March 22, 1949. F. J. WERTHMANN ET AL. 2,464,837

RADIO TELETYPE SYSTEM

Filed May 2, 1946 4 Sheets-Sheet 1

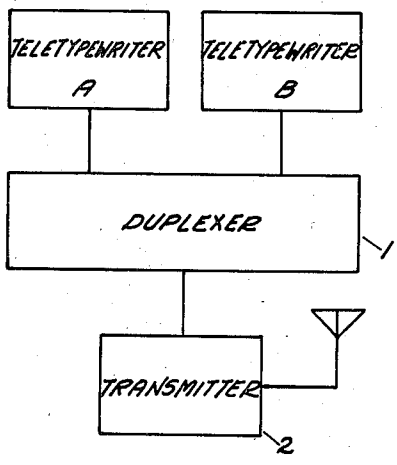


FIG. 1

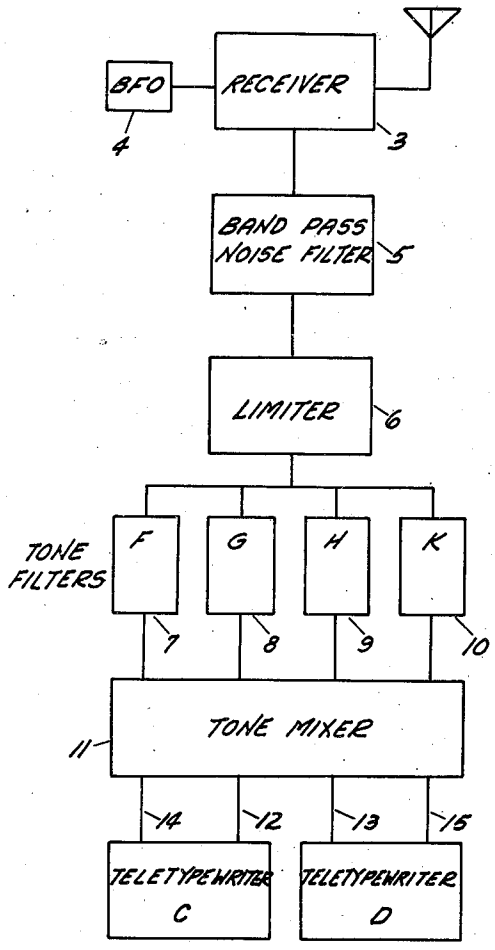


FIG. 2

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RADIO TELETYPE SYSTEM

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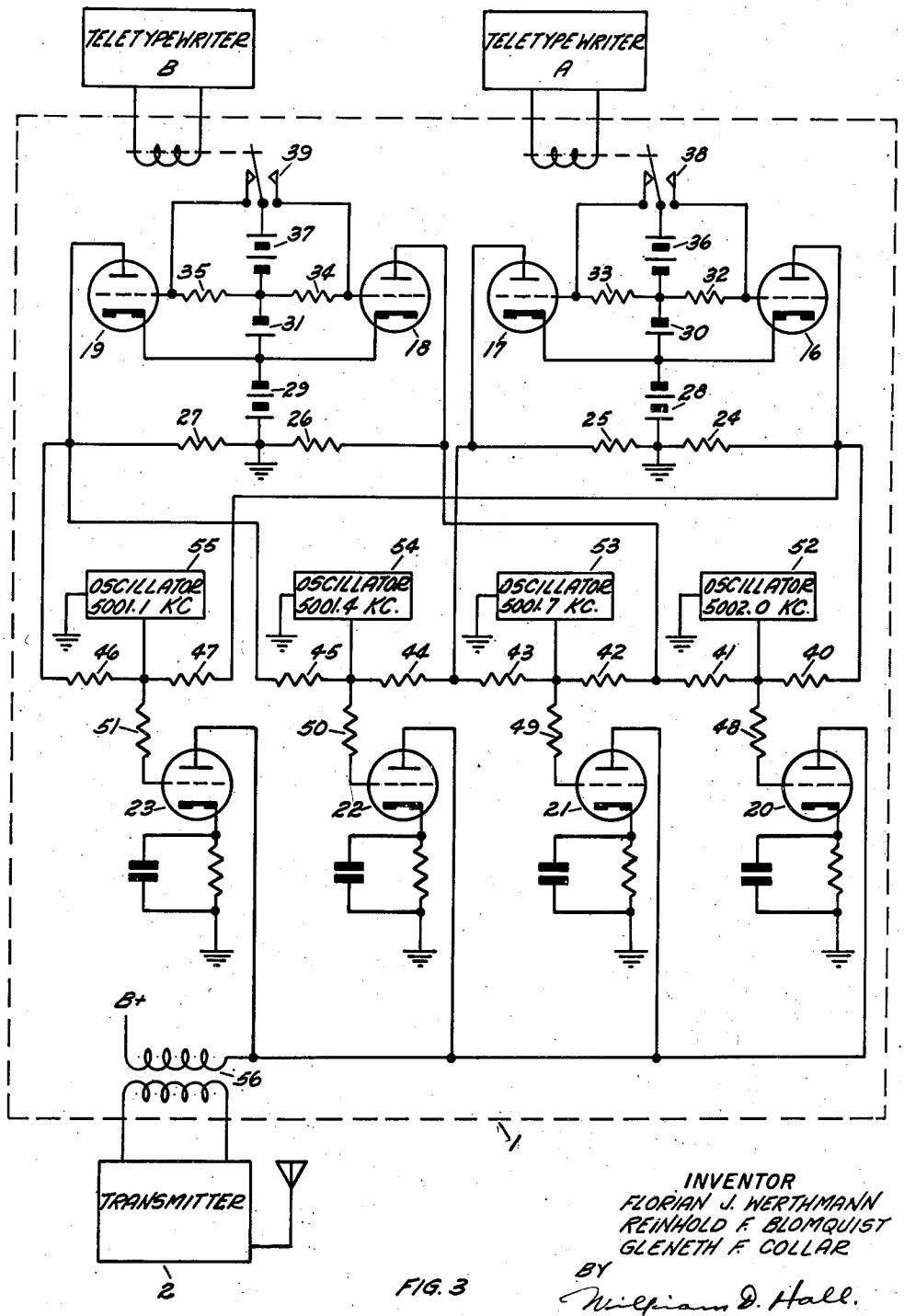


