1,530,660

March 24, 1925. 1,530,660

W. F. FRIEDMAN

PRINTING TELEGRAPH SYSTEM

Filed July 26, 1922

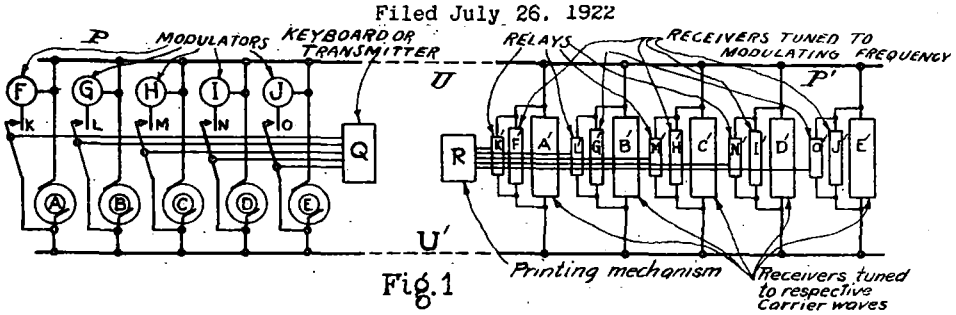

Fig. 1

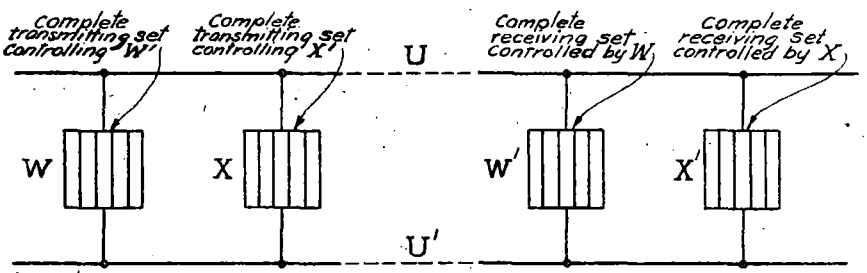

Fig. 2

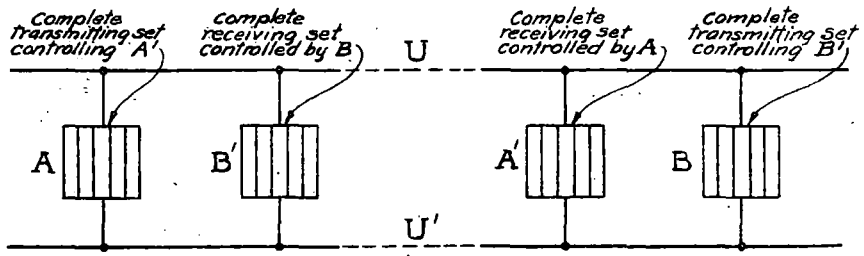

Fig. 3

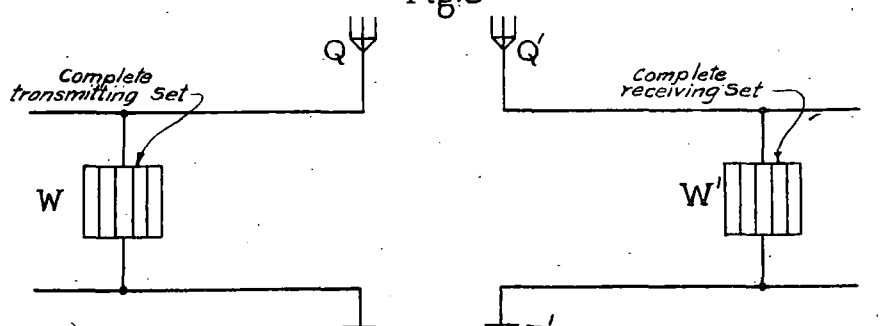

Fig. 4

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Patented Mar. 24, 1925. 1,530,660

UNITED STATES PATENT OFFICE.

WILLIAM F. FRIEDMAN, OF WASHINGTON, DISTRICT OF COLUMBIA.

PRINTING-TELEGRAPH SYSTEM.

Application filed July 26, 1922. Serial No. 577,649.

To all whom it may concern:

Be it known that I, WILLIAM F. FRIEDMAN, citizen of the United States of America, residing at 3220 17th Street NW., in the city of Washington and District of Columbia, have invented certain new and useful Improvements in Printing-Telegraph Systems, of which the following is a specification.

This invention relates to improvements in electrical signaling systems, more particularly to printing telegraph systems, and has for its object the simultaneous transmission and reception of a plurality of code signal impulses representing the individual elements of the message characters that are transmitted.

A further object is to reduce very materially the length of time necessary in the heretofore prevalent printing telegraph systems to transmit the code signals representing the message characters and thus increase the capacity of the line or channel employed.

A further object is to increase the number of separate messages which can be transmitted and received simultaneously, thus also increasing the capacity of the line or channel employed.

