

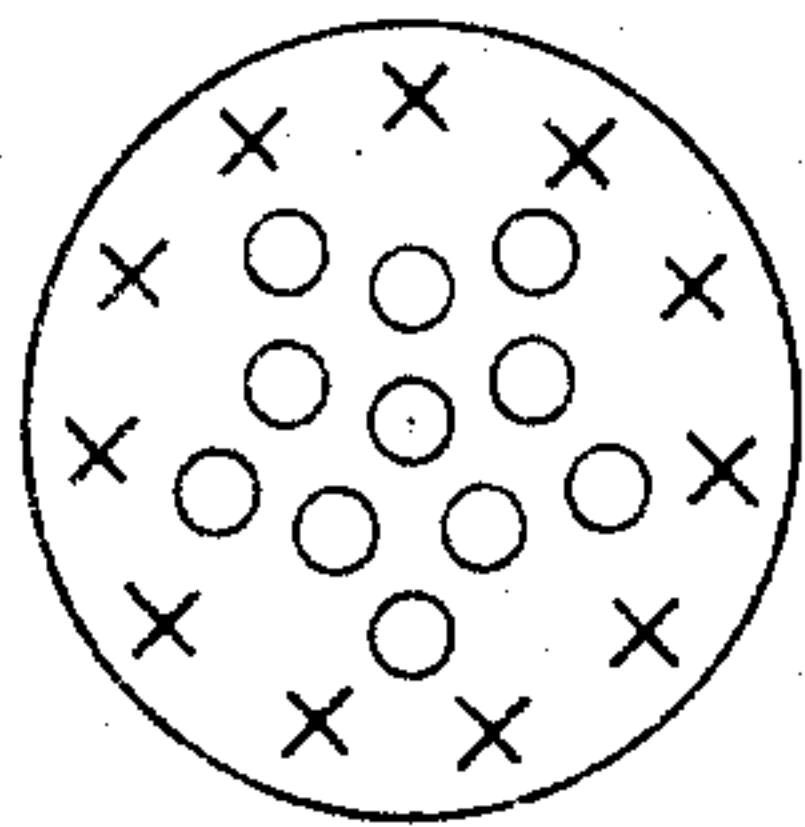
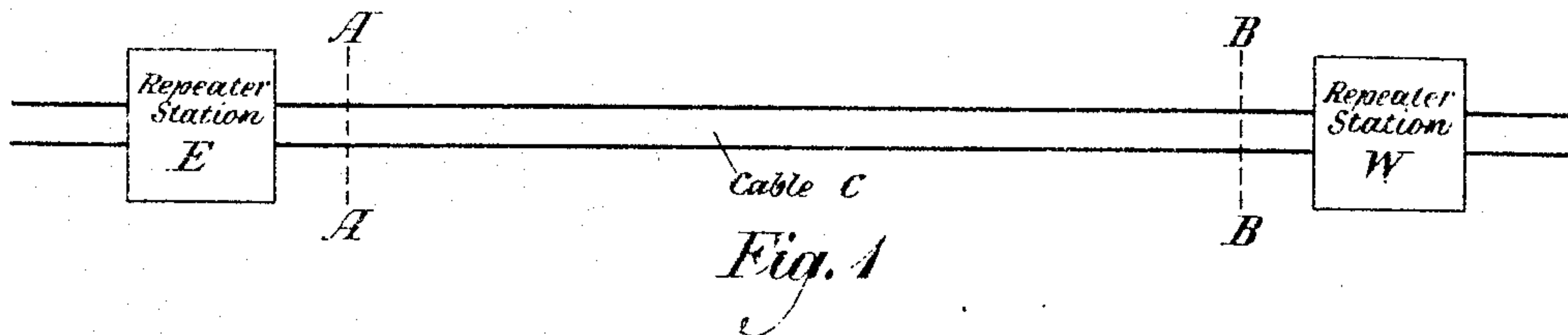
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R. G. McCURDY

