

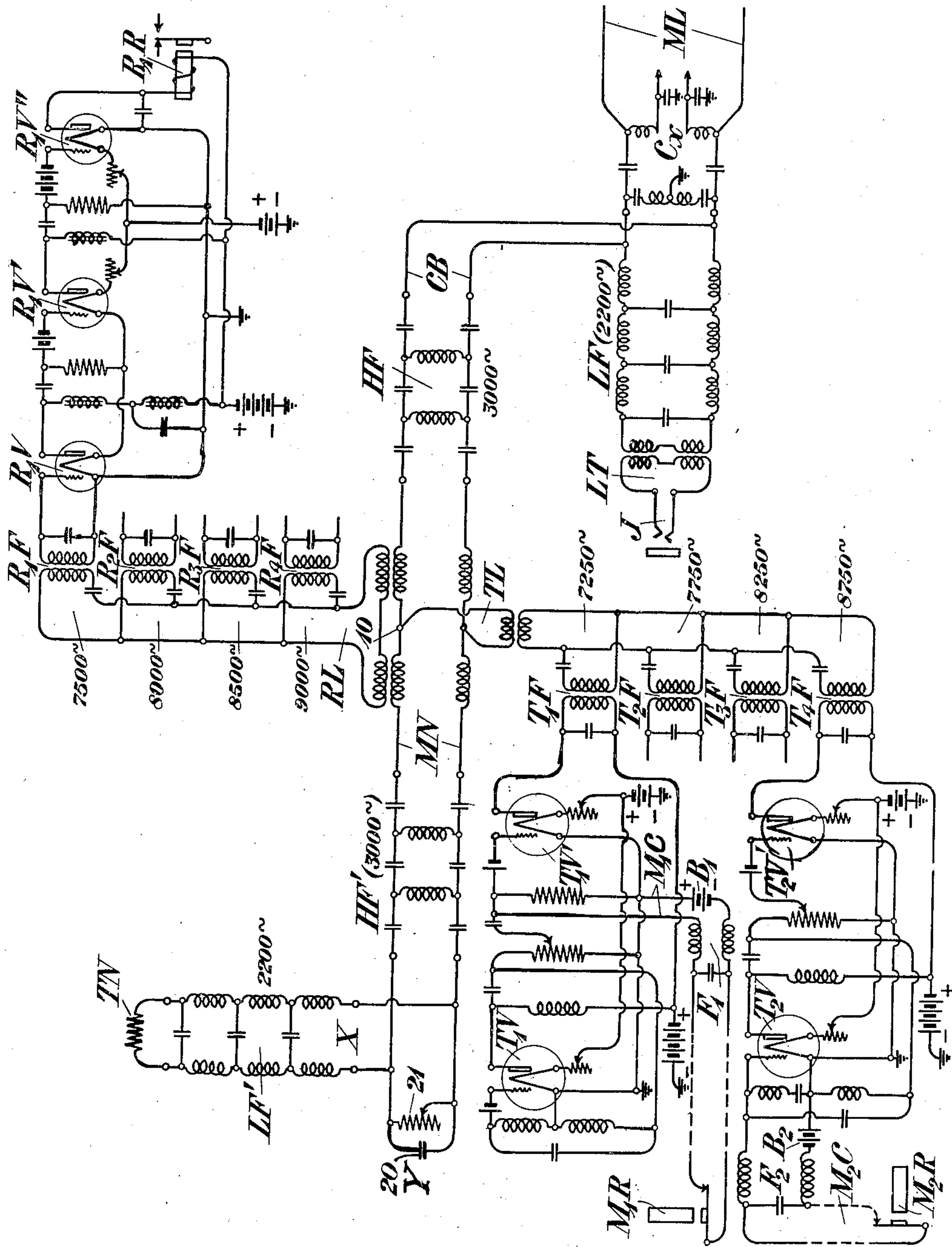
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MODULATING APPARATUS FOR TELEGRAPH SIGNALS

Filed July 29, 1919



INVENTOR

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BY

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UNITED STATES PATENT OFFICE.

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MODULATING APPARATUS FOR TELEGRAPH SIGNALS.

