now get forty-eight candlepower, but we cannot get sixteen candlepower in light for one-third as much electricity, as we use now, and the latter is what we desire. What has been accomplished will take years to realize, because we have to appreciate that the number of incandescent lamps being used in this country is fifty million each year. You see it will take a very long time before factories are established and put in running order to produce the country's supply for any new form of lamp. The mere enormous size of such an industry excludes any rapid change.

In electric railroading very much has been accomplished, and more probably the future will still bring. We have seen here in New York City the steam locomotives being replaced by electric locomotives. It may be imposing to see these big electric locomotives, more powerful than any steam locomotive ever built, pick up a heavy train and rapidly bring it up to speed. But far greater has been the effect on the social life of the nation, not of the big electric locomotive, but of the plain, ordinary trolley car. Here in the big cities we do not realize so much this fact. To realize it we have to go out in the country—in countries like Massachusetts and up in New York State, or out through the middle west—to realize that the trolley is eliminating, extinguishing the country and the rural sections. There are no rural sections any more—they are suburban districts, and the country has been brought into a suburb of the city and town. At the same time the town is rapidly beginning to cease to be a residence for people, but the people move back to the country, or rather to the suburbs, which were formerly the country, but are now the place of residence. Throughout the last generation or

two the country has been depopulated, and the cities have become overflowing with population, and we have so been confronted with a very serious situation, and no remedy appeared in sight to meet it. We have now a return to the country, not by the people leaving the cities and returning to the country, but by the country becoming a part of the city, and the difficulty so solves itself in an entirely unexpected manner. People who work in the city move out to live in the country. All over the state we see now that the residence place is becoming the country and the city becomes, as in former times, a place where business is being done, where factories are located, but not a place of residence. In this direction advance will probably go farther and farther, so that in the future, and not in the very far distant future either, the city will become a collection of factories and office buildings, and perhaps also boarding houses where bachelors live; but the families will move to the country again. (Laughter and applause.) Now, that makes it better, nicer, healthier, more satisfactory all around for the country as well as the city. But there is another more important feature that we must look into.

We are rapidly advancing to a time when we will not be able to live on our national capital, when we will have to economize. Now, when that time comes we will have to arrange systematically our method of work. At the present time farmers complain that there is not much help to harvest the crops, that the farms are suffering from lack of labor. At the same time the farms cannot attract labor because they want men to work for a few weeks, at the highest, a few months, during the year, and the rest of the year they have no use for them. Now, if we were like some animals that can live and work for a few months, and then sleep the rest of the year, that would be all right. We could live on the farms and work in the harvest time, and then go to sleep and wake up next harvest. But we cannot do that, and this is the main reason why the farms cannot get help. They cannot offer work throughout the whole year. By opening the farm to the town and the town to the farm, you see it becomes possible to work on the farms during those periods when the farm needs help, and work in the cities, in the towns, during the rest of the year. Now, at the present time that is not possible, but there will be a time when we will have to organize production systematically. We will not be able to get along haphazardly, as at present. There will come a time when all our nation will have to cooperate in systematic development, and then we will be able to combine the work of the farm with the work of the city and the town.

over. As we know, the North won, and the cotton mills grew up here in the North and English workingmen were starving for years until England raised cotton in India.

But there came a time when the South woke up to the idea that instead of sending the cotton North they could manufacture goods down South just as well, if not better. I remember in '94 I was down there, and there was just one cotton mill that had introduced electric motors—a cotton mill owned by northern capital. The first one owned by southern capital to introduce electric motors was just considering the question of getting the power from the river nearby. The South is rich in water power, the like of which we have nothing in the North. There are places down there where they can manufacture at a rate and under conditions that the North cannot compete with. And so they do now. So you see the gradual development from England to the northern states, and now from the North the cotton industry is moving South to the cotton fields, but that movement is becoming possible only by the development of water power. There is a great field for the electrical engineer in that direction, because while much has been done we have hardly begun to enter the field.

In the field of electro-chemistry, in metal reduction, electricity has made great strides. A large part of all the copper used in the arts is refined electrically, and all the aluminum that is being used is produced electrically. Many other things that we never realize, never know of, are also produced electrically. It is the least appreciated branch of electrical work, this electro-chemistry, but it takes up more power than almost any other branch of the industry, because the uses of electro-chemistry are growing in every direction and more rapidly than in any other field. It will probably be in the future the largest field in which electricity is used.

