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2,289,174

CARRIER TRANSMISSION SYSTEM

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FIG. 1

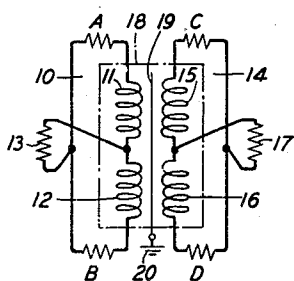


FIG. 2

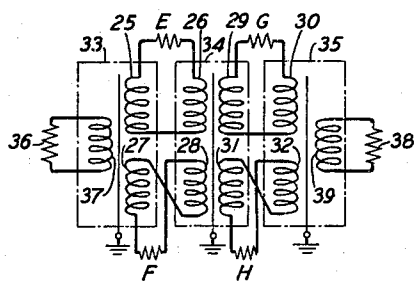


FIG. 3

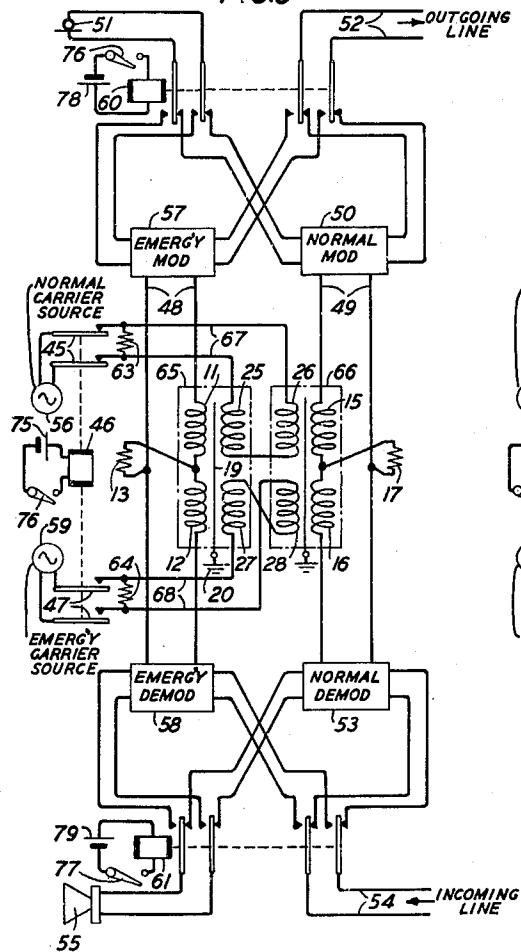
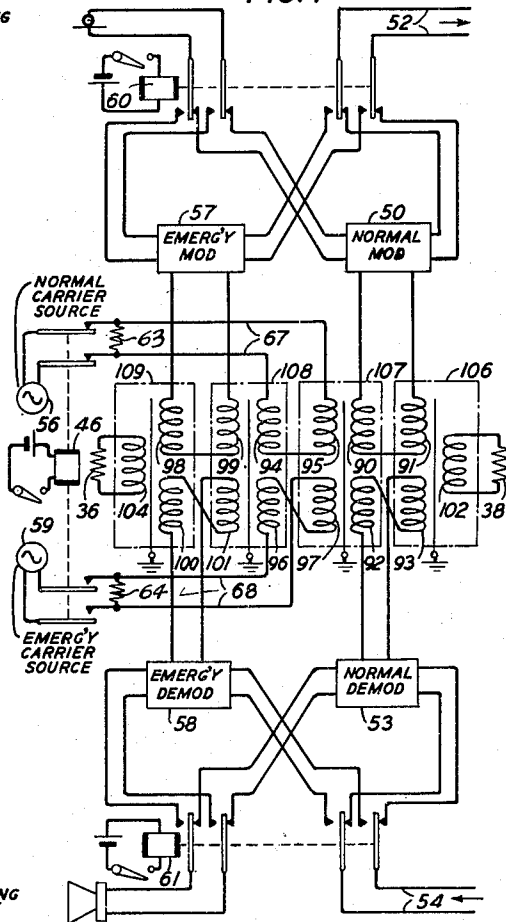


FIG. 4



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CARRIER TRANSMISSION SYSTEM

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11 Claims. (Cl. 178—44)

This invention relates to a carrier wave transmission system, and more particularly to a magnetic core coil arrangement for effectively connecting in such system normal and emergency carrier apparatus comprising modulators, demodulators and carrier wave generators.

