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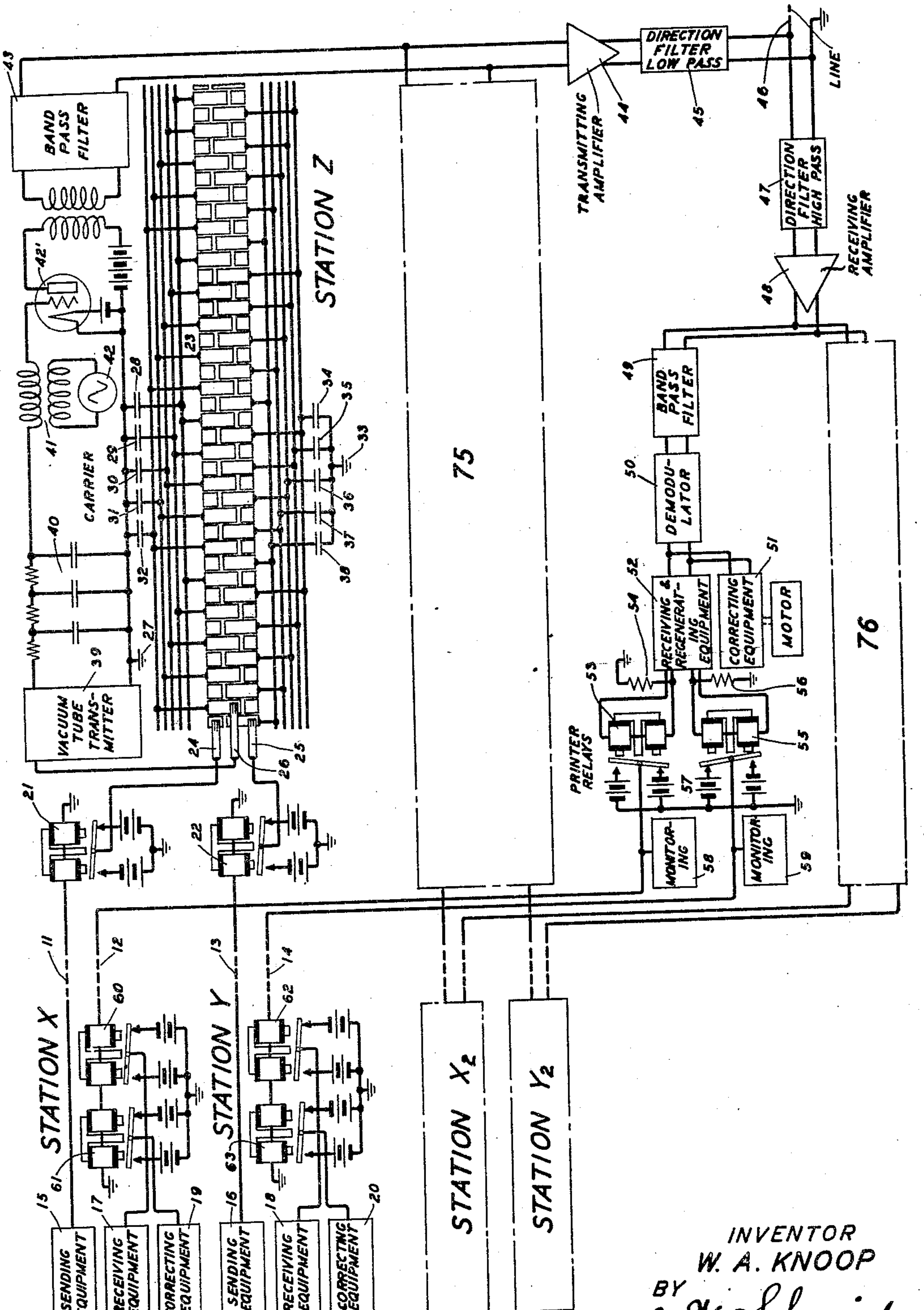

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SYNCHRONOUS SIGNALING SYSTEM

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This invention relates to a synchronous communication system and particularly to a system wherein a plurality of low speed lines are connected to a high speed cable, line or radio channel employing carrier current for transmitting signals.

An object of the invention is to increase the traffic capacity of such a carrier channel in a simple and efficacious manner.

