Feb. 3, 1942. J. E. SMITH 2,271,721

METHOD AND MEANS FOR TRANSMITTING A PLURALITY OF SIGNALS OVER THE SAME CHANNEL

Filed May 3, 1939 2 Sheets-Sheet 1

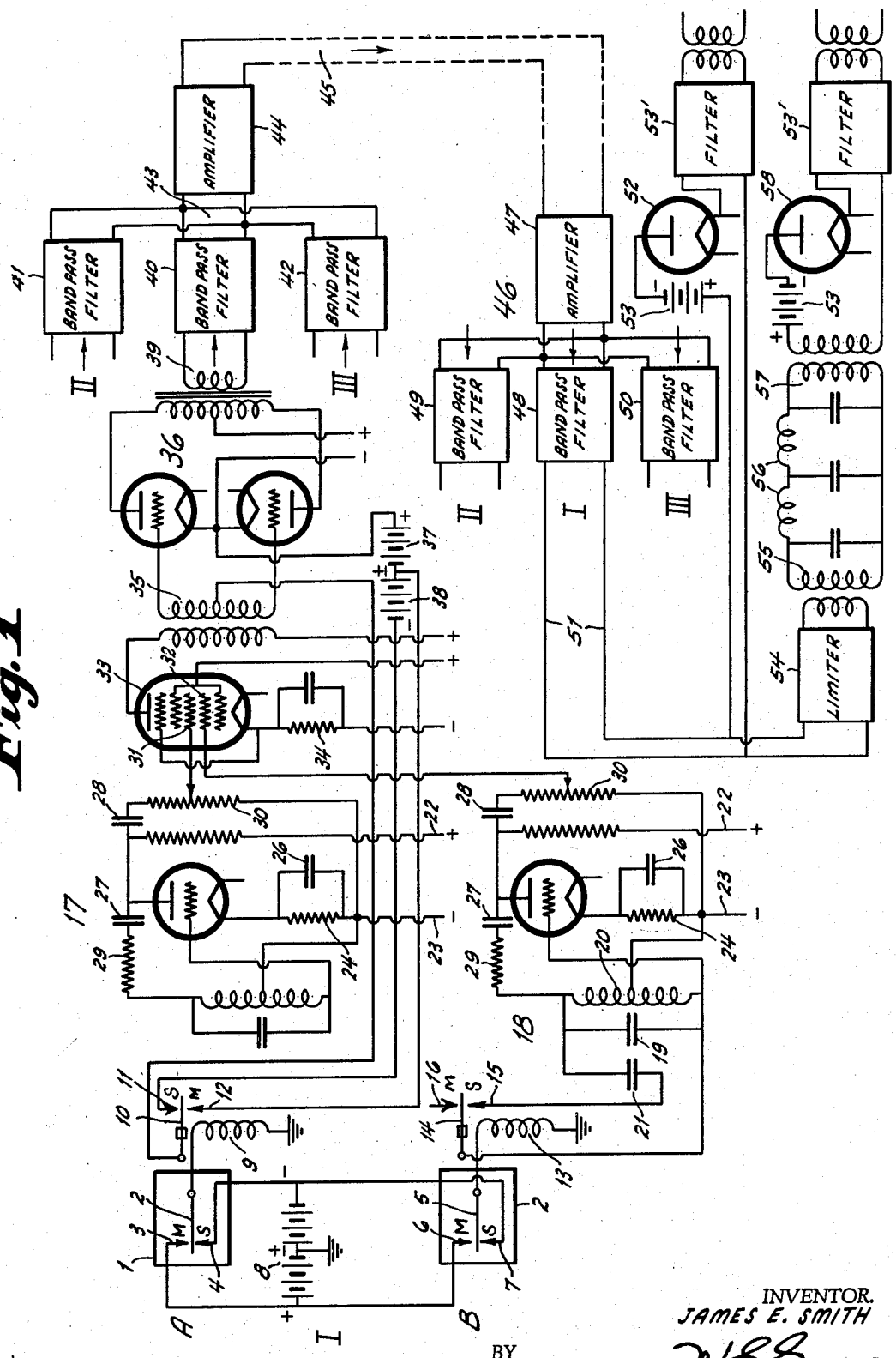

Fig. 1

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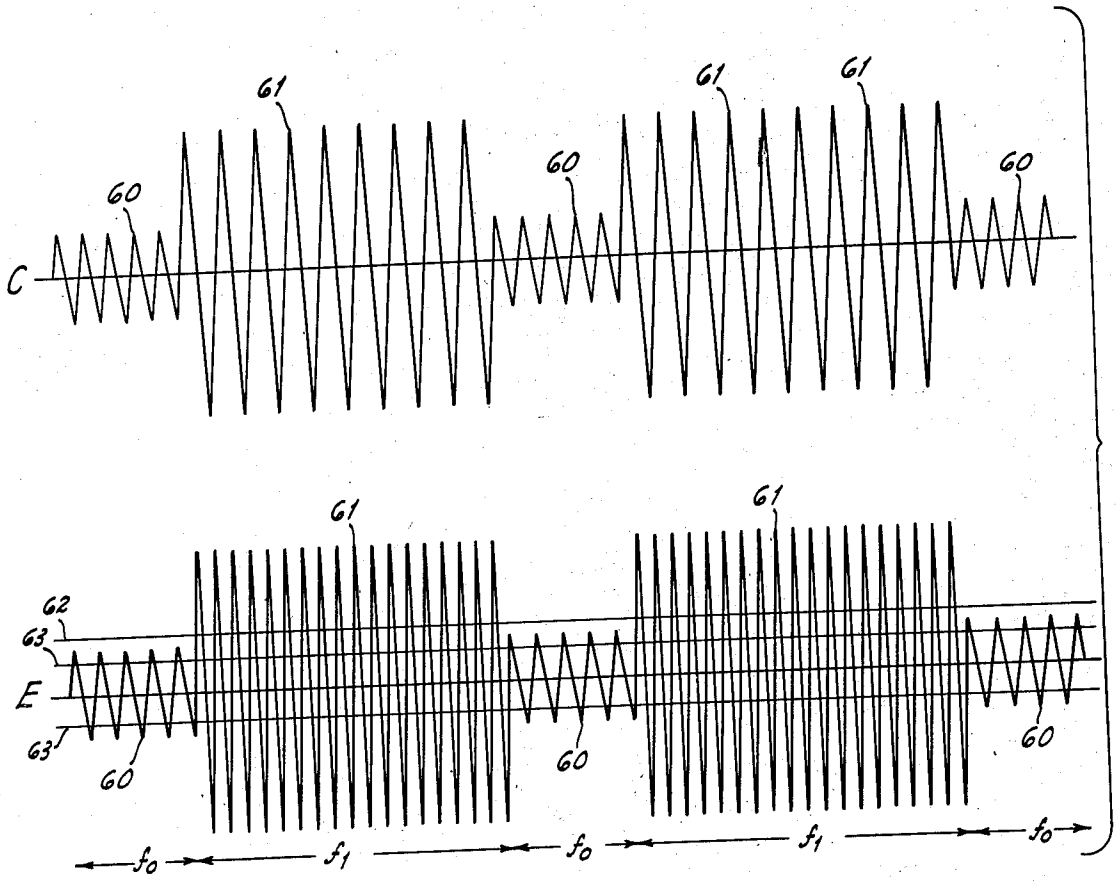

Fig. 2

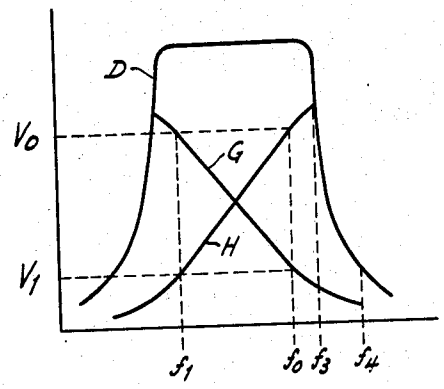

Fig. 3

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Patented Feb. 3, 1942

2,271,721

UNITED STATES PATENT OFFICE

2,271,721

METHOD AND MEANS FOR TRANSMITTING A PLURALITY OF SIGNALS OVER THE SAME CHANNEL

James Ernest Smith, Brooklyn, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application May 3, 1939, Serial No. 271,460

