

Nov. 8, 1949

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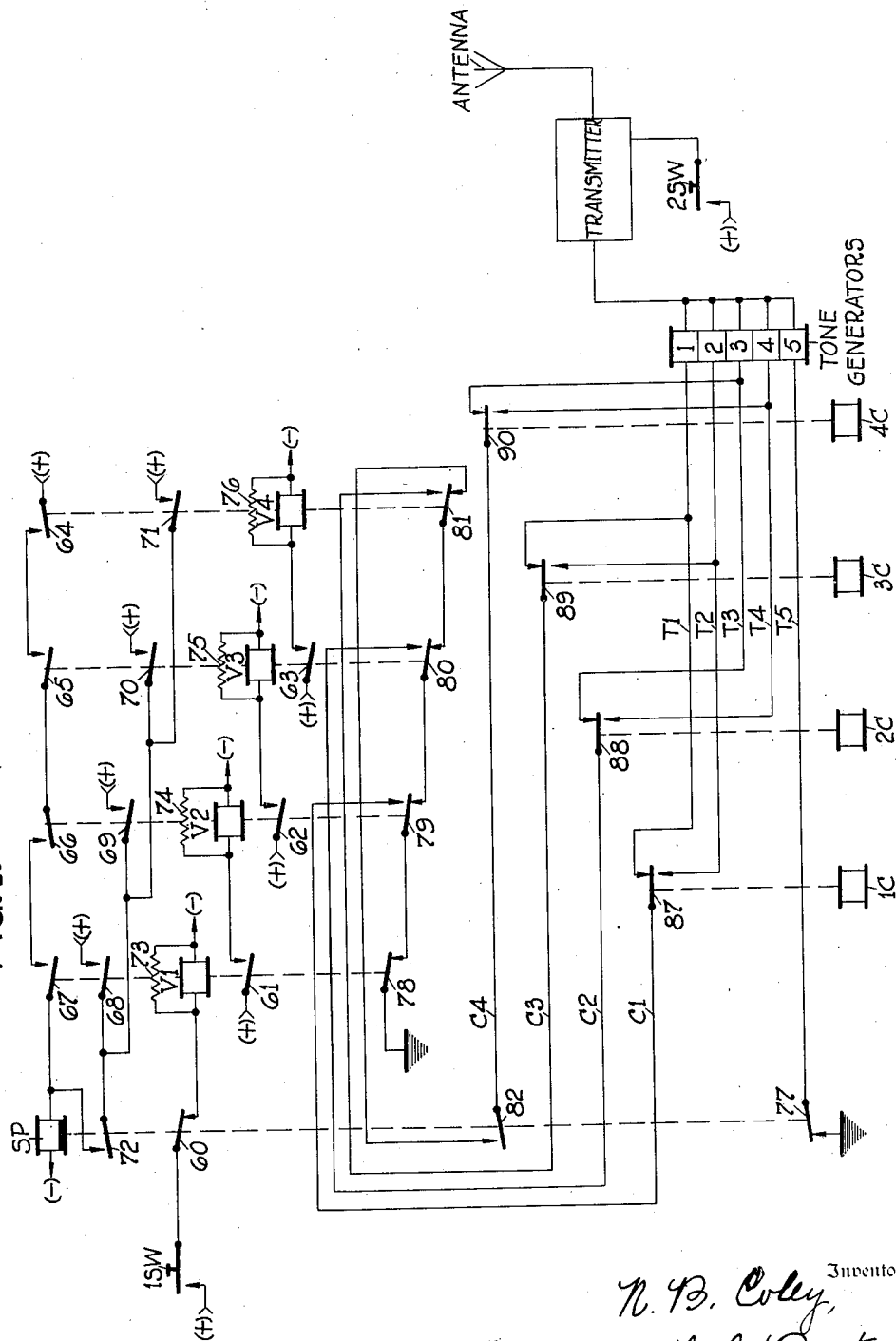
2,487,102

CODE COMMUNICATION SYSTEM

Filed May 2, 1947

7 Sheets-Sheet 1

Fig. 1.