In certain carrier transmission systems it may be desirable to provide both normal and emergency apparatus including modulators, demodulators and carrier wave generators so as to maintain continuity of transmission regardless of the occurrence of a fault on either the normal or emergency apparatus. Such provision ordinarily requires a multiplicity of magnetic core coils to connect operatively the various normal and emergency apparatus in the system. In designing a carrier system of this type, the number of such coils is a principal consideration, especially from the viewpoints of cost, modulation effect, tolerable over-all transmission loss, impedance matching and reflection requirements.

Accordingly, the present invention contemplates a magnetic core coil arrangement to connect electromagnetically the normal and emergency carrier generators to the normal and emergency modulators and demodulators in a carrier wave transmission system in such manner as to require substantially a minimum number of magnetic core coils while at the same time to isolate electrically each modulator or demodulator from the other modulators and demodulators and the normal and emergency carrier generators from each other.

It is an object of the invention to supply carrier waves simultaneously to both normal and emergency modulating and demodulating apparatus.

It is another object to render selectively effective the normal and emergency carrier apparatus in incoming and outgoing transmission paths.

It is a further object to preclude electrical interference between the idle and operative carrier apparatus.

It is still another object to obviate electrical interference between the normal and emergency carrier generators.

It is a still further object to minimize the effects of faults in the normal and emergency carrier apparatus.

It is also an object to isolate electrically each modulator or demodulator from the other modulators and demodulators.

Carrier transmission systems of a conventional type embody a signal source, an outgoing line, an incoming line, signal translating apparatus, nor-

mal and emergency apparatus including modulators, demodulators and carrier wave generators, and suitable switching devices to render effective selectively the modulators, demodulators and carrier wave generators in the respective outgoing and incoming lines.

In a preferred embodiment, the present invention comprises a plurality of multiwinding magnetic core coils for connecting electromagnetically the normal and emergency apparatus such that relatively low transmission loss is effectively provided between the carrier generators and both the modulators and demodulators, and relatively high transmission loss is effectively provided between the normal and emergency carrier generators, between the normal modulator and demodulator, between the emergency modulator and demodulator and between each modulator or demodulator and the other modulators and demodulators. Accordingly, carrier wave energy may be supplied from either of the carrier generators to the normal and emergency modulators and demodulators simultaneously, and each modulator or demodulator is isolated electrically from the other modulators and demodulators. This isolation renders it possible to apply the normal and emergency modulators and demodulators interchangeably to the outgoing and incoming lines.

The invention will be readily understood from the following description taken together with the accompanying drawing, in which:

Figs. 1 and 2 illustrate the invention in its simplest forms to connect electromagnetically two circuits having a high transmission loss therebetween with two other circuits having a high transmission loss therebetween; and

Figs. 3 and 4 represent the respective arrangements of Figs. 1 and 2 embodied in carrier transmission systems.

The same reference numerals are utilized to designate identical elements appearing in the several figures of the drawing.

Fig. 1 illustrates an electromagnetic coupling of circuits A and B with circuits C and D, and comprises branch 10 including the circuits A and B, equal windings 11 and 12 and a balancing network 13 applied across the junctions of the windings 11 and 12 and of one side of the circuits A and B, and branch 14 including the circuits C and D, equal windings 15 and 16 and a balancing network 17 connected to the junctions of the windings 15 and 16 and of one side of the circuits C and D. The circuits A, B, C and D are electromagnetically coupled by having the windings 11,

12, 15 and 16 wound on a common magnetic core 18. Shield 19 is applied to ground connection 20.

Transmission following the well-known action of hybrid coils is effected among the several circuits of Fig. 1 as follows:

Circuit A to circuits C and D and network 13

Circuit B to circuits C and D and network 13

Circuit C to circuits A and B and network 17

Circuit D to circuits A and B and network 17

High attenuation among the several circuits of Fig. 1 is provided as follows:

Circuit A and B

Circuit A and network 17

Circuit B and network 17

Circuit C and circuit D

Circuit C and network 13

Circuit D and network 13

Network 13 and network 17

Fig. 2 shows an electromagnetic connection of circuits E and F with circuits G and H, and comprises circuit E connected to equal windings 25 and 26, circuit F connected to equal windings 27 and 28, circuit G connected to equal windings 29 and 30, and circuit H connected to equal windings 31 and 32. The circuits E, F, G and H are electromagnetically connected by applying windings 25 and 27 to magnetic core 33, windings 26 and 28 and windings 29 and 31 to magnetic core 34, and windings 30 and 32 to magnetic core 35. Winding 37 coupling balancing network 36 to the windings 25 and 27 is associated with both latter windings on the magnetic core 33, and winding 39 coupling balancing network 38 to the windings 30 and 32 is associated with both latter windings on the magnetic core 35.