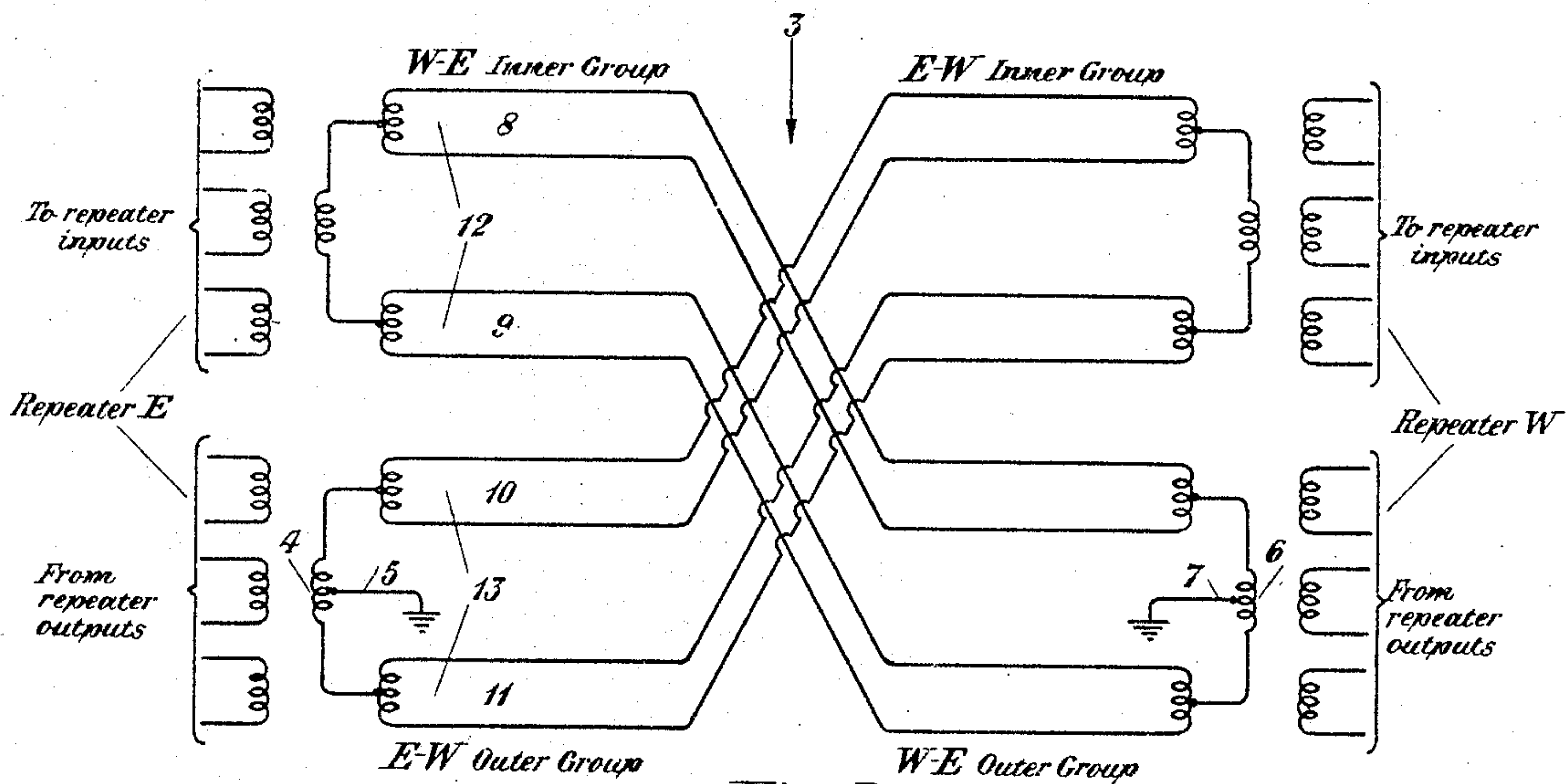
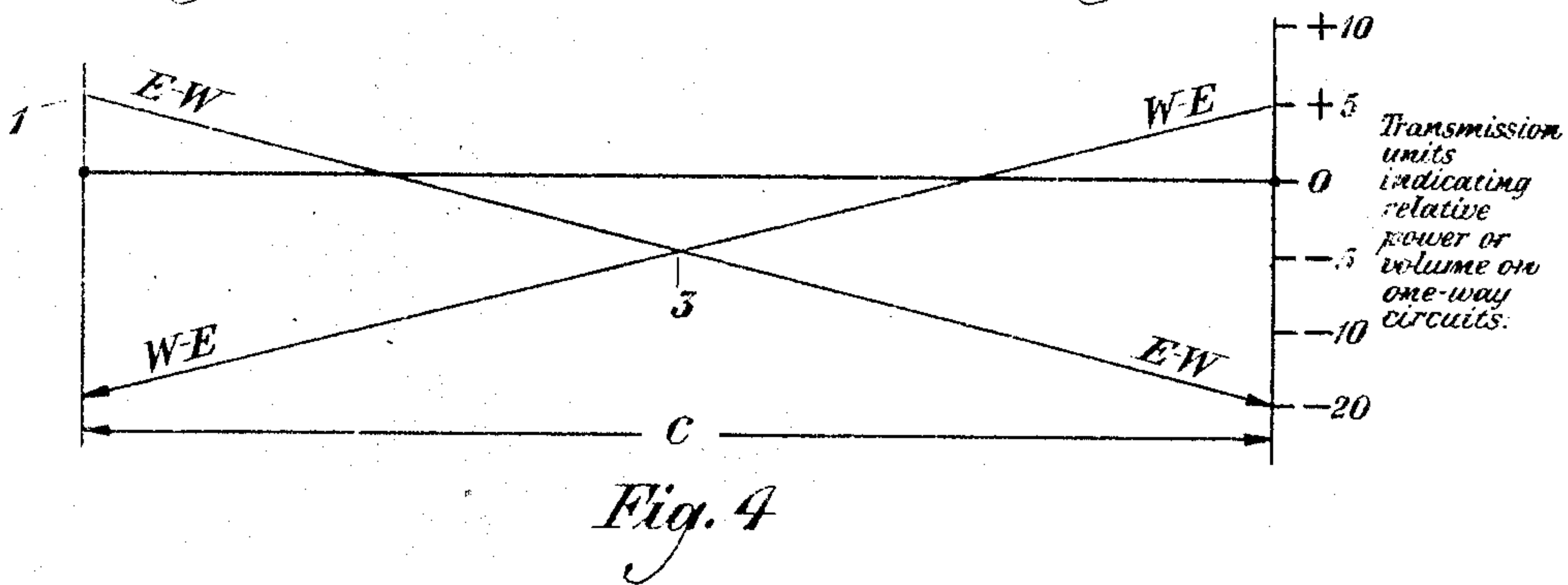
