A Tribute to Power Systems Guru Charles Concordia

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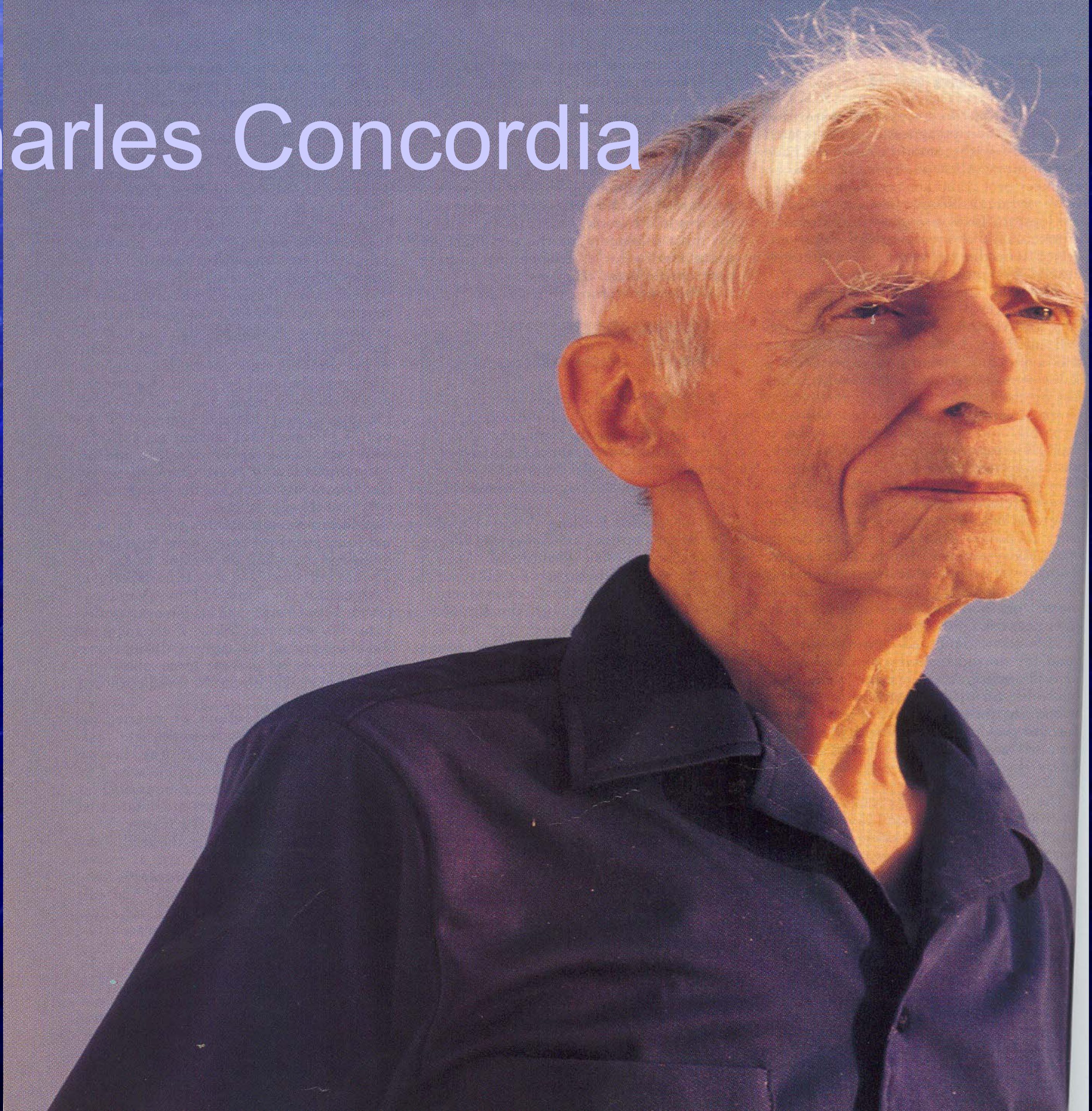
Charles Concordia