Windings 27 and 28 are connected in series-aiding relationship and windings 25 and 26 are connected in a series-opposing relationship which relationships are such that, assuming an observance of the requirements concerning the relations between terminations and the winding ratios, core reluctance and other design characteristics, a voltage applied across the windings 27 and 28 serves to induce equal and opposing voltages in the windings 25 and 26. Similarly, a voltage applied across the windings 25 and 26 serves to effect equal and opposite voltages in the windings 27 and 28. Likewise identical situations obtain with regard to the series-aiding windings 31 and 32 and the series-opposing windings 29 and 30. Consequently, substantially no transmission takes place between the circuits E and F, and between the circuits G and H.

Transmission among the several circuits of Fig. 2 is provided as follows:

Circuit E to circuits G and H and network 36

Circuit F to circuits G and H and network 36

Circuit G to circuits E and F and network 38

Circuit H to circuits E and F and network 38

High attenuation among the several circuits of Fig. 2 is effected as follows:

Circuit E and circuit F

Circuit E and network 36

Circuit F and network 36

Circuit G and circuit H

Circuit G and network 38

Circuit H and network 38

Network 36 and network 38

Fig. 3 shows a modification of a combination of the arrangements of Figs. 1 and 2 embodied in a carrier transmission system in which a normal modulator 50 has its respective input and output connected to a signal source 51 and an outgoing transmission line 52 via the closed contacts of normally unoperated electromagnetic re-

lay 60, and a normal demodulator 53 has its respective input and output applied to an incoming transmission line 54 and suitable signal translating apparatus 55 through the closed contacts of normally unoperated electromagnetic relay 61. Branch 49 supplying normal or emergency carrier waves to the modulator 50 and demodulators 53 in a manner to be explained subsequently embodies in one common side the equal windings 15 and 16 across whose junction and another common side of the branch 49 is applied the balancing network 17.

An emergency modulator 57 has its respective input and output connected to the signal source 51 and outgoing transmission line 52 via the open contacts of the normally unoperated electromagnetic relay 60, and an emergency demodulator 58 has its respective input and output connected to the incoming transmission line 54 and translating apparatus 55 through the open contacts of the normally unoperated electromagnetic relay 61. Branch 48 supplying normal or emergency carrier waves to the emergency modulator 57 and emergency demodulator 58, in a manner to be explained hereinafter, includes in one common side the equal windings 11 and 12 across whose junction and another common side of the branch 48 is applied the balancing network 13.

A normal carrier generator 56 is connected through a pair of closed contacts 45, 45 of normally unoperated electromagnetic relay 46 to the equal and series-opposing windings 25 and 26, and an emergency carrier generator 59 is connected through a pair of open contacts 47, 47 of the normally unoperated relay 46 to the equal and series-aiding windings 27 and 28. Thus, the respective normal and emergency carrier sources 56 and 59 may be individually applied to their associated windings 25 and 26, and 27 and 28 under control of the relay 46 in a manner and for a purpose, both of which will be hereinafter explained. It is to be understood that the modulators and demodulators may be of any well-known type. Windings 11, 12, 25 and 27 are wound on a magnetic core 65, and windings 15, 16, 26 and 28 are wound on a magnetic core 66. The shields 19 of both cores may be applied to the ground connection 20.

In the normal operation of Fig. 3, carrier voltage of the normal carrier source 56 is simultaneously transmitted via the closed contacts 45, 45 of the relay 46 to both the normal and emergency carrier branches 48 and 49 by the electromagnetic connection of the windings 25 and 26 with the windings 11, 12, 15 and 16. Therefore, the normal carrier voltage is simultaneously available in the normal modulator and demodulator and in the emergency modulator and demodulator with substantially no transmission loss. As previously pointed out, the respective normal modulator and demodulator and emergency modulator and demodulator are connected through the closed and open contacts of the normally unoperated relays 60 and 61 to the signal source and outgoing line and to the signal translating apparatus and incoming line. Consequently, the normal carrier voltage is effective in the normal modulator and demodulator and ineffective in the emergency modulator and demodulator in so far as any effect on signals in the respective outgoing and incoming transmission lines 52 and 54 is concerned.