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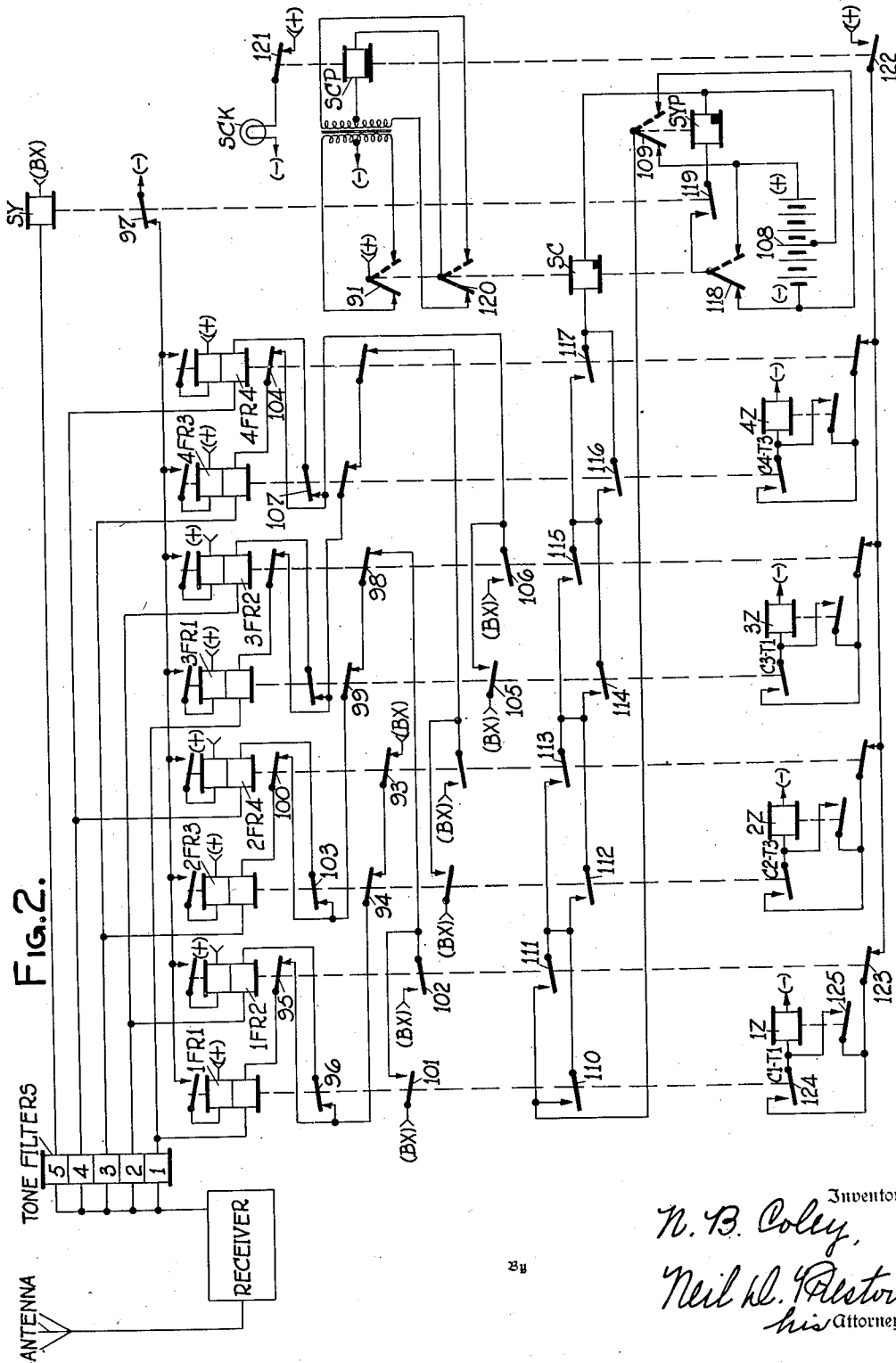
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CODE COMMUNICATION SYSTEM

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7 Sheets-Sheet 2



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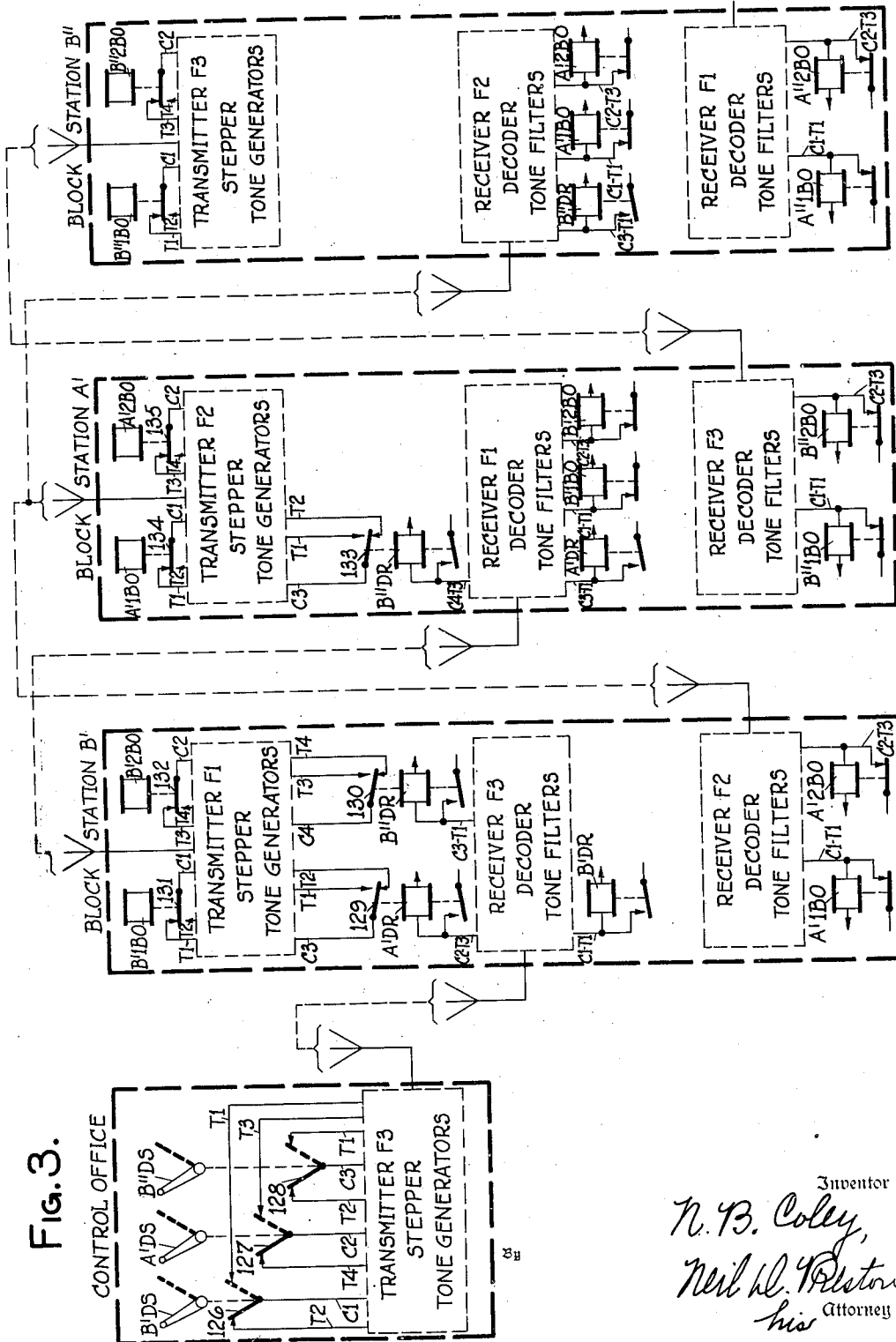
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CODE COMMUNICATION SYSTEM

