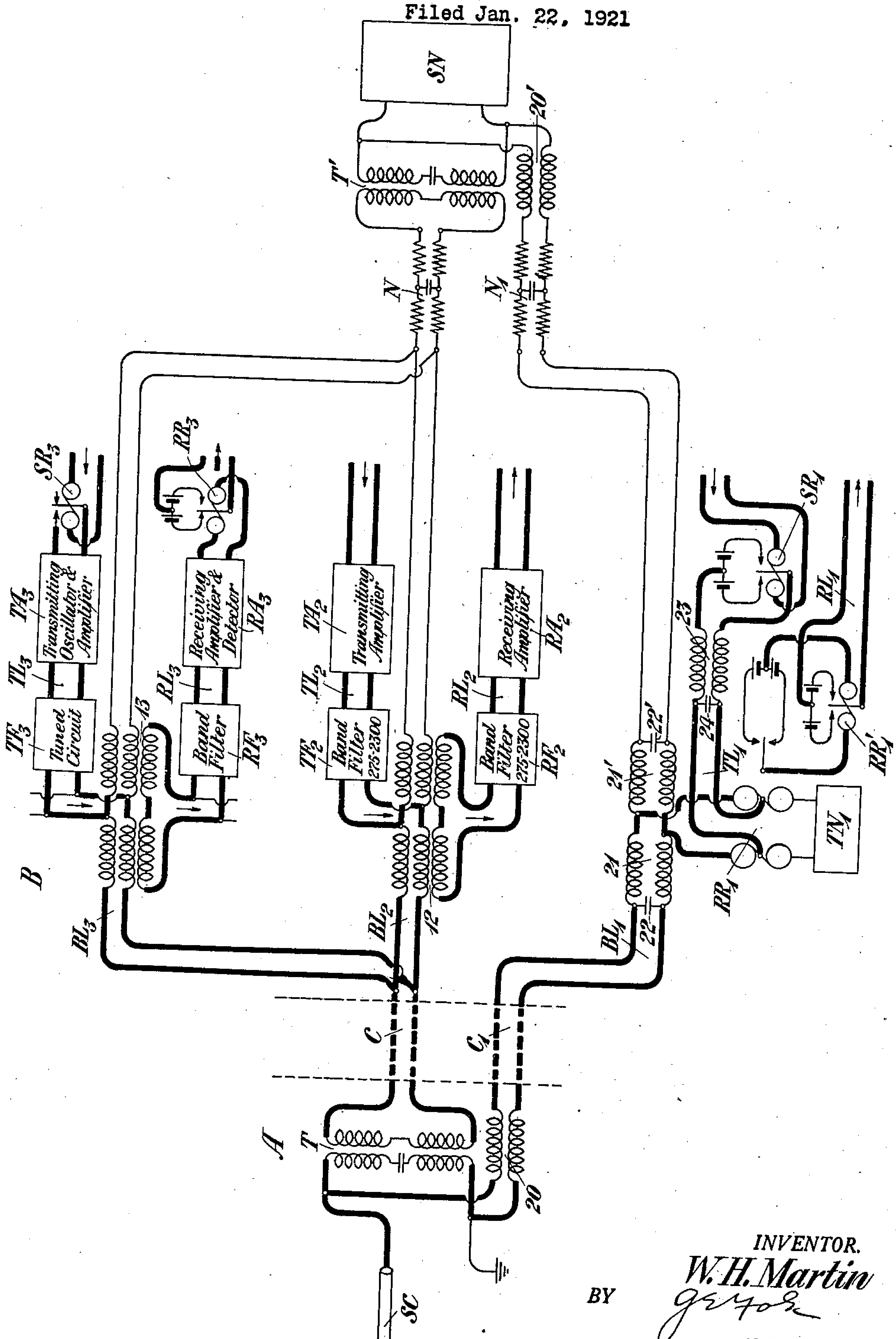
March 17, 1925. **1,529,801**

W. H. MARTIN

MULTIPLEX SUBMARINE CABLE

Filed Jan. 22, 1921



INVENTOR.
W. H. Martin
BY
ATTORNEY

Patented Mar. 17, 1925. **1,529,801**

UNITED STATES PATENT OFFICE.

WILLIAM H. MARTIN, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MULTIPLEX SUBMARINE CABLE.