A voltage applied at either the normal modulator or the normal demodulator would cause approximately equal currents to flow in the re-

spective normal and emergency carrier branches 67 and 68 for the reason that the impedances of the carrier sources 56 and 59 are relatively high as compared with those of respective equal resistances 63 and 64 applied thereacross. These equal currents cause substantially equal and opposite flux in the core 65. Accordingly, relatively high transmission loss would exist from either the normal modulator or the normal demodulator to both the emergency modulator and demodulator so that substantially no transmission would occur from either of the former to the latter. In addition, the hybrid action of the respective pairs of windings 11 and 12 and 15 and 16 causes a relatively high transmission loss to exist between the normal modulator and normal demodulator, and between the emergency modulator and emergency demodulator.

Due to the previously mentioned effect of the series-opposing and series-aiding relationship of the respective windings 25 and 26, and 27 and 28, a voltage from the normal carrier source 56 would cause equal and opposite voltages to be induced in the windings 27 and 28. Hence, the normal carrier voltage would cause substantially no normal carrier current to flow in the emergency carrier circuit 68. Therefore, relatively high transmission loss would exist from the normal carrier branch 67 to the emergency carrier branch 68.

Assuming the occurrence of a failure of the normal carrier source 56 of Fig. 3, then the relay 46 is energized from battery 75 by manually closing switch 76. This operates the relay 46 to open the pair of contacts 45, 45 and to close the pair of contacts 47, 47. Now, the emergency carrier generator is applied to its associated windings 27 and 28, and the normal carrier source is disconnected from its associated windings 25 and 26. Therefore, the emergency carrier voltage is simultaneously available to the emergency modulator and demodulator and to the normal modulator and demodulator with substantially no transmission loss.

Assuming further that faults occur in the normal modulator and in the normal demodulator, the switches 76 and 77 are closed to energize the relays 60 and 61 from the batteries 78 and 79, respectively. These relays operate to close their contacts associated with the emergency modulator and demodulator and to open their contacts associated with the normal modulator and demodulator. Accordingly, the emergency carrier voltage is effective in the emergency modulator and demodulator and ineffective in the normal modulator and demodulator, in so far as any effect on signals in the respective outgoing and incoming transmission lines 52 and 54 is concerned.

Due to the previously pointed out effect of the series-opposing and series-aiding relationship of the respective windings 25 and 26, and 27 and 28, a voltage from the emergency carrier source 59 would cause equal and opposite voltages to be induced in the windings 25 and 26. Consequently, the emergency carrier voltage would cause substantially no emergency carrier current to flow in the normal carrier circuit 67. Hence, relatively high transmission loss would exist from the emergency carrier branch 68 to the normal carrier branch 67.

A voltage applied at either the emergency modulator or demodulator in Fig. 3 would cause approximately equal currents to flow in the resistances 63 and 64 of the respective normal and

emergency carrier branches 67 and 68, because of the impedance difference between the carrier sources 56 and 59 and the resistances 63 and 64 and therefore would cause the production of equal and opposite flux in the magnetic core 66. Hence, relatively high transmission loss would exist from either the emergency modulator or demodulator to both the normal modulator and demodulator so that substantially no transmission would occur from either of the former to both the latter. Also, relatively high transmission loss would exist between the normal modulator and demodulator and between the emergency modulator and demodulator for the reasons mentioned above in connection therewith with respect to the normal operation of Fig. 3.

Fig. 4 is an alternate form of the invention, and comprises the arrangement of Fig. 2 embodied in the carrier transmission system described and illustrated above in connection with Fig. 3. It will be noted that the system of Fig. 4 includes four wound magnetic cores which number is double that required in Fig. 3. The arrangement of Fig. 4 permits greater isolation between the normal and emergency carrier apparatus, utilizes no metallic connections between any of the several circuits, and allows considerable flexibility in the selection of balancing network impedances as the latter are associated with their individual windings as it will be presently seen.

Referring to Fig. 4, the normal modulator and demodulator are connected to respective pairs of equal windings 90 and 91, and 92 and 93; the normal and emergency carrier sources are connected to respective pairs of equal windings 94 and 95, and 96 and 97; and the emergency modulator and demodulator are connected to respective pairs of equal windings 98 and 99, and 100 and 101. Coupled with the windings 91 and 93 is a winding 102 applied to the balancing network 38, and coupled with the windings 98 and 100 is winding 104 applied to the balancing network 36. Windings 91, 93 and 102 are wound on magnetic core 106; windings 90, 92, 95 and 97 are wound on magnetic core 107; windings 94, 96, 99 and 101 are wound on magnetic core 108; and windings 98, 100 and 104 are wound on magnetic core 109. Discrete pairs of windings 90 and 91, 94 and 95, and 98 and 99 are each connected in series-opposing relationship, and the discrete pairs of windings 92 and 93, and 96 and 97, and 100 and 101 are each connected in series-aiding relationship.