9 Claims. (Cl. 178—51)

This invention relates to radio signaling and particularly to radio telegraphic signaling in which a plurality of messages are sent over the same wire or radio link. The invention is capable of other uses but for purposes of explanation it will be disclosed in connection with a radio telegraph system in which a plurality of signals are sent over conducting wires to a radio transmitting station where the signals may be transmitted by radio to distant points. In a system of this sort the point of origin in the signal transmission is usually located in a large city and the transmitting station is a considerable distance away. The signals are transmitted over wire lines from the central office to the transmitting station in various forms of multiplexing, one being to convert the D. C. mark and space signals into interrupted alternating current that is referred to as tone frequencies because the frequency is sufficiently low to be heard in a telephone head set.

To send a plurality of signals over the line connection to the radio station, a plurality of tone frequencies have been used with appropriate band pass filters to separate the tone frequencies at the radio transmitting station. When the wire line is used as a single channel, for example, the interrupted tone current will be of optimum value so as to be well above the noise level. As this same conductor is progressively loaded with signals from additional channels, all tone generators will have the current progressively decreased and finally when the maximum number of channels is routed over one conductor the tone generator current on each channel will be decreased to such an extent that it may be within the noise level, which of course is quite objectionable.

It is an object of my invention to overcome this difficulty by providing means for increasing the wire line signals by interrupting the tone generator for one set of signals while varying the frequency of that same signal current for another set of signals.

Another object of the invention is to increase the wire line messages without reducing the wire line current.

Other objects will appear in the following description, reference being had to the drawings in which:

Fig. 1 is a part diagrammatic illustration and part block illustration of a transmission system for sending a plurality of messages in accordance with my invention.

Fig. 2 is a set of graphs illustrating the principles of the invention.

Fig. 3 is a set of graphs showing the voltage-frequency characteristics of filters used with varying amplitude and varying frequency signals.

Referring to the drawings, in Fig. 1, 1 indicates a perforated tape transmitting device of the Wheatstone, Creed or other type. These devices are well known in the art and have long been used for transmitting telegraph signals so the transmitter 1 is shown only in diagrammatic form as consisting of a switch member 2 caused to vibrate alternately against positive contact 3 and negative contact 4 by well known perforated tape mechanism, not shown. Transmitting device 2 may be a duplicate of device 1 in which the switch member 5 alternately contacts positive contact 6 and negative contact 7. Battery 8 is illustrated as the source of voltage supply for the devices 1 and 2. Polar relay coil 9 is connected to switch 2 and when energized moves the switch tongue 10 against either contact 11 or contact 12, depending upon the polarization chosen and the direction of current through the coil. Relay coil 13 is similarly connected to switch 5 and operates polar tongue 14. Contact 15 in this relay is the only one that conducts current, 16 being a dead contact. The illustration shows the polarization such that contacts 3, 12, 6 and 16 are mark contacts and contacts 4, 11, 7 and 15 are space contacts.

The tone generator could be an alternating current generator of any type but for convenience of control I prefer to use the beat type of oscillator where the tone frequency is produced by beating together of two vacuum tube oscillators. Reference character 17 generally indicates one oscillator which may have any desired frequency, for example, 75 kilocycles, and the other one differing therefrom by two beat frequencies, say .8 kilocycle and .7 kilocycle. In this case condenser 19 is connected in fixed relation with the inductance 20 so as to determine the frequency of 75.8 kilocycles in the oscillator 18. Condenser 21 is adapted to be connected in parallel with condenser 19 by switch tongue 14 which will change the frequency to 75.7.

