Dec. 2, 1941. J. W. COX 2,264,510

TELEGRAPH SIGNALING SYSTEM

Filed June 6, 1939 3 Sheets-Sheet 1

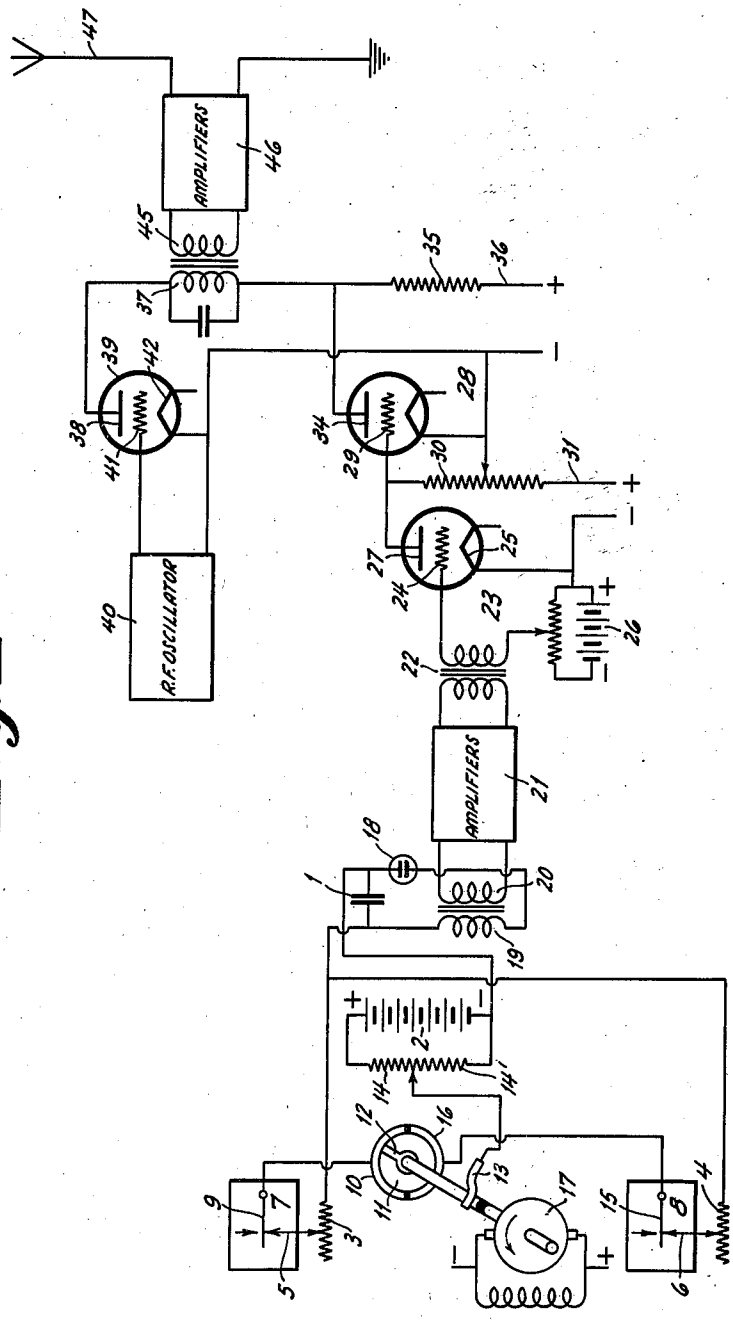


Fig. 1

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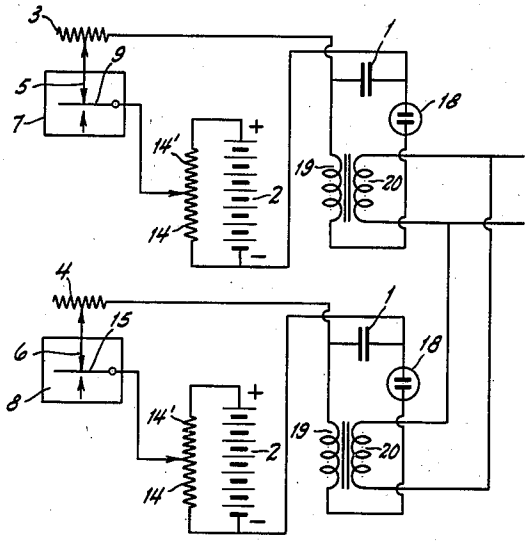


