

Sept. 21, 1948.

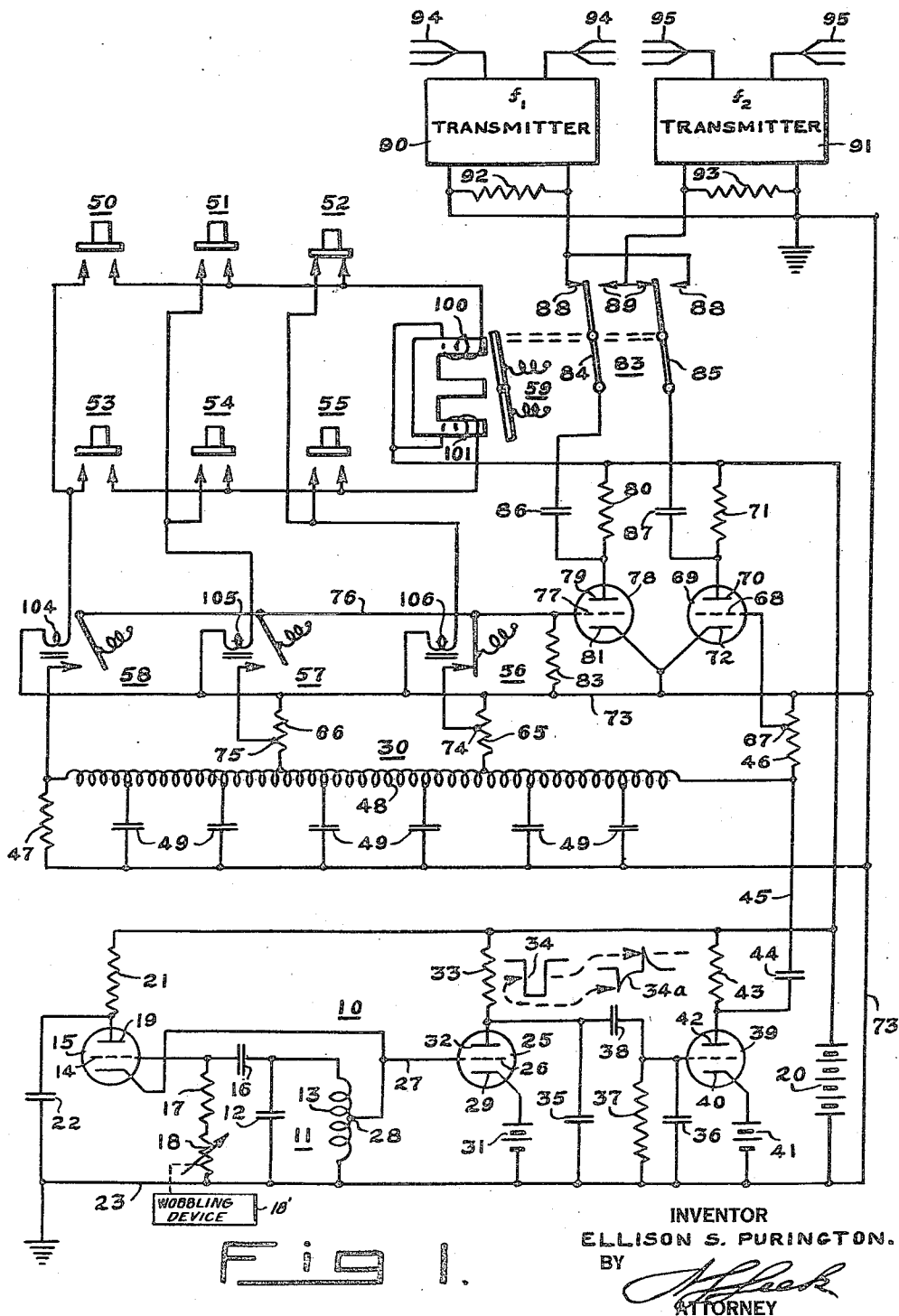
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2,449,819

