May 31, 1938. W. G. H. FINCH 2,118,917

DUAL TONE TELEGRAPHY SYSTEM

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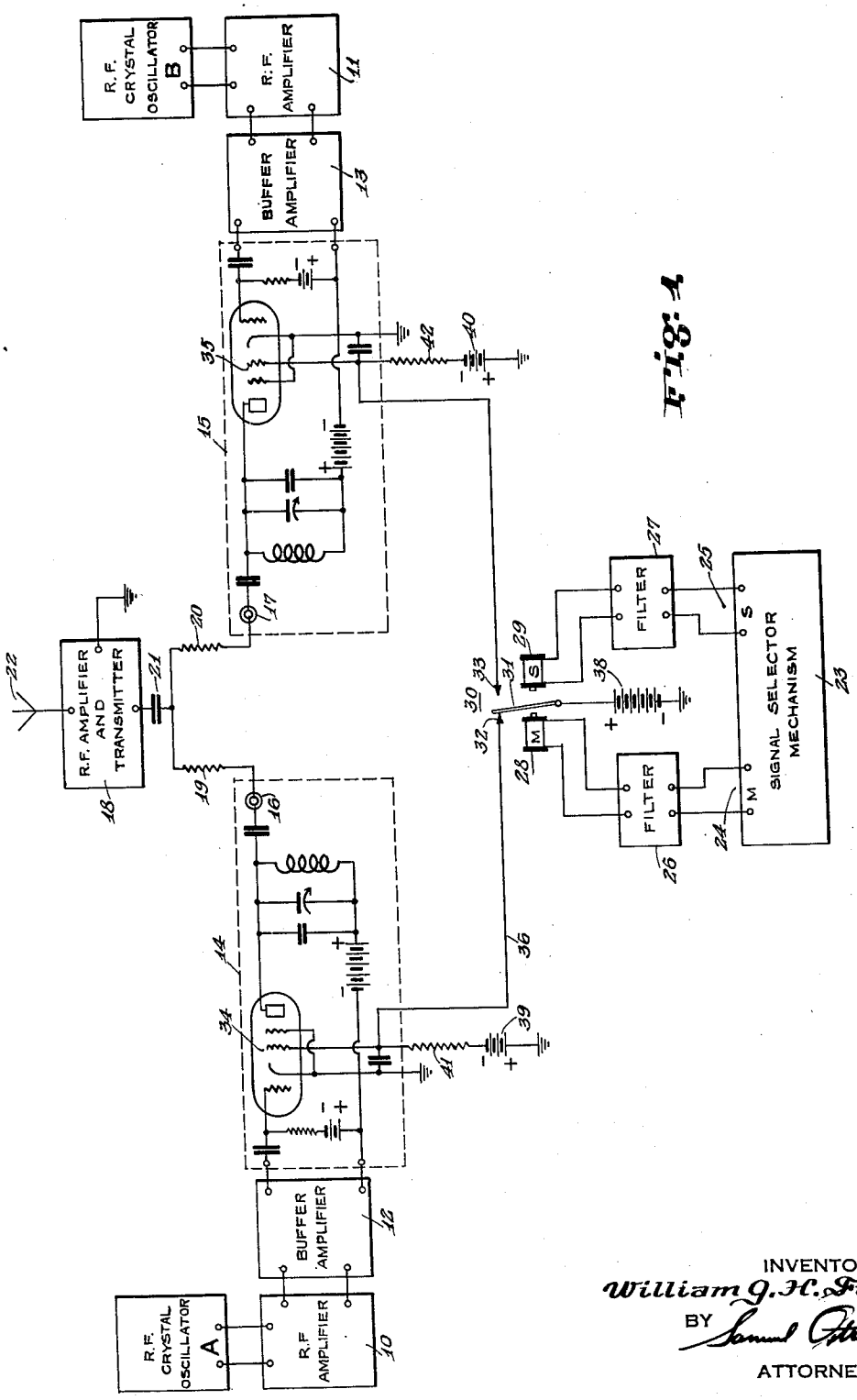

