

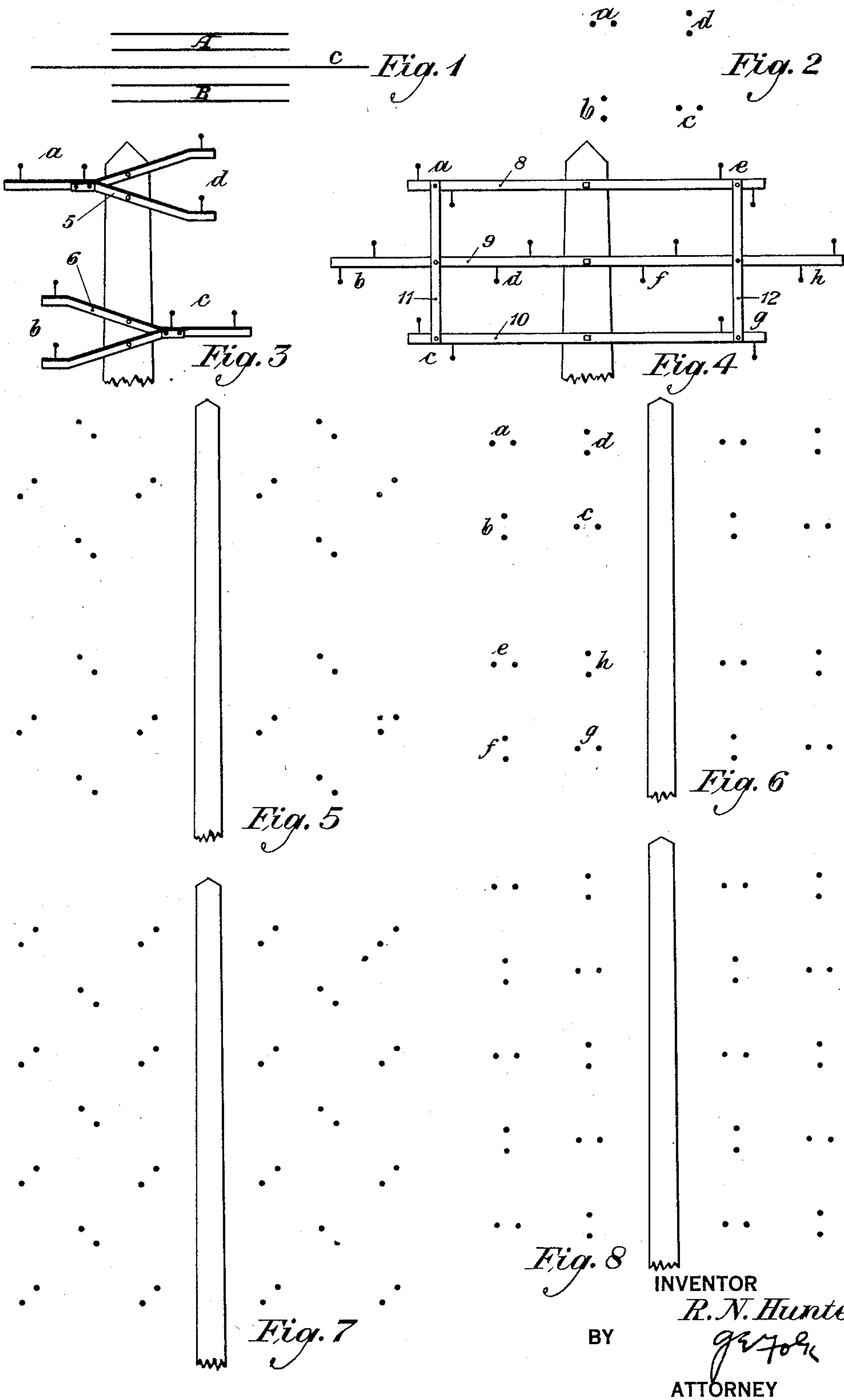
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R. N. HUNTER

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WIRE ARRANGEMENT IN POLE LINE SYSTEMS

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WIRE ARRANGEMENT IN POLE LINE
SYSTEMS

Russell N. Hunter, Westfield, N. J., assignor to
American Telephone and Telegraph Company,
a corporation of New York

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This invention relates to wire arrangements for reducing electrical coupling between open wire circuits such as are commonly carried on a series of poles and which will hereinafter be designated as open wire pole line systems.

The purpose of the invention is to so arrange the wires in such a system as to reduce the "cross-talk" to a minimum, due regard being had for overall dimensions of the pole line configuration.

Another purpose is to increase the number of signaling channels over such a configuration by making it feasible to go to higher carrier frequencies. Another purpose is to reduce the restrictions on the use of telephone repeaters, this, as well as the previous purpose, being made possible if the cross-talk between various channels, especially channels in different pairs, is reduced below that usually present in modern open wire transmission lines. Another purpose is to make the noise pick-up per unit length of wire less than in the present standard arrangement when the various circuits are adjusted to the same transmission level.

