Feb. 9, 1937. W. A. KNOOP 2,069,838

COMMUNICATION SYSTEM

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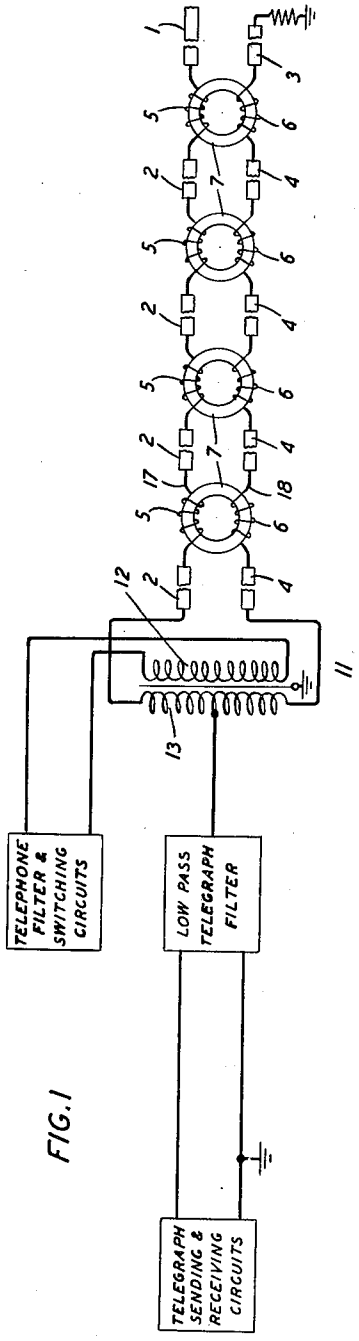

FIG. 1

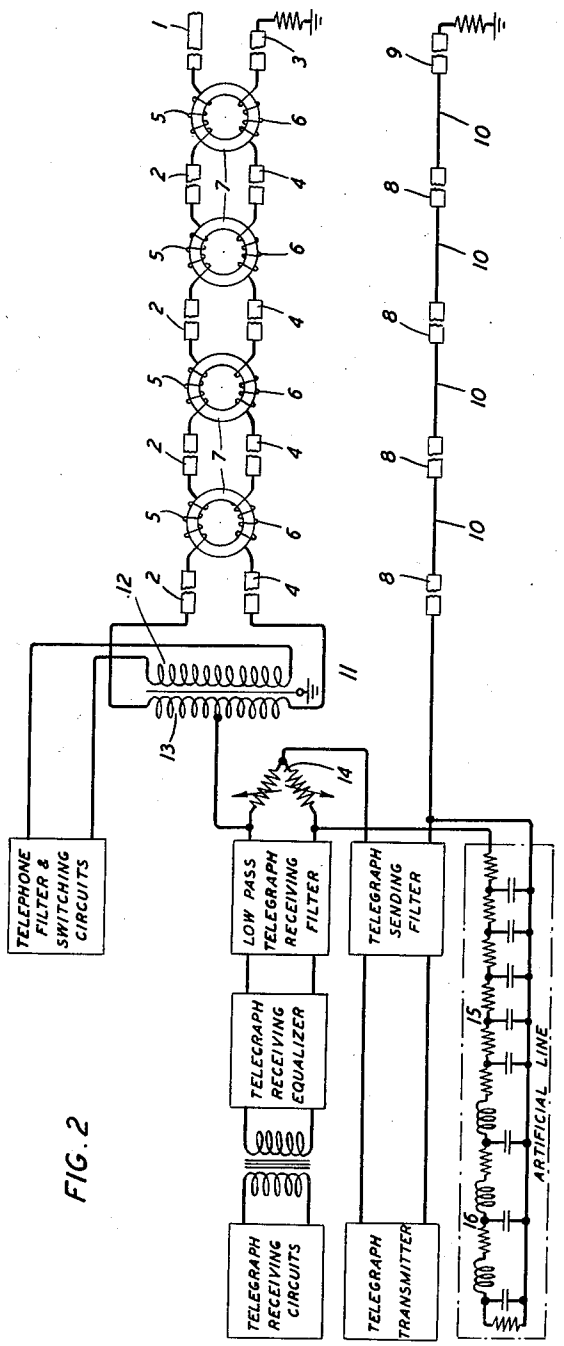

FIG. 2

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COMMUNICATION SYSTEM

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6 Claims. (Cl. 179—3)

This invention relates to electrical communication systems and more particularly to composite loaded communication systems for simultaneously transmitting both telegraph and telephone message currents.

In electrical communication cables it may be necessary to load the cable by winding a tape of magnetic material about the conductor or inserting loading coils having cores of magnetic material. This loading reduces the attenuation of the cable to electrical currents, but due to the characteristics of the magnetic materials the signals are modulated and distorted. In addition, in composite systems, the modulation products of one set of currents may disturb the other sets of currents. This effect is greatest when the transmission of one set of currents (say the telephone currents) is in one direction and the transmission of the other set, (the telegraph signals in this case), is in the opposite direction.