In high speed telegraph systems employing submarine cables, it has been the practice to disregard the effective transmission of signal impulses of unit length and of alternately opposite polarities and to employ at the receiving end of the cable an interpolating circuit for inserting in the train of received impulses unit length impulses of alternately opposite polarities corresponding to those which are lost in transmission. By using the interpolating circuit, the speed of signaling is increased to a point where only the positive and negative impulses of two or more units length are, after being amplified, capable of operating or controlling the receiving apparatus. By thus increasing the speed of transmission, the traffic capacity of the cable is increased.

According to the present invention the principle of the interpolating system is applied to carrier current telegraphy over a loaded submarine cable or any similar type of carrier whereby the traffic capacity of each carrier channel is increased. It is generally known that in systems wherein multiplex telegraph apparatus is operated over carrier circuits, the width of the signal frequency band plays an important part in determining the number of carrier channels that can be profitably used on a cable or line, so if it is desired to increase the traffic over a given channel it is necessary to make the frequency band convey more intelligence than it would ordinarily. This is accomplished in the present invention by utilizing each carrier channel for transmitting signals from two or more multiplex lines.

For illustration the invention is described herein as operating in a system designed to receive signals from two four-channel multiplex lines operated at the normal speed of the printing equipment, to a submarine cable operated at high speed over a carrier current channel. The carrier circuit is such that it will ordinarily permit the transmission of signals from only one four-channel line but by arranging the circuit to reject one half the length of each of the impulses received from the two lines, the other halves of the impulses received may be combined for further transmission. Thus the signals of eight channels are obtained for transmission over a carrier channel ordinarily designed to operate at a speed of four-channel transmission. The combined impulses are repeated through a network wherein the impulses of half unit length and of alternately opposite polarities, or in other words, the higher frequency reversals, are suppressed. The impulses of two or more half units length of the one polarity which pass through the network, apply potentials in series with the potentials from a carrier current source to the grid circuit of a vacuum tube wherein modulation takes place. The modulated current is transmitted over the carrier channel to the receiving station where it is demodulated. The signaling current after demodulation is impressed on a regenerating and interpolating circuit wherein the signaling current impulses are divided into two groups and the impulses constituting the higher frequency reversals are furnished to the two groups to replace those that were suppressed. The two groups of signals are then directed over two four-channel multiplex lines. In this way twice as many signal impulses from multiplex telegraph lines may be simultaneousy repeated over a single carrier channel to other multiplex telegraph lines as would ordinarily be possible.

This may be done conveniently by providing two multiplex lines feeding into the carrier system but may be accomplished by using any desired number operating at suitable speeds.

In general, the application of the foregoing principles enables the traffic capacity of any carrier telegraph circuit, of which the traffic capacity is limited by the band width, to be doubled.

By providing additional sources of carrier current of widely different frequencies at the repeater station, additional carrier channels are provided whereby other groups of multiplex lines may be connected for simultaneous operation over the one cable. In systems of this type, the carrier frequencies used for transmitting in one direction are all included within one range of frequencies and all the carrier frequencies used for transmitting in the opposite direction are included within another range of frequencies.

A more detailed description of one species of the invention is given in conjunction with the single figure shown in the drawing.

Referring to the drawing, two terminal stations X and Y each equipped with multiplex (four channel) equipment, are shown connected to a repeater station Z over conductors 11—12 and 13—14, respectively. Conductors 11 and 13 are paths over which signals are transmitted to the repeater station Z from sending equipments 15 and 16, respectively, and conductors 12 and 14 are paths over which signals received by station Z from the cable, are repeated to the receiving equipments 17 and 18, respectively, the received signals being also effective to operate the corrector equipments 19 and 20, respectively provided at the terminal stations X and Y. The sending, the receiving and corrector equipments are shown diagrammatically but are understood to comprise four channel rotary distributors arranged to be driven in synchronism. These equipments are well known in the art and require no further description.