We see, therefore, in what direction the development is going, but the indications at present which we find everywhere are that electricity is entering into new fields, or fields that have scarcely developed, as in electric heating, electric cooking. The one drawback is the high cost of producing electric power at present for such uses. There is no reason why we cannot cook by electric power. We can change it to heat completely, but at present, for general use, it is rather more expensive than the coal fire. Now, let us see why.

The electric current in most cases—in all cases where water power is not available—is generated by burning coal. If we use electric heat instead of burning coal in the kitchen range, we burn up the coal under the boilers of the steam engine at the station. We may perhaps get 60 or 70 per

cent. of the energy of the coal as heat in the steam; that steam goes into the steam engine. Now, of all the power that comes from the coal the steam engine can utilize only about 10 to 15 per cent. Most of the heat is unavailable energy, is wasted, and there seems to be at the present time no possibility of increasing very greatly the efficiency and of saving this enormous loss of power in the steam engine. You see, from the heat of the coal under the steam engine we get 70 per cent. at the most. From the steam we get 15 per cent. as electric power. Now, 15 per cent. of 70 per cent. is 10 per cent. Therefore, we can get only 10 per cent. of the coal which we burn; the other 90 per cent. is wasted on the way. We may improve the efficiency, we may sometimes get more, but it will never be very much more. If you burn coal in the kitchen range you do not get 10 per cent. of the heat you produce. You lose as much heat in the kitchen range as you lose in the steam engine station, so that the electric current could compete with the kitchen range in cooking if you could really supply it at the cost of the coal consumed.

But it is not only the cost of the coal which we have to pay in order to get the electric current. There are very many other items, the cost of which are sometimes many times greater than that of the coal.

Let us consider what makes up the cost of electric power. First, we have the cost of the generating station, the engines, the electric machinery, the transmission apparatus, the transmission lines, the conductors, all the plant. That is an enormous investment of capital, on which interest has to be paid and on which depreciation has to be paid. Now, that interest and depreciation go on all the time, whether you use all the power which you could generate or use only a very small part of it, or use nothing, and therefore the cost varies entirely with the load you have on the station. That is what is called the load factor. If we could build a generating station and use it all the time to its fullest capacity, we could supply power very cheaply. But if you have a use for the power for only one hour a day you must pay the same interest as when it is used twenty-four hours per day, and that part of the price which pays for interest and investment must be twenty-four times as great as it would be if you used it for twenty-four hours at full load. So, as I stated, the cost varies with the amount of power you use. In a steam station the coal used may be an appreciable part of the cost. If you have a waterpower station, the cost of the plant is very much higher than a steam plant. You need the dams, you need the land where you back up the river, you need the transmission lines across the country. All that is very expensive, and all that you have to pay interest on, you have to pay depreciation on, regardless of whether you sell the power or not. Therefore, you see the cost of electric power entirely depends on the duration of its use, on how long you can use it during the day. Now, if you use it for lighting, let us see how long you use it. In winter time probably we may use it in the living room five or six hours a day; in other parts, in the dining room, probably for an hour or so; in the kitchen probably also an hour or two. That is, the average length of time is probably one to three hours. That means that the average use of the electric power for lighting is not more than one or two hours a day. But we still have to pay all the fixed cost, all the interest, the cost of the investment, the cost of the machinery. With water power it makes very little difference whether you use it for one hour or twenty-four hours, the cost goes on just the same. Therefore, if you wish to sell electric power for use during two hours of the day, it must cost you nearly twelve times as much as if you could sell your power during the whole twenty-four hours of the day. That is the cause of the high cost of electric lighting at the present time.

Now, where you can use the power twenty-four hours a day, there you can get it very cheap. When you can sell the power during the times of spare power, when it is not needed for lighting—during the daylight—and where you do not need additional machinery, you also can reduce the cost of electric lighting.

Electric power used during the peak of the load, when the load is highest—during lighting hours—is needed for lighting, and cannot be spared for other purposes. But at other times, when the load is not at peak it can be spared, and here it is where the electrical engineer, the station operator, can do something. He can try to get an even distribution, an even consumption of power, by getting the power used during those hours when there is no light. And that often is the difference between success and failure of many electric lighting stations, and the success of the electrical engineer of a small lighting plant will often depend on whether he gets, even where the price of power is as high as 20 cents, his power distributed over the whole of the day as much as possible. He must organize the use of his power. Now we do it haphazard. We realize there is an advantage to get electric power used throughout the time when it is not needed for lighting; that it is an advantage to get power demand for twenty-four hours a day, or, better still, during the day time, or during the time when there is no lighting

load, but all that we can do at the present time is to try to get it. At best the effort is haphazard.