Fig. 4

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DUAL TONE TELEGRAPHY SYSTEM

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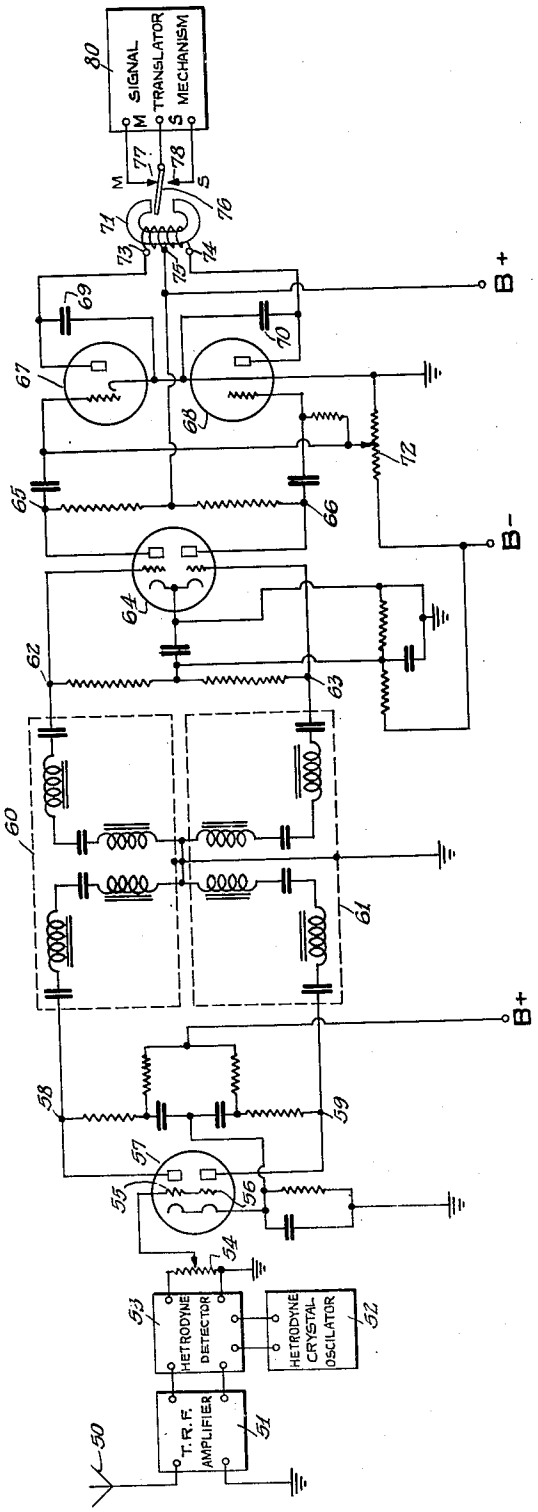

Fig: 2

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DUAL TONE TELEGRAPHY SYSTEM

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5 Claims. (Cl. 178—66)

This invention relates to radio telegraphy systems and more particularly relates to novel methods of and apparatus for high speed radio telegraphic communication employing a relatively narrow frequency spread.

Continuous wave telegraph systems of the prior art comprised a single carrier frequency which was either modulated by the telegraphy signals or interrupted in accordance with the signals. One prior art system extensively used is to transmit the carrier frequency wave during the marking periods of the signals and to key-off or prevent transmission of the carrier wave during the spacing periods. The received signals are heterodyned with a local oscillator to produce an audio frequency signal of predetermined frequency at the receiver corresponding to the marking impulses of the transmitter. One disadvantage of this system is that the marking impulse is positively actuated whereas the spacing impulse is necessarily bias actuated. Accordingly, the word rate is not as great as in a system employing positive actuation of both marking and spacing impulses. Another disadvantage is that the separated carrier signal impulse trains excite the receiver tuned circuits resulting in a reception which is not as selective as an uninterrupted carrier wave transmission.

A radio telegraphy system which overcomes these disadvantages utilizes a radio frequency carrier which is modulated by two audio frequency tones separated sufficiently so as to be filtered into respective marking and spacing relay members. Each of two frequencies, for example 300 cycles and 800 cycles, are caused to alternately modulate the radio frequency carrier in accordance with telegraphic impulses to be transmitted. The carrier is accordingly continuously transmitted and the selectivity materially increased. The individual marking and spacing audio frequency tone impulses provide positive actuation at the receiver. However, modern telegraphic radio channels are crowded and accordingly, the permissible frequency spread assignable in many classes of service is very narrow. The two tone modulated carrier system, even if transmitted as single side bands, requires too wide a frequency band for many commercial applications.