The signals are transmitted over conductors 11 and 13 simultaneously and are effective to operate two unbiased polarized sending-on relays 21 and 22. The relay armatures reproduce the incoming signals for transmission over the contact bars of a continuously rotating commutator 23, having engagement with the contact bars, three stationary brushes 24, 25 and 26, the direction of rotation of the commutator being indicated by an arrow on the drawing. The signals reproduced by relay 21 are impressed on the commutator over brush 24 and those reproduced by relay 22 and impressed over brush 25. The commutator is provided with forty contact bars of equal width, twenty of which are provided for each of the two four-channel distributors at the terminal stations X and Y to correspond to the five pulse code usually employed in multiplex channel systems. Twenty contact bars for one distributor are respectively arranged alternately with the twenty contact bars for the other distributor. Each contact bar is divided into a long and a short section, the latter being about one half the length of the former. The long sections are referred to herein as "live" sections because they are capable of transmitting signal impulses. The short sections, serving merely as spacers or buffers, are referred to as "dead" sections. The live sections of adjacent bars are in staggered relation with respect to each other as are also the dead sections. In other words, each of the brushes 24 and 25 which engage the end portions of the bars, passes over alternate live and dead sections, and brush 26 which engages the middle portions of the bars, passes over the long sections only. Brushes 24 and 25 are positioned the width of one bar or more in advance of brush 26. In this way brushes 24 and 25 engage each bar before brush 26. Brushes 24 and 25 are arranged to be in engagement with the long sections during the arrival of the center portions of the impulses which are to be stored. These brushes are independently orientable so that adjustment of any one brush may be made without interfering with either of the other brushes.

The long sections on each side of the commutator are interconnected to form five groups or multiples of four each, to correspond to the five pulse code employed in the four transmitters at each of stations X and Y. The five multiples engaged by brush 24 are arranged to receive signal impulses from transmitters A, B, C and D, respectively, at station X, and the five multiples engaged by brush 25 are arranged to receive signal impulses from transmitters E, F, G and H, respectively, at station Y, the transmitters not being shown but understood to be included in the blocks 15 and 16. The five impulses from each transmitter are received successively, the impulses from the transmitters in block 15 being received with those from the transmitters in block 16. The five multiples on one side of the commutator are successively engaged in continuous rotation by brush 24 and the five multiples on the other side are similarly engaged by brush 25. The five multiples engaged by brush 24 are connected to ground 27 through storing condensers 28 to 32, respectively, and the five multiples engaged by brush 25 are connected to ground 33 through storing condensers 34 to 38, respectively. It will be noted that only the long, or live, sections of the commutator bars are arranged to receive the transmitted impulses whereas the short sections are left dead and merely serve as buffer segments. The phase relations between stations X and Y are immaterial because the storing condensers hold the impulses until required and the combining commutator 23 releases the stored impulses.

By having brushes 24 and 25 positioned in advance of brush 26 the impulses produced by relay 21 cause each of condensers 28 to 32 in turn to be charged with its incoming impulses in rotation. The impulses reproduced by relay 22 cause each of condensers 34 to 38 in turn to be also charged in rotation. It will be noted that each of brushes 24 and 25 engage alternate live and dead sections. In this way only the center portions of the impulses are stored and the effect of slight variations of phase of the incoming impulses is eliminated. As brush 26 subsequently engages each of the live sections connected to a charged condenser, the charges are successively impressed on a vacuum tube transmitter 39 of any suitable type so that an impulse from a transmitter at station X is immediately followed by a corresponding impulse from a transmitter at station Y for transmission over the line. In this way the impulses of the transmitters at station X are interleaved respectively with impulses from the transmitters at station Y. The interleaved impulses in the output of vacuum tube transmitter 29 are impressed on network 40 wherein any square-topped portions are rounded to approach a sine wave form and the impulses of half unit length and of alternate opposite polarity are suppressed in order to decrease the width of the band of transmitted frequencies. By a unit length impulse, as used hereinafter is meant a half impulse which is stored on a condenser connected to the commutator. The signal current wave which passes through network 40 is impressed on grid of the modulator tube 42′ together with carrier voltage obtained from the secondary winding of transformer 41, the primary winding of which is connected to a source 42 of carrier current. The combined voltages as impressed on the vacuum tube modulator 42′ causes the variations of the signal wave to be impressed on the carrier wave. The modulated wave is passed through band pass filter 43, a transmitting amplifier 44 and a low-pass direction filter 45, in series, to the line or cable 46. The band pass filter is designed to pass only one side band of the carrier frequency produced at source 42 together with the carrier frequency. In a system of this type, as stated above, the carrier frequencies used for transmitting in one direction are included within one range of frequencies and all the carrier frequencies used for transmitting in the opposite direction are included within another range of frequencies. Therefore to meet this condition the carrier current originating at station Z is of a low frequency with respect to that originated at a repeater station at the opposite end of line or cable 46, and the direction filter 45 is of the low-pass type so as to prevent the higher frequencies incoming from the cable from entering the transmitting equipment at station Z.