In the normal operation of Fig. 4, a carrier voltage from the normal carrier source is simultaneously available to the normal modulator and demodulator as well as to the emergency modulator and demodulator, although it is effective only in the normal modulator and demodulator, in so far as any effect on signals in the outgoing and incoming transmission lines 52 and 54 is concerned. A voltage applied at either the normal modulator or the normal demodulator produces equal currents in the normal and emergency carrier branches 67 and 68 and thereby equal and opposite flux in the magnetic core 108 associated therewith. Hence, a relatively high transmission loss would exist from either the normal modulator or the normal demodulator to the emergency modulator and demodulator so that no transmission would take place from either of the former to the latter. In addition, the action hereinbefore described in connection with Fig. 2 between the series-opposing windings 90 and 91 and the series-aiding windings 92 and 93 causes

a high loss between the normal modulator and demodulator. Similarly, the action between the series-opposing windings 96 and 98 and the series-aiding windings 100 and 101 causes a high loss between the emergency modulator and demodulator.

Also, due to the corresponding action between the series-opposing and series-aiding relationship of the windings 94 and 95, and 96 and 97, a voltage from the normal carrier source 56 would cause equal and opposite voltages to be induced in the latter windings. Therefore, the normal carrier voltage would cause substantially no normal carrier current to flow in the emergency carrier circuit 68. Hence, relatively high transmission loss exists from the carrier branches 67 to the carrier branch 68. Thus, the foregoing action of Fig. 4 is substantially identical with the corresponding action of Fig. 3.

In the event of a failure of the normal carrier source 56 of Fig. 4, the relay 46 is energized to apply the emergency carrier source 59 to its associated windings 96 and 97, and at the same time to disconnect the normal carrier source 56 from its associated windings 94 and 95. Now the emergency carrier voltage is simultaneously available in the emergency modulator and demodulator and in the normal modulator and demodulator with substantially no transmission loss. Assuming further the occurrence of faults in the normal modulator and demodulator, the relays 60 and 61 are operated to close their contacts associated with the emergency modulator and demodulator and to open their contacts associated with the normal modulator and demodulator. The emergency carrier voltage is now effective in the emergency modulator and demodulator and ineffective in the normal modulator and demodulator, in so far as any effect on signals in the respective outgoing and incoming transmission lines 52 and 54 is concerned. The foregoing action is substantially identical with the corresponding action of Fig. 3.

Due to the previously pointed out effect between the series-opposing and series-aiding relationship of the respective windings 94 and 95, and 96 and 97, a voltage from the emergency carrier source 59 of Fig. 4 would cause equal and opposite voltages to be induced in the windings 94 and 95. Consequently, the emergency carrier voltage would cause substantially no emergency carrier current to flow in the normal carrier circuit 67. Hence, relatively high loss would exist from the emergency carrier branch 68 to the normal carrier branch 67.

A voltage applied at either the emergency modulator or demodulator in Fig. 4 would cause approximately equal currents to flow in the resistances 63 and 64 of the respective normal and emergency carrier branches 67 and 68, because of the impedance difference between the carrier sources 56 and 59 and the resistances 63 and 64, and accordingly would cause the production of equal and opposite flux in the magnetic core 107. Hence, relatively high transmission loss would be provided between either the emergency modulator or demodulator and both the normal modulator and demodulator so that substantially no transmission would occur from either of the former to both the latter. Also, a relatively high transmission loss would be provided between the emergency modulator and demodulator and between the normal modulator and demodulator for the reasons pointed out with regard to the normal operation of Fig. 4.

Obviously, a manipulation of the relays 46, 60 and 61 may enable either the normal or emergency carrier sources to be associated operatively with any desired combination of the normal and emergency modulators and demodulators, in so far as a connection to the coil windings is concerned without impairing the effectiveness of the signaling system; the idle or out-of-service apparatus may be tested without interfering with signaling transmission on the outgoing and incoming lines; and, although not shown, the individual modulators and demodulators may be interchangeably applied in any desired combination to both the outgoing and incoming transmission lines.

