

## GALLOPING CONDUCTORS

The phenomenon known in the electric power industry as galloping conductors or dancing conductors has been a problem to operators of overhead lines for decades. Its occurrence is largely limited to areas subject to icing of conductors at times when the wind is mainly crosswise to the line; more specifically, it is limited to periods of freezing rain when the temperature is about 30 Deg. F. On double circuit lines it has occasionally been noted that the conductors on the leeward side galloped violently, while those on the windward side were calm. A few observations have been reported of galloping that occurred on bare (free-of-ice) conductors.

The hazards presented by galloping conductors are contact between phases or between phase conductors and ground wires, and possible mechanical damage at supports, since the gyrations of the conductors are usually quite violent. Conductor contacts can be the source of physical damage to the strands and of trip-outs of the circuits. Damage to supporting structures has also resulted from the large, unusual forces they receive during periods of galloping.

During galloping, the conductors oscillate almost vertically in one or two loops per span, with vertical amplitudes of several feet. Sometimes two loops appear, superimposed on one basic loop. The path of the conductor at its antinode is usually an ellipse whose major axis is tipped at a small angle to the vertical. In the case of single loops, studies indicate that the major axis can be somewhat larger than the sag in the span under loaded conditions, and the minor axis can be up to about 40 per cent of this value. It has been noted that single-loop galloping rarely occurs in spans over 600 to 700 ft. This is fortunate, since it would be impracticable to provide clearances large enough in long spans to prevent the possibility of contact between phases.

Observations indicate that in longer spans galloping usually takes place with two loops per span, with the maximum motion of the conductor taking place at the quarter points of the span. In this case, amplitude of oscillation, as measured by the major axis of the elliptical path of motion, is smaller than that obtained in a single loop in the same span length.

The elliptical path of a conductor galloping in a single loop has been studied by A. E. Davison, formerly of the Hydroelectric Power Commission of Ontario. Davison's diagram shown in Fig. 32 indicates that the elliptical path has a major axis inclined to the vertical at a slight angle, and that the entire elliptical path is displaced leeward of the point of conductor support. This path of a conductor galloping in a single loop is defined by the equations under the diagram.

The elliptical paths and a diagram of the clearances for conductors galloping in two loops per span have been developed by L. W. Toye, of the Public Service Electric and Gas Co. of New Jersey. The equations showing parameters of the clearance diagrams for the galloping conductors of such spans are given in the right-hand column of Fig. 32.

Since actual galloping of conductors on transmission lines occurs so infrequently and usually under bad weather conditions, field observations are scarce, even though the phenomenon has been known for a long time. Personal observations have been recorded occasionally, and motion pictures have been obtained, but these have not been particularly helpful in the physical study of the prevention or cure of galloping.

Many attempts have been made to apply simulated ice build-ups so that normal winds might produce consistent galloping effects and the system could be studied at will, but here, too, results have been limited.

Stockbridge dampers, known for their ability to control the frequencies encountered with aeolian vibration, are not considered helpful in controlling galloping conductors; the dampers may, in fact, be damaged by the galloping. Other methods - most of them requiring expensive or impractical devices - have been tried or described, but no effective means of prevention is as yet available.

In areas where galloping has been observed or can be expected, towers, conductor spacing, etc. are designed, in accordance with empirical formulas, to avoid contact between conductors if dancing conditions should occur. Even these precautions may not prevent contact under all icing and wind conditions, unless extremely large-phase spacings are employed.