Application filed January 22, 1921. Serial No. 439,238.

To all whom it may concern:

Be it known that I, William H. Martin, residing at New York, in the county of Bronx and State of New York, have invented certain Improvements in Multiplex Submarine Cables, of which the following is a specification.

This invention relates to multiplex transmission systems, and more particularly to multiplex transmission systems for signaling over submarine cables.

In submarine cable systems it is customary to bring out the ocean cable proper at the shore into a small building known as a cable hut, and to connect the hut with a signaling station located at some more accessible or convenient part of the town or city by means of an extension of the cable or an independent conducting system, such, for example, as an underground cable. As is well-known, a submarine cable may be a grounded circuit, and if the submarine cable is to be used for telephone transmission it is undesirable that the cable system be continued as a grounded system from the cable hut to the distant central office, as a grounded conductor system in a city is impractical, because of interfering disturbances due to other signaling systems or power circuits or the like.

It is one of the purposes of this invention to overcome this difficulty in a simple and yet efficient manner. Therefore, in accordance with the present invention the submarine cable is grounded at the hut and a full metallic circuit is extended over an underground cable from the hut to the distant central office, the full metallic circuit being associated with the cable circuit through a transformer which insulates the full metallic circuit from the grounded circuit. In order to obtain the fullest utility from the submarine cable circuit it is desirable that a plurality of signals be simultaneously superposed upon the circuit, or, in other words, that the cable be operated upon a multiplex basis, and the present invention therefore contemplates as one of its objects the multiplexing of a system of this character. The full metallic circuit extending through the underground cable may obviously serve as the common transmission path for a number of channels utilizing alternating currents as a transmitting medium; for example, it may serve to carry ordinary telephonic currents as well as one or more alternating carrier frequencies for transmitting additional signals. The full metallic cable circuit above referred to cannot be used, however, for transmitting direct current signals, because of the tranformer connection. In accordance with the present invention an additional underground cable connection is therefore extended from the hut to the distant central office, said cable connection being directly connected to the submarine cable and serving as a channel for the transmission of direct current signals. This additional underground cable connection is, of course, connected directly to the cable ground, but it is possible to operate this channel upon this basis, because the disturbing electromotive forces encountered in the city do not so seriously affect the more powerful currents used in the transmission of direct current telegraph signals.

Other and further objects of the invention will be clear from the following detailed description when read in connection with the accompanying drawing, the figure of which is a schematic circuit arrangement of a multiplex signaling system embodying the invention.

Referring to the drawing, SC designates a grounded submarine cable terminating at the cable hut A in the primary winding of a transformer T, the secondary of which is included in circuit with a full metallic cable circuit C extending from the hut A to a distant central office B. At the central office B the metallic cable C is branched into a number of parallel transmitting paths, such as BL_2 and BL_3, these paths being joined together at their ends opposite the metallic cable C, and there associated with a balancing arrangement. The balancing arrangement comprises a network N for simulating the metallic cable C, a transformer T′ for simulating the transformer T, and an artificial line or network SN for simulating the submarine cable SC.

Transmitting and receiving channels may be associated with each of the branch paths; for example, a receiving telephone channel RL_2 is shown associated with the parallel path BL_2 through a balancing transformer arrangement 12, the corresponding transmitting channel TL_2 being connected to said path at the midpoints of the windings of the transformer 12, so that the channels

TL_2 and RL_2 are substantially conjugate. Each channel includes an amplifier, the transmitting amplifier TA_2 being included in the transmitting channel TL_2, and the receiving amplifier RA_2 being included in the receiving channel RL_2. These amplifiers may be of any well-known construction, as, for example, vacuum tube amplifiers such as are used in ordinary telephone practice. For the purpose of preventing interference with other signaling channels a band filter TF_2 is included in the transmitting channel TL_2 and a band filter RF_2 is included in the receiving channel RL_2. These filters are of the type disclosed in the U. S. patents to George A. Campbell, Nos. 1227113 and 1227114, issued May 22nd, 1917, and are so designed as to transmit frequencies lying within the ordinary voice range; for example, from 275 cycles to 2300 cycles.