MULTIPLEX RADIO COMMUNICATION

Filed May 29, 1944

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

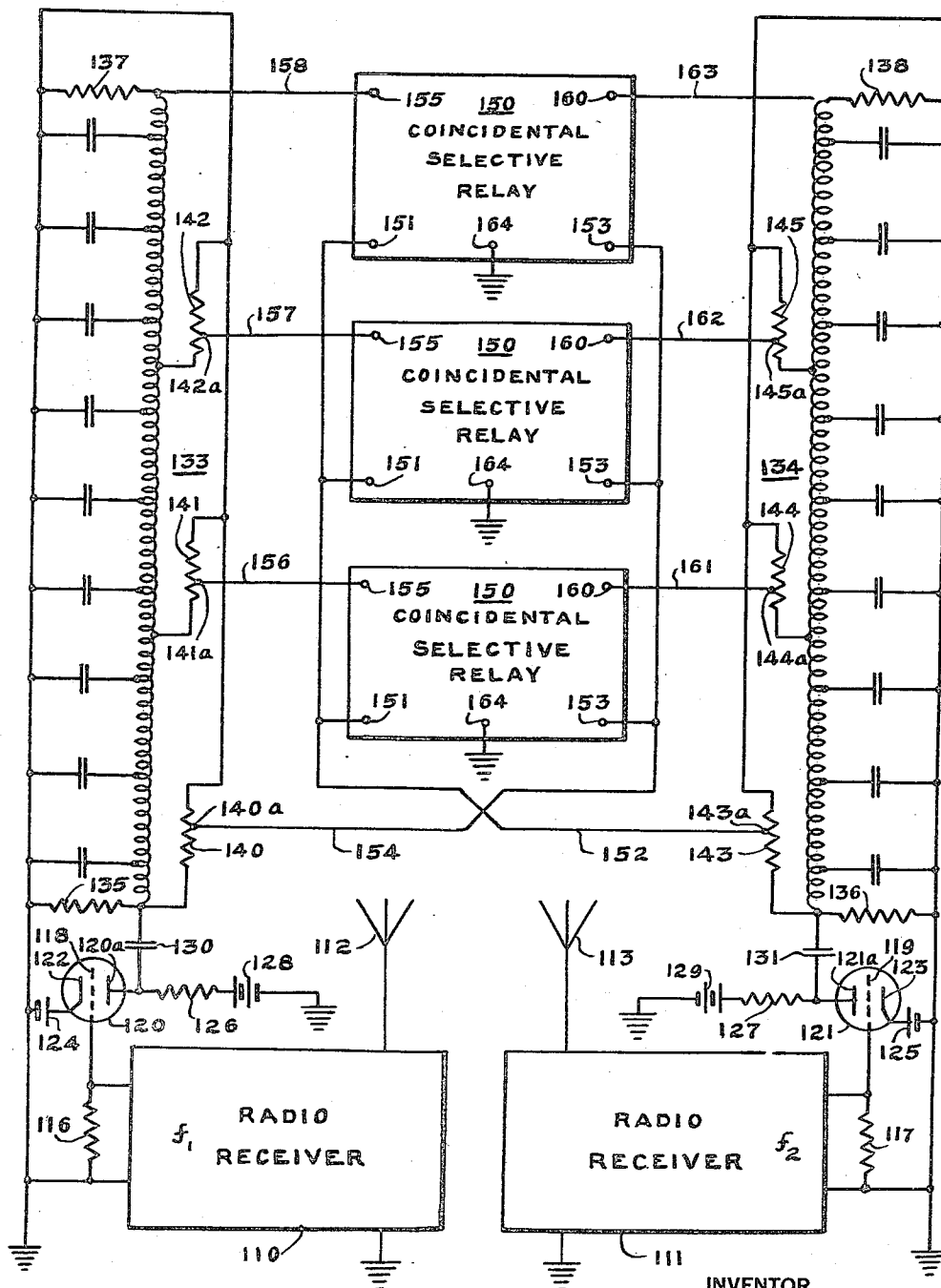


Fig. 2.

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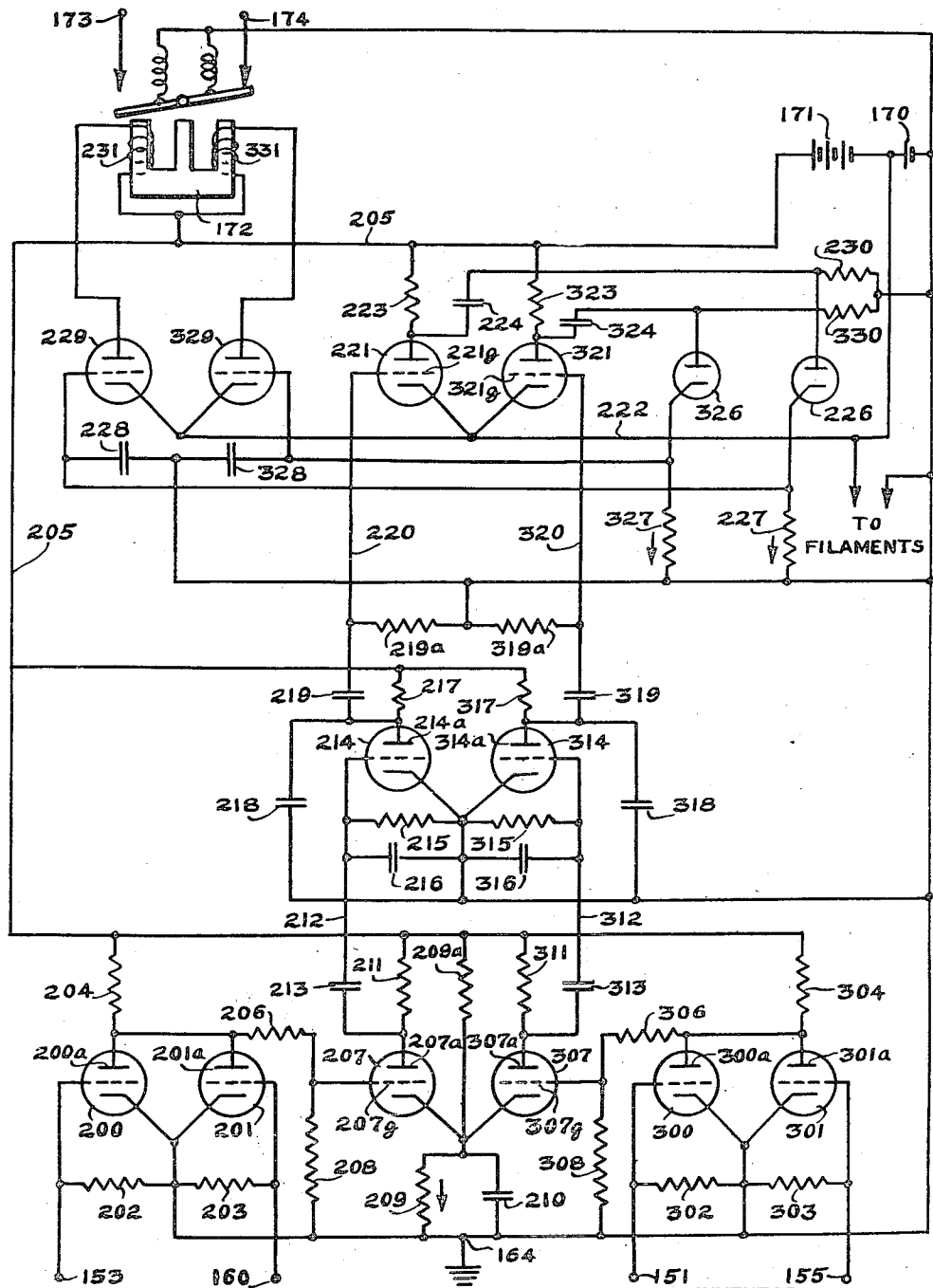