Charles Concordia – Lasting Influence

A small comment about that magnificent man Charles Concordia. While doing an extensive literature search in 1969 in relation to my doctoral studies, I noticed that Charles Concordia had published at least one important paper every year for more than 30 years

David W. Knudsen
Life Senior Member, IEEE

Vital Statistics

- *Name: Charles Concordia*
- *DOB: 20-June-1908, Schenectady, N.Y.*
- *Residence: Venice, Fla.*
- *Patents & Papers: 6 Patents, 130 Tech. Papers*
- *Honorary degrees: Ph.D. 1993, Iowa State University, D.Sc. 1971, Union College*
- *Academy Status: National Academy of Engineering, 1978 (U.S.)*
- *Fellow Status: IEEE, American Society of Mechanical Engineers, American Association for the Advancement of Science*
- *Interests: Mathematics, Classical Music, Walking & Languages*

Vital Statistics

- *Awards:*
  - *Coffin Award (GE, 1942)*
  - *Lamme medal (1961, AIEE)*
  - *Steinmetz Award (GE, 1973)*
  - *Philip Sporn Award (CIGRE, 1989)*
  - *Centennial Medal (IEEE, 1984)*
  - *Power Life Award (IEEE PES, 1992)*
  - *Medal of Honor (IEEE, 1999)*

"Power systems engineering is inherently multidisciplinary, in Concordia's view. It involves electrical, mechanical, hydraulic, and thermal phenomena, and ranges over such topics as sub-synchronous resonance and turbine blade vibration. 'We worry about all of these', he declared."

IEEE Spectrum Cover Story,
June 1999

Typically during his consultations, the teacher takes over "… it is best to let the client understand it himself. I always ask [him] 'what computing equipment do you have available?' and then design the method of calculation to fit what he has," he said. " I don't want to [give] them the answer on a silver platter. I want them to calculate it by themselves." He added, "You have to have a reputation of not claiming credit … "

IEEE Spectrum Cover Story,

June 1999

Advice to the power engineer:

"Today most power work is not technical but focused on legal and political problems, the medalist pointed out. Often "… the degree we get in college has little to do with [it], " he said, and power engineers need legal knowledge."

IEEE Spectrum Cover Story,
June 1999

"It has been said that a successful democracy depends on an informed citizenry. Thus, the state should have the responsibility of providing enough education to ensure the literacy and basic knowledge of history and politics and economics, and a spirit of consideration and discipline, to all those who aspire to become voting citizens …

… The important principle is that everybody, rich as well as poor, brilliant as well as stupid, healthy as well as handicapped, should have equal opportunity provided by the State. In our zeal to aid those we regard as unfortunate, we should not neglect those who are the resources to the future"

History and Reflections on the way things are,
IEEE Power Engineering Review, January 1999

"In a response to the question as to how much of their college education they themselves paid for many graduates have answered 100 percent.

This shows a basic lack of understanding that might even be regarded as shocking.

It indicates an acceptance of subsidies as a legitimate way of life in the future"

History and Reflections on the way things are,

IEEE Power Engineering Review, January 1999

"Several years ago, some educators discovered something that most other people already knew, namely that one learned most rapidly the things in which one was interested. This led them to the conclusion that students should be taught those things in which they were interested, and that much effort should be made to arouse interest.

But this misses the point that one of the most important and useful assets that we can have is the ability and the will to be able to study diligently subjects in which we are not interested. Even learning by rote should not be so utterly despised …"

History and Reflections on the way things are,
IEEE Power Engineering Review, January 1999

"Characterstics of a power system that have become of increased importance because of interconnection may be classified as:

- *Very small damping of disturbances*
- *Need for more voltage support*
- *Much more complex in design, operation, control, protection, and analysis*
- *Controls, much more pervasive and numerous*
- *New problems"*

Dynamic Performance and Security of Interconnected Systems,
IEEE Power Engineering Review, March 1992

"One might say that the whole point of power system interconnection is to assist in obtaining an adequate and reliable electric power supply in the most economical way by taking advantage of the opportunities for the economic interchange of energy and pooling of generating capacity.