The plate supply of oscillators 17 and 18 is indicated by terminals 22, 23. The voltage may be of any desired value. A negative bias may be placed on these oscillators of any sort, but I have illustrated by way of example resistance 24 having bypass condenser 26 for this purpose. Condensers 27 and 28 and resistances 29 and 30 are connected to the input and output electrode through coil 20 to constitute the well known Hartley oscillating circuit. Resistance 30 of

oscillator 17 is adjustably connected to control grid 31 and resistance 30 of oscillator 18 is similarly connected to control grid 32 of a mixing tube 33. This tube may have the usual plate and screen grid supply of suitable voltages and an appropriate bias typified by resistance 34, as well as a suppressor grid connected to the filament. The plate circuit of tube 33 feeds into the input coil 35 of a push pull keying-stage indicated generally at 36.

Tape transmitter 1 is adapted to apply a negative bias 37 to this keying stage on the signal mark and a greater bias by adding an additional battery 38 on the space of the signal, or the reverse if desired. This bias is not of the usual value that would block the grids of the keying stage on the space. It has sufficient negative bias value to permit some current to flow through the plate circuit of the push pull tubes on the space part of the signal. The amount of current allowed to thus flow through may be varied but I have found it satisfactory to permit 20% of the marking value of current to flow on the spaces of the signal for a purpose that will be later apparent.

The output of keying stage 36 passes into input coil 39 of a band pass filter 40 of the usual construction. Similar band pass filters 41 and 42 may pass signals of channels II and III. These will have frequencies differing from each other and from the frequencies of channel I and they may be equipped as in channel I for amplitude and frequency modulated signals if desired. Any number of these channels may be used and I have shown three only by way of example. All the channels unite at the input 43 of amplifier 44 to boost the signals to any desired value for transmission over the long lines 45 to the radio transmission station indicated generally at 46. At the transmission station the signals may be further amplified by the usual type of amplifier 47. The output of this amplifier contains all the signals.

The signals of channel I, both the A message and B message, pass through band pass filter 48 and the messages of channels II and III pass through band pass filters 49 and 50 respectively. Since the invention may be explained in connection with channel I, the apparatus for channels II and III is not further illustrated.

The output lines 51 of band pass filter 48 contain, as previously indicated, the A and B signals. Rectifier 52 connected to input lines 51 converts voltage therefrom into direct current voltage. Bias 53 causes this rectifier to pass current only above a predetermined threshold value. Filter 53' may be of the usual construction for smoothing out the alternating components.

The B signal which is frequency modulated, is passed through voltage limiter 54 of any desired type. These limiters are well known in the art and the details are therefore not illustrated. The output of the limiter passes into input coil 55 of a frequency converter or demodulator consisting of a plurality of series coils 56 and a plurality of shunt condensers 57. This arrangement is the well known type of low pass filter. The output of the converter passes into rectifier 58 having, if desired, a threshold bias 53 and the output of the rectifier passes into smoothing filter 53'.

The operation of the embodiment disclosing my invention will now be described.

Referring to Fig. 1, perforated tapes not illustrated containing the A and B signals will operate the pecker pins typified by switches 2 and 5, for example, to alternately engage contacts 3, 6, and 4, 7, on the mark and space parts of the signal. If no B signal is being transmitted the tone frequency will be, in the example given, 800 cycles because condenser 19 will be the only one in circuit with coil 20 of oscillator 18 and the beat produced will have this value. Therefore, as the A message is being sent the tone frequency signal produced by the shifting of the bias on keying stage 36 will produce an alternating current signal of a single frequency of 800 cycles for both marks and spaces as indicated by graph C in Fig. 2. In this stage there is still 20% current at 60 for the spaces. Reference character 61 indicates the mark of the signal, though of course the reverse could be the case as it is common practice to reverse signals. Band pass filter 40 passes the signal current of the keying stage 36 in accordance with graph D in Fig. 3, f_1 indicating the frequency at which the A signal is being sent when no B signal is being transmitted.

If a B signal is transmitted simultaneously with the A signal, pecker pins typified by switch 5 will be operated by the perforated tape, not shown, to alternately engage contacts 6 and 7. This will energize polar relay 13 and alternately move the switch tongue 14 between live contact 15 and dead contact 16. This, in accordance with the assumption previously made, will produce a frequency of 75.8 cycles for the mark of the signal by including condenser 19 alone in the oscillating circuit of the input of oscillator 18 when contact 16 is engaged.