Fig. 2

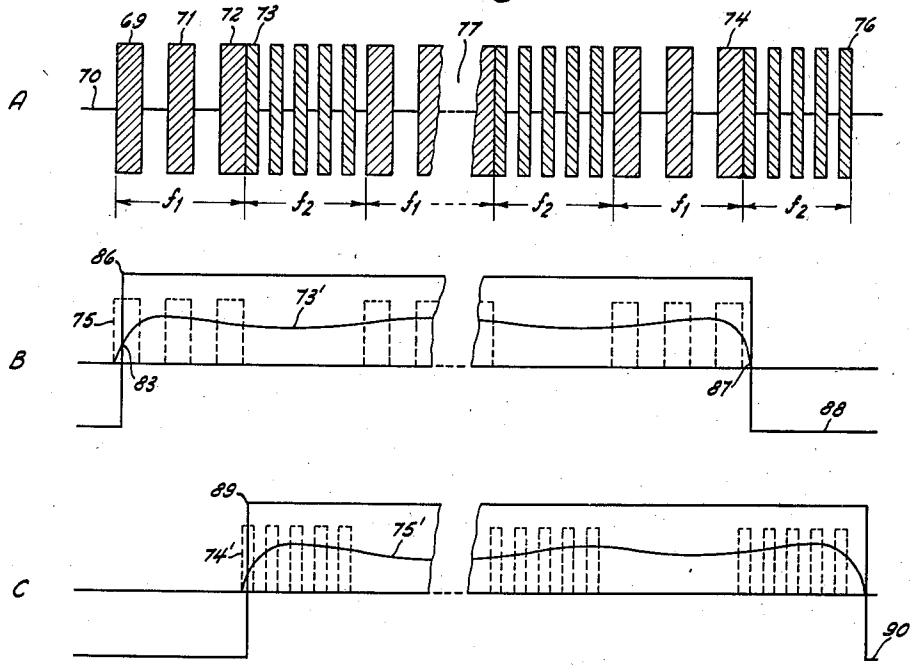


Fig. 4

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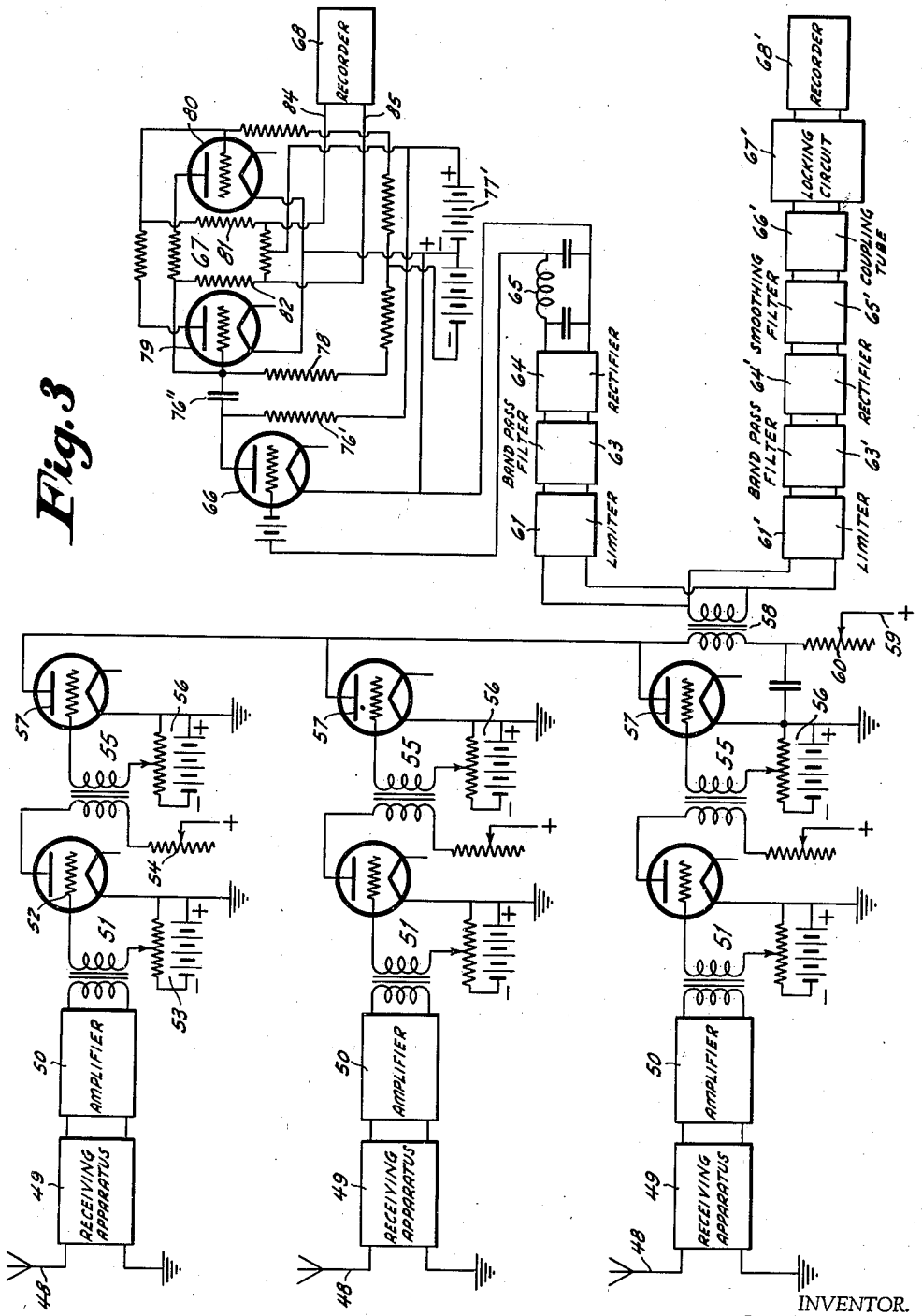
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TELEGRAPH SIGNALING SYSTEM

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Fig. 3



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Patented Dec. 2, 1941

2,264,510

UNITED STATES PATENT OFFICE

2,264,510

TELEGRAPH SIGNALING SYSTEM

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Application June 6, 1939, Serial No. 277,607

6 Claims. (Cl. 250—9)

This invention relates to telegraph signaling systems and is particularly applicable to multiplex telegraphy, though it can be altered for use in simplex telegraphy if desired.

A common method of sending a plurality of signals over the same radio or wire link is based on the time-division principle. This requires the use of synchronously running distributors at the transmitter and receiver. These timed division multiplex systems are successful in practice but the mechanism for maintaining synchronism between the receiving and transmitting distributors is expensive and the maintenance costs are quite material.

It is one object of my invention to devise a telegraph system for multiplex telegraphy that requires no synchronously running distributors at the transmitter and receiver.

Another object of the invention is to send messages by periodically interrupting the carrier wave by low frequency alternations.

Another object of the invention is to simultaneously transmit a plurality of signal messages by interrupting a carrier wave to form mark and space indications for each message and interrupting the mark indications for each signal at a predetermined low frequency, the frequencies of interruption being different for each signal message.

Another object of the invention is to transmit a plurality of messages with mark and space interruptions of a carrier wave in which the marking parts of the wave are interrupted at a plurality of predetermined low frequencies and separating the signal currents of the messages at the receiver by filtering.

Another object is to transmit a plurality of signal messages each acting on the same carrier wave to form mark and space interruptions in which the marking wave for each signal message is interrupted at a predetermined low frequency, the interrupting frequencies being different for each signal message.

Another object is to transmit a plurality of signal messages each alternately acting on the same carrier wave to form mark and space indications and interrupting the marking portions of the wave at predetermined frequencies, there being a different frequency for each signal message, and separating the signal messages by filters at the receiver.