Considerations of feasibility, economy, geography, public relations, environment, politics, available resources, and probably others lead naturally to a distribution of generation rather different from the distribution of load"

Dynamic Performance and Security of Interconnected Systems,

IEEE Power Engineering Review, March 1992

"The present large power system is never designed as we should have designed it ab-initio for its present load. Instead, it has grown gradually, additions being continuously made while leaving much of the old system unchanged. The system is left with many voltage levels, sometimes in parallel paths, and with many generators connected at lower voltage levels.

This puts constraints on the full utilization of all transmission capacity and above all makes protection much more difficult. It also sometimes leaves weak links in the system, so that a fault or loss of a line at some lower voltage may have an unduly large effect on the transfer capacity at the highest voltage."

Dynamic Performance and Security of Interconnected Systems,

IEEE Power Engineering Review, March 1992

"Another aspect of robustness can be illustrated by the fact that a weaker system that has a well tested plan for emergency procedures and for restoration may be more reliable than a stronger system with no such plan"

Dynamic Performance and Security of Interconnected Systems,

IEEE Power Engineering Review, March 1992

"Complexity is not only in the system itself, but also, and even more striking, in the amount of information that must be monitored, processed, and absorbed in order to calculate performance or to estimate the state of the system with regard to security and optimum performance"

Dynamic Performance and Security of Interconnected Systems,

IEEE Power Engineering Review, March 1992

"For an interconnected system, there is the question of how much of our neighbours' system it is necessary or desirable to include in detail. One must be careful to include enough detail and even more careful not to include too much."

Dynamic Performance and Security of Interconnected Systems,
IEEE Power Engineering Review, March 1992

System Model:

"How should we choose the model of our system for analysis?

- *A major consideration is the objective of study*
- *Another consideration is what aspect of performance is being studied*
- *Finally, there is the question of how much of the system should be modeled in detail and how much can be represented by an equivalent."*

Dynamic Performance and Security of Interconnected Systems,
IEEE Power Engineering Review, March 1992

"Perhaps the most publicized problem of interconnected systems is the widespread blackout that may involve a very large area. Such occurrences make one realize that to share in the benefits of interconnection one must also share in the problems.

Each system must realize that part of its responsibility is to be itself secure and ready to assist a neighbor in trouble.

Further, it must put limits on its own dependence on its neighbors. Even its own security criteria themselves depend to some extent on the neighbor's condition, its security and vulnerability"

Dynamic Performance and Security of Interconnected Systems,
IEEE Power Engineering Review, March 1992

"When an interconnection between tow or more utilities is made, the whole situation changes. Regardless of the primary objective, there are always numerous effects, many of which might be called side effects

- *The first side effect noted was the generation of spontaneous oscillations when relatively weak ties were heavily loaded*
- *A second side effect when more than one interconnecting tie was made was sometimes an undesirable distribution of line power flows. These have been miscalled circulating power and loop flow …"*

Power System Objectives Side Effects: Good and Bad,

IEEE Power Engineering Review, September 1990

"Finally, although interconnections have been made for many specific reasons, these reasons may be classified as

- *For economy energy interchange and*
- *For maintaining reliability with less reserve*

Ideally, both these objectives should be satisfied."

Power System Objectives Side Effects: Good and Bad,

IEEE Power Engineering Review, September 1990

"It is important to recognize that, when we speak of transmission of electricity, we must speak of electrical distances. For example, the reactance of a transformer may be as great as that of 50 miles of transmission line. Thus, when we consider that the average transmission distance in the United States is only of the order of 100 miles, it is evident that we do not really avoid transmission entirely unless the generation of reactive power is at the same voltage level as is the consumption to be supplied.