In accordance with my present invention, I contemplate a narrow frequency spread high-speed radio telegraphy system, obtaining the very narrow frequency spread without employing side band suppression and having positive marking and spacing impulse conditions at the receiver. I employ two carrier frequency oscillators separated by a small frequency difference. These oscillators are crystal controlled in order to insure accurate control of the frequency of the carrier waves. The two frequencies correspond to the "marking" and "spacing" impulses of the coded telegraphy signals to be transmitted. Transmission of the closely spaced carrier frequencies is alternately effected in accordance with the marking and spacing transmission impulses to provide a substantially continuous transmission current which may be readily received with high selectivity. The amplitudes of the carrier waves in my preferred system are equal, so that an oscillographic view of the signal transmission would appear as a substantially continuous wave front with a frequency change of a small predetermined amount between marking and spacing conditions.

The receiver of my novel system comprises a crystal controlled heterodyne oscillator which beats with the received signals to produce two audio frequency tones. The frequency difference between the two audio frequency tones is equal to the frequency difference between the two radio frequency carriers. By employing selective filtering, the two tones are individually impressed upon the respective marking and spacing members of the receiver relay to effect a positive marking and spacing actuation.

My present invention combines all the advantages of the continuous wave telegraphy and two tone modulation telegraphy systems. The transmitted signal has a substantially constant intensity and may be very selectively received. I have performed very high speed operation over greater distances than with other radio telegraphic systems due to the sustained character of the energy of transmission, the sharp selectivity features of the reception and the positive actuation of the marking-spacing relay.

It is accordingly an object of my present invention to provide a novel high-speed radio telegraphy system.

Another object of my invention is to provide a novel high speed radio telegraphy system operating on a very narrow frequency spread.

A further object of my invention is to provide novel circuit arrangements for transmitting and receiving radio telegraphic signals.

These and other objects of my invention will become apparent in the following description taken in connection with the drawings, in which:

Figure 1 is a circuit diagram of a preferred

transmitter for carrying out my present invention; and

Figure 2 is a circuit diagram of a preferred receiver for carrying out my present invention.

A preferred circuit arrangement for the transmitter is schematically illustrated in Figure 1. Two separate radio frequency oscillators A and B are used to generate the marking and spacing radio frequency carrier waves. These oscillators are crystal controlled in my preferred system to insure accurate transmission and reception and to insure the predetermined difference frequency between the transmitted carrier waves and to insure that the transmission is carried out within assigned frequency limits. The output of the oscillators is amplified by radio frequency amplifier stages 10 and 11 and by the buffer stage amplifiers 12 and 13 respectively. The output of the buffer amplifiers 12 and 13 is introduced to respective amplifier stages 14 and 15.

The output connections 16 and 17 of the amplifier trains for oscillators A and B respectively, are connected to a common radio frequency amplifier and transmitter 18. In Figure 1, there is illustrated a coupling between output points 16 and 17 to the transmitter 18 through respective resistances 19 and 20 and a common coupling condenser 21. The output of radio frequency transmitter 18 is radiated into space by antenna 22, in a manner well known in the art. The signal radiated by antenna 22 is two closely spaced radio frequency carriers alternately transmitted in a substantially continuous train.

The signal voltages at the outputs 16 and 17 of the oscillator-amplifier trains are arranged to be a maximum or zero in accordance with the "marking" and "spacing" signals to be transmitted. Should the frequency of radio frequency oscillator A be assigned for transmitting the "marking" signal impulses, then the output at point 16 of the A amplifier train would be a maximum during each "marking" impulse and zero during the transmission of the "spacing" impulses. Accordingly, the output at point 17 of the B radio frequency oscillator train assigned to "spacing" impulses would be a maximum during the "spacing" impulse conditions and zero during the "marking" impulse conditions.

In accordance with my present invention, the carrier frequency output of each amplifier train is transmitted for the duration of signal impulse periods, alternately and corresponding to the marking and spacing signals of telegraphic transmission.