Fig. 3.

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MULTIPLEX RADIO COMMUNICATION

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Application May 29, 1944, Serial No. 537,799

21 Claims. (Cl. 250—9)

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This invention relates to a radio control system of the type propagating timed pulses over a pair of radio frequency channels and has for an object to provide a system for selectively actuating a plurality of controls over a single pair of channels.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

In a copending application entitled "Radio control system," Ser. No. 536,104, filed May 18, 1944, I have disclosed a radio control system comprising two radio channels which are pulsed in succession with a control means to select the pulse sequence and pulse intervals for signalling or control purposes, and a receiver including relays which are selectively actuated in accordance with the pulse sequence and intervals. In that application, proper operation required the second pulse to be received within a definite time limit after the first pulse. That method provided for dual control, such as for example, the right or the left deflection of a remote mechanism in accordance with the selected pulse sequences and intervals.

In the present invention, I provide for a large number of controls by the general method of pulsing two radio communication channels in succession. The term "channel," as employed herein, comprises the necessary apparatus and includes the transmission media for wave transmission by a selected carrier frequency, or by a separate transmission line, whereby the transmission of two pulses or pulse series may be segregated in transmission. However, it is a feature of my present invention that the second pulse must arrive at the receiver at a time between upper and lower time limits after the first pulse in order that control may be exercised. Multiplex operation is therefore established by selection of the amount of transmission delay between the pulses on the two channels. As employed herein, the term "pulse interval" means the time interval between pulses on the two channels, and the term "pulse sequence" means the order in which the pulses are transmitted over the two channels.

In one embodiment the present system provides for six possible control operations, but this is merely for illustration and no definite limit is

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to be assigned to the number of channels that may be provided. Moreover, although I have shown work circuits in the form of electro-magnetic relays, it will be understood that direct electronic work circuits may be substituted. It is within the scope of my present invention that the various channels may for example correspond to different shades of facsimile picture values, or to different keys of a Teletype circuit, or any arrangement where a considerable number of different operations are required.

Although the novel features which are characteristic of this invention are pointed out more particularly in the claims appended hereto, the nature of the invention will be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof in which a specific embodiment has been set forth for purposes of illustration.

In the drawings:

Fig. 1 is a schematic diagram of a transmitting apparatus embodying my invention;

Fig. 2 is a schematic diagram illustrating a receiving apparatus therefor; and

Fig. 3 is a schematic diagram of a selector circuit of the receiver.

Fig. 1

With reference to the transmitter of Fig. 1, the essential parts comprise a pulse forming circuit 10, a time delay network 30, pulse amplifiers 69, 78, a bank of push button switches 50 to 55 for controlling three time delay selector relays 56 to 58, a radio channel reversing relay 59, and dual channel pulse type transmitters 90, 91.

For forming the pulses a so-called howling or blocking oscillator is used. It is well known that any type of negative grid oscillator with excessive feed back, and excessively high grid leak can be arranged to self modulate. The oscillator shown is of the electronic coupled type, with an oscillatory circuit 11 comprising a condenser 12 and an inductance 13 with one end of each connected to ground by a line 23 and the other ends coupled to the grid 14 of a space discharge tube 15 through a blocking condenser 16. A grid leak comprising a fixed resistance 17 in series with an adjustable resistance 18 is connected from grid of tube 15 to the ground line 23. The cathode

of tube 15 is connected to a tap 28 on the inductance 13. Voltage is supplied to the plate 19 of the tube 15 from a source 20, shown as a battery, through a resistor 21. A by-pass condenser 22 is connected between the plate 19 and the ground lead 23 to aid in establishing a proper D. C. voltage from plate to ground.

This oscillator is set to burst into violent oscillation. Thereupon high biasing voltage builds up across resistors 17 and 18 and the oscillations are quenched. By using a very high frequency oscillator this operation of starting and blocking can be made to occur in a very short space of time. For example with suitable choice of constants oscillation pulses can be produced at 100 pulses per second, with each pulse of about 100 microseconds duration.

These oscillation pulses are impressed upon a detector tube 25 having a grid 26 connected by a lead 27 to the tap 28 on the inductance 13 and having a cathode 29 positively biased by a battery 31 or its equivalent. The tube 25 is provided with a plate 32 connected through a plate resistor 33 to the source 20 and arranged so that a negative voltage pulse is produced across the plate resistor 33 as indicated by the curve 34. High frequency components are deleted from this pulse by condensive paths to ground comprising a bypass condenser 35, and a bypass condenser 36 shunted by a resistor 37, both coupled to the plate through a blocking condenser 38. The resistor 37 and condenser 36 are connected in the input circuit of a space discharge tube 39, operating as a clipper tube.