When contact 15 is engaged for the space of the signal the inclusion of condenser 21 in the oscillating circuit of the input of oscillator 18 will cause this oscillator to have a frequency of 75.7 kilocycles. Therefore, message B will be transmitted by a varying beat frequency having 800 cycles for the mark and 700 cycles for the space of the signal. If no A signal were being transmitted the mark and space would be of uniform amplitude but when the A signal is being transmitted the combined A and B signals will be indicated by graph E of Fig. 2. Here as in graph C, reference character 60 and 61 will indicate the space and mark signals respectively of the A message by the difference in amplitude of the current. In this case the A transmitter 1 varies the amplitude of a tone current having first a frequency of 700 and then a frequency of 800. As is illustrated in the drawings, the space is one frequency and the mark another frequency, but this is for illustration purposes only. The frequency of the tone generator might just as well change at any other points of the keying in the A signal.

The signal of the general form indicated in graph E will be combined with other signals of channels 2 and 3, if any, or even with a still greater number of channels. The combined current will be amplified by the usual amplifier 44, after which it will be transmitted over the long lines 45, to the transmitting station or to any other point.

At the transmitting station the combined current may be further amplified at 47 and the combined voltages appear at the inputs of all of the band pass filters 48, 49 and 50. Band pass filter 48 will be adjusted to pass only the varying beat frequency and to exclude the frequencies of tone frequencies, variable or not, of channels II and III. The voltage frequency characteristic of the band pass filter 48 is indicated by curve D in Fig. 3. This band pass filter is of sufficient width,

figuratively speaking, to pass the frequencies 700 cycles and 800 cycles indicated at f_1 and f_0 in Fig. 3.

The amplitude-modulated variable frequency voltage wave of graph E in Fig. 2 will appear at the input of both rectifier **52** and limiter **54**. By arranging the rectifier **52** either by an appropriate bias **53** or by other means known in the art, current above the line **62** in Fig. 2 only, will be passed. This will eliminate the pulsating current **60** in the spaces. The output of rectifier **52** passes preferably through a filter **53'** to smooth out the alternating component in the marking indication **61** of the signal. The pulsating unidirectional wave in the output of the filter **53'** can then be interpreted in any way, either recorded as a received message in a wire or cable telegraph system, or used to modulate a radio transmitter for transmission to distant points. This part of the system is not a part of my invention and is not described.

The limiter **54** which may be of any well known type, for example, as shown in my joint application with James N. Whitaker and Gilbert R. Clark, Serial No. 270,332, filed April 27, 1939, may be used for this purpose. This limiter will be so adjusted that current values greater than the maximum value of the spacing current **60**, will be cut off, for example, the limiter may be adjusted to cut off the signal at the lines **63**. Alternating current of uniform maximum amplitude will thus be introduced into secondary **55** of the frequency converter, or demodulator, and the amplitude of the voltage in the output of this converter will vary with the frequency. As the frequency increases the voltage will decrease, as shown by curve G of Fig. 3. Therefore, the voltage at the terminals of the rectifier **58** will be amplitude modulated and will have high and low portions for the marks and spaces. The output of the rectifier may be passed through a filter **53'** to smooth out the alternating components. By use of a threshold device such as bias **53**, for example, the output of the rectifier may be made to have current only for the marks of the signal and the output of the rectifier **58** will be of the same character as the output of rectifier **52**. This may be interpreted as a message at the final receiving station of a wire system or may be used to modulate a radio transmitter for transmission to distant points through the air. It will be apparent that my improvement can be used in strictly wire line communication or in a radio system.

Instead of using a low pass filter I may shift the sub-carrier frequency to one side of the channel filter to position f_3 in Fig. 3. The lower frequency value of the beat would then be f_3 and the upper frequency value would be f_4. The band pass filter would perform a double duty by acting also as a converter or demodulator. With this arrangement only one side band of the amplitude modulated A signal would pass through the band pass filter.

Instead of using low pass filters for a converter I also may use high pass filters. The voltage frequency characteristic in this case would be indicated by reference character H. Various other modifications may be made without departing from the spirit of the invention.