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To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Modulating Apparatus for Telegraph Signals, of which the following is a specification.

This invention relates to multiplex transmission and more particularly to systems either wire or wireless in which carrier currents are employed for the transmission of signals.

It has been proposed to multiplex an ordinary low frequency transmission line, such as a telephone or a telegraph line, by superimposing thereon a plurality of carrier currents of different frequencies, said carrier currents being used for the selective transmission of telephone or telegraph signals. Where the carrier current channels in such a system are to be employed for the transmission of telegraph signals, or where telegraph signals are transmitted by radio method, it has been customary to transmit the signals by making and breaking the carrier circuit in such a manner as to interrupt the carrier oscillations, either high frequency or low frequency, which are transmitted over a given channel.

This method of operation has certain objections. For instance, the making and breaking of the circuit results in impressing substantially a square topped telegraph wave upon the carrier circuit. This gives rise to oscillations known as transients in the selective circuits which are used to separate the various frequencies and transmit them through their proper channels, and these transients tend to limit the degree of electrical separation between the channels. This phenomenon may be appreciated by considering the square impressed wave as representing a relatively broad band of frequencies and taking up a correspondingly broad band in the carrier frequency range. Unless the outer borders of this band are suppressed they may extend so far in the frequency spectrum as to overlap the bands of the adjacent channels and thereby set up interfering "crosstalk" currents in the selective circuits of these adjacent channels.

Another objection to the system heretofore used arises from the fact that it is frequently desirable from an operating standpoint to

locate the control relay which makes and breaks the carrier circuit some little distance from the carrier apparatus proper, the long leads extending from the control relay to the carrier apparatus comprising an appreciable capacity tending to short circuit the relay contacts and permitting current to escape the control relay. Furthermore, the length of these leads gives an opportunity for high frequency crosstalk in the station wiring.

In order to overcome these objections it is proposed, in accordance with this invention, to impress the telegraph wave upon carrier alternations by modulation instead of mechanical interruption. Preferably, the modulation will be accomplished by means of vacuum tubes, although other modulating arrangements may be employed. In the case of the vacuum tube modulator, while the telegraph wave may be impressed upon either the input or output circuit of the modulator, it is herein illustrated as being applied to the input grid filament circuit. A filter is provided in the modulating circuit extending to the control relay, which filter functions to control the shape of the low frequency wave impressed upon the modulator. The filter also prevents high frequency oscillations from reacting in the control circuit so that the high frequency crosstalk in the station wiring may be largely eliminated. The modulator is adjusted by means of its grid battery so that the incoming wave causes the tube to operate around the curved portion of its characteristic curve thereby changing the amplification of the carrier current and affecting the modulation thereof.

The invention may now be more fully understood by reference to the following detailed description, when read in connection with the accompanying drawings, the figure of which constitutes a circuit diagram illustrating certain embodiments of the invention.

Referring to the drawing, ML designates an ordinary low frequency transmission line, such as a telephone circuit, said line being provided with the usual composite set Cx, whereby the circuit may be used for the simultaneous transmission of telephone signals and low frequency Morse signals. The main line ML is provided with a branch LT leading through a low pass filter LF

to a jack J, by means of which telephone connections over the main line ML may be established. The main line ML is also provided with a carrier branch CB including a high pass filter HF. The filters LF and IIF are of the general type disclosed in United States patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917, and as set forth in said patents may be designed to transmit any desired range of frequencies. The filter LF is so proportioned as to transmit frequencies running from zero to the upper limit of frequencies employed in ordinary telephonic transmission, which may be in the neighborhood of 2200 cycles. High frequency carrier oscillations are substantially suppressed by the filter and prevented from being transmitted to the terminal branch LT. The filter HF, on the other hand, is so proportioned as to suppress telephonic frequencies while transmitting frequencies within the carrier range. The convenient cut off point for the filter HF is 3000 cycles, although this is to be understood as purely illustrative and not as a limitation inherent in the arrangement.