FIG. 3

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RADIO TELETYPE SYSTEM

Filed May 2, 1946 4 Sheets-Sheet 3

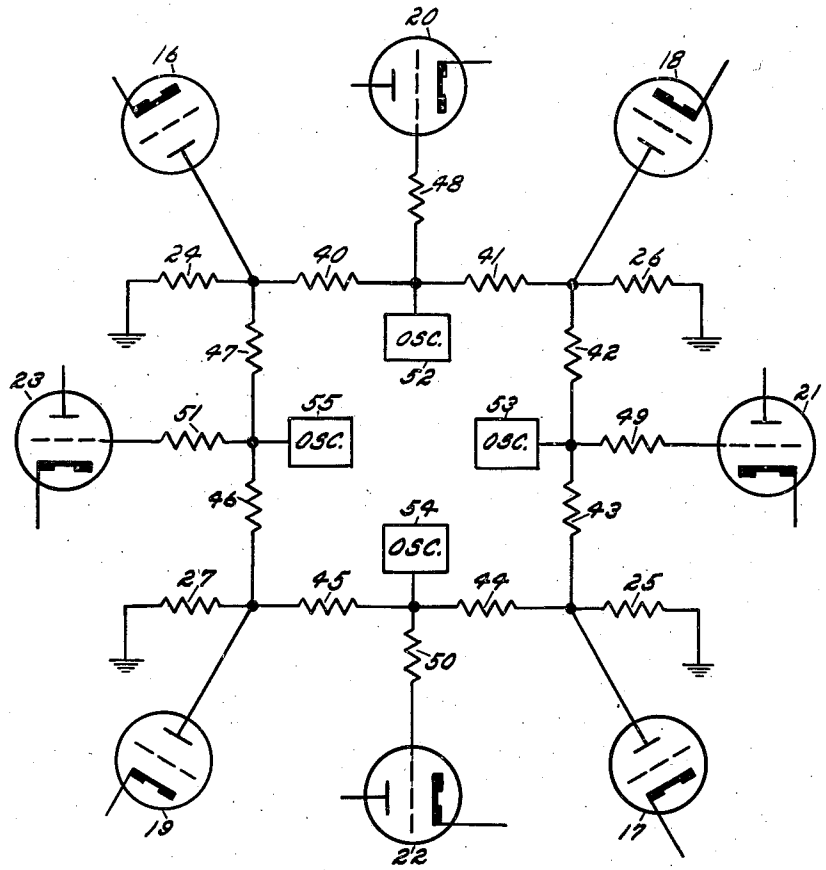


FIG. 4