The problem of cross-talk or induction between two or more pairs of wires is one which has been recognized for many years and numerous attempts have been made to solve it in part, such as by various transposition schemes, but as the standards of transmission have improved the problem still remains. With the introduction of numerous channels at carrier frequency the conditions have become more acute because of the greater amount of cross-talk which naturally occurs at higher frequencies. Furthermore, to work all circuits or channels at the same overall noise limit, it is evident that the longer circuits should be worked at higher transmission levels than the shorter ones and any steps in this direction will tend to increase the interference from the high level into the low level circuits; thus it is clear that wire arrangements giving low mutual coupling between pairs are required in order to make such a method of adjusting levels practical. Having made any improvements in cross-talk condition, it immediately becomes possible to increase the frequencies which may be successfully applied to the line, thus increasing the number of practical channels available.

My invention will be better understood by reference to the following specification taken with the accompanying drawing, in which Figure 1 is a sketch to illustrate better different types of interference; Fig. 2 is a cross-sectional view of a combination of four pairs of wires which I will hereinafter designate as the square T formation,

this formation constituting an important part of my invention; Fig. 3 shows one construction by which four such conductors could be mounted satisfactorily on a pole line; Fig. 4 is a modified form of suspension by which two such square T combinations may be used; and Figs. 5 to 8 represent aggregations of a larger number of such square T combinations in a pole line system.

Referring more particularly to Fig. 1, there is shown a pair of wires A and a pair B. As ordinarily arranged, there will be a certain amount of direct coupling between these two pairs, which may be spoken of as the primary interference. In addition there will be interference between one of these pairs and all other wires or pairs of wires in that general neighborhood, the effect of which could all be represented as that due to a single conductor C. Such interference would also be direct interference. In addition to this it will be seen that one pair of conductors, such as A, produces inductive effects in the group of wires represented by C, and these effects in C will in turn produce disturbances in the pair B. Such interference might be designated secondary interference. While it is possible to make two pairs, such as A and B, mutually non-inductive so far as direct effects are concerned, it is not feasible to make a large number of pairs each mutually non-inductive with respect to each and all of the other pairs. It is my desire by means of this invention to provide an arrangement which will reduce all of these interference effects to as small a value as is practicable or as is consistent with the economic factors involved in commercial signaling.

In Fig. 2 there is indicated a configuration of four pairs of wires, designated respectively, as *a*, *b*, *c* and *d*. It can be shown theoretically that if one has a pair of wires, such as *a*, there are quite a large number of distinct positions in which a second pair may be placed and oriented so that it is theoretically entirely non-inductive with respect to the pair *a* so far as direct interference is concerned. One of these positions, as may be readily understood, is in a plane drawn through the axis of the pair *a* and at right angles to the plane in which the wires of the pair *a* lie. The pair *b* occupies such a position. Any two pairs of transmission wires so placed with respect to each other will be strictly non-inductive except for such accidental variations as may take place in the positions of different parts of the transmission line. They will be referred to as the T formation. It will be seen further that the conductors *a* are positioned with respect to the pair *d* in the same way that the pair *b* is positioned with

respect to a . Therefore, the a pair is non-inductive with respect to the d pair, and by the reciprocal principle, the d pair will be non-inductive with respect to the a pair. A fourth pair c may be oriented and positioned such as to bear the same relationship to b and d that a bears to b and d and thus would be non-inductive to both b and d . The only source of direct interference, then, between these pairs of wires is that between a and c and that between b and d . It can be shown theoretically that the two pairs a and c may be parallel to each other and still be non-inductive if the pair c has been displaced in the horizontal direction from a by the proper amount. This relation is given by

$$S^2 = H^2 + D^2/2,$$

where D is the spacing between wires of a pair, H is the vertical distance between the planes of the two pairs and S is the distance which the axis of c has been displaced from a position directly below the axis of a . From this it will be seen that S should be made somewhat greater than H , and a and c would then be strictly non-inductive, but in that event b and d would not be properly spaced and would, in fact, show an increase in coupling. I find that the best results are obtained if the axes of the four pairs are at the corners of a square. This means that a will be non-inductive to b and d but will have a very small coupling to c . Similarly, b will be non-inductive to a and c but will have a small coupling to d , and so for the other pairs. This arrangement I will call a "square T arrangement" and I find it very effective as a means for providing four pairs of wires between which the coupling has been reduced to a very small order effect. Not only is there a marked reduction in the direct interference, for reasons explained above, but also in the secondary interference. In this connection, I have found that the distance between the axes of adjacent pairs should preferably not be less than about four times the distance between the wires of a pair in order that ordinary irregularities in construction shall not introduce values of electrical coupling large compared with that inherent in the arrangement.