A further object is to eliminate the necessity for the employment of synchronizing mechanisms such as are required in the heretofore prevalent systems.

The invention will here be illustrated as applied to a well known form of printing telegraph systems, but, as will be readily understood, is applicable to many other electrical systems and devices which at present necessitates the use of more or less complicated synchronizing devices.

The fundamental principle of my invention is the substitution of a plurality of modulated high frequency oscillations of different frequencies all transmitted simultaneously and instantaneously for a plurality of similar, equal potential, direct current impulses distributed through time.

In the heretofore prevalent forms of printing telegraph systems, the automatic operations concerned in causing a printing mechanism to function at a distance are controlled by groups of equal potential, direct current electrical impulses which pass over one and the same line, and actuate a set of relays, each impulse in the group affecting the operation of a particular relay, by a method described below. These relays actuate magnets which set up combinations of selecting discs in a printing mechanism, and each character of the message is determined by a different combination or arrangement of these selecting discs. Usually there are 32 such combinations, 26 for the ordinary letters and 6 others concerned in certain functions of the printer, such as carriage return, figure shift, and so on. The signals for message characters as commonly used in these systems, constitute what is usually termed a five-unit code, that is, it consists of permutations of two elements taken five at a time. In one system of operation these two elements may be positive and negative potentials, in which case the code signal for a character consists of the distribution through time of five elements composed of positive and negative impulses. In another system of operation the two elements may consist of a time-interval when an impulse is sent, and a time-interval when no impulse is sent, this being the method of closed and open circuit operation. The code signal for the letter "A", for example, is "++———", which in the positive and negative system of operation means that the first and second units of the signal are positive impulses, the third, fourth, and fifth, are negative impulses. In the open and closed circuit system of operation, this code signal means that only the first two time units are occupied by the passage of current, the last three, unoccupied. The permutations of transmitted impulses are governed by a set of make and break keys operated at the transmitting end manually, by means of a sending keyboard similar in form to the ordinary typewriter keyboard, or automatically by means of a transmitter controlled by a perforated tape.

In order that a plurality of relays shall be controlled by impulses of equal potential, and all coming over the same line, or through the same channel, and that the permutation of relays actuated at the distant end shall correspond to the permutation of depressed keys at the sending end, in the heretofore prevalent systems, connection is momentarily established between each key at the sending end and its corresponding relay at the receiving end and the five temporary connections between the five pairs of keys and relays are established in a fixed sequence, one after the other. Thus, for example, in the case of five relays respec-

tively controlled by five make and break keys, the time necessary to send the signals for one message character or letter is divided up into five equal intervals; during the first interval key 1 at the sending end is connected with its corresponding relay 1 at the receiving end; during the second interval, key 2 at the sending end is connected with its corresponding relay 2 at the receiving end, and so on. The method of effecting such a correspondence in action by transmiting similar impulses through one and the same channel involves the use of a distributor and various other apparatus included under the general term "synchronizing mechanism."

The principle of the synchronizing distributor is this: Two similar rings, one on the sending face of a distributor at the transmitting station, the other on the receiving face of an identical distributor at the receiving station, are each divided into at least five equal segments. A pair of rotating brushes on these distributors are connected to the line, and when these brushes revolve they sweep over and make contact with the segments of their respective rings. The brushes at the two ends of the line start from the same relative position and sweep over the contact segments with the same uniform angular velocity, thus connecting the first segment of the ring of the sending distributor with the first segment of the ring of the receiving distributor once per revolution of the brushes. Likewise, the second, third, fourth and fifth segments of the sending distributor are connected once per revolution of the brushes with the corresponding segments of the receiving distributor, the interval of each connection being the time of one-fifth of a revolution of the rotating brushes. Thus, each message character is transmitted as a combination of five separate or discrete impulses distributed equally and in a definite sequence through an interval of time, and for each revolution of the brushes, the code impulse combinations for one and only one character or letter are transmitted and received. The synchronization of the two distributors so that the respective brushes revolve with exactly the same angular velocity is a very complex feature of these printing telegraph systems, and acts as a limiting factor upon the speed of operation. In my system no such synchronization is necessary, for all of the signals comprising the combination of impulses for a single character are transmitted simultaneonsly, and at the receiving end are properly isolated by five selectively tuned circuits.

In order that the invention and its mode of application may be readily understood by persons skilled in the art, I have, in the accompanying illustrative drawings, and in the detailed following description based thereon, set forth an embodiment of the same.

Figure 1 is a diagrammatic sketch of one form of arrangement of circuits whereby each of a plurality of high frequency alternating currents may be modulated or non-modulated in permutations corresponding to code signals for message characters, the modulated currents impressed upon a line, and the modulations isolated at the receiving end by a plurality of selectively tuned circuits.

Figure 2 is a diagrammatic sketch of one form of arrangement of circuits whereby a plurality of complete sets of modulated alternating currents are simultaneously impressed upon a line, the members of each set being isolated at the receiving end by a plurality of selectively tuned circuits, thus effecting multiplex operation.