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RADIO TELETYPE SYSTEM

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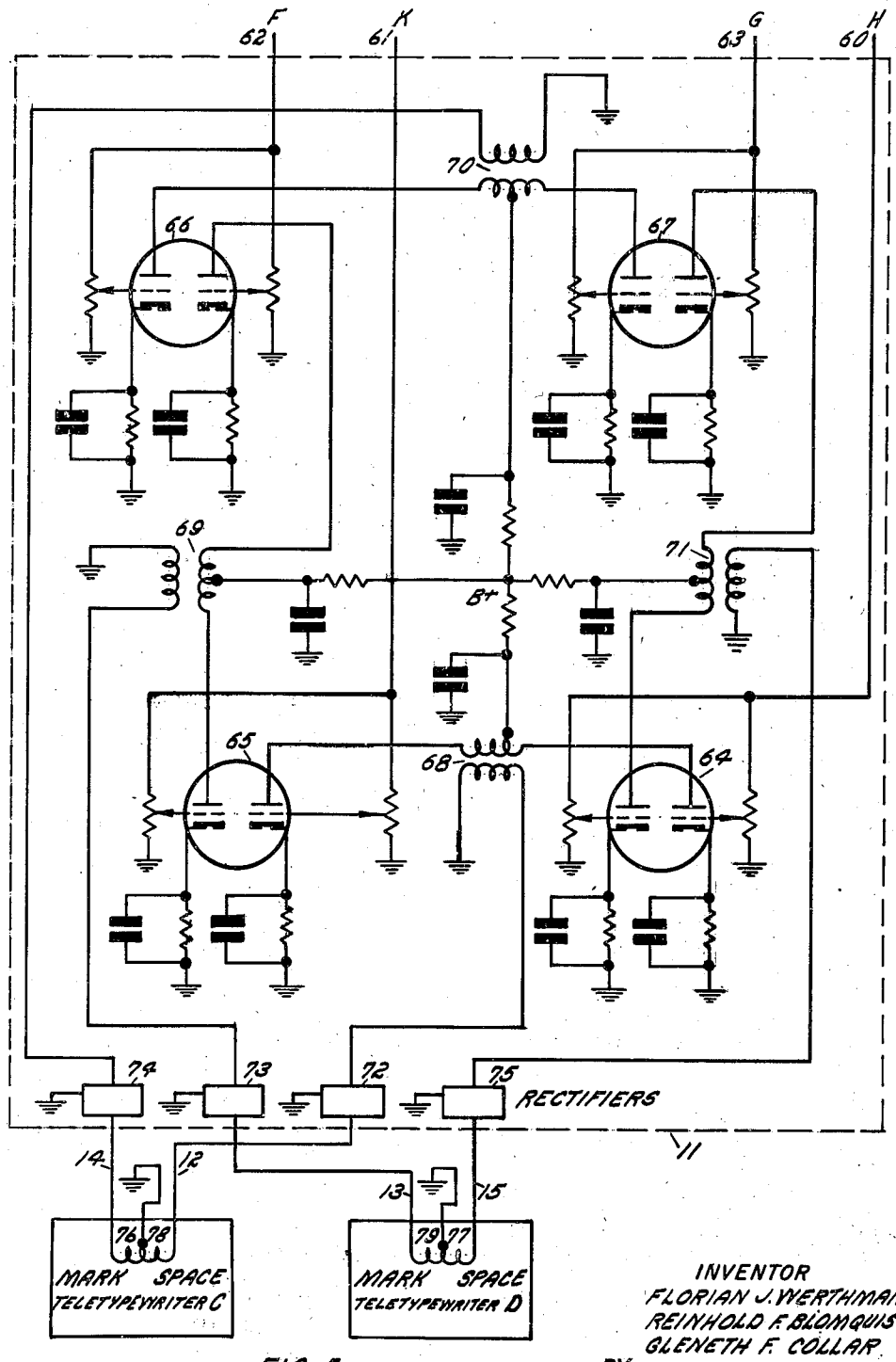