The carrier branch CB is associated with a common transmitting circuit TL and a common receiving circuit RL through a balanced transformer arrangement 10. In order to render the circuits TL and RL conjugate to each other, so that electrical variations in the one circuit will be without effect upon the other, a balance circuit MN is provided, including a filter HF' or equivalent apparatus for balancing the filter HF, and branches X and Y. The branch X includes a filter LF' or equivalent structure for balancing the filter LF in the terminal line LT, and a resistance TN for balancing the terminal line which may be associated with the jack J. The branch Y includes a network consisting of a capacity 20 and resistance 21 which may be adjusted to balance the main line circuit ML.

The common transmitting circuit TL is associated with a plurality of transmitting channels through filtering arrangements, such as T_1F , T_2F , T_3F , T_4F , and so forth, which are preferably in the form of sharply tuned circuits. Each of the channels has assigned to it a definite carrier frequency to which the filter elements are tuned, the assigned frequencies being indicated as 7250 cycles for the first channel, 7750 cycles for the second channel, 8250 cycles for the third channel and 8750 cycles for the fourth channel. These frequencies are indicated merely for purpose of illustration, it being understood that any desired frequencies may be assigned to the various channels so long as the frequencies are sufficiently separated to provide the desirable degree of selectivity.

The carrier apparatus of the first channel includes an oscillating tube T_1V , of well known form, having its output circuit coupled to its input circuit in a well known manner so that the tube oscillates at any desired frequency. The circuits of the tube are so adjusted that it oscillates at the frequency assigned to its particular channel, which in the case illustrated is 7250 cycles. A modulating tube T_1V' is also provided for the purpose of amplifying and modulating the oscillation supplied by the oscillator T_1V . The input circuit of the modulating tube T_1V' is associated with the output circuit of the tube T_1V so that the oscillations from the latter tube will be impressed upon the former. In order to impress the telegraph signals upon the carrier oscillations in such a manner as to modulate the carrier currents, a modulating circuit M_1C is connected across the grid filament circuit of the modulating tube T_1V' as indicated. The modulating circuit M_1C includes a battery B_1 which may have its negative terminal connected to the grid of the tube T_1V' under the control of the Morse relay M_1R thereby varying the grid potential of the tube T_1V' in accordance with the telegraph signal. A filter F_1 is included in the modulating circuit M_1C for the purpose of rounding off the Morse impulses supplied by the battery B_1 and for preventing high frequency oscillations from reacting in a portion of the modulating circuit M_1C extending to the Morse relay M_1R . This relay may be located at a point distant from the modulating apparatus and may even be located at a separate station. The filter F_1 is preferably located near the modulating apparatus so that high frequency oscillations will not be transmitted over the portion of the circuit M_1C extending to the Morse relay, thereby substantially preventing transmission loss in the carrier circuit due to the shunt capacity of the modulating circuit and preventing also crosstalk in the station wiring.

The carrier apparatus for the other channels may be similar to that already described. In order, however, to illustrate another form of modulating arrangement, a modified form of apparatus is illustrated in connection with the fourth carrier channel. In the modified arrangement the oscillating tube T_2V functions both as an oscillator and a modulator while the tube T_2V' functions merely as an amplifier. In order to secure this result the modulating circuit M_2C is connected to the grid filament circuit of the oscillating tube T_2V as illustrated and includes the filter F_2 for the same purpose as the filter F_1 in the first form. The Morse relay M_2R controls the application of potential from the battery B_2 to the grid of the oscillating tube T_2V so that the amplitude of

the oscillations generated by the tube may be varied in accordance with the Morse signals.

The common receiving circuit RL is associated with the individual receiving channels through filters, such as, R_1F , R_2F , R_3F , R_4F , and so forth, which are preferably in the form of sharply tuned circuits, tuned to the particular frequency assigned to the corresponding receiving channel.

The apparatus associated with the first receiving channel only is illustrated and comprises amplifying and detecting tubes R_1V , R_1V' and R_1V'' . These tubes are provided with circuits of the usual type for amplifying and detecting and need not be further described. A receiving relay R_1R is included in the output circuit of the last tube in the series and responds to the detected Morse signals impressed upon the carrier frequency assigned to its particular channel. The carrier apparatus for the other channels may be similar to that above described.