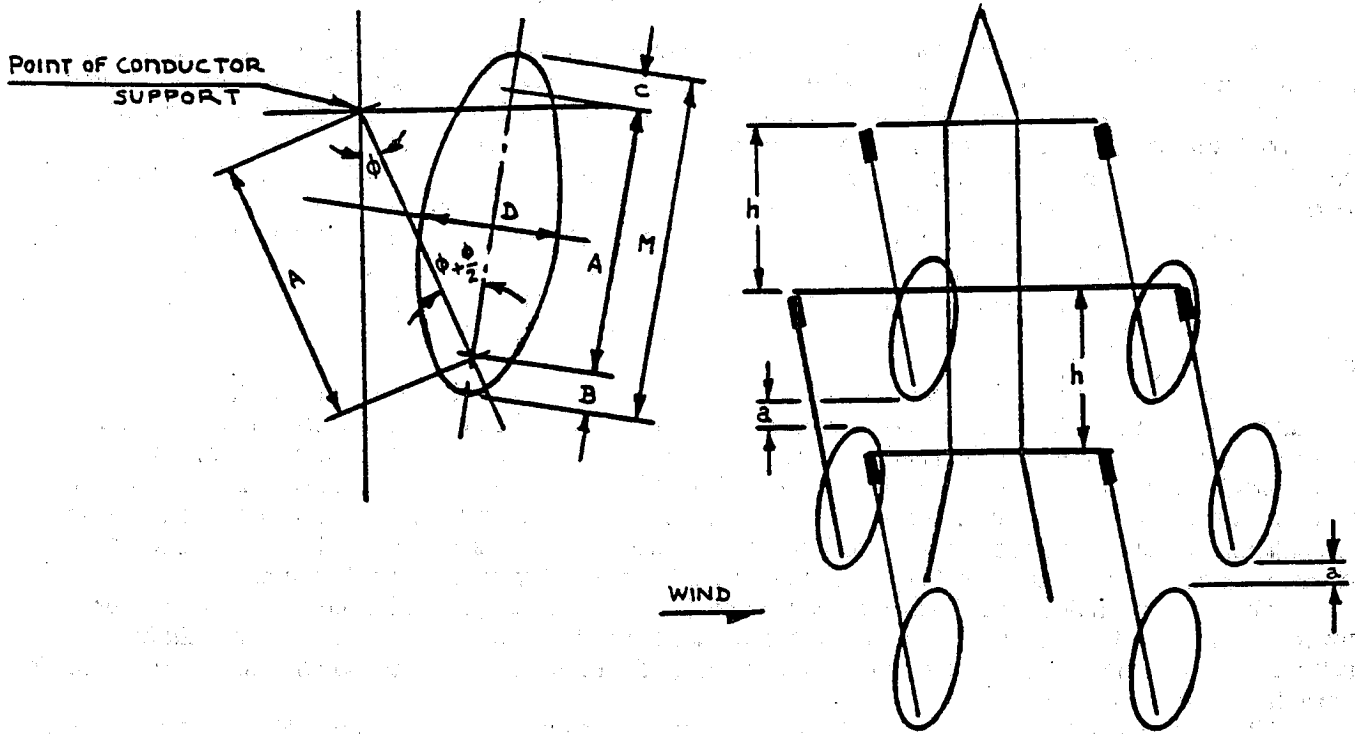


Fig. 32 - Schematic representations and equations of the elliptical paths of a conductor-in a single loop and in two loops per span.

Elliptical path of conductor when dancing in single loop.(A.E.Davison)

$$\Phi = \text{Tan}^{-1} \left( \frac{2 \text{Psf Wind Load on } 1/2" \text{ Ice}}{\text{Wt of Conductor} + 1/2" \text{ Ice}} \right)$$

A = Sag @ 1/2" ice, No Wind at 32 Deg F, Final

$$B = A/4$$

$$C = 1 \text{ Ft}$$

$$D = \text{Minor axis} = .4 * M \text{ (Major axis)}$$

$$M = B + A + C$$

Ellipse is the possible envelope of conductor travel during "dancing".

Elliptical path and clearance diagram for conductor dancing in two loops per span.(L.W. Toye)

$$M = \sqrt{\frac{3x \sqrt{\left(\frac{L}{2}\right)^2 + S^2} x \left( L + \frac{8xS^2}{3xL} - 2x \sqrt{\left(\frac{L}{2}\right)^2 + S^2} \right)}{8}}$$

$$K = \sqrt{(M+1)^2 - (M-1)^2} = \text{Minor axis of ellipse}$$

M = Major Axis of Ellipse

L = Span length between towers

S = Sag of conductor

$$h = (M + a + 1) \text{Cos}(\theta)$$

a = design clearance

θ = angle of swing of conductor