FIG. 5

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RADIO TELETYPE SYSTEM

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Application May 2, 1946, Serial No. 666,778

3 Claims. (Cl. 178—61)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

Our invention is concerned with the art of duplex telegraphy and is a system for simultaneous transmission of two teletype signals over a single channel by means of a signal in which the intelligence is conveyed by frequency changes which are permutations among four frequencies. This system has the advantages that the transmitted signal operates at all times at maximum energy, that the signal occupies a minimum of band width, and that interfering noises have no tendency to cause false signals. No synchronizing means are required. The transmitted signal at any instant is a continuous wave of fixed frequency.

It is one object of our invention to provide a system for simultaneous transmission of two teletype code signals over a single channel.

It is another object of our invention to provide a system for simultaneous transmission of two mark-space code signals over a single channel with constant signal energy and minimum band width.

It is another object of our invention to provide a system by which a one-to-one correspondence is set up between the four possible combinations of signal of two superposed mark-space codes and a selection one at a time from a group of four frequencies, as will appear more fully hereinafter.

It is another object of our invention to provide a duplexing system for teletype code not requiring synchronizing means between transmitter and receiver.

Our invention will be better understood by reference to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings,

Figure 1 is a block diagram of a transmitting portion of a complete system embodying our invention.

Figure 2 is a block diagram of a receiving portion of a complete system embodying our invention.

Figure 3 is a circuit diagram of the duplexer part of the transmitting system.

Figure 4 is a circuit diagram of part of the duplexer of the transmitting system.

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Figure 5 is a circuit diagram of the tone mixer part of the receiving system.

It is well known in the prior art to prepare on one teletypewriter a mark-space code signal representing the various characters and spaces of a typewritten message and to receive this signal on a second teletypewriter whereon the message is automatically typed. As constructed, each typewriter comprises both transmitting and receiving components. The output of each teletypewriter transmitter is a direct current of constant amplitude coded in marks and spaces. The input to each teletypewriter receiver is direct current, the marks being represented by current in one coil of a relay, the spaces by current in an oppositely acting coil of the relay.

The general method employed in our invention is to set up a correspondence between the various combinations of mark and space which are obtained by combining two mark-space signals and a selection of one frequency from a group of four frequencies.

The possible mark-space combinations and the correlated frequencies are listed below. The correlated frequencies have been denominated by letters, as well as given suitable values. The values are selected to have no simple harmonic interrelation, and so as to be separable in frequency selective filters.

	Correlated frequency
Code combination 1	F, 2000 cycles
Teletypewriter A on mark	
Teletypewriter B on mark	
Code combination 2	G, 1700 cycles
Teletypewriter A on mark	
Teletypewriter B on space	
Code combination 3	H, 1400 cycles
Teletypewriter A on space	
Teletypewriter B on space	
Code combination 4	K, 1100 cycles
Teletypewriter A on space	
Teletypewriter B on mark	

In our system of transmission, during the periods when combination 1 occurs, i. e. both teletypewriters are on "mark," frequency F is transmitted; similarly one of the three frequencies G, H, K is transmitted for each of the three other possible combinations. Thus there is continually transmitted some one of the four tones listed above. The transmission is made always at full amplitude and there is never more than one tone transmitted at any particular time.