The equipment at the repeater and terminal stations at the opposite end of the system (not shown) are assumed to be the same as those shown in the drawing except that at the distant repeater station the source of carrier current is of a high frequency and the direction filter employed in the transmitting circuit is of the high-pass type. Therefore the receiving equipment at repeater station Z and terminal stations X and Y will be used in describing the operation of the receiving equipment at the distant end of the cable in response to signals transmitted from station Y except that the incoming carrier current will be assumed to be of a high frequency.

The modulated incoming wave is received over cable 46 and is passed through high-pass direction filter 47 into the receiving amplifier 48 wherein the wave consisting of a high carrier frequency and its side band, is sufficiently amplified to operate mechanical relays located further on in the receiving circuit. The amplified modulated wave is passed through a band pass filter 49 which is selected of the particular side band of frequencies effective to pass the band pass filter in the transmitting circuit at the repeater station at the opposite end of the cable. Band pass filter 49 is adapted, of course, to pass a range of higher frequencies than band pass filter 43 because of the assumption that the incoming waves are employing carrier current of the higher frequency. The modulated wave is then impressed on the demodulator 50 wherein the low frequency modulating or signal wave is reproduced without the carrier current wave and directed to the receiving rings of a multiplex rotary distributor. This wave now closely resembles that produced by circuit 40 just prior to modulation; all the unit impulses are small in amplitude and are incapable of controlling the receiving equipment. The impulses consisting of two or more pulses of like polarity, however, are strong. The rotary distributor is maintained in synchronous phase with the incoming signals by a continuous electrical corrector circuit shown diagrammatically in block 51 and disclosed in various forms in the applicant's copending application Serial No. 354,954, filed April 13, 1929, wherein a detailed description may be had. Other equivalent correctors may be employed.

The rotary distributor is part of the receiving and interpolating equipment. Any suitable interpolating and rotary distributor equipment may be employed. This is shown diagrammatically by block 52. The details of one preferred form of receiving and interpolating circuit are disclosed and described in applicant's copending application Serial No. 432,288, filed March 1, 1930. This equipment comprises the receiving rings of the multiplex rotary distributor, which are adapted to receive signals over eight channels to correspond to the four-channel distributors at the terminal stations. The rings are arranged as shown in Fig. 1 of the drawings of the copending application Serial No. 432,288, supra, but there they are shown as being adapted for six channels, whereas in the present invention they are provided for eight channels. However, the arrangements in the copending application may be adapted for any even number of channels wherein the impulses of each pair of channels are interleaved with each other for transmission over the line. The receiving ring set comprises a continuous and a segmented ring, the latter ring being divided into eighty alternate long and short segments of twenty segments for each pair of channels. The long segments are connected in multiple to the output circuit of demodulator 50 and the short segments are connected in multiple to form two groups, the segments of one group being interleaved with the segments of the other group. The two groups of short segments are respectively connected to two vacuum tube storing circuits. Connected to the continuous ring is a storing condenser which is arranged to receive the incoming signal impulses from the output circuit of the demodulator as the distributor brush rotates over the long segments and to transmit the stored charges to either of the vacuum tube circuits as the brush subsequently rotates over the short segments. The two groups of short segments are arranged to respectively receive in succession the impulses which were received at the repeater station at the distant end of the line from the two terminal stations directly connected thereto. Thus the impulses transmitted from one terminal station are received by one vacuum tube circuit and those transmitted from the other terminal station are received by the other vacuum tube circuit.

The vacuum tube storing circuits each comprise a pair of vacuum tubes connected in cascade and with their plate circuits connected to a common battery. Connected in shunt to the plate circuits of each of the vacuum tubes is a receiving relay and any difference in potential occurring between the points of the circuit to which each relay is connected, will operate the relay. The normal plate currents of the vacuum tubes of each pair are balanced and therefore the relays which are of the unbiased polarized type will normally maintain their respective armatures in engagement with one of their associated contacts. The contacts of each relay are connected to opposite poles of the grounded battery. The armature of one receiving relay is connected in the circuit extending through the windings of a printer relay 53, through a regenerating resistance 54 to ground and the armature of the other receiving relay is connected in a circuit through windings of printer relay 55, regenerating resistance 56 to ground. The printer relays 53 and 55 and regenerating resistances 54 and 56 are shown in the drawing of the present application. Relays 53 and 55 are also of the unbiased polarized type and normally assume positions corresponding to those of the receiving relays respectively. Contacts of relays 53 and 55 are connected to opposite poles of battery 57. The armatures of relays 53 and 57 are respectively connected to monitoring circuits 58 and 59 which may be similar to the printer circuits shown in Fig. 1 of the copending application Serial No. 432,288, supra.