The arrangements hereinbefore discussed constitute the apparatus at one terminal station of the main line ML. It will be understood that similar arrangements will be provided at the distant terminal station. It will also be noted that the carrier frequencies assigned to the several receiving channels which, for purposes of illustration, are indicated as being 7500, 8000, 8500 and 9000 cycles, respectively, are intermediate between the several frequencies of the corresponding transmitting channels. This "staggered" arrangement of the transmitting and receiving frequencies serves to supplement by a frequency separation the separation due to the balanced relation between corresponding transmitting and receiving channels. In actual practice it is impractical to secure accurate balance between the transmission line and the artificial balancing arrangement so that by transmitting and receiving at different frequencies the oscillations transmitted from, say the first channel and reacting in the common receiving circuit RL due to the slight unbalance existing, will be prevented from being transmitted to any of the individual receiving channels due to the fact that it is filtered out by the tuned circuits. It will be understood, of course, that the frequencies assigned to the transmitting channels at the distant station will be the same as those assigned to the corresponding receiving channels at the station illustrated, while the receiving channels at the distant station will have the same frequencies as the corresponding transmitting channels at the station illustrated.

The operation is as follows: Oscillations of the frequency assigned to the first channel are produced by the oscillator T_1V and are impressed upon the amplifying and modulating tube T_1V' and after being filtered by the tuned circuit T_1F , these oscillations, to-

gether with oscillations from the other transmitting channels, are impressed upon the common transmitting circuit TL. The Morse relay M_1R operating in response to Morse signals opens and closes circuit M_1C and applies impulses of direct current across the grid filament circuit of the modulating tube T_1B' . These impulses vary the potential on the grid of the modulating tube and consequently vary the amplitude of the oscillations transmitted through the filter T_1F . The direct current impulses in the modulating circuit M_1C are not square topped waves owing to the fact that they are rounded off by the action of the filter F_1 . Consequently, the transients which would tend to be produced by the sudden reaction of a square topped wave upon a tuned circuit are considerably reduced and the corresponding cross-talk effect between adjacent tuned circuits is to a large extent eliminated.

The high frequency oscillations impressed upon the common transmission circuit TL from the various transmitting channels are transmitted through the filter HF and over the common branch CB to the main line ML for transmission to the distant station where they are separated in the proper receiving channels and detected.

The receiving operation may be understood from a consideration of the action at the station illustrated with respect to transmission from the distant station. Assuming that oscillations corresponding to the several carrier frequencies are modulated by Morse signals at the distant station and transmitted over the line ML from the distant station, the several modulated frequencies will pass into the carrier branch CB and through the filter HF, being prevented from flowing to the terminal line LT by means of the low pass filter LF. The several frequencies after passing through the filter HF are transmitted through the balanced transformer 10 to the common receiving circuit RL and are separated by means of the filters R_1F , R_2F , and so forth, into the corresponding receiving channels. Modulated oscillations having normal carrier frequencies of 7500 cycles pass through a filter R_1F and are amplified and detected by the tubes R_1V , R_1V' and R_1V'' in a well known manner. The low frequency detected currents corresponding to the modulating Morse signals operate the receiving relay R_1R in a well known manner.

The operation of the modified form of modulating apparatus illustrated in connection with the fourth transmitting channel is similar to that already described. The tube T_2V oscillates at the frequency corresponding to the channel and the oscillations supplied are amplified by the amplifier T_2V' and transmitted through the filter T_2F to the common transmitting circuit TL. The

Morse relay MR in response to Morse impulses applies direct current impulses to the grid circuit of the oscillating tube T₂V, thereby varying the potential of the grid circuit to correspondingly vary the amplitude of the oscillations generated. The filter F₂ curbs or rounds off the Morse waves applied to the modulator to reduce the transients resulting from square topped waves and prevent high frequency oscillations from reacting in the modulating circuit M.C.