In Figure 1 are shown two teletypewriter transmitters A and B adapted to pass code signal

in the form of direct voltage for the marks and absence of voltage for the spaces. These signals are combined in duplexer 1. The virtual equivalents of the four corresponding signal tones above referred to are formed in duplexer 1 and passed to radio transmitter 2, from which they are radiated. It is within the scope of our invention to transmit the four frequencies as four modulations in various orders of succession on a constant carrier. However, in the interest of compressing the band width used in transmission we prefer effectively to suppress the carrier and the lower side bands and transmit the upper side bands only. This physically consists in transmitting in successive permutations four continuous wave signals close together in frequency. For a virtual suppressed carrier of 5,000 kc. the actual frequencies of continuous wave transmission may have the values 5002.0 kc., 5001.7 kc., 5001.4 kc. and 5001.1 kc., to supply upper side bands corresponding to the virtual modulations of 2000, 1700, 1400 and 1100 cycles.

In Figure 2 is shown a receiver 3 for receiving the signals transmitted from transmitter 2. The virtual suppressed carrier of 5000 kc. is supplied at the input to receiver 3 from a local beat frequency oscillator 4. Beats between locally supplied carrier and the received side bands are then formed in receiver 3, and its audio output consists of the difference beat frequencies 2000, 1700, 1400 and 1100 cycles, so that the signals of frequencies F, G, H, and K correlated with the teletypewriter mark-space combinations at the transmitter are created in the receiver and in the sequence of the combinations.

From the receiver the audio signals are passed through a noise filter 5 designed to pass the band 1100 to 2000 cycles and suppress other frequencies, thence through a limiter 6 which cuts the signals down to a fixed amplitude and through a bank of four frequency selective filters 7 to 10 designed to isolate the four signals. The four filters 7, 8, 9 and 10 are tuned respectively to the four frequencies F, G, H and K.

The outputs of the filters are then recombined by pairs in tone mixer 11; that is, for signal output from either filter 7 or 8 a direct-current "mark" signal is passed to the teletypewriter receiver C over lead 14. For signal output from filters 8 or 9 a direct-current "space" signal is passed to teletypewriter receiver D over lead 15. Similarly for signal from either filters 9 or 10 a "space" signal passes to teletypewriter receiver C over lead 12, and for signal from either filters 10 or 7 a "mark" signal passes to teletypewriter receiver D over lead 13.

Thus the code signal from the teletypewriter transmitter A is applied to teletypewriter C and simultaneously the code signal from teletypewriter B is applied to teletypewriter D.

In Figure 3 is shown a preferred form of duplexer. It comprises essentially a bank of keying tubes 16, 17, 18 and 19, and a bank of keyed tubes 20, 21, 22 and 23.

Keying tubes 16, 17, have load resistors 24, 25 respectively in series with their respective plates and a common plate voltage supply 28, the positive terminal of which is grounded. Keying tubes 16, 17 have load resistors 32, 33 in series with their respective grids and a common negative bias supply which returns to the common junction of their cathodes and the negative terminal of the plate voltage supply 28.

In series with the negative bias supply 30 is a positive bias supply 36 having its negative terminal connected to the negative terminal of negative bias supply 30 and its positive terminal connected to the tongue of a single-pole double-throw relay 38. One fixed contact of relay 38 is connected to the grid of tube 16, the other to the grid of tube 17. Relay 38 is controlled by the mark-space signal from teletypewriter A to which its coil is connected, the control being in the sense that positive bias 36 is connected to the grid of tube 17 (and disconnected from the grid of tube 16) for a mark signal and connected to the grid of tube 16 (and disconnected from the grid of tube 17) for a space signal.

In entirely analogous manner the plates of keying tubes 18 and 19 are connected respectively through load resistors 26 and 27 to a common plate voltage supply 29 having its positive terminal grounded. Grids of tubes 18 and 19 are connected respectively through resistors 34 and 35 to negative bias supply 31, the positive terminal of which is connected to the common junction of the cathode of tubes 18 and 19 and the negative terminal of plate voltage supply 29.