And you more than I can help in this also. You will go out all over the country, and be in touch with the consumers. You can try to pick up loads when they are needed, and you can do more than anybody else. You can do more than legislative action can do. It may be possible to lower the cost of electric lighting by squeezing some water out of the capital of some companies, but you will not save very much in that direction. Instead of 15 cents it might be cut down to 10 cents; you may get it down 30, 40, 50 per cent. But if we could find a way to get an even use of power throughout the twenty-four hours we might be able to supply power at 1 or 2 cents a kilowatt hour. When we have accomplished that, electric power will be much cheaper than anything else, and then the end will come for gas and kerosene. And that time will come some time, and we will probably see it. (Loud applause.)

As I said before, we will get the highest use from electric power by directing the development in this direction. We must organize the use of the electric power by some general distributing system.

But there will come a time when it will not only be a question of economy, but a question of necessity. At present we still have coal. We use coal whenever we produce electric power by steam engine, but there will be a time when we will not have any more coal to use, and that is the not very far future. The anthracite coal will not last very long. Very many of us will probably see the last hard coal. Then the only coal will be soft coal. The next generations will see the time when even the soft coal will be exhausted. Possibly we may not, because there is very much more soft coal than hard coal, and it is more widely distributed. But we have already approached the end of wood as a fuel. The forests are destroyed, wasted. Wood does not come into consideration any more, except very locally, as fuel. Oil is too insignificant in its available supply to come into much consideration. Also, when coal has gone, what are you going to do then in the winter time to keep from freezing? It is a rather serious problem which the next generations will have to meet.

By that time the United States will have awakened to the viciousness of poisoning the air by burning soft coal. Whenever you go into one of those regions, as around Pittsburg, where soft coal is used, look around where you can see pine trees. The pine is the best indicator of the effect of the poisoning of the air by soft coal smoke. When you find that the pine trees are dying it is time to call a halt. These evergreen trees share with us the feature that they have only one set of lungs. The tree which gets new leaves every year gets a new set of lungs, and so can stand poisoning much better than the evergreen tree, as the pine, which has to get along with the same set of lungs throughout all its life, and so soon is killed, suffocated by smoke and coal gas. If you go where soft coal is being used very much you see no pine trees. Probably even before the soft coal is used up we will have awakened to the viciousness of poisoning nature and ourselves with smoke and coal gas.

When we reach the end of our resources in coal, in the not very far distant future, then the only remaining source of power, the only thing which will keep us from freezing will be the water power, which we will have to utilize electrically. At the present time, with all our so-called development of water power, the available supply is hardly touched. In a single New England state water power is running to waste many times greater than the power of Niagara. The water power that we use now is power that is collected in the waterfall, and as electric current it is sent out, but we have not yet started to collect the power. Now let us look at any of these water powers, like our Hudson, for instance. The Hudson River water power is being developed. In this state we now have some of these big falls where there is a considerable amount of power available used for lighting and supplying railroads in towns and cities. There is now an unbroken line of electric transmission from beyond Cleveland in Ohio and Toronto in Canada, far beyond Niagara Falls down to near Poughkeepsie. These are all joined together in circuits. So the railroads in Syracuse are run from Niagara Falls, but if the transmission line of Niagara Falls fails, breaks down, we have available and can receive the power from the Hudson River.

We are gradually extending the use of water power, but what we have done so far is very little. Consider the case of the Hudson River. We probably use up altogether from its falls something like 150 feet head. We do not make an attempt to get the enormous power which runs to waste through the spring floods, or in all the creeks and the rivers that feed into the big stream. Practically all that water comes down from elevations of two to three thousand feet above the ocean level. And of that power, practically all is wasted in all the little creeks and rivers which go to make up the big stream, all except 150 feet head. We cannot use that power at present, but methods will have to be developed, new ways of collecting the joined powers of all these

little streams, creeks and rivers so as to gather the power together. We will have to do all this when we are at the end of our resources, when the escape from freezing and starvation depends upon our getting the power.

There is an enormous field for the electrical engineer, and without him there would be hard times coming for future generations, much harder than we dream of now. We will then have to develop all that power that is now being wasted. We can see in which direction it can be done, only at present it would not be worth while doing it, because we can still use our capital in coal, but we will not always be able to use that. When that time comes we will have to economize; we will not be able to go haphazardly; we may even have to collect the rays of the sun, whenever it shines, to get that heat, because it takes a lot of electric power to produce very little heat.