Figure 3 is a diagrammatic sketch of an arrangement of circuits for the simultaneous operation of transmitting and receiving sets at the same end of the line so that stations may transmit and receive messages at the same time at both ends of the line.

Figure 4 is similar to Figure 1, except that the arrangements in the former are adapted for communication by radio.

Having more particular reference to the drawings and in connection with which like characters of reference designate similar parts throughout, in Figure 1, A, B, C, D, and E, are sources of high frequency alternating current of different frequencies, called hereafter "carrier waves" each of which is modulated telegraphically, by means now well-known in the art through the imposition of modulating frequency by modulators F, G, H, I, and J, respectively, when keys K, L, M, N, and O are operated. Q is a sending keyboard of well known form, or an automatic tape-controlled transmitter, also of well known form, which governs the action of the keys K to O in a permutative manner according the the combinations of the code signals representing message characters.

Let us suppose, for purposes of illustration, that A is a source of carrier wave current of a frequency of 20000 cycles per second; B is a source of carrier wave current of a frequency of 30000 cycles per second, and so on, up to E, which is a source of carrier wave current of a frequency of 60000 cycles per second. F modulates carrier wave A by 1000 cycles per second when key K is closed; similarly G, H, I, and J modulate the carrier waves B, C, D, and E, respectively by 1000 cycles per second, when keys L, M, N, and O, respectively, are closed. The modulated carrier waves are impressed upon the lines U and U', which at the receiving end branch off into the five

bridged across the lines U and U', I do not wish to restrict myself to this method of connections, for the modulated carrier waves may just as feasibly be inserted directly in series with the line circuit.

Furthermore, since the modulating frequency is the same for all the carrier waves, instead of having separate modulating elements such as those shown in F, G, H, I, and J, it is, of course, quite possible to have a single modulating element suitably connected to the keys K, L, M, N, and O, so that the modulation may be imposed upon any of the carrier waves.

Furthermore, the generators here described have a single period, but multi-period generators may be used, in which case the individual frequencies would be used in the separate transmitter circuits.

It is to be understood that either a two-wire complete metallic circuit, or a single wire ground return circuit is possible. In the drawings, the former method is shown.

While I have illustrated my invention as utilizing a code consisting of five elements, it is obvious that a code of a greater number of elements may just as easily be used, depending upon the printing mechanism that is employed, and I therefore do not wish to limit myself to a code consisting of any particular number of elements.

It is also obvious that instead of using a line upon which the modulated carrier waves are impressed, the modulated carrier waves may be of radio-frequencies and radiated into space by means of an antenna or any other suitable radiating device. This is shown in Figure 4 in which an antenna Q, with its ground, R, serves to radiate the waves into space and at the receiving station a corresponding antenna Q', with its ground, R', serves to receive the radiated waves. In this figure W and W' represent all the elements included under P and P', respectively, in Figure 1. The method of employing modulated different frequency carrier waves to eliminate the necessity of synchronizing mechanisms can also be applied to systems other than printing telegraphs, and it is intended that this feature be included among the others of my invention.

In fact, several modifications of the system are possible without departing from the spirit of the invention or the scope of the claims.

What I claim as my invention is the following:

1. In a printing telegraph system, the combination of a set of generators of radio-frequency oscillations of different radio-frequencies, means for telegraphically modulating said oscillations by a single modulating frequency, a set of make and break keys respectively controlling the modulation or non-modulation of said set of oscillations by said modulating frequency, means for operating said set of keys simultaneously and permutatively to correspond to the permutations of a plural-unit signaling code representing message characters, means for radiating said permutations of modulated and non-modulated oscillations simultaneously into space, means for receiving and detecting said radiated oscillations, said last named means being associated with a set of receiving instruments suitably arranged to isolate the respective said oscillations, means for detecting the presence or absence of modulation in each of said isolated oscillations, each of said last-named means being associated with and controlling a relay which is energized when said modulation is present, but is unenergized when said modulation is absent, and a printing or recording mechanism controlled by the permutative operation of said energized and unenergized relays.

2. In a multiplex printing telegraph system, the combination of a plurality of generators of radio-frequency oscillations of different radio frequencies, means for telegraphically modulating said oscillations in each set by a single modulating frequency, a plurality of sets of make and break keys respectively controlling the modulation or non-modulation oscillations by said modulating frequency, means for operating said sets of keys simultaneously and permutatively, to correspond to the permutations of a plural-unit signaling code representing message characters, means for radiating said sets of permutations of modulated and non-modulated oscillations into space simultaneously, a plurality of sets of receiving instruments tuned to receive and to isolate said radiated sets of oscillations, means for detecting the presence or absence of modulation in each of said isolated oscillations in each of said sets of oscillations, each of said last-named means being associated with and controlling a relay which is energized when said modulation is present, but is unenergized when said modulation is absent, and a plurality of printing or recording mechanisms individually controlled by the permutative operation of suitable groupings of said relays into operative sets.