In series with negative bias supply 31 is a positive bias supply 37 having its negative terminal connected to the negative terminal of negative bias supply 31 and its positive terminal connected to the tongue of a single-pole double-throw relay 39. One fixed contact of relay 39 is connected to the grid of tube 18, the other to the grid of tube 19. Relay 39 is controlled by the mark-space signal from teletypewriter B, to which its coil is connected, the contact being in the sense that positive bias 37 is connected to the grid of tube 19 (and disconnected from the grid of tube 18) for a mark signal and connected to the grid of tube 18 (and disconnected from the grid of tube 19) for a space signal.

Eight equal dropping resistors 40–47 are connected in series in a loop, as is shown quite plainly in Figure 4. The junction of resistors 40 to 41 is connected through limiting resistor 48 to the grid of keyed tube 20. In similar fashion the junction of resistors 42 and 43 is connected through limiting resistor 49 to the grid of keyed tube 21, junction of resistors 44 and 45 through resistor 50 to grid of tube 22, junction of resistors 46 and 47 through resistor 51 to grid of tube 23. The junction of resistors 47 and 40 is connected directly to plate of tube 16, of resistors 41 and 42 to plate of tube 18, of resistors 43 and 44 to plate of tube 17, of resistors 45 and 46 to plate of tube 19.

An oscillator 52 having a frequency of carrier plus frequency F, that is to say, 5002.0 kc., feeds its output into the grid cathode circuit of keyed tube 20 through resistor 48. Similarly an oscillator 53 having a frequency of carrier plus frequency G, that is, 5001.7 kc., feeds the grid of tube 21 through resistor 49; an oscillator 54 having a frequency of carrier plus frequency H, hence 5001.4 kc., is connected to the grid of tube 22 through resistor 50, and an oscillator 55 having a frequency of carrier plus frequency K, or 5001.1 kc., applies its output to the grid of tube 23 through resistor 51.

The plates of keyed tubes 20, 21, 22, 23 are tied together and receive their plate voltage through the primary of a radio frequency transformer 56. The secondary of transformer 56 feeds signal to transmitter 2 for transmission.

In operation a mark signal from teletypewriter A pulls down the tongue of relay 38, putting positive bias on the grid of tube 17 and hence negative bias on the grid of tube 16. Tube 16 draws

no current and its plate is at ground potential. Tube 17 draws current and its plate falls below ground potential. A simultaneous mark signal from teletypewriter B puts the plate of tube 18 at ground potential and the plate of tube 19 below ground potential. By reference to Figure 4 it is seen that this operation grounds the junction of resistors 40 and 41 and puts at negative potential the junctions of resistors 42 and 43, 44 and 45, and 46 and 47. Thus the grid of keyed tube 20 is biased to ground, permitting signal from oscillator 52 to pass through tube 20 to transformer 56. The grids of keyed tubes 21, 22, 23 are all biased so negatively that no signal is allowed to pass from oscillators 53, 54 and 55 to transformer 56.

It will be seen that any combination of mark and space signals from the two teletypewriters A and B results in signal being passed from one of the four oscillators and blocked from the other three. It will be seen further that the frequency of signal which is passed is carrier frequency plus the audio frequency correlated with the concomitant code combination as set up in the table above.

The tuning of transmitter 2 is broad enough to transmit all four frequencies without retuning.

It is seen that duplexer 1 has converted the code combinations from the two teletypewriters into a corresponding spectrum of four frequencies.

At the receiver station an inverse operation is effected in order to separate the two coded signals. A preferred circuit for accomplishing this result is shown in Figure 5, this circuit constituting the tone mixer 11.

Tone mixer 11 comprises four double triode tubes 64, 65, 66 and 67. The double grids of tube 64 are fed from a common input terminal 60, similarly the double grids of tube 65 are fed from terminal 61, those of tube 66 from terminal 62, and those of tube 67 from terminal 63. One plate of tube 64 is connected through primary of audio transformer 68 to one plate of tube 65. The other plate of tube 65 is connected through primary of transformer 69 to one plate of tube 66. Similarly plates of tubes 66 and 67 are connected through primary of transformer 70 and plates of tubes 67 and 64 through primary of transformer 71. The centers of these transformers, grounded for audio frequencies, are connected to the positive terminal of a common plate voltage supply.