In a similar manner a carrier receiving channel RL_3 may be associated with the parallel path BL_3 through a balanced transformer 13, and the corresponding transmitting channel TL_3 is associated with said parallel path by connecting it to the midpoints of the windings of the transformer 13. These channels may be used for the transmission and reception of telegraph signals by means of a suitable carrier frequency above the voice range. Consequently, a tuned circuit or other filtering arrangement TF_3 is included in the channel TL_3 and a band filter RF_3 of the Campbell type is included in the receiving channel RL_3. These filtering arrangements are designed to prevent interference with other channels. The transmitting channel TL_3 also includes a transmitting oscillator and amplifier arrangement of a well-known construction. The transmitting oscillator may, for example, be a vacuum tube oscillator whose circuit is controlled by a sending relay SR_3 to interrupt or modulate the carrier oscillations produced by the oscillator. The amplifier, which may in practice be included in the output circuit of the oscillator, may be any well-known type of amplifier, such as the vacuum tube amplifier. The receiving channel RL_3 is also provided with a receiving amplifier and detector RA_3. The receiving amplifier may likewise be of the well-known vacuum tube construction, and the detector may be of any well-known character, such, for example, as the vacuum tube detector. In circuit with the detector is a receiving relay RR_3 for transmitting the received detected signals to a receiving circuit.

In order to provide a channel for the transmission of direct current signals such as telegraph signals, an underground cable C_1 extending from the hut A to the central office B is bridged across the submarine cable SC on the primary side of the transformer T. The cable C_1 at the central office terminates in a branch path BL_1, similar to the branch paths BL_2 and BL_3, said branch path at its opposite end being connected to a balancing arrangement comprising a network N_1 for simulating the cable C_1 and the artificial line or network SN, to which the path BL_1 is connected in a manner similar to that by which the underground cable C_1 is connected with the submarine cable SC. In order to prevent shunting of the telephone and carrier currents through the capacity of the cable C_1, a retard coil 20 is inserted in the cable C_1 at the cable hut and a similar coil 20′ is included in the circuit BL_1 for balancing purposes. A similar retard coil 21 shunted by a capacity 22 is inserted in the branch path BL_1 at one side of the midpoint thereof and a similar balancing combination 21′—22′ is included in said path on the opposite side of the midpoint thereof. The retard coil 21 and condenser 22 coacts with the retard coil 20 and the capacity of the cable C_1 to form a filtering arrangement which freely transmits the low frequency direct current signals but offers a very large impedance to the higher frequency telephone and carrier currents. The Morse signaling apparatus associated with the branch path BL_1 comprises a four-winding differential receiving relay RR_1 of well-known type, having its terminals bridged across the midpoint of the path BL_1 on one side and connected on the other side to a balancing network TN_1. The transmitting channel TL_1 is connected to midpoints of the windings of the differential relay RR_1 and includes a filtering arrangement comprising a retard coil 23 and condenser 24. A winding relay SR_1 is arranged to send positive or negative impulses over the channel TL_1 in a well-known manner. The receiving channel RL_1 is controlled by an auxiliary receiving relay RR_1', which in turn is controlled by the main receiving relay RR_1.

The operation is as follows: Morse currents operate the sending relay SR_1 to transmit positive or negative impulses through the filter 23—24 to the midpoints of the windings of the receiving relay RR_1. The energy divides at this point, one half being transmitted to the balancing network TN_1 and the other half to the midpoints of the branch path BL_1, where the energy of the transmitted currents again divides, one half flowing through the balancing cable N_1 to the network SN, the other half flowing over the cable C_1 to the submarine cable SC. Similar currents received from the cable SC pass over the underground cable C_1 into the branch path BL_1 to operate the receiving relay RR_1, which in turn causes the auxiliary relay

RR_1' to transmit positive or alternating impulses through the receiving channel RL_1.

At the same time telephone currents may be transmitted through the transmitting amplifier TA_2 over the channel TL_2 through the filter TF_2 to the midpoints of the windings of the transformer 12, where the energy divides, part flowing to the balancing arrangement and part flowing over the cable C and through the transformer T to the submarine cable SC. Received telephone currents incoming from the cable SC pass through the transformer T over the underground cable C and through the transformer 12 to the receiving channel RL_2, where they pass through the filter RF_2 to be amplified by the amplifier RA_2. The filter RF_2 prevents currents lying without the voice range from entering the receiving channel.