This partially explains the superficially strange fact that we can often observe in the same network, shunt compensation in the form of capacitors in the distribution system and shunt inductors in the transmission system."

Foreword in the book "Reactive Power Control In Electric Systems"
by T.J.E. Miller,John Wiley & Sons

"There is a fundamental and important interrelation between active and reactive power transmission. We have said that the transmission of active power requires a phase displacement of voltages. But the magnitudes of these voltages are equally important. Not only are they necessary for power transmission, but also they must be high enough to support the loads and low enough to avoid equipment breakdown.

Thus, we have to control, and if necessary, to support or constrain, the voltages at all key points of the network."

Foreword in the book "Reactive Power Control In Electric Systems"
by T.J.E. Miller,John Wiley & Sons

"Incidentally, while we have been discussion primarily the transmission system, we must keep in mind the fact that, of the three functions, generation, transmission and distribution, transmission has practically always been by far the least cost.

Thus, it may not be prudent to struggle to get the most out of our transmission system if this reduces margins and puts restriction on generation dispatch. And, to aggravate this situation, it has sometimes been recommended that lightly loaded transmission lines, installed to ensure reliability, are a good place to add non-utility generation"

Electric Power Systems: Past, Present, and Future,

IEEE Power Engineering Review, February 1999

“We must remember that both the past and the future are here in the present. Europe and North America can see their past in many of the developing countries, and should provide guidance to help them avoid our past mistakes. On the other side, the developing countries should themselves learn from our mistakes.”

Electric Power Systems: Past, Present, and Future,

IEEE Power Engineering Review, February 1999

"Another aspect of the future is the structure of the electric utility industry. This has been debated since the beginning, and is not yet settled.

Should it be private or government operated?

Should it be geographically integrated?

Is there an optimum system size or geographic extent?

In fact, at present, systems that exemplify all possible answers to these questions are in successful operation."

Electric Power Systems: Past, Present, and Future,

IEEE Power Engineering Review, February 1999

"What should we conclude from this brief and far from complete history?

- *From the standpoint of planning, have a vision of the future.*
- *From the standpoint of operation, keep in touch with our neighbors' practices and system condition."*

Electric Power Systems: Past, Present, and Future,

IEEE Power Engineering Review, February 1999

"Indeed, in a typical system some machines are almost always either at maximum load or on load limit so that their governors are inactive. This has sometimes contributed to poor dynamic performance, but apparently not enough to discourage the practice.

Thus from all aspects of system control it seems desirable to reduce the dead band to the smallest possible value."

Effects of Prime-Mover Speed Control Characteristics on Electrical Power System Performance,
IEEE Trans. On PAS, Vol. PAS-88, No. 5, May 1969

"From time to time, attempts have been made to determine an optimum size of interconnection beyond which there is no net benefit. If one considers only the questions of required reserve and of diversity of generation, this is indeed a point of diminishing returns.

However, if one considers also the questions of adequate transmission capability, transmission system design, emergency support, economic energy interchange, system voltage control, etc., one sees that it is usually desirable for a company to connect with its neighbors on all sides, for purely local reasons."

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"The author cannot agree with those who have suggested the possibility of dividing the country into regions, thus creating more borders, possibly connected by DC ties.

This idea may be a way of avoiding the increasingly more complex problems of planning, operation and control encountered as interconnections become larger and more widespread, but it may also lead to an increased tendency towards service interruptions. "

Interconnections – Tutorial,

Electrical Power and Energy Systems,Vol. 3, No. 3, July 1981, pp 167-174

"The grid has also been though of as a superposed, government-owned network. At least in part for that reason, it has generally been opposed by the private electric utility industry. This is not to say that the industry does not approve of strong transmission. But it favors the evolutionary process that has been, and is, taking place, with presumably proper economic justification for each increase in transmission capacity. In fact, there is much more to the question than just a strong network. There are aspects of national planning, operating agreements, conflicts among various State interests and regulations and between State and Federal regulations, and, of could the interests of various utility companies.