This invention is applicable for the transmission of dot-dash telegraphic signals such as result from keying operations but has particular advantageous operation in the transmission of the marking and spacing coded signal combinations resulting from well known automatic printing telegraphic communication operating on, for example, a five-unit Baudot code system. I prefer to employ any form of block signalling generator in combination with my novel transmitting and receiving system. At 23 I have schematically illustrated a "signal selector mechanism" which, it is to be understood, refers to any preferred form of established code selecting or generating device. The preferred tape and mechanical feeler combination operating with a rotary distributor is one form of the selector 23 whereby high speed operation is feasible. However, any automatic or manual keying device may be utilized to generate successive signal impulses at the outputs 24 and 25 of selector 23 corresponding to alternate marking and spacing signal conditions.

In order to limit the frequency spread transmitted and further stabilize the circuits, keying noise suppressors 26 and 27 are connected to the outputs 24 and 25. Suppressors 26 and 27 are essentially filter circuits designed to by-pass the harmonic frequencies of keying or signal impulse generation. The outputs of suppressors 26 and 27 are connected respectively to marking and spacing solenoids 28 and 29 of relay 30. The tongue 31 of the signal relay is accordingly attracted by solenoids 28 and 29 to correspondingly connect to contacts 32 and 33 of the relay in accordance with the "marking" or "spacing" impulse conditions to be transmitted.

In accordance with my present invention, one radio frequency carrier is transmitted at full amplitude for the duration of one signal condition to be transmitted and another radio frequency carrier is transmitted at full amplitude for the duration of a second signal condition to be transmitted. The two signal conditions are correlated and alternately effective to produce the substantially continuous full amplitude transmission of alternate, distinct radio frequency carrier waves corresponding to the transmitted signals. By utilizing crystal controlled oscillators A and B, the absolute frequency of and the frequency difference between the two radio frequency carrier waves are accurately predetermined. For commercial application, the difference frequency may conveniently be made seventy cycles to confine the frequency band transmitted to within narrow limits to fall within communication traffic assignments for narrow band widths. The substantially sustained character of the transmitted signals permit selective reception at relatively greater distances for a given antenna power output since both the marking and spacing signal impulses are transmitted at maximum carrier amplitudes.

The substantially sustained character of the transmitted signals produce, in effect, a continuous carrier wave signalling condition. The advantage of such signalling condition resides in that a very selectively tuned receiver may be used to receive the signals and sharply reject adjacent signal bands in the crowded communication channel. The substantially continuous wave signalling permits the use of a receiver with sharply tuned circuits of relatively low decrement factor. Interrupted continuous wave signalling is disadvantageous in that less sharply selective receiving circuits can be used. The substantially continuous wave signalling produced by my present invention causes positive actuation of the receiver translating relay in accordance with the two tones corresponding to the two closely separated independent radio frequency carrier currents. By employing stable circuit arrangements permitting a low frequency difference, a very narrow channel provided for telegraphic communication may be used with my system. I shall hereinafter refer to the narrow frequency separation, preferably of the order of 100 cycles, as a "low frequency difference" for the two independent radio frequency carriers.

The keying of the A and B carrier frequency waves to alternately impress them upon the transmitter 18 in correspondence with the marking and spacing signals to be transmitted, may be effected in different ways. I prefer to accomplish the keying of the characters electronically for insuring rapid and inertialess operation in switching the carrier waves to and from the

transmitter. A preferred manner for alternately keying the oscillator A and B outputs is accomplished by changing the bias conditions of the screen grid electrodes 34 and 35 of the respective pentode amplifier stages 14 and 15 as illustrated in Figure 1. The other components of the amplifier stages 14 and 15 are connected in a contentional manner. Screen grid 34 is connected to relay contact 32 by connection lead 36; screen grid 35 is connected to relay contact 33 by connection lead 37. A source of potential 38 is connected between relay tongue 31 and ground. The positive terminal of the battery 38 is connected to the relay tongue 31 to provide suitable operating potential for the screen grid electrodes 34 or 35 in accordance with the relay contact 32 or 33 being contacted.