To interpolate impulses at station Z in order to replace those of unit length (half length) which were suppressed at the distant end of the cable, currents of alternate positive and negative polarities are generated from the local source of potential 57 as the brushes rotate over the receiving or monitoring ring sets, provided, of course, that no signaling impulses of two or more units length are received in the interim from the demodulator 50. The interpolating of the unit impulses of alternately positive and negative polarity which are produced by printer relays 53 and 55 which normally maintain their respective armatures in opposite positions, is described in detail in copending application Serial No. 432,288, supra.

The armatures of relays 53 and 55 are respectively connected over lines 12 and 14 to the receiving circuits at stations X and Y. Lines 12 and 14 are connected at stations X and Y respectively to the windings of relays 60 and 61, in series, and to the windings of relays 62 and 63, in series. Relays 60 to 63 inclusive are of the biased polarized type. Relays 60 and 61 reproduce the impulses received over line 12 to operate the receiving equipment 17 and the corrector equipment 19 at station X and relays 62 and 63 reproduce the impulses received over line 14 to operate receiving equipment 18 and corrector equipment 20 at station Y. The receiving distributor rings at stations X and Y may be similar to the printer distributor rings shown in Fig. 1 of the drawings in the copending application, Serial No. 432,288, supra, and therefore, inasmuch as the printer relays 53 and 54 are alternately operated or energized, their armatures will remain in either position sufficiently long to operate the slow acting printer magnets. In this way the impulses as originally transmitted, but changed to half unit length by the commutator, are restored to their original length.

The above description treats of a system having one carrier channel but it is understood that the present invention may be applied to a system having several such channels. In the drawing is shown in dot and dash lines a block 75 which represents diagrammatically a second commutator circuit connected to another pair of terminal stations X_2 and Y_2. This circuit comprises sending-on relays, a commutator and its associated brushes, a vacuum tube transmitter, suppressing network, a source of carrier current of a different frequency from that of source 42, but within the lower range so as to pass low-pass direction filter 45, a modulator and a band pass filter designed to pass one of the side bands of the frequency of the carrier source connected to it. This block 75 is shown connected to transmitting amplifier 44. In order to complete the two-way transmission, a second source of carrier current is employed at the distant repeater station but in the range of higher frequencies and the modulated signal wave incoming over cable 46 at station Z will be received in a second receiving circuit shown diagrammatically by block 76 and transmitted over lines to the second pair of terminal stations X_2 and Y_2.

What is claimed is:

1. A system for the transmission of intelligence comprising a carrier system, a distributor system for supplying to the carrier waves at the transmitting end impulses representing intelligence to be transmitted in combination with means at the receiving end of the carrier system comprising a distributor synchronized with the distributor system at the transmitting end of the carrier channel for interpolating impulses necessary for the reception of the transmitted intelligence and of a smaller time duration than those derived in effective amplitude from the modulated carrier wave.

2. In a system for increasing the message capacity of a carrier wave channel employing modulated waves without increasing the frequency of recurrence of the modulating impulses, which comprises means for producing single unit impulses and impulses which are a multiple of the length thereof, means for suppressing the single unit impulses, means for modulating a carrier wave by the remaining impulses, a demodulator for the carrier wave, and means controlled by the products of demodulation for regenerating the unit impulses in their proper relationship to the multiple unit impulses.

3. A system for the transmission of intelligence comprising a carrier system, a carrier current channel, a plurality of multiplex systems connected to each end of said channel, a distributor system for supplying from the plurality of multiplex systems at the transmitting end to the carrier wave impulses representing intelligence to be transmitted, in combination with means at the receiving end of the carrier system comprising a distributor synchronized with the distributor system at the transmitting end of the carrier channel, for interpolating impulses necessary for the reception of the transmitted intelligence and of a smaller time duration than those derived in effective amplitude from the modulated carrier wave.

4. In an impulse transmission system, a plurality of multiplex transmitting circuits, a plurality of multiplex receiving circuits, a circuit for interconnecting said transmitting and receiving circuits, characterized in this, that a portion, with respect to time, of an impulse received from one of said transmitting circuits is combined with a portion of an impulse received from the other of said transmitting circuits to form other impulses for transmission over said interconnecting circuit to said receiving circuits.

5. In an impulse transmission system in accordance with claim 4, further characterized in that means are employed intermediate said transmitting circuits and said interconnecting circuit for suppressing those portions of transmitted impulses which form single impulses of alternately opposite polarities for transmission over said interconnecting circuit.