Therefore the reasons both for and against a national grid are primarily political rather than technical "

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"The term 'interconnections' has been used mostly by the electric utility industry to mean the transmission ties connecting different companies, and thus crossing corporate boundaries. But in a more technical way, one can classify the functions of transmission as :

- *transporting energy from generation to load.*
- *interconnecting generation and loads so as to provide for flexibility of load sharing"*

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

Benefits of Interconnection:

"Ties have been said to have two kinds of functions, the economic interchange of energy and the sharing of generation reserve"

Interconnections – Tutorial,

Electrical Power and Energy Systems,Vol. 3, No. 3, July 1981, pp 167-174

"If a tie is installed to allow an economic interchange of energy, then it can only be counted upon for reserve support if it has enough margin of capacity at its maximum normal load to withstand a sudden further increase of power flow equal to at least the capacity of, for example, the largest generating unit of the receiving system. Thus, it is the dependable pick-up capacity, rather than the total capacity, that is significant. On the other hand, if the import is so great that loss of a generator causes the tie lines to trip, then even more generation is lost, so the situation is made worse.

That is, a tie will make things either better or worse; it cannot remain neutral."

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"From a technical standpoint, there is a vast amount of information to be gathered and comprehended, and a diversity of operating practices that must be coordinated and made compatible. In many cases, information about the state of one's neighbours' operating conditions may be just as important as information about one's own situation. . "

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"Another problem that has occurred in widespread networks, especially when power transfers are made over relatively weak links, is the development of very weakly damped, or even negatively damped, tie line oscillations. With properly sized transmission, these will occur only after a fault may have tripped out one of the ties and so further weakened it. The primary cause was seen to be in the negative component of damping contributed by the high-response generator voltage regulators and excitation systems that had been installed for the very purpose of improving stability."

Interconnections – Tutorial,

Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"We have already seen that a utility interconnected with many other utilities must depend on them to a considerable extent. It must be ready to help as well as to receive help in emergences. With so many companies connected together, there is also the danger of the spread of local trouble to other companies.

That is, one can export trouble as well as help. In fact, it is only by sharing the troubles that help is possible. The secret is to know the limitations of the network, both in transmission and generation, so that one can supply help only up to a safe limit, and know when to cut loose if that limit is exceeded."

Interconnections – Tutorial,

Electrical Power and Energy Systems,Vol. 3, No. 3, July 1981, pp 167-174

"Some design and operating principles are summarized as follows:

- *Power systems must be designed so that they generation and transmission capacity will always be adequate to prevent any single incident from precipitating a second incident.*
- *Power systems must be operated within such limits as will ensure an adequate margin to avoid cascading. The condition of the network must be continuously monitored.*
- *Regardless of these precautions, plans must be made to hold to a minimum the magnitude and duration of any service interruption caused by a disturbance greater than any planned for."*

Interconnections – Tutorial,
Electrical Power and Energy Systems, Vol. 3, No. 3, July 1981, pp 167-174

"It is more or less obvious that the more the active power of load decreases with decreasing frequency (i.e., a positive slope of dP/df) the more stable the system. As to reactive characteristics, a negative slope dQ/df is best."

Load Representation in Power System Stability Studies,
IEEE, Trans. On PAS, Vol PAS-101, No. 4 April 1982

"To assure reliability of electric power, it is essential to have effective transmission and adequate interconnections, adherence to operating limitations, and recognition that, in spite of all that can be done, there is always the chance that an unforeseen contingency will cause system separation and possibly generator deficiency. The first consideration requires system studies to demonstrate that no single disturbance will cause cascading trip outs of lines or generators; the second may be facilitated by automatic monitoring of the system condition; the third requires automatic load shedding on low frequency."