The secondaries of transformer 68, 69, 70, 71 are connected respectively to rectifiers 72, 73, 74, 75.

Output of rectifier 72 is conducted through lead 12 to the space control coil 78 of teletypewriter receiver C. Similarly, output of rectifier 73 is conducted by lead 13 to mark control coil 79 of teletypewriter D; output of rectifier 74 is conducted by lead 14 to mark control coil 76 of teletypewriter C; output of rectifier 75 is conducted by lead 15 to space control coil 77 of teletypewriter D.

The four frequencies F, G, H and K are received from tone filters 7, 8, 9 and 10 at terminals 62, 63, 60 and 61, respectively. Responsive to signal H tube 64 passes signals to both transformers 71 and 68 and thence to rectifiers 72 and 75, respectively, wherein the audio-frequency signals are converted into direct-current signals. Similarly tube 65 responsive to signal K passes signals to both transformers 68 and 69, which are rectified in rectifiers 72 and 73. Thus a

direct-current control signal appears in the output of rectifier 72 responsive to either H or K signals but to no others. Hence the output of the rectifier 72 produces the space signal of teletypewriter A and this signal is applied through lead 12 to the space control coil 78 of teletypewriter receiver C, so that teletypewriter C reproduces the space signal initiated at teletypewriter A. Similarly both signals F and G produce signal in rectifier 74 and in mark control coil 76 of teletypewriter receiver C; so that teletypewriter C reproduces the code of teletypewriter A.

Similarly, signal appears at rectifier 73 responsive both to signals K and F applied to terminals 61 and 62, respectively. Accordingly the output of rectifier 73 reproduces the mark signal of teletypewriter transmitter B and this signal is applied through a lead 13 to the space control coil 79 of teletypewriter receiver D. Accordingly there is reproduced in teletypewriter D the mark signal of teletypewriter B. Lastly signals G and H through rectifier 75 reproduce the space signal of teletypewriter B in coil 77 of teletypewriter D. Thus teletypewriter D reproduces the message of teletypewriter B just as teletypewriter C reproduces the message of teletypewriter A.

Having described one embodiment of our invention we wish it understood that the invention is not to be limited to the particular embodiment described but only by the appended claims.

What we claim and desire to protect by Letters Patent is:

1. A duplexer comprising, a loop of eight serially connected impedances having a first set of four alternate junctions and a second set of four alternate junctions, four keying means connected respectively to each of the four junctions of said first set whereby the potential at each of these four junctions may be keyed between ground and a negative direct potential, and four sources of alternating potential together with four bias-responsive means connected respectively to the four junctions of said second set whereby each said bias-responsive means passes alternating potential from said source therewith connected when the junction therewith connected lies between two adjacent junctions of said first set which are at ground potential but blocks passage of alternating potential from said source therewith connected when the junction therewith connected lies adjacent to a junction of said first set which is at negative potential.

2. In a duplexing system, four primary "on-off" keying means arranged as in analogy to the corners of a square with opposite pairs of said keying means being oppositely "on" and "off", four secondary "on-off" keying means arranged as in analogy to sides of said square and responsive to said four primary keying means, and means for setting at "on" only that one of said secondary keying means which is positioned on that side which lies between the two corners at which the said primary keying means are set at "off."

3. In a receiver for a duplexed code signal having the character of four components of different frequencies in permutation, frequency selective means for isolating the components of the signal in four separate channels, respectively designated A, B, C, D, and means connecting channels A and B at their output terminals unilaterally to a first rectifier, means connecting channels C and D at their output terminals unilaterally to a second rectifier, relay means responsive to said first and second rectifiers acting in mutual opposition,

means connecting channels A and C at their output terminals unilaterally to a third rectifier, means connecting channels B and D at their output terminals unilaterally to a fourth rectifier, and relay means responsive to said third and fourth rectifiers acting in mutual opposition.

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