Filters are usually employed to separate telephone and telegraph currents which lie in different frequency ranges but the filters are unable to attenuate those modulation products which have the same frequencies as the desired currents selected by the filters.

The object of this invention is to provide means for preventing the telegraph currents from modulating the telephone currents and at the same time to balance the modulation products of the telephone currents out of the telegraph receiving apparatus.

A feature of the invention is that the cable conductor is loaded in such a manner that telephone channel is effectively loaded while the telegraph channel is effectively non-loaded, so that telegraph message currents may be transmitted in both directions simultaneously with transmission of telephone message currents in either direction over the cable.

A further feature of the invention is that the loading is accomplished by loading coils and disturbances due to the "Barkhausen effect" in the magnetic material of the loading coil due to the telegraph currents are balanced out of the telephone channel.

These objects are accomplished in one specific embodiment of the invention to a deep sea submarine cable by providing special shore end sections to the cable having a telephone sea-earth conductor or cable and a telegraph sea-earth conductor or cable in addition to the main cable or conductor. The main cable conductor and the telephone sea-earth conductor are provided with loading coils having mutual inductances between them. The telegraph circuit is then taken from the midpoint of the main cable and the telephone sea-earth cable and the telegraph sea-earth cable.

In order that the invention may be more fully understood two embodiments of the invention will now be described in connection with the attached drawing in which:

Fig. 1 illustrates one embodiment of the invention as applied to a submarine cable and,

Fig. 2 illustrates another embodiment of the invention in which the telegraph circuits which include a transmitting circuit, a receiving circuit, the artificial line circuit and the telegraph sea-earth circuit are shown in detail.

Referring now to Fig. 1, the portion 1 of the main deep sea cable is preferably continuously loaded, but need not be. Connected to each end of cable 1 is a shore-end or terminal section as illustrated in Fig. 1 which is loaded with loading coils 7 having windings 5 and 6. Non-loaded cable sections 2 and 4 which are connected between loading coils 7 may be the conductors or cores of twin core cables or two individual core cables. Conductors or cable sections 2 are connected in series with the windings 5 of the loading coils 7 and the main deep sea cable 1. Cable sections 4 are connected in series with windings 6 of loading coils 7 and the telephone sea-earth or balancing earth through a cable section 3 which is preferably similar in construction to cable 1 and may extend a considerable distance beyond the loading coil most distant from the shore. Connected to the shore-end of the cable sections 2 and 4 closest to the shore is the primary winding 13 of a telephone transformer 11 which is center tapped. The secondary winding 12 of transformer 11 is connected to the telephone filters and switching circuits while the center tap of primary winding 13 of transformer 11 is connected to the telegraph transmitting and receiving circuit through the telegraph low pass filters.

The shore-ends of the cable, are coil loaded so that mutual coupling is provided between the main cable and the sea-earth cable. It should be noted that the coils 5 and 6 are so connected to the main cable conductor and the sea-earth cable conductor so that they are series aiding for the telephone current, but series opposing for the telegraph circuit.

Now let us consider what will happen in the first loading coil. The telephone current from the primary winding 13 of transformer 11 traverses winding 5 of the first loading coil 7, flows

through the cable to ground, back through the telephone sea-earth conductor and the other winding 6 of the first loading coil 7 to the primary winding 13 of telephone transformer 11. If the iterative impedances Z_c and Z_s of the main cable conductor and the sea-earth conductor from points 17 and 18 to earth respectively are equal and the windings 5 and 6 of loading coil 7 are identical, the midpoint of the primary 13 of transformer 11 will remain at earth potential during the reception and transmission of the telephone currents.

However due to the characteristics of the magnetic loading material Z_c and Z_s vary with the current flowing in the cable. This causes harmonic voltages or modulation products to be induced in the loading coils or in loaded conductors. A more detailed description of this type of distortion, modulation products and harmonic voltages may be found in an article "Harmonic production in ferromagnetic materials" by E. Peterson published in the Bell System Technical Journal, vol. VII, pp. 762–796 for October 1928. By winding the coils connected in the two conductors on the same core Z_c and Z_s will vary in the same manner and amount if the two windings are identical and the modulation products or harmonic voltages will be equal in both coils and also have the same relative phase so that voltages will not appear at the center point of winding 13 of transformer 11.

If there is no mutual coupling between the windings 5 and 6 of the loading coils 7 or if the conductors 2 and 4 are continuously loaded by wrapping tape about them not only must Z_c and Z_s be equal, but the modulation products which are generated in each conductor due to magnetic loading material must be equal at each point along the cable and also be generated at the same phase at each point along the cable if the center tap of the primary winding 13 of the telephone transformer 11 is to remain at ground potential during the transmission and reception of the telephone currents. Since it is impossible to manufacture loaded conductors sufficiently alike to meet these requirements the advantage of a coil loaded shore section in which the same magnetic material is employed to load both the main cable and the sea-earth cable becomes quite apparent.