Another object of the invention is to assign a carrier wave successively to each of a plurality of transmitting channels and transmitting mark and space indications in the carrier wave while interrupting the marking portion of the wave at a predetermined low frequency, the frequency of interruptions being different for each channel.

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

Fig. 1 is one form of transmission system for carrying out my invention.

Fig. 2 is a modified form of transmission system.

Fig. 3 is a receiving system for carrying out my invention.

Fig. 4 is a series of graphs showing a portion of the carrier wave for making the indications.

Referring to Fig. 1, the low frequency oscillator consists of a condenser 1 having one terminal connected to the negative terminal of a battery 2 and the other one connected to two adjustable resistances 3 and 4 which are joined to live contacts 5 and 6 of well known perforated tape transmitters generally indicated at 7 and 8. The tongue 9 of tape transmitter 7 is connected to segment 10 of a distributor or commutator 11 having rotating brush 12. The brush 13 of this distributor is adjustably connected to potentiometer 14, 14', connected across battery 2. The tongue 15 of relay 8 is connected to the remaining segment 16 of the distributor. The distributor may be run at any desired speed by motor 17 but it should have a frequency of interruption materially less than the frequency of the oscillations produced by the condenser 1. A vacuum tube type of distributor such as the multi-vibrator described in patent to R. E. Mathes, No. 1,979,484, November 6, 1934, could also be used, as the invention is not dependent upon any particular type.

Neon or equivalent tube 18 is connected across condenser 1 through primary 19 of a transformer having secondary 20 connected to appropriate amplifiers 21. The output lines of the amplifier are connected to transformer 22 feeding the tone keyer stage 23. The secondary of this transformer is connected between the grid 24 and filament 25 through a negative bias 26. The value of this bias is such that the tube is blocked except during the positive alternation of the oscillations produced by the oscillating condenser 1, as hereinafter described.

The plate 27 of the tone keyer stage 23 is coupled to transmitting keyer 28 through adjustable resistance 30 connected to positive terminal 31. Tube 28 is blocked when tube 23 conducts and it passes current when tube 23 is

blocked. The plate 34 of keying stage 28 is connected to one end of resistance 35, the other end of the resistance being connected to positive terminal 36. The first mentioned end of resistance 35 is connected to the primary 37 of a radio frequency transformer and the other end of this primary is connected to the plate 38 of modulator tube 39. The radio frequency oscillator 40 is connected between the grid 41 and filament 42 of tube 39 and the filament is connected to the negative terminal. The secondary 45 of the output transformer of tube 39 is connected to appropriate power amplifiers 46 and the output of the amplifiers is connected to an appropriate antenna 47 and to ground.

The amplifiers 21 and 46 and the oscillator 40 may be of any type well known in the art and are therefore shown only in block diagram.

In the modified form of transmitting system shown in Fig. 2, I have omitted the distributor 11 and the perforated tape transmitter 7 and 8 are connected to individual oscillating condensers with their respective neon tubes 18. Devices similar to those of Fig. 1 have been given similar reference characters, so they need not be described in detail. The outputs of the oscillators 18 are connected through apparatus to and including the antenna that is exactly the same as shown in Fig. 1 and hence it has not been illustrated.

In the receiving circuit shown in Fig. 3 one antenna may be used but on account of general fading usually met with in radio systems, I prefer to use the diversity receiving antenna well known in the art and described in the patent of H. H. Beverage, No. 1,874,866, August 30, 1932. This may be generally described as consisting of three antennas 48, connected to three receivers 49, which may have well known receiving apparatus consisting of radio frequency tuning stages, heterodyne oscillators, intermediate frequency tuning stages and detectors which are well known in the art and hence have not been specifically illustrated. The receiving apparatus 49 is connected to appropriate amplifiers 50 and the amplifiers are connected to current or voltage limiters 51 to further overcome the effects of fading. The limiters of the three circuits of the diversity receiving system are all similar and a description of one is sufficient. In the limiter, the grid 52 is connected through a negative bias of sufficient value to cut off the desired part of the negative wave in the limiting action. Resistance 54 in the plate circuit of this limiting tube is of such value as to cut a similar part of the positive half cycle due to electron saturation effects in the tube.