There is still an enormous, far vaster problem, confronting the nations of the earth, which at the present time only electricity seems to be able to solve. In bygone ages all civilization started in the Far East, in the big river valleys of Asia, in countries which are deserts now. These large, dense populations earned their living by tilling the soil. That soil does not bring any crops now. It is exhausted, has been exhausted a long time ago. You cannot get any crops there without putting back in the soil in some way whatever you take out in crops. There is no capital any more in the soil there. And it is the same all over Europe. In America we have been more fortunate. We have had an enormous capital in the soil here. First, in the eastern states. Well, New England is a farming country no more. It was once, but the farms are exhausted. There is still the West, with its vast resources, but it is only a question of time when all those farms of the West will reach the same end as the farms of New England, as the farms of Europe and of the Euphrates valley, and when that time comes we will not be able to do as we have done in former ages—go West. No, for as we get farther west we meet the Pacific Ocean, beyond which are the countless millions of China, whose lands have all reached that stage long ago. So the last capital is just being used up now, but when that is gone whatever we take out as crops will have to be put back in the soil as fertilizer. For ages there were accumulating stores of fertilizer on earth. There was guano, bird manure. We have long ago used this up. It is not now available as fertilizer, because it is gone. There is saltpetre. Saltpetre in Chile is still available, but the supply will be exhausted in less than ten years. It is already so far exhausted that the price is beyond reach for general use. There is nothing further in view. The capital is gone in that direction. We have to produce fertilizer now.

All what we take out of the soil as crops we now dump in the rivers to pollute the streams. But soon it will not be a mere sanitary question any more of polluting the rivers. We are sending millions and millions worth of fertilizer down to the sea, lost forever, but in the future we will have to use that waste to keep from starvation, and all that refuse, all the waste of the cities and towns and farms must go back to the farm, to the soil from which it was taken. But all that which we now waste, when collected and returned to the farms will not replace what you take out, because there is a very large unavoidable loss in the spontaneous self-destruction of nitrogen compounds, and electric power apparently is the only efficient means which at present seems to be able to combine these elements of the air, nitrogen and oxygen, which are necessary as a fertilizer, and which cannot completely be recovered.

At present we do not use electric power for this purpose, to any extent, because we still have our capital of virgin soil, and the cost of electric power is too high, but every year we can see the necessity increasing of producing by electric power a method of restoring the capital to our farms. That problem is a very urgent one, and will have to be met within our lifetime.

But now that we have so many uses for electric power, and the only available supply is from water power, what we will need is a method of completely and successfully collecting all the power which there is in the water courses of this country. When that is done there will be no more rapid creeks and rivers, and these streams which furnish electric power will be slow-moving pools, connected with one another by power stations, and the creeks will be empty, because their water power will be needed to maintain our life. There will then be no more question of saving the beauty of nature when it becomes a question of saving our lives, and that takes precedence over the beauty of nature. We will need electric power then for heating, cooking, keeping ourselves warm, and for restoring the fertility of our farms. You see that power will have to be saved, and we will no more be able to waste it as now.

These are the problems which we electrical men will have to meet in the future, as well as in a short time, and we all will have to cooperate so as to organize all those forces which can be used for developing power. We must use electricity economically, find out how we can spread the use

over the twenty-four hours of the day and all the days of the year, so as to get the highest possible load factor, the most efficient use from our available power. Likewise, we must furnish power at the lowest cost. In other words, we must get the greatest benefit out of electricity that we can.

Now all this means that the world needs men who know something of electricity, of the operation and control of electric power. It needs all of us, and will need us more every year. We could get along without physicians. Some people believe that we may even live longer if we had no physicians. (Laughter.) I do not believe that, but the human race, whether it had physicians or not, would still need to have electricians. Its very existence will depend on them.

At the present time there are about three classes of electricians. There is one class, a few dozen, who do the pioneer work, who can go out into new fields where no man has yet trod, open up new avenues for the future development, originate. Then there is another class, hundreds of men. They can follow the theoretical reasoning of the first class, can understand what they do; and then there is the third class, thousands and thousands of men, who can understand the objects although they may not be able to follow the reasoning in every detail. It is the last class, after all, on which the world must rely for the most part. If those persons of the first class were taken away, new ones would spring up from the rank and file. But if that large majority of men, who can understand and follow and use the work of the pioneers, did not exist, the pioneers' work would be useless; there would then be simply some theories, laid down in the archives of science, to be read as we read of happenings in bygone days, as we read, for instance, that the steamboat was not discovered by Fulton, because somebody before Fulton ran a boat by steam. For the world's progress it is immaterial whether that first man ran a boat by steam engine or not, for the world received no benefit until Fulton came. He was the leader in that direction.