It will be understood that condensers 35 and 36 may be represented in part by the internal capacitances of the tubes and circuit wiring. Condenser 38 and resistor 37 serve to couple the pulses onto the clipper tube 39 and are chosen with very short time constants so that a sharp negative pulse and a sharp positive pulse are produced in the resistor 37 corresponding to the leading and following edges of the pulse in the resistor 33 as indicated by the curve 34a.

The cathode 40 of the tube 39 is biased positively by a battery 41, so that tube 39 passes current only during a small portion of the positive pulse, thereby producing a very narrow rectangular or trapezoidal current pulse in its output circuit. The plate 42 of the tube 39 is connected to the source 20 through a resistor 43 in which a corresponding negative voltage pulse is produced.

This method of pulse sharpening can for example convert pulses of the order of 100 microseconds duration to pulses of the order of 10 microseconds duration. With this type of pulse forming circuit, the rate of pulsing is readily controlled and adjusted by variable resistor 18. It is not required that this pulse rate be highly stable. In fact, there may be advantages in making the pulse rate vary and this can be accomplished by causing variations in the value of resistance 18 by mechanical or other methods such as a "wobbling device" 18'.

The output pulses of the pulse former 10 which are produced in resistor 43 are transferred through a blocking condenser 44 and are impressed as negative pulses by a line 45 upon the time delay network 30, across the input of which is connected a tapped resistor 46, and across the output of which is connected a resistor 47. This time delay network is here shown as an artificial transmission line using a plurality of recurrent low pass units including series inductances 48

and shunt condensers 49 with mutual inductance between adjacent inductors. The design of such a line to pass with suitable fidelity a given pulse is well known to those skilled in the art and will not be here described. It is of course important that the line be suitably terminated so that the output wave form will represent the input wave form to a suitable degree.

At suitable points, tapped resistors 65 and 66 are connected across the artificial line, the values of these resistors being high in comparison with those of the terminating resistors 46 and 47. By proper design, a pulse can be made to occur across resistor 65, centered, for example, 50 microseconds after the middle of the pulse at the entrance of the artificial line across resistor 46. Similarly pulses across resistors 66 and 47 may occur, for example, 100 and 150 microseconds respectively after the initial pulse across the resistor 46.

A tap 67 on the resistor 46 is connected to the control grid 68 of an amplifier tube 69 having a plate 70 connected through a resistor 71 to the source 20. The cathode 72 of the tube 69 is connected to the lead 73 which is connected to the negative side of source 20 and is grounded.

The pulse across resistor 46, after attenuation by the use of a tap 67 is thus impressed upon the grid of the amplifier tube 69. The input pulse to 69 is negative and the output pulse across the resistor 71 is a positive voltage pulse.

Selector relays 56, 57 and 58 are provided for connecting tap 74 of resistor 65, or tap 75 of resistor 66, or the ungrounded end of resistor 47 to a lead 76 connected to the grid 77 of an amplifier tube 78, having a plate 79 connected through a resistor 80 to the source 20 and having a cathode 81 connected to the ground lead 73. Relays 56, 57, 58 selectively close circuits to supply voltage from one of the three resistors 65, 66 and 47 to the grid of amplifier tube 78. A resistor 83, of high impedance in comparison with resistor 47, is connected from grid 77 to ground so that the grid circuit of the tube 78 is not opened when the relays 56, 57 and 58 are all open. The taps on resistors 65, 66 and 46 are so chosen that the magnitude of the pulses on tubes 69 and 78 is approximately the same. Since these pulses are negative, and they may be made of sufficient magnitude to cause cut off of the tubes 69 and 78, the output pulse across resistor 80 may be of substantially the same wave shape as the immediately preceding pulse across resistor 71.

A relay 59 of the balanced armature type is connected to actuate a double pole double throw switch 83. The switch 83 includes movable contact blades 84 and 85 connected respectively through blocking condensers 86 and 87 to the plates 79 and 70 of the tubes 78 and 69, and fixed contacts 88 and 89 connected respectively to input circuits of transmitters 90 and 91 which are of standard type to radiate waves on channels f_1 and f_2 modulated by the pulses from the tubes 78 and 69. The transmitters are shown as having input resistors 92 and 93, and as connected to radiators 94 and 95 respectively for radiating waves on selected frequencies f_1 and f_2 .

The relay 59 is provided with windings 100 and 101. The winding 100 is connected to one side of key operated contacts 50, 51, and 52 and the winding 101 is connected to one side of key operated contacts 53, 54 and 55. The other sides of contacts 50 and 53 are connected through winding 104 of relay 58 to ground. The other sides of contacts 51 and 54 are connected through winding 105 of relay 57 to ground. The other

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sides of contacts 52 and 55 are connected through winding 106 of relay 56 to ground. The return of windings 100 and 101 is connected to the source 20.

For simplicity, the radio transmitter is shown as two separate transmitters, one operative at frequency f_1 , and the other at frequency f_2 . With the relay contacts positioned as shown, the initial pulse from the amplifier 69 is transmitted on channel f_2 , and the following pulse from the amplifier 78 is transmitted on channel f_1 . Push button switches 50—55 serve to select the channel which is to be pulsed first, and to determine the interval between the two pulses. Each push button corresponds to a definite control operation.

