of headings under which capital expenditure may be distributed, it will be noticed that the cost of certain of them will be practically unaffected by any change in span length. These items are (*a*), (*d*) and (*j*). The cost of wires and splices may be assumed to be independent of span length, for most transmission cables are strong enough in any event to carry their loads over comparatively long spans while the increase in cable length—due to larger sags—may be neglected. Similarly the cost of guy wires (*d*) and of engineering services may be regarded as being independent of span length.

The items now remaining are those whose costs vary with the changes in the span length. If short spans are to be used there will be a large number of light towers, or perhaps poles, with consequently heavy costs for insulators, and possibly for erection. On the other hand, the right-of-way will be less expensive than were longer spans desired. This will be easily appreciated when one considers the fact that long spans necessitate increased distances centre to centre of conductors at cross-arms, and also large sags in the cables which, in heavy winds, must have wide arcs of swing. These facts naturally require for the line wider limits, and consequently a more expensive right-of-way, in order that the cables shall at all times and under all circumstances remain within the limits of the property or passage right acquired.

As the spans increase in length the towers become, of course, heavier, but there are naturally fewer of them to the mile and it must be borne in mind that the cost of insulators varies directly with the number of towers. Pole lines usually have spans of 150 ft. to 300 ft. long while tower lines have spans of from 300 ft. to 2,500 ft., depending on the judgment of the engineer.

In flat country, a succession of equal spans with as few horizontal angles as possible will give the most economical arrangement. In mountainous country the high points along the lines should be selected for the tower sites, and very little effort should be made to keep all spans of equal length. For sake of repairs, shipping, storage of spare parts, etc., all towers should be made alike unless some exceptional circumstances should demand a few special towers.

By selecting high points for the towers in rough country, a considerable saving may often be effected owing to the fact that the conductors will in general be above the trees, and consequently the necessity for a large amount of expensive clearing on the right-of-way is obviated. Also tower sites in mountainous country should not be placed in the path of possible snow or land slides, while towers placed near rivers that are liable to overflow their banks should be protected by cribs or piling.

The cost of foundations will naturally increase as the number of towers increases, and will, in general, be cheapest per mile when long spans are selected. The cost of erection will, within certain limits, vary directly as the number of towers. The question of lightning also enters into the discussion to a small extent. It has been found to be practically true that lightning most frequently discharges through one of the pin insulators to the tower rather than travel along the line to a lightning arrester provided for the purpose. Consequently the fewer towers and insulators with, however, the same number of lightning arresters per mile, the less likelihood of damage by lightning.

A somewhat theoretical solution of a portion of the problem of span length has been given by D. R. Scholes in a communication presented to the American Institute of Electrical Engineers, Vol. xxvi., part 2, in which he has determined the effect of varying span lengths on the cost per 1,000 ft. of the line. Mr. Scholes has considered in this presentation the cost of towers, of insulators and of foundations. In the first part of his paper he showed that for a 500-ft. span, a tower having a ratio of base to height of about ¼ is the most economical.

Using throughout his subsequent calculations, a tower of this proportion he deduced by means of a derived formula the varying weights of towers necessary for spans of from 200 ft. to 1,000 ft, and plotted the cost of these on a base of span length in feet, and with ordinates of cost in dollars per 1,000 ft. of line.

Plotting on the same scale the cost of insulators, and the cost of foundations, the sum of these three quantities was plotted and a curve drawn. The result showed 425 ft. as the most economical span (considering towers, insulators and foundations only) giving 12½ towers to the mile.

In weighing this result certain related facts must be carefully considered: (i) On the shorter span, *i.e.*, from 150 ft. to 300 ft., a tower is not nearly so economical as a pole, for two reasons:—

(*a*) Pole lines with short spans only need a comparatively narrow right-of-way, owing to two facts, firstly, the pole bases are perhaps only 2 ft. 6 ins. or 3 ft. 0 in. wide (instead of 10 ft. or 11 ft.), and secondly, the vertical arrangement of the wires permits short cross-arms, and small centre to centre distance for outside conductors.

(*b*) The actual cost of a pole for short spans is less than a tower because of the fact that tower sections for light loads cannot be reduced beyond a certain amount, say, 3/16 in., and hence this steel is not working satisfactorily.

(ii) On the longer spans no allowance has been made for increased cost of right-of-way or possible decreased cost of erection.

To briefly summarize the foregoing factors may not be inappropriate. By short spans are meant those from 150 ft. to 300 ft., while by long spans are meant those from 300 ft. to 2,500 ft. or thereabouts. For reasons already outlined, structural steel poles* are the more economical for short spans and without further comment will be assumed to be used. The advantages of short spans with poles are as follows:—

Short cross-arms and small bases permit narrow rights-of-way; frequent supports for conductors by reducing sags and hence swings, enable lines to have a narrow right-of-way. (One of the two-circuit lines of the Provincial Light and Power Co. has a right-of-way of only seven (7) feet); steel in poles is likely to be economically used; and riveting on poles is done in the shop, which is superior to the field bolting necessary for towers.

The disadvantages are higher costs for steel supports and insulators per mile. It will have been recognized by this time that great emphasis has been laid upon the cost of right-of-way and the saving that may be effected by reducing its width. The importance of this can hardly be over-estimated, especially in regions where land is expensive. It will generally be found that in modern transmission lines entering cities or towns, the saving in cost of right-of-way more than compensates for any increased cost of insulators or poles.

*The technical difference between a pole and a tower will be discussed in a subsequent portion of this article.

(Continued in the next issue.)