In the illustrated embodiment, relay tongue 31 is shown contacting relay contact 32 to impress a positive bias upon screen grid 34 to permit normal functioning of the amplifier stage 14. The amplified carrier frequency current from oscillator A is accordingly further amplified by stage 14 and directly impressed on the R. F. transmitter 18 to be radiated by antenna 22. During the normal functioning of amplifier stage 14 due to the positive screen grid bias thereof, the amplifier stage 15 is "choked" since the potential from battery 38 is disconnected from its screen grid 35. To insure a positive choking action of the pentode amplifier stages 14 and 15 when no positive screen grid bias is applied thereto, I provide batteries 39 and 40 connected with their negative terminal to the respective screen grids 34 and 35 through corresponding series resistances 41 and 42. Accordingly, when the relay 30 is actuated to disconnect the positive bias 38 from a screen grid electrode, the negative bias of the batteries 39 and 40 are effective to suppress the passage of the carrier signals through the negatively biased amplifier stage. The function of resistances 41 and 42 is to limit the amount of current drained from the higher voltage positive potential source 38 when it is connected to a screen grid electrode. The voltage of battery 38 is made sufficient to neutralize the effect of negative bias batteries 39 and 40 and provide normal positive biasing potential for the screen grids when connected thereto.

In accordance with my present invention, the signal selector mechanism 23 such as a printing telegraph distributor, actuates alternately the marking and spacing solenoids to correspondingly attract the relay tongue 31 for alternately contacting relay contacts 32 and 33 to correspondingly alternately normally bias the screen grid electrodes 34 and 35. When either screen grid is positively biased by relay 30, the corresponding carrier frequency A or B is transmitted. Since the amplifier stages 14 and 15 block the passage of the carrier frequency oscillations therethrough when not connected to the battery 38, the particular carrier frequency transmitted over antenna 22 corresponds to the particular relay contact 32 or 33 connecting with relay tongue 31. It will now be evident that only one carrier frequency can be transmitted at one time by my novel circuit arrangement and that the carrier waves are transmitted at maximum amplitude condition. The interval for the transmission of these carriers corresponds to the duration of the relay contacting periods which in turn are dependent upon the code combinations of signals to be transmitted.

Figure 2 is a diagram of a preferred receiving circuit for my present invention. The radiated signals from the transmitter are intercepted by antenna 50 and amplified by the selective sharply tuned radio frequency amplifier 51. A crystal oscillator 52 is used to generate a current of predetermined frequency for heterodyning with the received signals. The oscillator is connected to the heterodyne detector 53 for beating with the radio frequency signals to produce an audio frequency corresponding to the difference between the oscillator 52 frequency and the frequency of the received signals. The output of detector 53 is connected to a potentiometer 54 and in turn connected to the grids 55 and 56 of the dual amplifier stage 57. The output of the dual amplifier stage 57 is duplicated and similar at the points 58 and 59 from which they are introduced to individual sharply tuned filter networks 60 and 61.

The filters 60 and 61 are designed to be sharply selective so as to definitely differentiate between the resultant two audio frequencies seventy cycles apart. My present invention is rendered commercially practical by the utilization of crystal oscillators for the transmitter R. F. generators A and B and a crystal oscillator for the heterodyne frequency generator 52 which is predetermined in accordance with the transmitting stage frequencies. When a difference frequency of seventy cycles between the transmitted radio frequencies A and B is employed, the audio frequencies 60 and 61 accordingly must separate two audio frequencies which are also seventy cycles apart. The crystal oscillator 52 used for heterodyning with the received frequencies A and B is designed to produce the predetermined audio frequencies for which the sharp filters 60 and 61 are designed to operate.

For example, if the A carrier frequency is 100,000 cycles and the B carrier frequency is 100,070 cycles, the two carriers will be alternately radiated with a seventy cycle frequency difference. The heterodyne crystal oscillator 52 may be designed to have a frequency of 99,500 cycles, producing at the output 54 of the heterodyne detector 53 audio signal frequencies of 500 cycles and 570 cycles. Accordingly, there will be impressed upon the grids 55 and 56 of the dual audio amplifier stage 57, alternate signal impulses of 500 and 570 cycles per second in frequency. If the filter 60 is sharply tuned to pass 500 cycles and reject the 570 cycle signals, the other selector filter 61 is tuned to pass with maximum efficiency the 570 cycle signals and reject the 500 cycle signals. Therefore, the output point 62 of filter 60 will receive the 500 cycle signals which, in the present example, correspond to the marking impulses since they are produced by heterodyning with the A oscillator frequency. The output point 63 of filter 61 receives only the 570 cycle impulses corresponding to the spacing impulses transmitted. The filters 60 and 61 may be designed according to principles well known in the radio art and the illustrated embodiment is composed of inductances and condensers enclosed in a grounded shielded structure.