3. In a system of multiplex printing telegraphy, the combination of an antenna, a set of transmitters and a set of receivers electrically associated with said antenna, said transmitters generating radio-frequency oscillations of different frequencies, and said set of receivers being adjusted to be separately in resonance for frequencies corresponding to those generated by the transmitters at some other station from which signals are received, means for telegraphically modulating said oscillations in

selectively tuned circuits A′ to E′, each of which is responsive only to a certain predetermined frequency. For example, in my illustration, A′ is a circuit responsive to a carrier wave current of a frequency of 20000 cycles per second, and no other; B′ is responsive only to a carrier wave current of a frequency of 30000 cycles per second, and so on, up to E′, which is responsive only to a carrier wave current of a frequency of 60000 cycles per second.

F′ is a circuit for rectifying the high frequency current received by A′, and thus converts the high frequency current into a low frequency current which is the modulating frequency, and then this current passes on to relay K′, tuned to respond to the modulating frequency imposed on the carrier wave A by modulator F. Current will flow through F′, for example, only when key K is closed, or, in other words, when carrier wave A has been modulated by F. When this key is open, no current will flow through F′, thus leaving relay K′ inoperative. G′, H′, I′, and J′ are similar circuits, adjusted in the same way as F′ for rectifying the high frequency currents received by B′, C′, D′, and E′ respectively, and thus keys L to O and circuits G′ to J′ control the operation of relays L′ to O′, respectively in the same manner as key K and circuit F′ control relay K′. Relays K′ to O′ are operatively connected to R, which is a printing mechanism of well known form, and is controlled by the permutatively energized and unenergized conditions of these relays so that it prints or records the message characters transmitted from the sending station.

Let us suppose that it is desired to transmit the signals for the letter "Z", the code combination for which is represented by the symbols "+———+". This means that relays K′ and O′ are to be energized, the others are to remain unenergized. The key "Z" on the manually operated keyboard, Q, is depressed, or an automatic tape-controlled transmitter functions, to cause keys K and O to be closed simultaneously, thus causing the modulators F and J, respectively to modulate the carrier waves from A and E, respectively, but leaving the carrier waves from B, C, and D, unmodulated. In my illustration, lines U and U′ will be simultaneously traversed by waves of the following frequencies: 19000–21000, 30000, 40000, 50000, and 59000–61000 cycles per second. At the receiving end circuits F′ and J′ will be the only ones that will allow current to reach the relays, for circuits G′, H′ and I′ will just neutralize the unmodulated carrier waves from G, H, and I, respectively, and therefore only relays K′ and O′ will be energized. This action corresponds therefore to the permutation of closed keys at the transmitting end. It is thus seen that although the five relays K′ to O′ are all operated by currents simultaneously traversing the line U—U′, the operation of any one of the five relays is independent of and will not be interfered with by the operation of any other of the five relays. The heterogonous combination of modulated carrier waves is broken up into the homogenous elements of individual impulses in a permutation corresponding to the proper code signal for the character transmitted. It is apparent, furthermore, that in this system not only is the time necessary to transmit a single character reduced to one-fifth of the time required in the heretofore prevalent systems, but also the speed of the transmission and reception can be materially increased because no limiting speed of operation is introduced in this method by any synchronizing devices.

It is obvious that the system here proposed permits of multiplex operation of a single pair of lines, since a wide range of non-interfering frequency bands are available for use and since a plurality of high frequency waves of different frequencies may be impressed upon the same line and selectively separated at the receiving end by extending the system described. This is shown in Figure 2 in which W and X are transmitting sets, each of which is similar in construction and operation to the single transmitting set P, of Figure 1, and W′ and X′ are their corresponding receiving sets, each of which is similar in construction and operation to the single receiving set, P′ of Figure 1. It is to be understood that W and W′ of Figure 2 comprise all the elements included in P and P′, respectively of Figure 1. It is of course unnecessary that all of the transmitting sets be located at one end of the line, and all of the receiving sets at the other end of the line, and in fact this would not be the practical method of operation. A plurality of transmitting sets and a plurality of receiving sets may co-exist at both ends of the line with no interference whatever, so long as proper frequencies are selected for the operation of each corresponding transmitting and receiving set. This is shown in Figure 3 where A and B represent complete transmitting sets comprising all the elements included by transmitting set P of Figure 1, B and B′ represent complete receiving sets comprising all the elements included by receiving set P′ of Figure 1. Transmitting set A controls receiving set A′ and transmitting set B controls receiving set B′, but transmitting set A and receiving set B′ are located at one end of the line, while transmitting set B and receiving set A′ are located at the other end of the line.

While I have shown the transmitting sets

each of said transmitters by a single modulating frequency, a set of make and break keys associated with each of said sets of transmitters, each of said set of keys respectively controlling the modulation or non-modulation of the oscillations of the set of transmitters with which set of keys is associated, means for operating each of said set of keys simultaneously and permutatively to correspond to the permutations of a plural-unit signaling code representing message characters, means, associated with each of said receivers, for detecting the presence or absence of modulation in the oscillations received by each of said receivers, each of said last-named means being associated with and controlling a relay which is energized when said modulation is present, but is unenergized when said modulation is absent, and a printing or recording mechanism, said mechanism being controlled by the permutative operation of said energized and unenergized relays.