Having described my invention, what I claim is:

1. In a telegraph reception, a link having a signal wave with its frequency and its amplitude changing from a higher to a lower value to indicate two messages, two utilization circuits, a limiter connected between said link and one of said circuits for passing current only above the lower amplitude value and a limiter connected between said link and the other of said circuits for passing current only below said amplitude value.

2. In a telegraph reception, a link having a signal wave with its frequency and its amplitude changing from a higher to a lower value to indicate two messages, two utilization circuits, a limiting rectifier connected between said link and one of said circuits for passing current thereinto only above the lower amplitude value and a limiter connected between said link and the other of said circuits for passing current thereinto only below said amplitude value.

3. In telegraph reception, a link having a signal wave with its frequency and its amplitude changing from a higher to a lower value to indicate two messages, a limiting rectifier connected to said link for passing current only above the lower amplitude value, a limiter connected to said link for passing current only below said amplitude value, a filter connected to said rectifier to eliminate the frequency changes in its output and means connected to said limiter to convert the frequency changes in its output into amplitude modulation with two amplitude values.

4. In telegraph reception, a link having a signal wave with its frequency and its amplitude changing from a higher to a lower value to indicate two messages, a limiting rectifier connected to said link for passing current only above the lower amplitude value, a limiter connected to said link for passing current only below said amplitude value, a filter connected to said rectifier to eliminate the frequency changes in its output, means connected to said limiter to convert the two frequency values in its output into amplitude modulation with two amplitude values and a limiting rectifier connected to said means for passing current only above the lowest of the last-mentioned values.

5. In telegraph reception, a link having a signal wave with its frequency and its amplitude changing from a higher to a lower value to indicate two messages, a limiting rectifier connected to said link for passing current only above the lower amplitude value, a limiter connected to said link for passing current only below said amplitude value, a filter connected to said rectifier to eliminate the frequency changes in its output, means connected to said limiter to convert the two frequency values in its output into amplitude modulation with two amplitude values, a limiting rectifier connected to said means for passing current only above the lowest of the last-mentioned values and a filter connected to the last-mentioned rectifier to eliminate frequency changes therein.

6. In the reception of a wave having its amplitude varied between two finite values to produce mark and space signals of one telegraph message and the frequency of the wave varied to produce mark and space signals of another message, the steps in the method which consists in passing wave energy of one sign only above the lower of said values into one circuit to eliminate the frequency variations of the second message in the spaces of the first message and passing wave energy below said lower value into another circuit to eliminate the amplitude variations of the first message.

7. In the reception of a wave having its amplitude varied between two finite values to produce

mark and space signals of one telegraph message and the frequency of the wave varied to product mark and space signals of another message, the steps in the method which consists in rectifying and passing wave energy above the lower of said values into one circuit to eliminate the frequency variations of the second message in the spaces of the first message, filtering the passed energy to smooth out the frequency variations in the marks, passing wave energy below said lower value into another circuit to eliminate the amplitude variations of the first message and converting the frequency variations of the last-mentioned energy into amplitude variations.

8. In the reception of a wave having its amplitude varied between two finite values to produce mark and space signals of one telegraph message and the frequency of the wave varied to produce mark and space signals of another message, the steps in the method which consists in rectifying and passing wave energy, against a counter electromotive force equal to the lower of said values to eliminate the frequency variations of the second message in the spaces of the first message, filtering the passed energy to smooth out the frequency variations in the marks, passing wave energy below said lower value into another circuit to eliminate the amplitude variations of the first message and converting the frequency variations of the last-mentioned energy into amplitude variations.

9. In the reception of a wave having its amplitude varied between two finite values to produce mark and space signals of one telegraph message and the frequency of the wave varied to produce mark and space signals of another message, the method which consists in rectifying and passing wave energy above the lower of said values into one circuit to eliminate the frequency variations of the second message in the spaces of the first message, filtering the passed energy to smooth out the frequency variations in the marks, indicating said passed energy to reproduce the first message, passing wave energy below said lower value to eliminate the amplitude variations of the first message, converting the frequency variations of the last-mentioned energy into amplitude variations and indicating the last-mentioned variations to reproduce the second message.

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