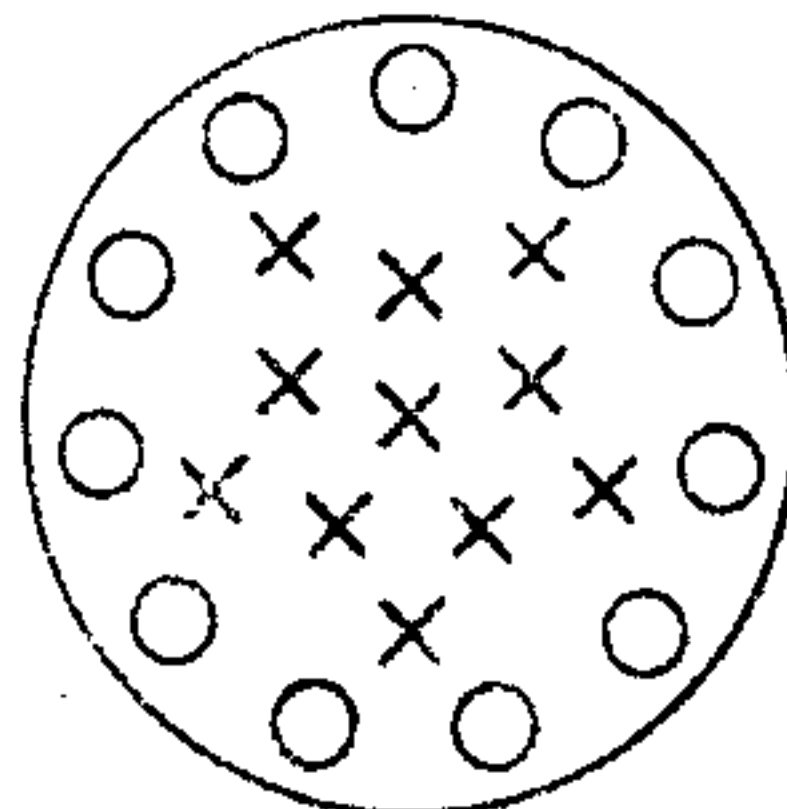
1,586,633