4. The method of radio-telegraphically effecting a correspondence and simultaneity of action between the elements of a set of controlling electrical instruments and the corresponding elements of one or more sets of controlled electrical instruments, by means of a plurality of carrier waves of different frequencies, said carrier waves being permutatively modulated or non-modulated by a modulating frequency according as the respective elements of said set of controlling instruments are operated permutatively, the several carrier waves being isolated individually at the controlled stations by selectively tuned circuits associated with said sets of controlled instruments, the presence or absence of said modulating frequency in said isolated carrier waves respectively causing the elements of said set of controlled instruments to be actuated or non-actuated as the case may be.

In testimony whereof I affix my signature.

WILLIAM F. FRIEDMAN.

Patented Dec. 11, 1928. 1,694,874

UNITED STATES PATENT OFFICE.

WILLIAM F. FRIEDMAN, OF WASHINGTON, DISTRICT OF COLUMBIA.

METHOD OF ELECTRICAL SIGNALING.

Application filed July 10, 1922. Serial No. 573,981.

(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757.)

This invention relates in general to electrical signaling systems and more particularly to systems for the simultaneous transmission of a plurality of messages through one and the same channel, and has for its object the provision of a new and more simple system of circuits for achieving this end.

A further object of the invention is to effect a reduction of the length of time necessary to transmit and receive each of a plurality of messages by the heretofore prevalent systems of multiplex printing telegraphy, and thus increase the capacity of a single channel.

A further object is to effect an increase in the number of telegraph messages which can be transmitted over a single channel by the heretofore prevalent systems of multiplex telegraphy.

A further object is to achieve a system of multiplex radio telegraphy by the use of a single wave instead of a plurality of waves of different frequencies.

The fundamental principle of my invention is the differential modulation of a single carrier wave and the selective isolation of the several modulating frequencies at the receiving end, each so isolated modulating wave affecting a different independent circuit.

In order that the invention and its mode of application may be readily understood by persons skilled in the art, I have, in the accompanying illustrative drawings, and in the detailed following description based thereon, set forth an embodiment of the same.

Figure 1 is a diagrammatic sketch of one form of arrangement of circuits whereby a high frequency current carrier wave is modulated by several modulators of different character, the modulated carrier wave impressed upon a line and the several modulating frequencies selectively separated at the other end of the line.

Figure 2 is a diagrammatic sketch of one form of arrangement of circuits whereby a plurality of high frequency carrier waves are each modulated by several modulators of different characters, and at the other end of the line these modulated carrier waves are first separated by tuning to the frequencies of the carrier waves and then tuning again to the modulating frequencies.

Figures 3 and 4 are the same as Figures 1 and 2, respectively, except that the arrangements in Figures 3 and 4 are adapted for radio transmission instead of line transmission.

Having more particular reference to the drawings, and in connection with which like characters of reference designate similar parts throughout, in Figure 1, A is a source of high frequency oscillations of constant frequency, designated hereafter as the carrier wave; B and C are arrangements for modulating the carrier wave, each differently modulating the carrier wave A; D and E are keys which respectively control the modulation elements B and C. These keys may be operated manually by individual operators employing the Morse code signals but as shown in the figure they are here illustrated as operatively connected to I, which is a sending keyboard or an automatic tape-controlled transmitter, both of well known form. F and F′ constitute the line which the carrier wave traverses. B′ and C′ are selectively tuned circuits responsive to the carrier wave A; D′ and E′ represent circuits selectively tuned to respond individually to the respective modulating frequencies; G and H are relays which may be of well known forms, and are operable by the currents passed by D′ and E′ respectively, but they may be any other form of device suitable for making the currents of the isolated frequencies perceptible to the eye or ear, or for recording these currents in a suitable manner. The figure, however, shows G and H to be relays operatively connected to J, a printing or recording device of any of the well known forms.

Let us suppose that A impresses upon the line F—F′ a carrier wave of 50000 cycles per second, that B modulates the carrier wave by 1000 cycles per second and that C modulates the carrier wave by 2000 cycles per second. Therefore a carrier wave modulated in one instance to a 49000–51000 cycle wave, and in the other instance to a 48000–52000 cycle wave is impressed upon the line. At the receiving end of the line B′ and C′

are circuits tuned to the carrier frequency of 50,000 cycles, and the carrier wave current will divide, part, passing to one circuit, B′, and a part passing to the other circuit, C′. But D′ and E′ are arranged to respond to different modulating frequencies, that is, one will be acted upon only by the 1000 cycle modulating frequency, and the other will be acted upon only by the 2000 cycle modulating frequency. In that way the different modulating frequencies are separated. Hence relays G and H will respond selectively to the modulating frequencies of B and C.