The respective outputs 62 and 63 from filters 60 and 61 are amplified by the dual audio frequency amplifier stage 64 in a conventional manner. The outputs 65 and 66 of amplifier 64 correspond to the signals received at points 62 and 63 but in amplified form. The 500 and 570 cycle signals occur alternately corresponding to the marking and spacing impulses generated by the

signal selector mechanism 23 and may be used to actuate a local relay to translate these signals in a manner well known to those skilled in the art. The marking and spacing signals are positively actuated since the amplitude of the respective signal impulses are equal. The alternating current signals may be used with corresponding alternating current relays. However, I prefer to rectify these individual and segregated signals before actuating the translator relays.

Accordingly, I employ detector stages 67 and 68, the inputs of which are connected respectively to the outputs 65 and 66 of the dual amplifier stage 64. By-passing condensers 69 and 70 are connected across the anode-cathode circuits of the detector stages 67 and 68 to by-pass the alternating current components and permit the uni-directional signal impulses to be impressed upon the differential relay 71. A potentiometer 72 connected between ground and the B-terminal is used to supply a suitable bias to the grids of the rectifier stages 67 and 68. The output of rectifier 67 is connected to terminal 73 of relay 71, and the output of rectifier stage 68 is connected to terminal 74 of relay 71. The midpoint 75 of the relay 71 is connected to the anode potential source B to complete the output circuits of the rectifier stages 67—68.

The following is an outline of the operation of the telegraphy system of my present invention. When the signal selector mechanism 23 actuates the marking solenoid 28, the relay tongue 31 is attracted to connect with contact 32 to impress the positive operating bias potential upon the screen grid electrode 34 in the amplifier train for oscillator A, relieving the blocking action of the amplifier stage 14 and permitting the 100,000 cycle oscillator frequency to be transmitted over antenna 22. At the receiver, the heterodyne crystal oscillator of 99,500 cycles beats with the 100,000 cycle received and amplified signals, to produce a 500 cycle audio frequency impulse at both the outputs 58 and 59 of the dual amplifier stage 57. The selective filter 60 which is sharply tuned to 500 cycles permits this signal to be further amplified and impressed upon the rectifier stage 67. The other filter 61 by-passes the 500 cycle signal to ground and prevents it from reaching the other rectifier 68. When the 500 cycles impulse reaches rectified stage 67, a uni-directional current flows through the section 73—75 of the differential relay 71 and attracts the tongue 76 of the relay to connect with contact 77 corresponding to the local marking impulse conditions.

The spacing signal impulse is transmitted in a manner similar to the marking impulse and corresponds to the attraction of spacing solenoid 29 of the relay tongue 31 away from contact 32 to connect with contact 33. The oscillator A amplifier train simultaneously blocks the transmission of the A carrier frequency and permits the B carrier frequency to pass through the pentode stage 15 to be transmitted over antenna 22. In the present case, the B frequency is 100,070 cycles, which when heterodyned with the 99,500 cycle oscillator, produces the 570 cycle signal which passes through selector filter 61 to be rectified by rectifier 68. A corresponding uni-directional impulse passes through the coil section 75—74 of the differential relay to attract the relay tongue 76 to the spacing contact 78 for the local spacing circuit condition.

The relay armature 76 together with the relay contacts 77 and 78 are connected to a local signal translator mechanism 80. The translator 80 corresponds to the type of selector mechanism 23 employed at the transmitter to suitably translate the transmitted signals. The relay armature 76 is positively actuated to the spacing and marking positions.

It is to be understood that different frequency ranges may be employed for the system of my present invention and that modifications therein which fall within the broader spirit and scope of my invention will be evident to those skilled in the art. Accordingly, I do not intend to be limited except as set forth in the following claims.

I claim:

1. In a signalling system, means for producing alternate signal conditions to be transmitted; first and second oscillators arranged with inherent frequency stability to generate first and second carrier currents having a predetermined low frequency difference; and means controlled by said signal conditions for transmitting said first carrier current during the occurrence of one signal condition and for transmitting said second carrier current during the occurrence of another signal condition comprising a first buffer amplifier stage having a grid electrode for amplifying said first current, and a second buffer amplifier stage having a grid electrode for amplifying said second current, means associated with said grid electrode for normally blocking the transmission of said currents, and means for permitting the transmission of said first or second currents in accordance with the signal conditions said normal blocking means being effective to rapidly block the transmission of signal energy from each amplifier at the termination of each operative period thereof whereby substantially continuous carrier wave signalling is effected.

