can overcome grades with heavy loads which were impossible to the horse-drawn vehicle, and highway officials responsible for the maintenance of our city streets and of the country highways leading out of them are greatly concerned at the damage inflicted upon road surfaces by these loads. The only effective remedy appears to be the enactment of drastic ordinances and laws which will absolutely prohibit the use of vehicles having more than a specified load per inch width of tire, and that load should probably be less for steel tires than for rubber tires.

The width and length of such vehicles is a matter of serious concern, especially on city streets. Where roadways have been designed to accommodate a certain number of lines of traffic and the number of lines is reduced through an increase in the width of the vehicles, the capacity of the roadway is reduced in still greater proportion, and if this increase in width is allowed to proceed, very costly street widenings will become necessary. In this case, also, it would appear to be necessary to prohibit absolutely the use on our highways of vehicles having more than a certain specified width.

Fortunately, the tendency of the manufacturers of motor trucks appears to be in the direction of more moderate loads. Of 221 manufacturers producing commercial vehicles at the beginning of the present year, 133 confined themselves to those of less than three tons capacity. Of the 88 manufacturers offering trucks of more than three tons capacity, twelve appear to have increased this capacity in their models for this year, only two of these increases being the six tons, while six have decreased the capacity of their trucks, one from four to three and one-half tons, three from five to three and one-half tons, one from six to four tons, and one from seven and one-half to five tons. Of twelve newcomers in the field, only one offers a truck with a capacity of six tons and two of five tons, while the rest provide for smaller loads.

While the imposition of an absolute limit upon wheel loads and upon the dimensions of vehicles seems necessary to preserve our highways, both in the city and country, the development of the motor vehicle appears on the whole to present no problems to highway officials, especially problems relating to street congestion, which will not solve themselves with the more general improvement of our streets and roadways and with the adoption of a higher standard of real estate development which will make the subsidiary highways more attractive to those using motor vehicles.

HIGH-TENSION TRANSMISSION LINES AND STEEL TOWERS.*

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THE truest economy in transmission line design may only be attained by a close co-operation between the electrical and structural engineers after a careful weighing of all the various conditions that affect the whole project. The following few notes are prepared from the point of view of the structural engineer who may be called into consultation when a transmission line is under consideration. The first part treats in a general way of the basic conditions that govern a design, and of the criteria on which the economy should be judged; the second part outlines present practice, touching certain details and recommending various structural requirements.

General Characteristics.—When electrical power is to be developed and then carried over any considerable distance, the necessary transmission line becomes one of the most important items in the estimated cost of the whole installation. It will be admitted that the aim should be, not to so design the line that the original investment is a minimum, but rather to so lay out the whole scheme that, consistent with satisfactory operation, the annual outlay is reduced to the smallest possible dimensions. Before going further it would be well to note at this point that the term "satisfactory operation" is a very difficult one to either define or equate to a definite financial basis, but an attempt will be made, however, to reduce it to tangible terms.

The *annual cost* of a line may be assumed to divide itself roughly under the following heads:—

(I.) Interest on the original capital investment.

(II.) Depreciation.

(III.) Operating costs, *e.g.*, engineering services, repairs, patrolling and (*a*) any premiums on accident or interruption liability insurance, or (*b*) the annual equivalent of any monetary damages due to interruptions to service (unless covered by policies under iii.-a).

(I.) (II.) and (III.) are not isolated or independent channels of expenditure, but are related one to the other; and will consequently overlap to a certain extent. It is desirable to touch briefly on this interdependence. In the past it was often considered that if the capital investment was reduced to a minimum, the line would then be the most economical one possible. This is now felt to be only partly true, for a cheaply constructed line with frequent interruptions and accidents, with perhaps heavy damages, may prove in the long run to be far more costly than a well-designed line involving a larger capital outlay. The problem thus resolves itself into preparing a design on which the sum of (I.), (II.) and (III.) is a minimum.

Capital.—It will be readily seen that items (I.) and (II.) will contribute a fairly important part of the total annual cost, and consequently, any attempt to reduce the capital investment will result in the reduction of both the interest and depreciation charges. The following list comprises the various heads under which the capital expenditure is distributed: (*a*) Wires and splices. (*b*) Towers or poles. (*c*) Insulators. (*d*) Guy wires. (*e*) Right-of-way complete, or (*f*) Land for towers with right of passage for overhead wires. (*g*) Foundations. (*h*) Erection including the delivery of towers. (*j*) Engineering services.

The cost of all the foregoing will vary, of course, with every change in the layout of the line. The minimum clearance of wires from the earth, all the electrical characteristics, such as voltage, number of circuits, number of phases, power per circuit, sizes and types of insulators, etc., and the average span length, will all affect the total capital cost. But for purposes of discussion, from the point of view of this paper, it may be assumed that all electrical features have been fixed together with the minimum clearance of wires from ground. This leaves span length as a remaining variable whose changes will affect the capital cost.

The effect of span length on capital cost is a little difficult to predict with any certainty, but various characteristics undoubtedly influence it, and these characteristics will be examined. Reverting now to the list

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