Fig. 3 shows one method in which this square T arrangement may be suspended or supported on poles. A bifurcated member 5 is fastened to the pole, the spacing of the bifurcated portions being appropriate to the spacing which is to be given to wires of a pair. A second bifurcated member 6, identical to the first, is also secured to the pole but in reversed position, thus bringing the supported conductors into the proper positions, with respect to each other. As an illustration of the effectiveness of this configuration of wires, I would point out that calculations and measurements show that with a spacing between wires of a pair of 15 inches, and between axes of two adjacent pairs of 35 inches, the mutual inductance per mile of conductors between any two pairs which form a T is zero, while that between two diagonal pairs which are not completely non-inductive is 1.3 microhenries per mile. This compares with a mutual inductance of approximately 100 microhenries per mile in present day standard transmission lines, where spacing between the wires of pairs and of adjacent pairs is uniform and is equal to 12 inches.

Fig. 4 shows a modified form of suspension in which a square T combination is placed on each side of the pole. In the figure, three horizontal bars 8, 9 and 10 are mounted, the length of the

bar 9 being somewhat greater than the others. Vertical bars 11 and 12 are also supplied tying the three bars together near their ends. On the one-half of this rigid framework is then mounted a square T group, and symmetrically on the other side of the pole a similar group. It will be noted that these square T's are similar in their arrangement to that of Fig. 2 but have been oriented through an angle of 45° about the length of the wires.

A further mode of mounting these square T groups is shown in Fig. 5, this being virtually a doubling of the arrangement of Fig. 4. For simplicity also the supporting members have been omitted and the cross-sections of the wires are shown in configuration only. It will be noted that the different groups are quite widely spaced so that while there is some coupling between a pair of one group and most of the pairs of the other groups, the distances are large enough so that this coupling is comparatively small and in any event is much less than that ordinarily existing in present day transmission lines.

Fig. 6 shows a slight modification over Fig. 4 in that the groups are oriented differently, the particular orientation shown in the configuration of Fig. 6 being the same as that of Fig. 2. Here again the spacing between the groups is kept fairly large to reduce coupling. Also, it will be noted that two such pairs as f and a are in T formation so that they are non-inductive with respect to each other. Also, it will be noted that b and e , as well as c and h , are non-inductive to each other because of the T arrangement. Thus, upon examination it will be observed that the pairs of any one group which are closest to the pairs of the adjacent group are non-inductive with respect thereto, so that the configuration as a whole is a very useful one.

Fig. 7 is a modification of the configuration of Fig. 5, and it will be observed that the change consists in introducing additional pairs in the configuration of Fig. 5 where the space between any two pairs is large. This, of course, increases the mutual inductance between the various pairs but the gain in number of pairs will in some cases be sufficient to justify such additional lines.

Similarly, Fig. 8 represents a modification of Fig. 6, in which additional pairs have been introduced between the upper and lower groups so that, again, horizontally or vertically adjacent pairs have the non-inductive T arrangement with respect to each other. Again, the introduction of these additional conductors would increase the coupling between many of the pairs but the advantage of the larger number of conductors will in some cases justify this.

It is apparent that numerous modifications may be made to my invention, which consists primarily in the use of a square T group either alone or associated in various combinations of which some typical forms have been shown and described.

What is claimed is:

1. An open wire pole line system comprising four pairs of wires supported by poles in a square T arrangement such that each pair lies in a plane passing through the axis of the adjacent pair and perpendicular to the plane of that adjacent pair.

2. An open wire pole line system comprising four pairs of wires supported by poles, the axes of the pairs being at the corners of a square, the two pairs of adjacent corners forming in each case a T.

3. In an open wire pole line system, a configu-

ration of wire arrangement described in claim 1, characterized by the fact that a plurality of such groups is symmetrically placed with respect to the supporting pole.

- 5 4. An open wire pole line system as described in claim 1, characterized by having a plurality of such square T groups on each side of the pole, the diagonals of the squares being aligned in a vertical and in a horizontal direction.
- 10 5. An open wire pole line system as described in claim 1, characterized by having a plurality of such square T groups vertically and horizontally aligned, the sides of the squares being horizontal and vertical, respectively.
- 15 6. In an open wire pole line system, a plurality of pairs of wires arranged in horizontal and vertical array, each pair in one horizontal array being so placed that its plane makes an angle of

substantially 45° with a horizontal reference line, and each pair in the adjacent horizontal array making an angle of substantially 135° with said reference line.

7. An open wire pole line system comprising 80 four pairs of wires supported by poles in a square T arrangement such that each pair lies in a plane passing through the axis of the adjacent pair and perpendicular to the plane of that adjacent pair, the spacing between the pairs being sub- 85 stantially larger than that between the wires of a pair.

8. An open wire pole line system as described in claim 1, characterized by having a plurality of such square T groups, the axes of the groups 90 arranged to form larger squares.

RUSSELL N. HUNTER.

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