DRAINAGE METHOD FOR FOUR-WIRE CABLE SYSTEMS

Filed Oct. 7, 1925



X Quads used for E-W circuits
O Quads used for W-E circuits



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UNITED STATES PATENT OFFICE.

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DRAINAGE METHOD FOR FOUR-WIRE-CABLE SYSTEMS.

Application filed October 7, 1925. Serial No. 61,101.

This invention relates to transmission systems and more particularly to improvements in four-wire circuits in such systems in which the conductors are grouped together in cables between stations.

Because of the close association and frequent twist of the conductors comprising the pairs and quads which make up the cable, and because of the presence of the sheath, noise due to direct capacitance unbalance and mutual inductance between power circuits and telephone circuits in cable is very small. Noise is, however, often introduced by voltages induced along the conductors which causes longitudinal currents and voltages between the various quads, between quads and sheath and between quads and ground at points where terminal equipment is connected. These longitudinal currents and voltages cause noise through their action on the small unbalances of the circuits. These unbalances are of two general types, those due to differences in the series impedance of the two sides of circuits and those due to differences in the shunt admittances to other conductors to the sheath and to ground in the case of central office equipment. The purpose of this invention is to provide arrangements particularly adaptable for circuits of the well known four-wire type for materially decreasing the noise introduced on such circuits by conditions of unbalance. This reduction in noise is accomplished by novel methods of drainage whereby the drainage is applied to the circuits at points therein where the volume or power level is comparatively high, such as at the output of the four-wire repeaters. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

In cases where series unbalances are small and shunt unbalances are of considerable importance, reductions in noise may be obtained by drainage. By drainage is meant connecting the wires of the circuit to ground in such a way that the average voltage to ground of the two sides of the circuit is greatly reduced without appreciably lowering the magnitudes of the useful voltages and currents of the circuit. On a telephone circuit this may be accomplished by connecting to ground the midpoint of a well balanced retardation coil or phantom coil whose terminals are connected across the circuit. If

this be done on a phantom coil, both side circuits and the phantom circuit of the quad will be drained. However, in cases where shunt unbalances are unimportant and series unbalances are fairly large, drainage will result in an increase of noise. This is due to the fact that the magnitude of the longitudinal currents will build up toward and reach a peak near the drainage point and hence at this point the noise introduced in the circuit due to series unbalance will be greatest. In the general case, unbalances of both the series and shunt types are present so that little effect one way or the other is accomplished through drainage, as the reduction in effect of the shunt unbalance may be largely neutralized by the increased effect of the series unbalance.

Where four-wire circuits are involved, however, it is possible according to the methods and arrangements of this invention to take advantage of the unilateral propagation characteristics and changes in the volume or power level along the circuits to obtain a beneficial effect from drainage so as to materially reduce the noise introduced in the circuits. In a four-wire circuit it will be noted that near the repeater points, the volume or power level in the circuit transmitting in one direction is relatively high and in the other circuit transmitting in the opposite direction at the same point the volume or power level is relatively low. Noise introduced on the circuit by drainage at a point where the volume or power level is high will have a small effect on the circuit as compared to a similar noise introduced on the circuit where the volume or power level is low. Accordingly, in accordance with the arrangements of this invention, drainage is accomplished by grounding the midpoints of the line sides of repeating coils on the phantoms on the output sides of the repeaters in cable circuits of the four-wire types. Accordingly noise caused by the effect of shunt unbalance in the circuits may be eliminated by the drainage method of this invention and at the same time the noise caused by the effect of series unbalance will have a small effect on the circuit. The voltages to ground of the circuits transmitting in the opposite direction which are not drained, are greatly reduced through the shielding effect of the large number which are drained and the effects of shunt unbal-

ances to ground on these undrained circuits are greatly reduced without any corresponding increase due to series unbalances. As the power level on these circuits is low at the point where the effects of shunt unbalances to ground are reduced, a considerable reduction of the total noise on the circuit is obtained.

The invention may be more fully understood from the following description together with the accompanying drawing in the Figures 1, 2, 3, 4 and 5 of which the invention is illustrated. Fig. 1 shows schematically a cable circuit between repeater stations. Figs. 2 and 3 show the arrangements of the quads in the cable at different points on the circuit. Fig. 4 is a diagram illustrating the volume or power level at different points on the circuits and Fig. 5 is a detailed circuit diagram of the circuit and drainage arrangements of the four-wire system of the invention.