The output of each limiter is connected to mixing tubes 55 which may be the same in each of the three circuits. Each mixing tube has a negative bias 56 of such value as to block the tube for the negative half of the low frequency cycles of the condenser-neon tube oscillator and thus permit the passage only of the positive cycles. This prevents cancellation due to any difference in phase conditions of the currents in the three circuits and permits proper summation of the signals.

The plates 57 of the mixing or combining tubes are connected in parallel through the primary of a transformer 58 to positive terminal 59 and adjustable resistance 60 may be connected in this lead for obtaining the proper plate potential. The secondary of transformer 58 is connected in parallel to two limiters 61 and 61' and the output of each limiter is connected to band pass filters 63 and 63', one of these filters, say 63, being adjusted to pass one of the low frequencies, say, that controlled by perforated tape transmitter 7, and the other one, 63' being adjusted to pass the low frequency controlled by the other perforated tape transmitter 8. The output of the band pass filter 63 feeds into rectifier 64 and the rectified output passes through smoothing filter 65 and is impressed across the grid filament circuit of coupling tube 66.

The output of the band pass filter 63' passes similarly through rectifier 64', smoothing filter 65' and coupling tube 66'. The output of coupling tubes 66 and 66' feed into a signal regenerating circuit shown as the well known locking circuit 67, 67' of the patent to Finch, No. 1,844,950, February 16, 1932. The regenerated signals from the locking circuits pass into utilization devices such as recorders 68 and 68' of any kind.

The limiters 61 and 61' may be like the limiters 51 or they may be of any other type. The band pass filters 63, 63', are well known in the art and need not be illustrated or described except to say that it is preferable to design these filters with a narrow band width to pass the frequency initiated by one perforated tape transmitter and exclude that of the other. The rectifiers 64, 64' may be of the usual vacuum type, or any other type.

The operation is as follows:

Referring to Fig. 1 when tongue 9 is brought into engagement with contact 5 by the perforated tape mechanism, condenser 1 charges by current passing from the positive terminal of the battery through resistance 14, to brushes 13 and 12, the latter being assumed to be in engagement with segment 10. The current then passes through tongue 9, contact 5, resistance 3, condenser 1, and back to the negative terminal of the battery. As the condenser charges, its voltage increases and finally the potential is sufficient to discharge across neon tube 18 through transformer coil 19 after which it recharges. The time constant of the condenser 1 and circuit may be made anything desired by adjusting resistances 3 and 14, but for purpose of explanation and illustration it will be assumed to be such as to produce a frequency of 500 cycles per second. Assuming that distributor 12 is run at say, 60 cycles, the brush 12 will be in engagement with segment 10 for a sufficient length of time to permit the condenser-neon tube oscillator to produce a plurality of cycles at the frequency of f_1 of 500 cycles per second. The secondary 20 of the transformer connected in the circuit of the neon tube 18 will therefore feed the low frequency oscillations into the amplifiers 21 and then into the vacuum tube stage 23, which in this case has sufficient negative bias to block the plate current on the negative half cycle.

The flow of plate current in tube 23, when a positive half cycle voltage is impressed across the input circuit, places such a heavy drop in resistance 30 that tube 28 is blocked by the negative voltage. There being no plate current in tube 28 during this positive half wave of the voltage wave initiated by perforated tape transmitter 7, the drop in resistance 35 produced thereby is removed and tube 39 passes current under influence of the radio frequency impressed across its input by oscillator 40. A radio frequency wave is thus radiated from antenna 47 during the time of this low frequency half cycle. This is indi-

cated by reference character 69, in graph A of Figure 4.

When the positive half cycle of the condenser-neon tube oscillator ends and the negative half cycle begins, tube 23 is blocked by the negative grid bias and no drop is produced in resistance 30. The negative grid bias being removed, tube 28 draws full plate current and places such a heavy drop in resistance 35 that practically no radio frequency carrier is passed by amplifier 46, tube 39 being virtually short-circuited. Therefore, during the negative half cycle there is no radiation from antenna 47, as indicated at 70 in Fig. 4.