The tuning of the receivers B′ and C′ to a modulated wave which covers a narrow band of frequencies as in the preceding example, 49000 to 51000 cycles or 48000 to 50000 cycles, may be accomplished by the well known methods in the art, which may be by the use of band filters, or any other suitable circuit arrangements.

In the same way a plurality of carrier waves of different frequencies may be employed, each carrier wave separately modulated by several modulations of different characters, and at the receiving end the different frequency carrier waves are first separated by suitable tuning and by further tuning the individual modulating frequencies on each carrier wave may be isolated. Thus a multiplex system of extremely wide range is made possible. This is shown diagrammatically in Figure 2, where A represents one unit of carrier wave current of one frequency from source C, with its associated modulating frequencies D and E, and B represents another unit of carrier wave current of another frequency from source F, with its associated modulating frequencies, G and H. A′ represents a system of circuits comprising circuits C′ and C″ selectively tuned to the frequency of the carrier wave C, and circuits D′ and E′, selectively tuned to the modulating frequencies D and E, which are produced at A, and I, J, are relays actuated by circuits D′, E′, respectively. B′ represents a system of circuits comprising circuits F′ and F″, selectively tuned to the frequency of the carrier wave, F, and circuits G′ and H′, selectively tuned to the modulating frequencies, G and H, which are produced at B. and K, L are relays actuated by circuits G′, H″, respectively. M, N, O, and P are the keys controlling the modulating circuits at A and B, and Q, Q′ is the line.

It is obvious also that transmitting sets can be placed at both ends of the line, and their corresponding receiving sets at both ends of the line, so that multiplex operation is possible. For such operation a plurality of single period generators or a single multiperiod generator can be employed. This arrangement is especially adapted for printing telegraph systems which employ code signals consisting of a plurality of elements or units affecting a plurality of relays associated with a printing or a recording mechanism. It may be desirable to discuss briefly this aspect of the invention.

In the heretofore prevalent forms of printing telegraph systems, the automatic operations concerned in causing a printing mechanism to function at a distance are controlled by groups of equal potential, direct current electrical impulses which pass over one and the same line, and actuate a set of relays, each impulse in the group effecting the operation of a particular relay, by a method described below. These relays actuate magnets which set up combinations of selecting discs in a printing mechanism, and each character of the message is determined by a different combination or arrangement of these selecting discs. Usually there are 32 such combinations, 26 for the ordinary letters and 6 others concerned in certain functions of the printer, such as carriage return, figure shift, and so on. The signals for message characters as commonly used in these systems constitute what is usually termed a five-unit code, that is, it consists of permutations of two elements taken five at a time. In one system of operation these two elements may be positive and negative potentials, in which case the code signal for a character consists of the distribution through time of five elements composed of positive and negative impulses. In another system of operation the two elements may consist of a time-interval when an impulse is sent, and a time-interval when no impulse is sent, this being the method of closed and open circuit operation. The code signal for the letter "A" for example, is "— — — — —," which in the positive and negative system of operation means that the first and second units of the signal are positive impulses, the third, fourth, and fifth, are negative impulses. In the open and closed circuit system of operation, this code signal means that only the first two time units are occupied by the passage of current, the last three, unoccupied. The permutations of transmitted impulses are governed by a set of make and break keys operated at the transmitting end manually, by means of a sending keyboard similar in form to the ordinary typewriter keyboard, or automatically by means of a transmitter controlled by a perforated tape.

In order that a plurality of relays shall be controlled by impulses of equal potential, and all coming over the same line, or through the same channel, and that the permutation of relays actuated at the distant end shall correspond to the permutation of depressed keys at the sending end, in the heretofore prevalent systems, connection is

established between each key at the sending end and its corresponding relay at the receiving end at a different instant, and the several connections necessary to transmit the code signal for each message character are made in a definite, fixed sequence. Thus, for example, in the case of five relays respectively controlled by five make and break keys, the time necessary to send the signals for one character is divided up into five equal intervals; during the first interval connection is established between key 1 at the sending end and its corresponding relay 1 at the receiving end; during the second interval, connection is established between key 2 at the sending end and its corresponding relay 2 at the receiving end; and so on. The method of effecting such a correspondence in action by transmitting similar impulses through one and the same channel involves the use of a distributor and various other apparatus included under the general term "synchronizing mechanism."

The principal of the synchronizing distributor is this: two similar rings, one, on the sending face of a distributor at the transmitting station, the other on the receiving face of an identical distributor at the receiving station, are each divided into five equal segments. A pair of rotating brushes on these distributors are connected to the line, and when these brushes revolve they sweep over and make contact with the segments of their respective rings. The brushes at the two ends of the line start from the same relative position and sweep over the contact segments with the same uniform angular velocity, thus connecting the first segment of the ring of the sending distributor with the first segment of the ring of the receiving distributor once per revolution of the brushes. Likewise the second, third, fourth, and fifth segments of the sending distributor are connected once per revolution of the brushes with the corresponding segments of the receiving distributor, the interval of each connection being the time of one-fifth of a revolution of the rotating brushes. Thus, each message character is transmitted as a combination of five separate or discrete impulses distributed equally and in a definite sequence through an interval of time, and for each revolution of the brushes, the code impulse combinations for one and only one character or letter are transmitted and received. The synchronization of the two distributors so that the respective brushes revolve with exactly the same angular velocity is a very complex feature of these printing telegraph systems, and acts as a limiting factor upon the speed of operation. In my system no such synchronization is necessary, for all of the signals comprising the combination of impulses for a single character are transmitted simultaneously, and at the receiving end are properly isolated by five selectively tuned circuits.