By means of the arrangement above disclosed the high frequency current can be kept out of the local control circuit by means of the filter included in such circuit and the transmitting relay can be located at any point in the operating room or at the distant end of a line extending to another station. The low frequency waves impressed upon the carrier oscillations can also be curbed to any desired extent thereby relieving the high frequency selective circuits of some or all of this duty with the consequent improvement in their selective action. While the invention has been illustrated as embodied in certain specific forms, 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 transmission system, a modulator, a source of alternating carrier current, connections for impressing carrier currents from said source upon said modulator, a controlling circuit for supplying telegraph impulses to said modulator, and a frequency selective filter in said controlling circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and without substantial attenuation frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, and the cut-off point being located well below the carrier frequency but sufficiently high to transmit the essential frequencies of the telegraph impulses thereby preventing the carrier current from reacting in said controlling circuit.

2. In a transmission system, a modulator, a source of alternating carrier current, connections for impressing carrier current from said source upon said modulator, a controlling circuit for supplying telegraph impulses to said modulator, and a frequency selective filter in said controlling circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above said cut-off point, the cut-off point be-

ing so set as to eliminate the higher harmonics of the dot telegraph frequency thereby rounding off the telegraph impulses and decreasing the transient oscillations due to sudden changes in the telegraph impulses.

3. In a transmission system, a vacuum tube modulator including a filament, grid and plate, an output circuit connected to the filament and plate and an input circuit connected to the grid and filament, a source of alternating carrier current, connections for supplying carrier currents from said source to the grid filament circuit, a controlling circuit for supplying telegraph impulses to said grid filament circuit, and a frequency selective filter in said controlling circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing frequencies above the cut-off point, the cut-off point of the filter being set well below the carrier frequency but sufficiently high to freely transmit the essential frequencies of the telegraph impulses thereby preventing the carrier currents from reacting in said controlling circuit.

4. In a transmission system, a vacuum tube modulator including a filament, grid and plate, an output circuit connected to the filament and plate and an input circuit connected to the grid and filament, a source of alternating carrier current, connections for supplying carrier current from said source to the grid filament circuit, a controlling circuit for supplying telegraph impulses to said grid filament circuit, and a frequency selective filter in said controlling circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point being so set as to suppress the higher harmonics of the fundamental dot telegraph frequency thereby curbing said telegraph impulses and decreasing the transient oscillations due to sudden changes in the telegraph impulses.

5. In multiplex carrier telegraphy, the method of reducing interference between neighboring high frequency channels which comprises preventing the transmission of the unessential side frequencies of the high frequency wave of each channel before impressing the bands upon the channel selecting circuits, and then transmitting the bands thus narrowed through channel selecting circuits.

6. In high frequency multiplex telegraphy in which high frequency waves are varied in accordance with low frequency signaling impulses, the method of reducing interference between neighboring high fre-

quency channels which comprises reducing the abruptness of the signal variations in the modulated high frequency waves.

7. In high frequency multiplex telegraphy in which high frequency waves are varied in accordance with low frequency signaling impulses, the method of reducing interference between neighboring high frequency channels which comprises reducing the abruptness of the variations in the high frequency waves by modifying the wave form of the low frequency signaling impulses.

8. In high frequency telegraphy in which a high frequency wave is controlled in accordance with low frequency signaling impulses, the method of eliminating the unessential side frequencies accompanying a transmitted high frequency wave which comprises selectively attenuating the low frequency signaling impulses used to control said high frequency wave.

9. The method of high frequency telegraph transmission which comprises producing high frequency waves and low frequency signaling impulses, attenuating selectively said low frequency signaling impulses to reduce their sharpness, and controlling said high frequency wave in accordance with the attenuated signaling impulses.

10. The method of producing a signal-controlled high frequency wave for telegraphy, unaccompanied by unessential side frequencies, which comprises producing a high frequency wave, producing telegraph signal impulses, selectively attenuating said impulses to reduce their sharpness, and controlling said high frequency wave in accordance with said attenuated signal impulses.

11. A signal transmitting system comprising a source of high frequency carrier waves, a source of substantially abrupt signaling impulses, a circuit for transmitting said impulses, said circuit including a selective filter for reducing the sharpness of said impulses, the said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point being so set as to eliminate the higher harmonics of the fundamental dot frequency, and means for controlling said high frequency wave in accordance with the signaling impulses as modified after transmission through the filter.