Preferably neither transmitter is to be pulsed except when it is desired to operate a control. When no control switch is closed, the relay 59 will be in neutral, and no pulses will be delivered to either transmitter. In the illustration shown, switch 52 is closed for the purpose of establishing a definite control operation, causing current to flow from the positive end of battery 20 through the winding 100 of relay 59, and through the winding 106 of relay 56 to the negative side of battery 20, thereby causing channel f_2 to be pulsed from the amplifier 69 and the channel f_1 to be pulsed from the amplifier 78. Since the amplifier 78 is fed from the resistor 65 there will be 50 microseconds delay between centers of the pulses.

With the switch 51 closed instead of the switch 52 the tube 78 would be pulsed from the resistor 66 with 100 microseconds delay and with the switch 50 closed the tube 78 would be pulsed from the resistor 47 with 150 microseconds delay. With the switches 55, 54 or 53 closed the same respective delays would be introduced but the winding 101 would be energized to reverse the switch 53 so that the first pulse from the tube 69 would be fed to the channel f_1 by the transmitter 90 and the later pulse would be fed to the channel f_2 by the transmitter 91.

Six possible combinations of time delays are provided by the system shown, but it is obvious that the number of possible combinations may be increased greatly by using lines of greater length, or by increasing the number of taps in the line shown.

The radio transmitters 90, 91 may be of any standard design for pulse transmission. Here are shown two independent units corresponding to channels f_1 and f_2 , respectively, provided with individual radiators 94 and 95. However, a single transmitter operating on two frequencies with a single antenna may be used as disclosed in my copending application Serial No. 543,918, filed July 7, 1944, or in a system of the general type disclosed in U. S. Patent 1,601,109, granted to E. L. Chaffee on September 28, 1926.

Fig. 2

In Fig. 2 are shown two radio receivers 110, 111 operated from antennas 112 and 113 and terminated with detectors to produce positive pulses across output resistors 116 and 117. These receivers may be of any well known construction such as of the superheterodyne type.

The output resistors 116 and 117 are connected to control grids 118 and 119 of pulse inverting amplifying triodes 120, 121 having cathodes 122, 123 positively biased by batteries 124, 125 and having anodes 120a, 121a, connected through output resistors 126, 127 to plate batteries 128 and 129 respectively. The tubes are biased to

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accept positive pulses and negative pulses are delivered from the resistors 126 and 127. The anodes 120a, 121a are connected through blocking condensers 130 and 131 to two artificial transmission lines 133 and 134 having input termination resistors 135, 136 and output termination resistors 137, 138. The lines 133 and 134 may be similar to the line 30 above described and designed to introduce similar delay periods. Across the lines 133, 134 at suitable points are bridged tapped resistors 140 to 142 and 143 to 145 respectively having taps 140a to 145a respectively so adjusted that substantially the same amount of pulse energy is available at the taps as at the output termination resistors 137, 138. The resistors 140, 143 are connected at the input end of the lines 133, 134. The resistors 141, 144 are connected at points corresponding to the resistor 65 of Fig. 1, the resistors 142, 145 are connected at points corresponding to the resistor 66 of Fig. 1, and the terminal resistors 137, 138 correspond to the resistor 47 of Fig. 1 so that corresponding delays are introduced by the intervening portions of the artificial lines.

Three coincidental selective relay systems 150 (shown in detail in Fig. 3) are provided with input terminals 151 connected by a line 152 to the tap 143a on resistor 143 and with input terminals 153 connected by a line 154 to the tap 140a on the resistor 140. The three relay systems are provided with input terminals 155 which are connected respectively by lines 156, 157 and 158 to taps 141a and 142a on resistors 141 and 142 and to the terminating resistor 137, and with input terminals 160 which are connected respectively by lines 161, 162 and 163 to taps 144a and 145a on resistors 144 and 145 and to the terminating resistor 138. The relay systems 150 are also provided with ground terminals 164. Each system 150 is designed to be selectively operative in response to coincidental pulses at terminals 151 and 155 or terminals 153 and 160. Since the pulse from the receiver 110 is delayed by the line 133 and the pulse from the receiver 111 is delayed by the line 134 the first relay system 150 is responsive to pulses having a 50 microsecond spacing, the second relay system 150 to pulses having 100 microseconds spacing, the third relay system 150 to pulses having 150 microseconds spacing, and each relay system is selective to a reversal in pulse sequence. For the case shown in Fig. 1, the time interval for example is 50 microseconds, with channel f_2 actuated first, so that the pulse from radio receiver 111 (channel f_2) will arrive at the terminal 160 of the first relay system 150 coincidentally with the arrival of the pulse from radio receiver 110, (channel f_1) at its terminal 153 and the corresponding relay will operate. On the other hand, for this unit, there will be 100 microseconds interval between the two pulses arriving at its terminals 151 and 155 and the second relay will not operate. A similar selection is made by the other relay systems 150 for pulses having 100 microsecond spacing and 150 microsecond spacing respectively, giving six selections corresponding to the six key switches 50 to 55 of Fig. 1.