2. In a signalling system, means for alternately producing signal conditions to be transmitted; first and second oscillators arranged with inherent frequency stability to generate first and second radio frequency carrier currents having a predetermined low frequency difference; and means controlled by said signal conditions for transmitting said first carrier current during the occurrence of one signal condition and for transmitting said second carrier current during the occurrence of the other signal condition comprising a first buffer amplifier stage having a grid electrode for amplifying said first current, and a second buffer amplifier stage having a grid electrode for amplifying said second current, means for normally blocking the transmission of said currents by negatively biasing said electrodes and means for applying normal biasing potential to said electrodes for permitting the transmission of said first or second currents in accordance with the signal conditions, the negative biasing condition being effective to rapidly block the transmission of signal energy from each amplifier when the normal biasing potential means is removed from the associated electrode, whereby substantially continuous carrier wave signalling is effected.

3. In a signalling system, means for alternately producing signal conditions to be transmitted; first and second oscillators arranged with inherent frequency stability to generate first and second radio frequency carrier currents having a predetermined low frequency difference; and means controlled by said signal conditions for transmitting said first carrier current during the occurrence of one signal condition and for transmitting said second carrier current during the occurrence of the other signal condition com-

prising a first buffer amplifier stage having a screen grid electrode for amplifying said first current, and a second buffer amplifier stage having a screen grid electrode for amplifying said second current, means for normally blocking the transmission of said currents by negatively biasing said electrodes and means for applying normal biasing potential to said electrodes and for counteracting said negative biasing condition for permitting the transmission of said first or second currents in accordance with the signal conditions, the negative biasing condition being effective to rapidly block the transmission of signal energy from each amplifier when the normal biasing potential means is removed from the associated electrode, whereby substantially continuous carrier wave signalling is effected.

4. In a telegraph system, selector means for producing alternate marking and spacing signal conditions in accordance with character codes to be transmitted; first and second oscillators arranged with inherent frequency stability to generate first and second radio frequency carrier currents having a predetermined low frequency difference; and means controlled by said signal conditions for transmitting said first carrier current during the occurrence of one signal condition and for transmitting said second carrier current during the occurrence of the other signal condition comprising a first buffer amplifier stage having a grid electrode for amplifying said first current, and a second buffer amplifier stage having a grid electrode for amplifying said second current, means for normally blocking the transmission of said currents by sufficiently negatively biasing said electrodes and means for alternately applying normal biasing potential to said electrodes for permitting the transmission of said first or second currents; said last mentioned means comprising a relay having an armature and two contacts individually connected to said electrodes, a source of potential with the positive terminal connected to said armature, said armature being controlled by said selector means for connecting said source of potential to the grid electrode of the amplifier of the current to be transmitted in response to the signal conditions whereby substantially continuous carrier wave signalling is effected.

5. In a telegraph system, selector means for producing alternate marking and spacing signal conditions in accordance with character codes to be transmitted; first and second crystal controlled oscillators arranged with inherent frequency stability to generate first and second radio frequency carrier currents having a predetermined low frequency difference; and means controlled by said signal conditions for transmitting said first carrier current during the occurrence of one signal condition and for transmitting said second carrier current during the occurrence of the other signal condition comprising a first buffer amplifier stage having a screen grid electrode for amplifying said first current, and a second buffer amplifier stage having a screen grid electrode for amplifying said second current, means for normally blocking the transmission of said currents by sufficiently negatively biasing said screen grid electrodes and means for alternately applying normal biasing potential to said screen grid electrodes and for counteracting said negative biasing condition for permitting the transmission of said first or second currents; said last mentioned means comprising a relay having an armature and two contacts individually connected to said electrodes, a source of potential with the positive terminal connected to said armature, said armature being controlled by said selector means for connecting said source of potential to the screen grid electrode of the amplifier of the current to be transmitted in response to the signal conditions whereby substantially continuous carrier wave signalling is effected.

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