An electromagnetic connection of the normal and emergency apparatus in a carrier transmission system in the manner discussed above in connection with the present invention as exemplified in Fig. 3 involves substantially minimum cost as only two wound magnetic cores are utilized whereas in other systems known heretofore at least three wound cores would be required to achieve a corresponding result; in addition, such connection tends to reduce substantially harmonics, or modulation effect, produced by the wound magnetic coils for the reason that the present invention employs but two wound magnetic cores while other systems known heretofore would embody at least three wound magnetic cores. This means that cheaper magnetic cores and windings from the modulation effect standpoint may be used in the wound magnetic cores without exceeding a certain tolerable modulation effect. Furthermore, a limit of two wound magnetic cores tends to reduce substantially transmission loss occasioned thereby. Consequently, from this loss standpoint cheaper wound magnetic cores may be employed while at the same time maintaining a certain over-all transmission loss.

Moreover, the maintenance of impedance matches to obtain efficient operation of the necessary filters, although not shown in the drawing, involves relatively severe reflection requirements. A limit of two wound magnetic cores as in Fig. 3 in accordance with the present invention over the requirement of at least three wound magnetic cores in heretofore known arrangements for the same purpose tends to simplify impedance matching and thereby to maintain expeditiously a certain tolerable impedance match. Accordingly, from the latter standpoint the wound magnetic cores may also be cheaper. In addition, a control of transmission loss in the wound magnetic cores per se is readily accomplished as the previously mentioned relatively high transmission loss between the normal modulator and demodulator depends on the impedance match of the respective normal and emergency carrier branches 67 and 68 to the balancing network 17, in Fig. 3, or the balancing network 38 in Fig. 4, and the high transmission loss between the emergency modulator and demodulator depends on the impedance match of the respective normal and emergency carrier branches 67 and 68 to the balancing network 13 in Fig. 3, or the balancing network 36 in Fig. 4. Obviously, such simplification of impedance matching is unable of accomplishment in arrangements heretofore requiring more than three wound magnetic cores. The foregoing advantages apply similarly to Fig. 4 requiring a minimum of four magnetic core coils which minimum is less than other systems of the same general type

known heretofore for accomplishing a corresponding result.

It is to be understood that while the present invention is described and illustrated in connection with a carrier transmission system, it is not necessarily limited thereto and may be expeditiously adapted to any electrical system for electromagnetically connecting a plurality of discrete circuits with each other such that different amounts of transmission loss exist therebetween; that suitable signaling circuits may be substituted for the balancing networks shown in the several figures of the drawing; and that the present invention is to be considered as limited by the scope of the appended claims.

What is claimed is:

1. In combination, a plurality of discrete electrical circuits, and a plurality of multiwinding magnetic core coils to connect electromagnetically said circuits with each other such that relatively low transmission loss exists between each of two circuits and the other circuits, said coils including a pair of magnetic cores and a plurality of pairs of windings connected to said plurality of circuits and applied to said cores such that one winding of each of two pairs of windings connected to said two circuits and a pair of windings connected to two of said other circuits are on one core and the other winding of each of said two pairs of windings connected to said two circuits and a further pair of windings connected to a further two of said other circuits are on a second core.

2. In combination, a plurality of discrete electrical circuits, and a plurality of multiwinding magnetic core coils to connect electromagnetically said circuits with each other such that transmission is effective between each of two circuits and the other circuits, said coils including a plurality of magnetic cores and a plurality of pairs of windings connected to said circuits and applied to said cores such that the pairs of windings connected to said other circuits are on at least two different cores and one winding of each of two pairs of windings connected to said two circuits is individual to one of said two different cores.

3. In combination, a plurality of electrical circuits, a plurality of balancing networks, and means comprising a plurality of multiwinding magnetic core coils to connect electromagnetically said circuits with each other such that relatively low transmission loss is provided between two circuits and each of four other circuits and relatively high transmission loss is provided between said two circuits and between each of said four other circuits and the remaining circuits thereof, said coils comprising a pair of magnetic cores and a plurality of pairs of windings connected to said circuits and applied to said cores such that one pair of windings in series in a common side of two circuits of said four other circuits and one winding of each of two other pairs of windings connected to said first-mentioned two circuits are on a first core and a further pair of windings in series in a common side of a further two circuits of said four other circuits and the other winding of each of said two other pairs of windings connected to said first-mentioned two circuits are on a second core, said two other pairs of windings having a series-aiding and series-opposing relationship, one of said balancing networks being applied across the mid-point of said one pair of series windings and another common side of said first two circuits of

said four other circuits, and another of said balancing networks being applied across the mid-point of said further pair of series windings and another common side of said further two circuits of said four other circuits.