Since the frequency of the condenser-neon tube oscillator is considerably higher than the frequency of interruption by distributor 11, a number of groups of high frequency waves 69, 71, 72, will be radiated before brush 10 leaves segment 10. When the brush leaves this segment and engages contact 16, condenser 1 and circuit then has another time constant by virtue of the substitution of resistance 4 for resistance 3 and another low frequency, 1000 cycles, per second, for example, is produced by the condenser-neon oscillator in secondary 20 and the radio frequency carrier of oscillator 40 is radiated from antenna 47 in a number of groups starting at 73. These groups have the frequency f_2 or 1000 in the example given. In this way the perforated tape transmitters 7 and 8 will cause alternate groups of radio frequency waves to be radiated, the one group having a frequency of f_1 and the other f_2.

The mark indications of the two transmitters 7 and 8 may start at any time as they are independent of each other, but by way of example, I have indicated a mark for transmitter 7 as starting with group 69 and ending with group 74. Similarly the mark for transmitter 8 is illustrated as commencing with group 73 and ending with group 76. Graph A is broken away at 77 to indicate that there are more groups for the marks than can be shown in the drawings with a suitable scale.

The radiated waves are received and detected at 49 and amplified at 50 in all three of the channels in the diversity receiver. The amplified audio currents are then limited at 51 to cut off the desired amount of the positive and negative cycles to reduce fading effects. The output of the three limiters are mixed in the plate circuits of the rectifiers 55 and introduced into the two channels through limiters 61, 61'. Band pass filter 63 passes the low frequency alternations f_1 and excludes f_2 while band pass filter 63' passes f_2 and excludes f_1. The two signals are thus isolated and when rectified at 64, 64' will appear as indicated by the dotted line 75 in graph B. At this point the voltage will have positive pulses of frequency f_1, broken up at the lower frequency of the distributor 11. However, when the voltage passes through the smoothing filter 65 it will be smoothed out as indicated by line 73'. Similarly the rectified voltage of frequency f_2 and the smoothed out voltage will be indicated by 74' and 75', respectively, of graph C, which indicate the marks of the respective signals. The spaces of these signals are caused by the tube 28 normally shorting the plate voltage of amplifier 39 when no signals are being sent out by tape transmitters 7 and 8.

The signals after being rectified could be used to operate the recorders 68, 68', directly but it is preferable to square up the marks by a regenerating device such as the locking circuits 67, 67'. Referring to graph B, when the voltage 73' is applied to tube 66 it produces a drop in resistance 76' by the plate current and condenser 76'', previously charged to full line voltage, discharges through the plate filament circuit of tube 66 to the center of the battery 77', through one-half of the battery and resistance 78 to the other side of the condenser. The drop in resistance 78 places a heavy bias on the grid of tube 79 and blocks the tube. Tube 80 was previously blocked by the drop in resistance 81 caused by the plate current of tube 79 and when it is removed the voltage of the grid of tube 80 rises to full positive value. Tube 80 then draws plate current and instantly blocks tube 79 by the negative drop applied to its grid by resistance 82. This happens at a predetermined value of the signal voltage, say that indicated at the point 83 of graph B. The voltage across lines 84, 85, of the recorder, rising instantly to the value 86 in graph B, will remain constant until the balance of the locking circuit is disturbed by the decrease of the signal to a predetermined value 87. It will be noted that at this time output line 84 is positive and line 85 is negative.

When point 87 in the voltage curve 73' is reached, the charging current through condenser 76'', due to decrease of drop in resistance 76', becomes heavy enough to place a sufficient positive drop in the grid of tube 79, to cause that tube to conduct current. This instantly causes tube 80 to block due to the negative voltage placed on its grid due to the drop in resistance 81. The voltage across lines 84 and 85 immediately reverses at point 87 and the space 88 starts to form. This space will continue until the beginning of another mark starts to form, whereupon the balance will be again disturbed by the condenser again discharging, it having been charged to full battery voltage while the space was being formed.