Fig. 3

Fig. 3 shows the unit 150 in detail, with input terminals 151, 153, 155 and 160 corresponding to like numbered terminals of Fig. 2. This unit is powered from a battery 170 for filaments (not shown) and cathode bias purposes, and a battery

171 for plate supply. An output relay 172 is of the balanced type and is provided with output terminals 173 and 174. The conditions are shown with pulses on terminals 151 and 155 non-coincident as for example being 100 microseconds apart, but with the pulses on terminals 153 and 160 coincidental.

A pair of space discharge tubes 200, 201 have input circuits connected across resistors 202, 203, which are connected between terminals 153, 160 respectively and ground terminal 164 to carry the respective input pulses. The anodes 200a and 201a of the tubes 200, 201 are connected to the source 171 through plate resistor 204 and line 205. The plates 200a, 201a are also connected through a resistor 206 to the control grid 207g of a space discharge tube 207 having a grid resistor 208 and a grounded cathode bias resistor 209 with a bypass condenser 210. A resistor 209a is connected from the cathode of tube 207 to the line 205. The anode 207a of the tube 207 is connected to the line 205 through a plate resistor 211.

The anode 207a is connected by a line 212 and blocking condenser 213 to the input circuit of a space discharge tube 214 having a resistor 215 and condenser 216 connected between grid and grounded cathode, and having an anode 214a connected to the line 205 through a plate resistor 217 and connected to ground through a condenser 218.

The anode 214a of tube 214 is connected through blocking condenser 219 and line 220 to the control grid 221g of a space discharge tube 221. A resistor 219a is connected between the line 220 and ground. The cathode of the tube 221 is connected by a line 222 to the positive side of battery 170 and its anode is connected through a plate resistor 223 to the plate supply line 205.

The tube 221 is resistance coupled by the plate resistor 223 and a condenser 224 to the anode of a rectifier tube 226. The cathode of the rectifier tube 226 is connected to ground through a cathode resistor 227, shunted by a bypass condenser 228, which is connected across the input circuit of a space discharge tube 229. A resistor 230 is connected from the anode of the rectifier tube 226 to ground for D. C. return purposes. The anode of the tube 229 is connected to one end of winding 231 of the relay 172, and the other end of the winding is connected to line 205.

The tubes and circuits above described constitute one channel of the unit between the input terminals 153, 160 and the winding 231 of the relay 172. A similar channel connects the input terminals 151, 155 and a second winding 331 of the relay 172. To avoid duplicating the description, the parts of the second channel have been given the same reference characters as the corresponding parts of the first channel, but increased by 100 and it is to be understood that the above description also applies thereto. It will be understood that cathode biasing resistors 209 and 209a, and bypass condenser 210 pertain to both channels, as also do certain other parts, but in the main channels are independent.

Tubes 200 and 201 are key tubes for pulses impressed on terminals 153 and 160, and tubes 300 and 301 are key tubes for pulses impressed on terminals 151 and 155. Tube 207 is a clipper tube actuated from the conjoint outputs of tubes 200 and 201, and tube 307 is a clipper tube actuated from the conjoint output of tubes 300 and 301. Tubes 214 and 314 are selective integrator tubes, tubes 221 and 321 are rectifier driver tubes, tubes 226 and 326 are rectifier tubes, and tubes 229 and

329 are relay tubes for actuating the windings 231 and 331 of relay 172.

Each of the key tubes 200, 201, 300, 301 may be thought of as a resistor having a value of, say, 10,000 ohms when the grid is at cathode potential, but as a resistor of infinite impedance when the grid is sufficiently negative. The voltage of the grid of tube 207 with respect to ground will have a low positive value when no voltage exists across resistor 202 or 203, a higher value when either terminal 153 or 160 is highly negative and the other is at cathode potential, and a very substantially higher value when both terminals 153 and 160 are highly negative. Bleeder resistor 209a is connected to make the cathodes of tubes 207, 307 suitably positively biased with respect to ground. Adjustments are such that no current passes through resistor 211 unless both of the tubes 200 and 201 are of very high impedance. Cutoff for tube 207 may occur for example when the two tubes 200, 201 in parallel have an impedance of, say, 50,000 ohms, with full current flowing only when the parallel impedance is infinite. No current therefore will flow through resistor 211 unless both terminals 153 and 160 are at the same time highly negative with respect to ground. Thus with overlapping negative pulses on terminals 153 and 160, a current pulse will pass through resistor 211 for the duration of the time of overlap, but with pulses on terminals 151, 155 which occur 100 microseconds apart without overlap there will be corresponding pulses through the resistor 304 but not of sufficient amplitude to produce a pulse through the resistor 311. Therefore of the six sets of inputs for units 150 of Fig. 2, only terminals 153 and 160 of one unit will be coincidentally pulsed to produce pulses in the clipper tube output resistor 211.

The output pulses of tubes 207, 307, whenever such exist, are negative pulses, and these are applied to the amplifiers 214 and 314 which serve as pulse integrators, or as selective amplifiers. The cathodes of these integrator tubes are at ground potential, and the pulses from the preceding tubes drive the grids negative. The values of the condensers 213, 216, 218 and 219 and resistors 211, 215, 217, 219a are suitably chosen so that pulses of current through resistor 211 are efficiently amplified, broadened, and integrated to produce a very high value of the fundamental alternating voltage across resistor 219a. This choice of values can be readily made by those skilled in the art. Preferably the circuit will be designed for maximum efficiency of production of A. C. voltage across resistor 219a at pulse rates corresponding to those of the transmitter, say 100 pulses per second for the illustrative case considered.