Similarly, Morse currents operating the sending relay SR_3 cause Morse signals to be superposed on the carrier frequency generated by the transmitting oscillator and amplifier TA_3, and the resulting currents are transmitted through the filter TF_3 to the midpoints of the windings of the transformer 13, where the energy divides, half flowing to the balancing arrangement, and the other half through the branch circuit BL_3 and over the underground cable C to the cable SC. Similar carrier currents received from the cable SC pass through the transformer T over the underground cable C and branch path BL_3 through the transformer 13 into the receiving channel RL_3, where they are selected by the band filter RF_3, amplified by the amplifying portion of the arrangement RA_3, and detached by the detector of the combination RA_3. The detected currents operate the receiving relay RR_3 to transmit Morse signals to the Morse line. The filters TF_3 and RF_3 prevent currents of frequencies other than the frequencies assigned to these channels from entering the channels TL_3 and RL_3. The parallel conductors connected to the channels TL_3 and RL_3 indicate the manner in which additional transmitting and receiving channels may be impressed upon the branch circuit BL_3 through the common balancing transformer 13. It will be understood that each of these transmitting and receiving channels will include filtering arrangements and translating devices similar to those included in the channels TL_3 and RL_3, these filters and translating arrangements being designed with reference, however, to the transmission of other carrier frequencies than those employed by the channels TL_3 and RL_3.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is—

1. In a multiplex transmission system, a grounded transmission path upon which a plurality of signaling channels may be superposed, a full metallic circuit associated with said grounded conductor, means for insulating said full metallic circuit from said grounded conductor while permitting the transmission of alternating currents, means for superposing a plurality of two-way signaling channels upon said full metallic circuit, an additional circuit galvanically connected to said grounded circuit, and means for transmitting direct current signals over said additional circuit.

2. In a multiplex transmission system, a grounded conductor upon which a plurality of signaling channels may be superposed, a full metallic circuit associated with said grounded conductor and extending from the terminal thereof to a distant point, means for insulating said full metallic circuit from said grounded conductor while permitting the transmission of alternating currents, a plurality of two-way signaling channels associated with said full metallic circuit, an additional conducting system galvanically connected to said grounded conductor also extending to said distant point, and means at said distant point whereby direct current signals may be transmitted over said additional conductor and said grounded conductor.

3. In a multiplex transmission system, a submarine cable terminating at the shore in a ground connection, a full metallic circuit associated with said cable and extending from the shore to a distant point, means for insulating said full metallic circuit from said grounded cable while permitting the transmission of alternating currents, means for superposing a plurality of two-way signaling channels upon said full metallic circuit, an additional conductor galvanically connected with said submarine cable and extending from the shore to said distant point, and means at said distant point whereby direct current signals may be transmitted over said additional conductor and said submarine cable.

4. In a multiplex signaling system, a submarine cable terminating at the shore in a ground connection, a full metallic circuit extending from the hore to a distant point, means for insulating said full metallic circuit from said submarine cable while permitting the transmission of alternating currents, branch paths connected to said full metallic circuit at said distant point, said branch paths being joined at their opposite ends to balancing apparatus for balancing said submarine cable, full metallic circuit and associated apparatus, transmitting and

receiving channels associated with each parallel path, an additional conductor extending from the shore to said distant point, said additional conductor being galvanically connected to said submarine cable and being similarly connected at said distant point to said balancing apparatus, and apparatus associated with said additional conductor whereby direct currents may be transmitted to and received from said submarine cable.

5. In a multiplex transmission system, a submarine cable terminating at the shore in a ground connection, a full metallic circuit extending from the shore to a distant point, means for insulating said full metallic connection from the submarine cable while permitting the transmission of alternating currents, a plurality of branch paths leading from said full metallic circuit at the distant station and connected together at their opposite ends with balancing apparatus, an additional conductor extending from the shore to said distant point, said additional conductor being galvanically connected to said submarine cable and connected at said distant point with said balancing apparatus, transmitting and receiving apparatus associated with each of said branch paths and said additional conductor at said distant point, a retard coil included in said additional conductor at a point near its junction with the submarine cable, filter apparatus included in said additional conductor at said distant point, said retard coil, together with the capacity of said additional conductor, functioning with said filter apparatus to form a filter, permitting the passage of currents of low frequency over said additional conductor, but preventing the transmission of higher frequency currents from other channels.

In testimony whereof, I have signed my name to this specification this 21st day of January 1921.

WILLIAM H. MARTIN.