Furthermore, since coils 5 and 6 are wound on the same core and are connected in series opposition to the telegraph currents no "Barkhausen effects" are produced in the telephone channel. Also since the coils are connected in series opposing for the telegraph current, these currents will produce no magnetic effects in the cores of the loading coils so that the telegraph currents are unable to modulate the telephone currents or to produce any harmonics in these cores which might disturb the telephone current.

Since the telegraph currents traverse the windings 5 and 6 in opposing directions, this shore section of the cable is effectively unloaded with respect to the telegraph currents which enables the telegraph circuit to be readily balanced for duplex operation as shown in Fig. 2. Here the deep sea cable 1 is connected to coil loaded shore cable sections similar to those shown in Fig. 1. In addition a telegraph sea-earth cable 9 is provided which is connected through cable sections 8 to the telegraph artificial line and transmitting apparatus. In this case as in Fig. 1, cable sections 2, 4, and 8 are non-loaded and may be individual cables or may be conductors or cores in a triple core cable or conductors 2 and 4 may be in a twin core cable and 8 in an individual cable. In the case that 2, 4 and 8 are in a triple core cable, cores or conductors 8 may be joined together as shown by wire 10.

Since the shore end of the cable system is not loaded with respect to the telegraph current, it is unnecessary to provide variable inductances in the artificial line which is therefore much easier to construct and maintain. However, it is necessary to include inductance elements which correspond to the inductance elements of the loaded main cable 1 as shown in sections 16 of the artificial line. However, since there is appreciable attenuation in the initial sections 15 corresponding to the non-loaded shore section, changes in the value of these inductances or in the value of the inductance of the loaded cable do not appreciably affect the balance of the bridge 14 of the telegraph circuit.

While the drawing and above description disclose two specific embodiments of the invention, it is to be understood that they are not to limit the scope of the invention as defined in the appended claims.

What is claimed is:

1. A communication system for simultaneously transmitting voice frequency telephone message currents and low frequency telegraph message currents comprising a main cable section, terminal cable sections connected to the ends of said main cable section, said terminal cables having a main conductor, a telephone balancing earth conductor, a telegraph balancing earth conductor, a plurality of double wound loading coils one winding of which is connected in series with said main cable conductor and the other winding of which is connected in series with said telephone balancing earth conductor, means for transmitting and receiving said telephone message currents over said main conductor and said telephone balancing earth conductor, and means for transmitting and receiving telegraph message currents between said telegraph balancing earth conductor and the midpoint of said telephone transmitting and receiving means.

2. A submarine communication system for simultaneously transmitting voice frequency telephone message currents and low frequency telegraph message currents comprising a main cable section and terminal cable sections connected to the ends of said main cable section, characterized in this that said terminal cable sections comprise a main conductor, a telegraph sea earth conductor and a telephone sea earth conductor.

3. A communication system comprising a main loaded single conductor cable, terminal sections connected to the ends of said main cable comprising a main cable conductor, a telephone balancing sea earth conductor, a telegraph balancing sea earth conductor, loading coils having a coil connected in series with said main cable conductor and another coil connected in series with said telephone sea earth conductor said coils having mutual inductance between them, and means for transmitting and receiving telephone signal currents to and from said main cable section and said telephone sea earth conductor, and means for transmitting and receiving telegraph current to and from said telegraph sea earth conductor and the midpoint between said main conductor and said telephone sea earth conductor.

4. A composite deep sea communication system for simultaneously transmitting and receiving telegraph and telephone signal currents which

comprises a main loaded cable, short cable sections connected thereto having a main conductor and a telephone sea earth conductor, loading coils for loading said conductors for telephone currents having two windings mutually coupled together, one of the windings of each of said loading coils being connected in series with said main conductor and the other of said windings of each of said coils being connected in series with said telephone sea earth conductor, and means for applying said telephone signal currents between said conductors and additional means for applying said telegraph currents to said conductors equally and to ground.

5. A deep sea communication system comprising a deep sea cable section, a shore cable section connected to the ends of said deep sea cable section, said shore cable section comprising a main conductor, a telephone sea earth conductor and a telegraph sea earth conductor, loading coils having two windings mutually coupled together, one of which is connected in series with said main conductor, the other winding of which is connected in series with said telephone sea earth conductor, and means for simultaneously transmitting and receiving voice frequency telephone message currents and low frequency telegraph message currents connected to the conductors of said shore cable section whereby the inductance for said telephone currents is increased but the inductance to said telegraph currents is not increased.

6. A deep sea communication system for simultaneously transmitting and receiving both voice frequency telephone message currents and low frequency telegraph message currents, comprising a deep sea cable section, shore cable sections connected to the ends of said deep sea cable section, said shore cable sections comprising a main cable conductor, a first sea earth conductor and a second sea earth conductor, a plurality of loading coils having two windings mutually coupled together one of which is connected in series with said main conductor and the other of which is connected in series with said first sea earth conductor, means for transmitting and receiving one of said message currents to said main conductor and said first sea earth conductor, and means for transmitting the other of said message currents equally over said main cable conductor and said first-mentioned sea earth conductor and over said second sea earth conductor.

WILLIAM A. KNOOP.