4. In combination, a plurality of electrical circuits, a plurality of balancing networks, and means comprising a plurality of multiwinding magnetic core coils to connect electromagnetically said circuits with each other such that relatively low attenuation is provided between two circuits and three or more other circuits and relatively high attenuation is provided between said two circuits and between each of said other circuits and the remaining circuits thereof, said coils comprising a plurality of magnetic cores and a plurality of pairs of windings connected in individual pairs to individual circuits and applied to said cores such that one winding of each of two pairs of windings connected to said first-mentioned two circuits and two pairs of windings connected to each two circuits of said other circuits are on each pair of two adjacent pairs of said cores, said two pairs of windings connected to said first-mentioned two circuits having a series-aiding and series-opposing relationship and said two pairs of windings connected to each two circuits of said other circuits having a series-aiding and series-opposing relationship, and a winding on one core of each pair of said adjacent pairs of cores coupling one of said networks to the windings applied to said one core.

5. In combination, incoming and outgoing signaling transmission paths, a plurality of circuits, circuit means to connect certain of said circuits with said paths, means comprising a plurality of multiwinding magnetic core coils to connect electromagnetically said circuits with each other such that transmission is effective between each of two other circuits of said circuits and at least three of said certain circuits and ineffective between said two other circuits and between each of said certain circuits and the remaining circuits thereof, said coils comprising a pair of magnetic cores and a plurality of pairs of windings connected to said circuits and applied to said cores such that a first core embodies one pair of windings connected to two of said certain circuits and one winding of each of two other pairs of windings connected to said two other circuits and a second core embodies a further pair of windings connected to two further circuits of said certain circuits and the other winding of each of said two other pairs of windings connected to said two other circuits, said two pairs of windings applied to both said cores being arranged in a series-aiding and series-opposing relationship, a balancing network applied to the pair of circuits embodying the pair of windings individual to each of said cores, and switching means to render said two other circuits and said certain circuits effective selectively in said transmission paths.

6. In combination, signal transmitting and receiving paths, normal and emergency signal modulating and demodulating apparatus, normal and emergency carrier wave generators, circuit means to connect said normal and emergency modulating and demodulating apparatus to said paths, a pair of balancing networks, switching means to render effective selectively said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier generators in said paths, and means comprising a plurality of multiwinding magnetic

core coils interposed between said modulating and demodulating apparatus and said carrier generators to provide electromagnetic connection therebetween such that substantially minimum attenuation is effectively provided between either of said carrier generators and said normal and emergency modulating and demodulating apparatus and substantially maximum attenuation is effectively provided between said normal modulating and demodulating apparatus, between said emergency modulating and demodulating apparatus, between said normal and emergency carrier generators, and between each of said modulating and demodulating apparatus and the other apparatus thereof, said coils comprising a pair of magnetic cores and a plurality of pairs of windings connected to said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier generators and applied to said cores such that the pair of windings connected to said normal modulator and demodulator is on one core, the pair of windings connected to said emergency modulator and demodulator is on the other core and the pairs of windings connected to said normal and emergency carrier generators are on both said cores in a series-aiding and series-opposing relationship, one of said balancing networks is connected across the mid-point of the pair of windings on said one core and a portion of said circuit means common to both said normal modulator and demodulator and the other of said balancing networks is connected across the mid-point of the pair of windings on said other core and a portion of said circuit means common to both said emergency modulator and demodulator.

7. In combination, signal transmitting and receiving paths, normal and emergency signal modulating and demodulating apparatus, normal and emergency carrier wave generators, circuit means to connect said normal and emergency modulating and demodulating apparatus to said paths, a pair of balancing networks, switching means to render effective selectively said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier generators in said paths, and means comprising a plurality of multiwinding magnetic core coils to connect electromagnetically said normal and emergency modulating and demodulating apparatus to said normal and emergency carrier generators and said networks such that carrier energy from either of said carrier generators is simultaneously transmitted to said normal and emergency modulating and demodulating apparatus and transmission is effectively prevented between said normal modulating and demodulating apparatus, between said emergency modulating and demodulating apparatus, between said normal and emergency carrier generators, and between each of said normal and emergency modulating and demodulating apparatus and the remaining apparatus thereof, said coils comprising a plurality of magnetic cores, a plurality of pairs of windings connected in individual pairs to each of said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier generators and applied to said cores such that a first adjacent pair of said cores embodies one winding of each of the pairs of windings connected to said normal and emergency carrier generators and in a series-aiding and series-opposing relationship the pairs of windings con-

nected to said normal modulator and demodulator and a second pair of adjacent cores embodies the other winding of each of the pairs of windings connected to said normal and emergency carrier generators and in a series-aiding and series-opposing relationship the pairs of windings connected to said emergency modulator and demodulator, the pairs of windings connected to said normal and emergency carrier generators being arranged in a series-aiding and series-opposing relationship, a winding on one core of said first adjacent pair of cores coupling one of said balancing networks to said windings connected to said normal modulator and demodulator, and a winding on one core of said second adjacent pair of said cores coupling the other of said balancing networks to said windings connected to said emergency modulator and demodulator.