12. In a high frequency signaling system, means for producing high frequency carrier waves controlled in accordance with low frequency signaling impulses, and means for eliminating the unessential side frequencies of said high frequency waves, said means comprising a selective filter through which

low frequency impulses are transmitted, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially, negligible attenuation all frequencies below the cut-off point while substantially suppressing frequencies above the cut-off point, the cut-off point being so set as to suppress the higher harmonics of the fundamental dot signaling impulses.

13. In a high frequency signaling system, means for producing a high frequency carrier wave controlled in accordance with low frequency signaling impulses, and means for eliminating the unessential side frequencies of said high frequency wave, said means comprising a selective filter through which the low frequency impulses are transmitted, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing frequencies above the cut-off point, the cut-off point being so set as to eliminate the higher harmonics of the fundamental dot signaling impulses thereby reducing the sharpness of said impulses.

14. In a high-frequency signaling system, a source of high frequency carrier waves, means for transmitting said waves, a circuit for controlling said waves in accordance with low frequency signaling impulses, and a low pass filter in said circuit for transmitting said impulses, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point of the filter being so set as to eliminate the higher harmonics of the fundamental dot signaling impulses thereby reducing the abruptness of said impulses.

15. In a high frequency signaling system, a source of high frequency carrier waves, a device for acting upon said waves to control their transmission, a circuit for acting upon said device in accordance with signaling impulses in said circuit, and a low pass filter in said circuit for transmitting said signaling impulses, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point being so set as to eliminate the higher harmonics of the fundamental dot signaling impulses thereby rounding off said signaling impulses before acting upon said controlling device.

16. In a high frequency telegraph system, a line, sources of high frequency waves for

said line, means for varying the energy of each high frequency wave in accordance with signal impulses to be transmitted, and means for reducing interference between
 5 said different high frequency waves comprising filters for reducing the sharpness of the signal impulses used to vary the several high frequency waves.

17. In a high frequency signaling system,
 10 a source of high frequency carrier waves, a repeater for reproducing said waves for transmission, connections between said source and said repeater, a circuit for controlling the reproduction of said waves by
 15 said repeater, a source of signaling impulses in said circuit, and a frequency selective filter in said circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with
 20 substantially negligible attenuation all frequencies below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point being so
 25 set as to eliminate the higher harmonics of the fundamental dot signaling impulses thereby reducing the abruptness of said impulses.

18. In a high frequency telegraph system, a source of high frequency waves, an amplifier for said waves, connections between
 30 said source and said amplifier, a circuit for controlling said amplifier in accordance with telegraphic signals to transmit said waves and a low pass filter in said circuit
 35 for reducing the abruptness of said signals.

19. In a high frequency telegraph system, a generator of sustained high frequency waves, a circuit for producing telegraphic signals comprising a line including a source
 40 of direct current, and a key, selective at-

tenuating means in said circuit for reducing the abruptness of the "makes" and "breaks" by said key, a current controlling element, connections between said generator and said current controlling element, and
 45 means for impressing said high frequency waves and the attenuated telegraphic signals upon said element to control transmission of the high frequency wave in accordance with the impressed signals.

20. In a high frequency telegraph system, a transmitting amplifier comprising a suitably mounted cathode, anode, and a grid impedance controlling element, a grid battery for normally making the input impedance of the amplifier practically infinite, a
 55 source of high frequency carrier waves for said amplifier, connections between said source and said amplifier, a circuit for decreasing the input impedance of said amplifier to transmit said high frequency waves
 60 in accordance with telegraphic signals, said circuit including a source of voltage to oppose the voltage of said grid battery, a key for controlling said circuit, and a selective
 65 filter in said circuit, said filter having a substantially sharp cut-off and being so designed as to transmit uniformly and with substantially negligible attenuation all frequencies
 70 below the cut-off point while substantially suppressing all frequencies above the cut-off point, the cut-off point of said filter being so set as to eliminate the higher harmonics of the fundamental dot telegraph
 75 impulses thereby reducing the sharpness of the telegraphic impulses in said circuit.

In testimony whereof, I have signed my name to this specification this 28th day of July, 1919.

LLOYD ESPENSCHIED.