conductor is independent of e.m.f. and distance, and is proportional to the current." The determination of the current value to be used in the calculation of conductor sections is a real difficulty. It must not be supposed that even a knowledge of the load factor is sufficient by itself. The load factor being the ratio of average load to maximum load, does not give the relation between the average I^2R loss and the I^2R loss of maximum output. The power lost in the conductors of a constant potential supply is proportional to the square of the power transmitted. On the basis of the average hydro-electric load curve, if the load factor is 50 per cent., the load on which the average transmission line losses should be based, being the square root of the mean of the square of the power, will probably be found to be more nearly 60 per cent. than 50 per cent. of the maximum load.

Economic Voltage.—Clearly, the choice of the transmission voltage is a very important matter; but as it is possible to determine the proper voltage on purely economic grounds, the use of exceptionally high pressures merely because of their interest from an engineering point of view, should be discouraged. On the other hand, it would appear that most transmission line troubles occur on lines working at pressures between 30,000 and 80,000 volts; and an important consideration to bear in mind is that more trouble may be experienced with heavy currents than with high voltages, owing to the more serious effects of interruptions or transient disturbances when the current is large, so that greater security may sometimes be obtained by increasing the voltage with a view to reducing maintenance and operating costs. A remarkable instance of high pressure being used for short-distance transmission occurs in Germany at Lauchammer. This is the first 110,000-volt installation in Europe. The line is only 35 miles long, but the power to be transmitted is considerable, being 20,000 kw. The engineers claim that, owing to large fluctuations expected through rolling-mill load, low voltages would be uneconomical. Under ordinary circumstances, the trend of modern practice would indicate something above 60,000 volts as the best pressure in this case; but when there is little difference between the cost of a 60,000-volt and an 80,000-volt scheme, it is wise to adopt the higher pressure.

When figuring on the best voltage for any particular scheme, the capital cost of all works, buildings, or apparatus which is liable to be influenced by the transmission-line pressure, together with all operating and maintenance charges which may be similarly influenced, must be taken into account. It will usually be found convenient to reduce all such costs or differences of cost to the basis of annual charges.

Costs Other Than Transmission Line, Liable to be Influenced by Voltage Variations.—The cost of a generating station complete with all plant and machinery, but not including transmission line, may be anything from $20 to $200 per horsepower installed. It will depend on total output, that is, on the size of the station, on location, and transport and labor facilities. The cost of a hydro-electric station will depend on the head of water, the amount of rock excavation, the size of dam, etc.

Approximate costs per kilowatt of medium head hydro-electric power station and sub-station (not including transmission line) for total output of about 10,000 kilowatt appear below.

The figures given in the accompanying table are approximate costs for a medium head hydro-electric development suitable for a total output in the neighborhood of 10,000 kw., to be transmitted over two outgoing 3-phase feeders. The usefulness of these figures lies mainly in the indication they give of the probable differences in cost with the variation of transmission-line pressure.

	Transmission-Line Voltage:		
	30,000	60,000	100,000
Hydraulic works outside power-station buildings	$15.00	$15.00	$15.00
Power-station building, including excavations	5.00	5.06	5.10
Receiving-station building	1.00	1.03	1.05
Switch-gear (both ends)	1.20	1.35	1.70
Electrolytic lightning arresters	0.34	0.66	1.20
Transformers (both ends)	2.50	2.90	3.50
Generaters and exciters	8.00	8.00	8.00
Cables in buildings, entering, bushings, etc.	0.40	0.40	0.50
Crane, sundries, and accessories, including preliminary work	2.00	2.10	2.20
Turbines and hydraulic equipment	10.00	10.00	10.00
Total cost per kilowatt	$45.44	$46.50	$48.25

Annual Charges Depending on Voltage.—These charges may be summarized as follows:

1. A percentage on all capital expenditure, whether for generating station, transmission line, or receiving stations, which is not constant irrespective of voltage.

2. The yearly cost of the power lost in the transmission line.

3. The yearly cost of power lost in generators and transformers (the efficiency of the electrical plant will not necessarily be the same for all voltages).

4. The yearly cost of maintenance and operation. This may depend upon length of spans in transmission line, and on the necessary plant, switch-gear, etc., to be attended to, and kept in working order.

The percentages referred to under item (1) must include interest on capital invested, and depreciation. The accompanying table gives the percentage to allow for depreciation for various terms of years. Depreciation, which may include what is sometimes referred to as obsolescence,

Depreciation Table.

(On basis of 5 per cent. compound interest earned by money put aside annually.)

Life. (yr.)	Depreciation. (%)	Life. (yr.)	Depreciation. (%)
2	48.70	28	1.710
4	23.20	30	1.505
6	14.70	32	1.325
8	10.50	34	1.175
10	7.95	36	1.045
12	6.28	38	0.928
14	5.10	40	0.828
16	4.23	42	0.740
18	3.55	44	0.662
20	3.03	46	0.593
22	2.60	48	0.532
24	2.25	50	0.477
26	1.96		

is the amount to be set aside annually in order to reproduce, at the end of a term of years, the capital originally invested. This term of years in the "life" of the works or materials on which the percentage depreciation is to be calculated. It is assumed that, at the end of this term of years, the value of such works or materials is nil. It is also assumed that the amount put aside annually earns interest at the rate of 5 per cent. compound.

Method of Determining Most Economical Voltage.—Consider the case of a typical medium head hydro-electric power station:

Distance of transmission = 50 miles.

Duplicate three-phase line with copper conductors.

Cost of conductors = $15 per 100 pounds.

Power demanded = 15,000 h.p. or 11,200 kw. (It is assumed that this power will be required continuously day and night for industrial purposes, and that it is the probable limit of the water-power available).

Power factor = 0.8.

Selling price of power = $21 per horse-power-year.

Interest on capital invested, allow 6 per cent.