Rectifier driver tubes 221 and 321 operate with cathodes positively biased to utilize the positive and negative swings of voltage across their grid resistors. These driver tubes for simplicity are shown as resistance coupled to the plates of rectifiers 226, 326. The rectifier outputs are fed through cathode resistors 227 and 327, bypassed by condensers 228, 328 to relay tubes 229, 329. Relay tubes 229, 329 are positively cathode biased by battery 170 so that with no rectified voltage across the input circuits, little or no plate current flows through the relay 231, 331. When sufficient rectified voltage is developed, the relay coil will be energized to close the circuit from ground to relay terminal 173 or 174 according to the channel pulsed.

In the operation of this circuit, when termi-

nals 153 and 160 are simultaneously pulsed negative to cutoff, a pulse is produced across resistor 211. These pulses will be recurrent due to the rate of recurrence of the pulse on terminals 153, 160, and are integrated, broadened and efficiently amplified at the pulse rate to actuate the grid of tube 221 with alternating current of the pulse rate. Tube 221 amplifies the A. C. input and the amplified output is rectified to produce direct current through the input resistor 227 of tube 229, causing current through the relay winding and closure of the relay contact 173 as above described.

It will be understood that a specific embodiment of the invention has been set forth for purposes of illustration. While I have specifically indicated operation by radio channels and electrical delay lines, it is obvious to those skilled in the art that the method is applicable to other channels such as by sound transmission.

What is claimed is:

1. The method of signalling which comprises propagating a pair of radiant energy pulses over different communication channels at predetermined spaced time intervals, selecting the time period between said pulses and selecting the pulse sequence for signalling, receiving said pulses at a remote point, selecting the received pulses in accordance with their timing and sequence, and utilizing the selected received pulses for signal reception.

2. The method of signalling over a pair of radio frequency communication channels which comprises producing a series of pairs of pulses with controlled timing between pulses and between pairs, radiating one pulse of each pair over one of said radio frequency channels and radiating the other pulse of each pair over the other of said radio frequency channels, selecting the timing between pulses and selecting the pulse sequence on the two channels for signalling, receiving said pulses at a remote point, selecting the received pulses in accordance with their timing and sequence, and utilizing the selected received pulses for signal reception.

3. A multiplex signalling system comprising means producing a pair of pulses having predetermined time separation, a pair of radio frequency communication channels, means for propagating said pulses over different ones of said radio frequency channels, means for selecting the timing of said pulses and for selecting said pulse sequence for signalling, receiving means receptive of both of said pulses, means selective of the received pulse sequence and timing, and signal utilizing means selectively actuated by said last means.

4. A multiplex signalling system comprising a pair of radio frequency signalling channels, means producing a series of pairs of pulses having predetermined time intervals between pulses and between pairs of pulses, means propagating one pulse of each pair over one of said radio frequency channels, means propagating the other pulse of each pair over the second of said radio frequency channels, means selecting the timing of the pulses of each pair and for selecting said interval for signalling, receiving means receptive of both of said selected propagated pulses, means selective of the received pulse interval and timing, and signal means selectively actuated by said last means.

5. A multiplex signalling system comprising a circuit for deriving pulses, a delay circuit connected to receive said pulses and provide delayed

pulses, a pair of radio frequency transmitters, means for feeding said transmitters with said derived and delayed pulses from different parts of said delay circuit whereby a predetermined time delay is introduced between pulses, receiving means receiving both of said transmitted pulses, a delay circuit connected to introduce a time delay into the first transmitted pulse received to cause the two received pulses to coincide in time, and signal means actuated by the conjoint effect of said coincidental pulses.

6. A multiplex signalling system comprising a circuit for deriving pulses, a delay circuit connected to receive said derived pulses and to progressively delay the same, a pair of radio transmitters, modulating circuits therefor, a plurality of selectors selectively connecting said modulating circuits to different parts of said delay circuit to propagate said derived and delayed pulses in different selected time intervals, receiving means for receiving both of said propagated pulses, a delay circuit connected to introduce a time delay into the first propagated pulse received to cause the two propagated pulses to coincide in time, and signal means actuated by the conjoint effect of said coincidental pulses.

7. A multiplex signalling system comprising a circuit for deriving pulses, a delay circuit connected to receive said derived pulses and to progressively delay the same, a pair of radio transmitters, modulating circuits therefor, a plurality of selectors for selectively connecting said modulating circuits to different parts of said delay circuit to propagate said derived and delayed pulses in different selected time sequences, receiving means connected to receive both of said propagated pulses, a plurality of selector channels fed by said receiving means, said channels having different pulse delay circuits corresponding to the different delays introduced at the transmitter by said selectors and designed to make the two propagated pulses coincidental in one channel only, and signal means actuated by the conjoint effect of said coincidental pulses.

8. A pulse transmitter comprising a pulse forming circuit, a delay circuit connected to receive pulses from said circuit and to progressively delay the same, a pair of radio transmitting means to propagate waves on two communication channels, and means for selectively modulating each of said transmitting means from different parts of said delay circuit to introduce a predetermined time delay between pulses propagated on the two channels.

9. A pulse transmitter comprising a circuit for deriving pulses, a delay circuit connected to receive said derived pulses, and to progressively delay the same, a pair of radio transmitting means to propagate waves on two communication channels, means for modulating one of said transmitting means by said derived pulse direct from said pulse forming circuit, means for modulating the other of said transmitters by said delayed pulse after traversing selected portions of said delay circuit, and means for selecting said delay circuit portion for introducing different predetermined time delays between pulses.