In all three classes we find college graduates and men who have never seen the inside of a college. Perhaps in the class of men who can follow the theoretical reasoning of the pioneers there are mainly college graduates, very few men who have not had a college training, because those men without college training who can rise to the second class have risen instead to the first class, the class of the pioneers.

I do not want to decry college training, because college training means you devote eight years of your life in high school and college just to accumulate knowledge, and it is extremely difficult to make up for that outside of college.

But, for all that, we find that the grandmaster of electrical engineering, Faraday, never had a college training. So you see it is not necessary to be a college graduate to be a leader. You can get the same outside of college. It is good, however, for you to to devote eight years of your life to study if you can afford it; if not, even if you can devote only the evenings, you can get a lot of knowledge.

But to the college training there is one great drawback—that is, that the college trained man, especially when he leaves college, often thinks that he knows all, and since nobody else agrees with him in this respect he frequently is absolutely useless until the world has knocked thoroughly out of his head the idea that he knows anything. As soon as he comes down to that understanding then he is very useful for what he really knows.

There is, however, not only knowledge necessary. We also need practical experience. That is just as essential as theoretical knowledge, and far more essential than either practical experience or theoretical knowledge is for the electrical man to be reliable, not to lose his head in emergencies, and the importance of the latter is rising continuously, because with the increasing importance of electricity, the increasing size and power of electric stations, the amount of power which may be let loose by any mistake is getting larger and more destructive. And if anything goes wrong, things are liable to move at a rate and with a power that no lightning stroke ever approaches. I figured out some years ago how many ounces of dynamite would be about equal to the power which is represented by opening a short circuit on one of our big electric distribution systems of New York City, and if that power were let loose it would have a destructive effect of the same magnitude of quite a number of dynamite cartridges. That power it is necessary for the electrical man to control. It is very important that he should not lose his head when he sees things move rapidly. He must be absolutely reliable, because on him, even if only a simple cog in the wheel of the electrical system, depends safety and life. So that not to lose your head is really more important than practical experience and theoretical knowledge, although the latter are also essential.

The theoretical knowledge you can get better in college than outside of it. But the college training is not necessary. Edison never went to college, and the chief engineer of the greatest electrical manufacturing company in the world did not go to college. But reliability and not losing your head must be acquired if they are not already born in one.

By reading we can learn. Reading carefully, studying

privately, is a good thing, but it is very limited, because we do not know what to read. Everybody writes a book on electricity or anything else, and the less he knows about it the more he tries to explain it to someone else. Furthermore, if you read you are always handicapped by the difficulty of things you do not understand, and that means you must have assistance. One institution which has done much good in this direction is the correspondence school. In our city of Schenectady, for instance, something like a thousand pupils are enrolled in the correspondence schools. The correspondence schools represent a vast advance over private reading, but their limitation is soon reached. They can direct men who desire to know what to study. If one finds anything he does not understand, if he communicates by correspondence, he can have it explained. The great difficulty is to find out that we do not understand anything. That is the difficulty with reading a lecture. We think we understand it, but only by questioning or discussing it, or trying to apply it practically, we find out that after all we were mistaken, that we did not understand it. But even when we realize that we do not understand a thing the second difficulty is how to ask the questions so as to make the questions clear to the one who answers them. In other words, how to make him understand what we do not understand. And then another difficulty is that we can get an explanation, but the explanation raises another question. So while we can do very much by correspondence schools, particularly where we cannot get anything else, as out in the country, and they do a good work, far superior to correspondence instruction must always be the instruction by somebody with whom we can talk and ask questions and in conversation get information.

Nobody realizes this advantage of conversation better than the business man, who is willing to pay for a long-distance telephone call, at a very high rate, rather than send a telegram and return telegram. There is nothing like conversation, and that the correspondence schools cannot replace.

And that is where the big cities have the advantage over the smaller towns. You have the chance to get your education under the direction and by direct intercourse with a teaching staff. The man in the small town may go to somebody and ask him. Everybody may be willing to advise, and may be very willing to take advice, but we are all too busy, and so very little can be done in this way. It is only in a large city that we can get the best advantage, by a school, for instance, like this. It is next to a college, but it differs from a college in that it accommodates those who cannot devote eight years of their life exclusively to study, but gives them the best that can be given in the shorter available time. It also differs that you have practical experience, and that you do not need to have that additional year after you leave school to realize that you do not know all, and so to become useful.