The signal initiated by tape transmitter 8 after the current passes through smoothing filter 66' will operate locking circuit 67' in exactly the same way locking circuit 67 was operated and the final square signal wave at the input terminals of recorder 68' will be as indicated by 89, 90, of graph C. No distributor is required at the receiver and hence synchronization between transmitter and receiver is entirely absent.

In the modified transmitting system of Fig. 2 the distributor 11 of Fig. 1 has been omitted and two condenser-neon tube oscillators have been used. Condenser 1 of the respective channels will each oscillate at a low frequency depending upon the constants of the circuit as in Fig. 2. The tape transmitters 7 and 8 will cause these oscillators to generate alternating voltage each time a marking contact is made. Each oscillating circuit is independent of the other and the low frequency output of the secondaries 20 are superposed on each other, and from there on the circuit to and including the antenna will be as described in connection with the apparatus of Fig. 1 except for the interrupter 11. The receiving operation will also be as described in connection with Fig. 3 with a similar exception in respect to the interruption of the distributor 11 which will be absent. The modified form in Fig. 2 will be satisfactory but it is not preferred because the signal of one channel modulates the signal of the other by interaction. However, there will remain sufficient pulses at the band pass filters to enable the latter to separate the signals at the receiver and they will produce a suitable record.

In both forms of transmitting systems I may

use any kind of low frequency oscillator, the one disclosed being by way of example only. Various other modifications may be made without departing from the spirit of the invention.

Having described my invention, what I claim is:

1. In multiplex radio telegraphy, a generator of high frequency oscillation, means for generating a plurality of alternating electromotive forces each having a different low frequency, signal transmitting devices each having means to send mark and space signals by interrupting current from the first-mentioned means for one of a plurality of messages, means for rectifying the interrupted currents of the generating means, a distributor connected to the signal transmitting devices for interrupting the signals therefrom at a frequency below the frequency of the low frequency generating means, and means for transmitting said high frequency oscillations only during the time periods of the current pulses in said rectified currents.

2. In multiplex radio telegraphy, an antenna, a generator of high frequency oscillations, means for generating a plurality of alternating electromotive forces each having a different low frequency, signal transmitting devices each having means to send mark and space signals by interrupting current from the first-mentioned means for one of a plurality of messages, a distributor connected to the signal transmitting devices for interrupting the current therefrom at a frequency below the frequency of the low frequency generating means, means for rectifying the output of the generating means, and means for passing the high frequency oscillations to the antenna only during the time periods of the pulses in said rectified current.

3. In signaling systems having a plurality of channels, a high frequency oscillator, means for producing a plurality of currents of different low frequency, means for modulating each current in accordance with a message, a rectifier, means to pass the modulated low frequency currents to the rectifier in timed succession for a uniform time interval materially longer than the periodic time of the lowest frequency of the first-mentioned means, and means for modulating the high frequency oscillator by the rectified low frequency currents.

4. In signaling systems having a plurality of channels, a high frequency oscillator, means for producing a plurality of low frequency currents, means for rectifying the low frequency currents, means for modulating the high frequency oscillator successively by each of the rectified low frequency currents during an interval of time greater than the periodic times of the frequencies, and means for interrupting the low frequency currents to form mark and space signals of materially greater time length than said time intervals.

5. In signaling systems having a plurality of channels, a high frequency oscillator, means for producing in each channel current of a low frequency differing from the frequency of the other current, means to interrupt each low frequency current to form mark and space signals, a rectifier, means to pass each interrupted low frequency current in succession to said rectifier for uniform periods of time materially longer than the periodic time of any of said low frequencies and shorter than the time length of the shortest signal, and means for modulating the high frequency oscillator by the rectified low frequency currents.

6. In signaling systems having a plurality of channels, a high frequency oscillator, means for producing in each channel current of a low frequency differing from the frequency of the other current, a modulator connected to said oscillator, means to pass each low frequency current in succession to said modulator for uniform periods of time materially longer than the periodic time of any of said low frequencies and shorter than the shortest signal, and means to interrupt each low frequency current to form mark and space signals, said modulator having means for causing said oscillator to oscillate only during alternate half cycles of said low frequencies.

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