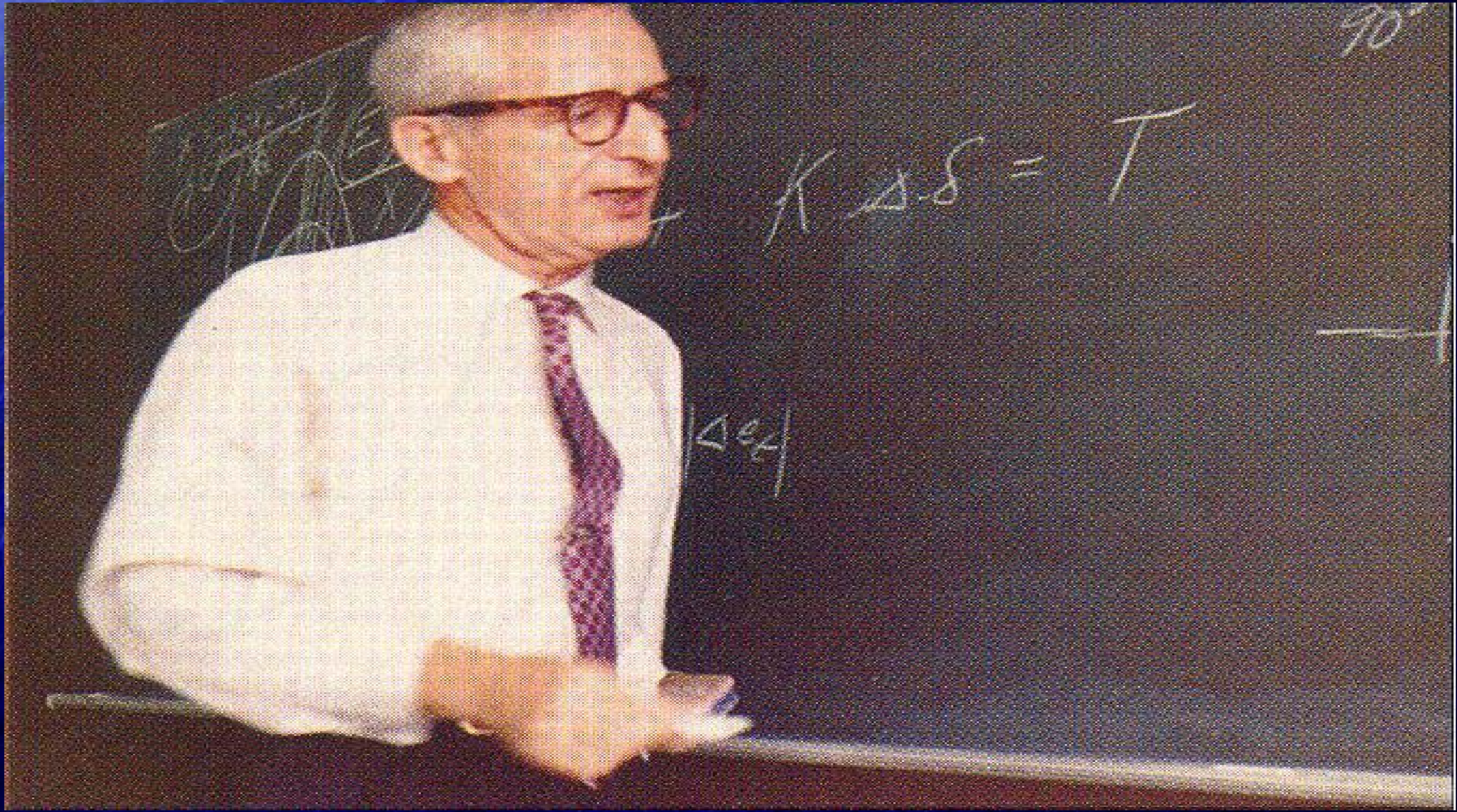
Considerations in Planning For Reliable Electric Service,

IEEE Spectrum August 1968

1958 Model Rolls Royce Served him for 20 years

IEEE Spectrum Cover Story,
June 1999

In a class on Electric Machines



IEEE Spectrum Cover Story,

June 1999

And the story goes on …