10. A pulse transmitter comprising a circuit for deriving pulses, a delay circuit connected to receive said derived pulses and to progressively delay the same, radio transmitting means to propagate waves on two channels, means for modulating one of said transmitting means by said derived pulse direct from said pulse forming circuit, means for modulating the other of said

transmitters by said delayed pulse after traversing selected portions of said delay circuit, means for selecting said delay circuit portion for introducing different predetermined time delays between said derived and said delayed pulses, and reversing means connected to said pulse deriving and delay circuits to select the sequence and intervals of said pulses to the respective transmitters.

11. A pulse receiver for receiving and selecting from a plurality of radio frequency channels a plurality of pulses having different time intervals, comprising receiving means to receive a pair of pulses over different ones of said radio frequency channels, a plurality of circuits connected to be fed by said received pulses, said circuits each having different pulse delay networks connected to delay one of said received pulses so that both of the received pulses are made coincidental in each of said circuits, and signal means connected to said circuits to be actuated by the conjoint effect of said coincidental pulses.

12. A pulse receiver for receiving and selecting from a plurality of radio frequency channels a plurality of pulses having different time intervals, comprising receiving means to receive a pair of said pulses over different ones of said radio frequency channels and to segregate said received pulses, a pair of delay circuits connected to be fed by the respective received segregated pulses, a plurality of circuits connected to different points on said delay circuits, said points being selected to make the pulses coincidental in each of said circuits, and signal means connected to said circuits to be actuated by the conjoint effect of said coincidental pulses.

13. A pulse selector circuit comprising a pair of space discharge tubes each connected to be fed by different series of pulses having different occurrence time intervals, a key space discharge device connected to be fed by the outputs of said pair of tubes and biased to respond only to the conjoint action of such of said differently occurring pulses of said different pulse series as are received simultaneously in both of said pair of tubes, an integrator space discharge tube circuit connected to said key tube and responsive to repeated pulsings of said key tube, a rectifier fed by said integrator tube circuit, and a relay actuated by said rectifier in synchronism with simultaneous occurrence of pulses in said different pulse series.

14. A pulse selector circuit comprising a pair of space discharge tubes each connected to be fed by different series of pulses having different occurrence time intervals, a key space discharge device connected to be fed by the outputs of said pair of tubes and biased to respond only to the conjoint action of such of said differently occurring pulses of said different pulse series as are received simultaneously in both of said pair of tubes, an integrator space discharge tube circuit connected to said key tube and responsive to repeated pulsings of said key tube, an amplifier tube fed by said integrator tube circuit, a rectifier fed by said amplifier tube, a power tube fed by said rectifier and a relay fed by said power tube, said relay being actuated by said power tube in synchronism with simultaneous occurrence of pulses in said different pulse series.

15. The method of signalling which comprises propagating and receiving one of a pair of differently timed energy pulses over one channel, propagating and receiving the other of the pair of

energy pulses over a second channel, and differently utilizing the received pulses in accordance with the time interval by which the pulse received over the first channel precedes that received over the second channel.

16. The method of signalling which comprises propagating and receiving the two pulses of a pair of energy pulses over two separate channels, selectively choosing the time interval between the pulses, selectively choosing the sequence of pulse propagation on the two channels, and selecting said received pulses for signal reception in accordance with their sequence of occurrence and the time interval between the two received pulses on the two channels.

17. The method of signalling which comprises propagating and receiving a first recurrent series of energy pulses on one communication channel and propagating and receiving a second differently timed recurrent series of energy pulses on another communication channel with the same rate of pulse recurrence on both channels, and selecting said received recurrent series of pulses for signal reception in accordance with the time interval between the most nearly simultaneous pulses of the two received recurrent series of pulses.

18. The method of selective signalling which comprises propagating and receiving a recurrent series of energy pulses on one communication channel and propagating and receiving a second differently timed recurrent series of energy pulses on another communication channel with the same rate of pulse recurrence on both channels, selecting said received pulses in accordance with the time interval between the two most nearly simultaneous pulses of the two series, selecting the communication channel on which the series made up of the first of said most nearly simultaneous pulses is transmitted, and selecting the received pulses for signal reception both in accordance with the said selections of pulses by time interval and selected communication channel.

19. A signalling system comprising a pulse forming circuit for forming an energy pulse, a two communication channel pulse energy transmitter, a transmission line pulse delaying circuit with input and output terminations, means for feeding said line circuit from said pulse forming circuit, means for feeding one transmitter channel from the input of said line and means for feeding the other transmitter channel from the output of said line.

20. A signalling system comprising a pulse forming circuit for forming an energy pulse, a transmission line pulse delaying circuit with a plurality of input, intermediate and output terminations providing different amounts of time delay, means for applying pulses to said line circuit from said pulse forming circuit, a two communication channel pulse transmitter, and means for applying relatively delayed pulses to the two communication channels of said transmitter from two of said plurality of terminations of said line.

21. A signal receiving system comprising a two communication channel receiver, two transmission line delay circuits, provided with at least two terminations, means for feeding one line circuit from one communication channel of said receiver, and means for feeding the other line circuit from the other communication channel of said receiver, a utilization circuit responsive only to coincidental signals from two inputs, means for feeding one of said inputs from a termination

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of one of the two line circuits, and means for feeding the other of said inputs from a termination of the other of said two line circuits.

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