6. In an impulse transmission system, groups of multiplex signaling lines, a carrier current channel interconnecting said groups of lines, characterized in this that portions, with respect to time, of the transmitted impulse respectively, received from the lines of one of said line groups are combined in successive order for transmission over said carrier channel to a terminating station whereat means are provided for interpolating single unit impulses of alternately opposite polarities in the incoming impulse wave to replace those that are lost by attenuation and for separating the received and interpolated impulses into groups for transmission over their respective lines of the other of said groups of lines extending to said terminating station.

7. In a communication system, groups of multiplex signaling lines, a carrier current channel interconnecting said groups of lines, characterized in this that portions, with respect to time, of the signal impulses received from the lines of one of said line groups are combined in successive order and impressed on a circuit wherein the single unit impulses of alternately opposite polarities are suppressed and the successive unit impulses of one polarity are permitted to be transmitted over said channel, single unit impulses of alternately opposite polarities being interpolated at the terminating end of said channel where the signal and interpolated impulses are separated into groups for transmission over the respective lines of the other of said groups of lines.

8. In a communication system, groups of multiplex signaling lines, a carrier current channel interconnecting said groups, means for receiving signal impulses from the lines of one of said groups, means for storing portions, with respect to time, of each of said impulses, means for combining in a successive order the stored portions of the impulses respectively received from the lines of one of said groups and for utilizing such combined portions to form a wave of high signaling

frequency, means for suppressing in said wave the unit length impulses of alternately opposite polarity, means for modulating the carrier current over said channel with the signal wave constituted of impulses of only two or more units length, and means at the terminating end of said channel for interpolating the suppressed impulses and directing both the interpolated and received impulses to the lines of the other of said groups.

9. In a signaling system, a group of low speed transmission lines, a second group of low speed transmission lines, a carrier current channel capable of transmitting high frequencies interconnecting said groups of lines, multiplex equipment arranged to transmit signals of positive and negative polarity over each of said low speed lines of the first mentioned group, means for combining in a successive order the signal impulses respectively received over the lines of said first mentioned groups, means for suppressing the unit length impulses of alternately opposite polarities in the combined impulse wave, means employing carrier current for transmitting combined impulses of only two or more units length of one polarity over said channel, and means at the receiving end of the channel for separating the signals from said carrier current, interpolating current impulses of unit length corresponding to the unit length impulses suppressed before transmission over the channel and directing the signals as originally transmitted over each line of the first mentioned group to a line of the second mentioned group.

10. In a signaling system in accordance with claim 6 wherein the means for combining signal impulses comprises a rotating commutator, a plurality of contact brushes for receiving impulses in random phase from the lines of one of said groups and impressing them on different sections of the commutator, groups of storing elements respectively provided for the lines of one of said groups, the storing elements in each group being respectively arranged to store a portion, with respect to time, of each of the impulses received, and another contact brush for effecting the connection of said storing elements in succession for transmission of their respective charges over the carrier channel.

11. In a signaling system, groups of low speed transmission lines, other groups of low speed transmission lines, a transmission circuit for interconnecting said groups, a plurality of sources of carrier current capable of transmitting currents of widely different frequencies, multiplex equipment arranged for transmitting signals of positive and negative polarity over each of said low speed lines, means for combining in a successive order the signal impulses respectively received from the lines of each group, means for suppressing the unit length impulses of alternately opposite polarity, means employing the carrier currents from said plurality of sources for simultaneously transmitting over said interconnecting circuit adjacent unit length impulses of like polarity respectively received from lines of each of the first mentioned groups, and means at the receiving end of said interconnecting circuit for separating the carrier currents into separate channels, subsequently separating the signal impulses from their respective carrier currents, then simultaneously dividing into separate groups the interleaved signal impulses received from the lines of each of the first mentioned groups and interpolating in each of said separate groups impulses of unit length and of alternately opposite polarities corresponding to the unit length impulses suppressed before transmission over its respective channel, and directing the signals as originally transmitted over each of the lines of each of the first mentioned groups to its corresponding line of each of the second mentioned groups.

12. In a signaling system in accordance with claim 11 wherein the means for dividing the interleaved impulses of each incoming signal wave into separate groups and interpolating the unit length impulses of alternately opposite polarities in said groups comprises a rotary distributing device.

In witness whereof, I hereunto subscribe my name this 20th day of May, 1930.

WILLIAM A. KNOOP.