There is, of course, nothing novel in modulating a carrier wave either telephonically or telegraphically. The novelty of my invention consists in modulating a single carrier wave telegraphically by several distinct modulating frequencies, and isolating each modulating frequency individually. In telephonic modulation a relatively wide band of modulating frequencies is imposed upon the carrier wave, and this band of heterogeneous side frequencies is faithfully reproduced by the telephone receiver at the receiving end. The human ear hears all of these heterogeneous side frequencies simultaneously, but is able to distinguish them and hear them separately if an effort is made. For example, when orchestral music is being transmitted by radio telephone, the radio audience hears the ensemble effect but there is absolutely no difficulty in distinguishing the music produced by a violin from that produced by a cornet. Both sounds are being transmitted on one and the same vehicle or carrier wave, but the modulating frequency of the sound vibrations of the violin is different from that of the cornet. While in the illustration given above the separation of the modulating frequencies is effected by the ear, in the arrangement of this invention the separation of the modulating frequencies is accomplished by mechanical or electrical tuning devices.

In Figure 3 the arrangements of circuits is identical with that shown in Figure 1, but instead of having a line upon which the modulated carrier waves are impressed, a transmitting antenna, F, with its ground I, serves to radiate the modulated waves into space, and a receiving antenna F′, with its ground I′, serves to receive the waves radiated by F.

In Figure 4, the arrangement of circuits is identical with that shown in Figure 2, but instead of having a line upon which the modulated carrier waves are impressed, a transmitting antenna, Q, with its ground R, serves to radiate the modulated waves into space, and a receiving antenna, Q′, with its ground, R′, serves to receive the waves radiated by Q.

It is obvious that the arrangements shown in Figure 1 for controlling the operation of the keys governing the modulating circuits and for controlling the operation of the printing or recording mechanism, when a system of printing telegraph is employed, also apply to Figures 2, 3, and 4. But it is also obvious that the modulating keys may be operated manually by individual operators, as stated before, and at the receiving end, instead of having relays, several oper-

ators may receive the messages transmitted in ordinary Morse characters by using telephone receivers.

It is obvious that radio-frequency oscillations must be employed for radio communication by the systems illustrated in the last two figures.

While I have not indicated in the figures any particulars regarding the means to be employed in producing the carrier wave or the manner of modulating the carrier wave, or the manner in which the modulated carrier waves are impressed on the line or radiated into space, it is to be understood that any of the means and methods now well known in the art may be employed. Nor have I indicated any details with respect to the exact means to be used in receiving the modulated carrier waves, selectively separating the modulating frequencies, and causing them to affect selectively tuned relays or recording devices, for here also the means and methods now well known in the art apply to this invention.

What I claim as my invention is the following:

1. In a printing telegraph system, a source of high frequency electrical oscillations constituting a carrier wave; a set of modulators of different modulating frequencies which can be impressed upon said carrier wave, each of said modulators being associated with a make and break key which determines whether the modulating frequency controlled thereby will or will not be impressed upon the said carrier wave, said keys together comprising a single set of keys acting as a single unit associated with a keyboard mechanism, said keyboard mechanism being so constituted as to control said set of keys permutatively as a unit according to a plural-unit code suitable for the representation of message characters, means for transmitting the permutatively modulated carrier wave representing the message characters, a receiving station, means at said receiving station for detecting said transmitted permutatively modulated carrier wave, means for detecting the presence of and for isolating each modulating frequency of said permutatively modulated carrier wave, said latter means comprising a set of resonant circuits appropriate for the purpose, each of said resonant circuits being associated with and adapted to control a relay which is operative when the modulating frequency to which the respective resonant circuit is responsive is present, and is inoperative when the modulating frequency to which said resonant circuits is responsive is not present, a plurality of relays acting as a single unit associated with a printing mechanism, said printing mechanism being controlled as a unit by the joint and permutative action of said set of relays in such a manner as to print the message characters represented by the permutatively modulated transmitted and received carrier wave.