In Fig. 1 is shown a cable C interconnecting the repeater stations E and W. The cable would be composed of quads, the conductors of which would make up the one-way circuits of a four-wire system. These conductors are shown in more detail in Fig. 5 in which circuits 10 and 11 would be one-way circuits transmitting from repeater E to repeater W. A phantom circuit 13 would also be composed by these two circuits. Circuits 8 and 9 would be one-way circuits transmitting from repeater W to repeater E. A phantom circuit 12 would also be composed by these two circuits. The repeating coils, or transformers, whereby these circuits are connected to the inputs and outputs of the repeaters would be located at approximately the points indicated in Fig. 1 by the dotted lines A, A and B, B, or in other words close to the repeaters. As is well known the one-way circuits of a four-wire system have the characteristic that the volume or power level will fall off materially from a point close to the repeater output to another point near the successive repeater input. The volume or power drop on the circuits 10, 11 and 13 between points such as A, A, and B, B would be shown in Fig. 4 by the line E—W. The volume or power drop on the circuits 8, 9 and 12 between points B, B, and A, A would be shown by the line W—E. Accordingly at these points A, A, and B, B of high volume or power level the line side windings 4 and 6 of the phantom circuit coils of the repeater outputs are drained by means of the ground connections 5 and 7 respectively. This drainage will eliminate noise due to the effect of shunt unbalances, and at the same time this may increase the noise due to the series unbalance, nevertheless it is pointed out that this noise is introduced on the circuit at points such as A,

A, and B, B where the volume or power is at a relatively high level, and hence will have a relatively smaller effect than if introduced elsewhere. It is pointed out that the connection of the drainage to the midpoint of the phantom coil serves to drain both side circuits as well as the phantom. Furthermore, when a fairly large number of the circuits in the cable are grounded by the arrangements of this invention, the voltage to ground of other non-grounded pairs of conductors in the cable is also reduced without any increase in their longitudinal currents. Hence the effects of shunt unbalances on these pairs of conductors are reduced at a point where the power or volume level is low without any increase in the effects of their series unbalances. There is thus a considerable reduction obtained in the total noise on these circuits.

The beneficial effect of the drainage arrangements of this invention is most marked when the quads of the cable are arranged as shown in Figs. 2, 3 and 5. As shown in these figures, the quads of the cable are grouped for four-wire transmission by utilizing conductors in the outside layers for transmission in one direction and conductors in the inner layers for transmission in the opposite direction. At a point, such as 3 of Fig. 5, midway between repeater stations, the two groups of quads are interchanged and connections are made at the ends so that repeater outputs in all cases are connected to the circuits in the outer group and repeater inputs to circuits in the inner group. Cross-sections of the cable at points A, A, and B, B, illustrating this arrangement are shown in Figs. 2 and 3 respectively.

While the arrangements of the invention have been disclosed as embodied in certain specific forms which are deemed desirable it is understood that the invention is capable of embodiment in many other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. In a four-wire transmission system two repeater stations interconnected by a cable circuit, said cable circuit comprising a plurality of quads, a substantial number of said quads comprising one-way side and phantom circuits of said four-wire system, and means in certain of said quads for grounding the midpoint of the line side of the phantom circuit repeating coil on the output sides of said repeaters.

2. In a four-wire transmission system two repeater stations interconnected by a cable circuit, said cable circuit comprising a plurality of quads, a substantial number of said quads comprising one-way circuits for transmission in the same direction over said four-

wire system, and means for applying drainage to the circuits of said quads at points thereon where the volume or power is relatively large.

- 5 3. In a four-wire transmission system comprising two repeater stations interconnected by a cable circuit in which said cable circuit comprises a plurality of quads and a substantial number of said quads include
10 one-way circuits for transmission in the same direction over said four-wire system, the method of reducing noise on said circuits

due to the effect of shunt unbalances thereon without effectively increasing the noise on said circuits due to the effect of series unbalances thereon which consists in introducing drainage on said circuits at points thereon where the volume or power level is relatively large. 15

In testimony whereof, I have signed my name to this specification this 5th day of October, 1925. 20

RALPH G. McCURDY.