8. In a signaling system, an outgoing transmission path, an incoming transmission path, normal and emergency modulating and demodulating apparatus, normal and emergency carrier wave generators, circuit means to apply said normal and emergency modulating and demodulating apparatus to said paths, means to connect electromagnetically said normal and emergency modulating and demodulating apparatus with said carrier generators, said connecting means comprising a plurality of pairs of windings, two of which pairs are individually applied across each of said carrier generators and two of which pairs are individually connected in series in one common side of each of said normal and emergency modulating and demodulating apparatus, a pair of balancing networks, one of which networks is applied across a junction point of one pair of windings in said one common side of said normal modulating and demodulating apparatus and a junction point of another common side of both said latter apparatus and the other of which networks is applied across a junction point of the other pair of windings in said one common side of said emergency modulating and demodulating apparatus and a junction point of another common side of both said latter apparatus, and a pair of magnetic cores, said windings and said cores arranged such that one core embodies one winding of each of said pair of windings associated with each of said carrier generators and said pair of windings associated with said normal modulating and demodulating apparatus and the other core embodies the other winding of each of said pair of windings associated with each of said carrier generators and said pair of windings associated with said emergency modulating and demodulating apparatus, said individual pairs of windings applied to said carrier generators being arranged on said cores in series-opposing and series-aiding relationship, and switching means to render said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier apparatus effective in desired combinations in both said transmission paths.

9. In a signaling system, an outgoing signaling transmission path, an incoming signaling transmission path, normal and emergency signal modulating and demodulating apparatus, normal and emergency carrier wave generators, a pair of balancing networks, circuit means to apply said normal and emergency modulating and demodulating apparatus to said paths, means to connect electromagnetically said normal and emergency modulating and demodulating apparatus with

said carrier generators, said connecting means comprising a plurality of pairs of windings two of which pairs are individually applied across each of said carrier generators, four of which pairs are individually applied across each of said normal and emergency modulating and demodulating apparatus, a single winding to connect one balancing network to said windings connecting said normal modulating and demodulating apparatus, a single winding to connect the other balancing network to said windings connecting said emergency modulating and demodulating apparatus, a plurality of magnetic cores, said cores and windings arranged such that a first core embodies one winding of each of said pairs applied to said normal modulating and demodulating apparatus and said winding connecting said one balancing network therewith, a second core embodies said other winding of each of said pairs applied to said normal modulating and demodulating apparatus and one winding of each of said pairs applied to each of said carrier generators, a third core embodies the other winding of each of said pairs applied to each of said carrier generators and one winding of each of said pairs applied to said emergency modulating and demodulating apparatus, and a fourth core embodies the other winding of each of said pairs applied to said emergency modulating and demodulating apparatus and said winding connecting the other balancing network therewith, the pairs of windings on associated pairs of cores being arranged in a series-aiding and series-opposing relationship, and switching means to render said normal and emergency modulating and demodulating apparatus and said normal and emergency carrier generators effective selectively in both said paths.

10. In combination, a plurality of discrete electrical circuits, and means to connect electromagnetically said circuits with each other such that transmission is effective between at least one of said circuits and the others of said circuits, said means including a plurality of magnetic cores and a plurality of pairs of windings connected to said circuits, each pair of windings being individual to one of said circuits, and applied to said cores such that each winding of the pair of windings connected to said one circuit is on one of two different cores and one winding of each of two pairs of windings connected to at least two of said other circuits is on one of said two different cores and the other winding of each of said two pairs of windings connected to said two other circuits is individual to one of two further cores.

11. In combination, a plurality of discrete electrical circuits, and means to connect electromagnetically said circuits with each other such that transmission is effective between each of two circuits and the other circuits, said means including a plurality of magnetic cores and a plurality of windings connected to said circuits, each pair of windings being individual to one of said circuits, and applied to said cores such that one winding of each of the two pairs of windings connected to said two circuits is on one of two different cores and one winding of each four pairs of windings connected to four of said other circuits is on one of said two different cores and the other winding of each of said four pairs of windings connected to said four other circuits is on one of two further cores.

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