2. In a printing telegraph system comprising a source of high frequency electrical oscillations constituting a carrier wave, a set of modulators of different modulating frequencies which can be impressed in a permutative manner representing message characters in a plural-unit code upon the said carrier wave by means of a keyboard mechanism controlling a set of keys, governing the action of said set of modulators, a receiver capable of receiving the permutatively modulated carrier wave representing message characters, a set of resonant circuits, each of said resonant circuits being responsive to one individual and only one of said modulating frequencies, a set of relays controlled as a unit permutatively by the said set of resonant circuits, and a printing mechanism controlled by the said set of relays and suitable for printing the received message characters, the method of permutatively and simultaneously impressing the said modulating frequencies upon the said carrier wave, transmitting and subsequent receiving and detecting the said permutatively modulated carrier wave, detecting and isolating the said modulating frequencies, causing the said isolated modulating frequencies to control the operation of a set of relays permutatively according to the plural-unit code representing the message characters transmitted, the said set of relays acting as a unit to control the action of a printing mechanism suitable for printing the message characters.

In testimony whereof I affix my signature.

WILLIAM F. FRIEDMAN.

Dec. 11, 1928 1,694,874

W. F. FRIEDMAN

METHOD OF ELECTRICAL SIGNALING

Filed July 10, 1922

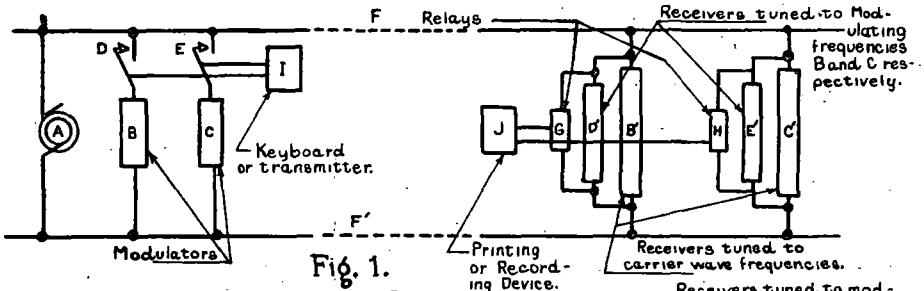

Fig. 1.

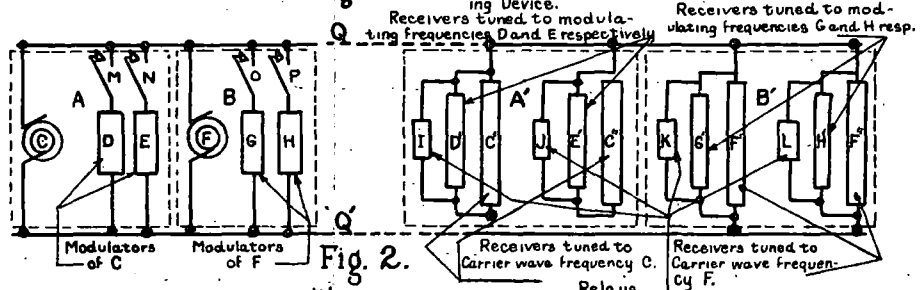

Fig. 2.

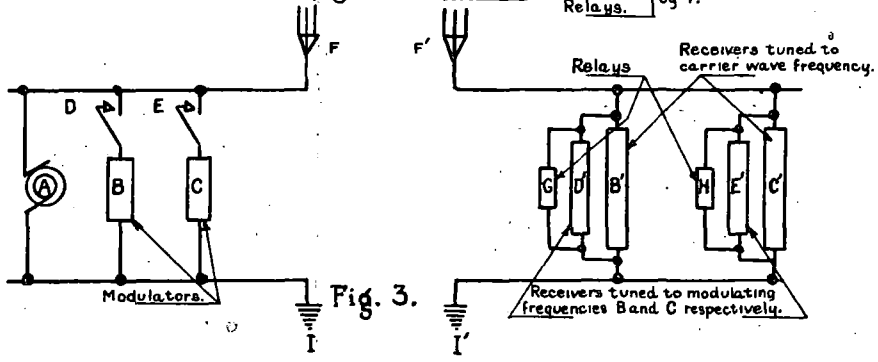

Fig. 3.

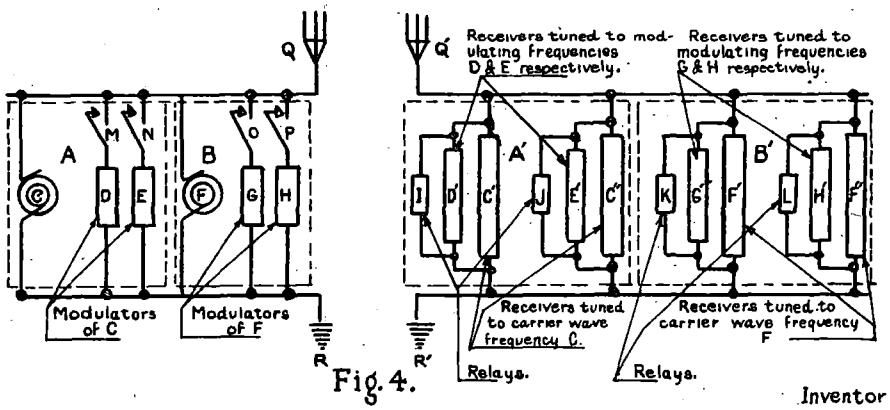

Fig. 4.

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Friedman
1,694,874