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7 Sheets-Sheet 3



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7 Sheets-Sheet 4

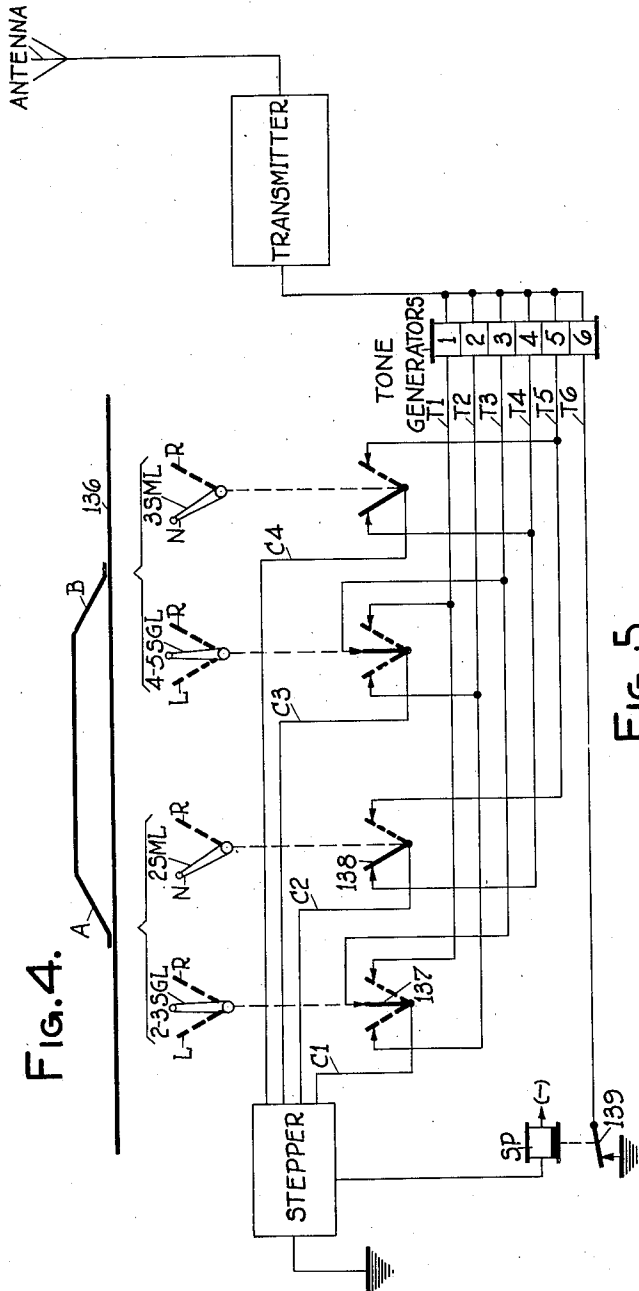


Fig. 5.
CODE CHART

STATION	CHANNEL	tone	FUNCTION
STATION A.	C1	1	SIGNAL RIGHT
		2	SIGNAL LEFT
		3	SIGNAL STOP
STATION B.	C2	4	SWITCH NORMAL
		5	SWITCH REVERSE
	C3	1	SIGNAL RIGHT
		2	SIGNAL LEFT
		3	SIGNAL STOP
STATION B.	C4	4	SWITCH NORMAL
		5	SWITCH REVERSE

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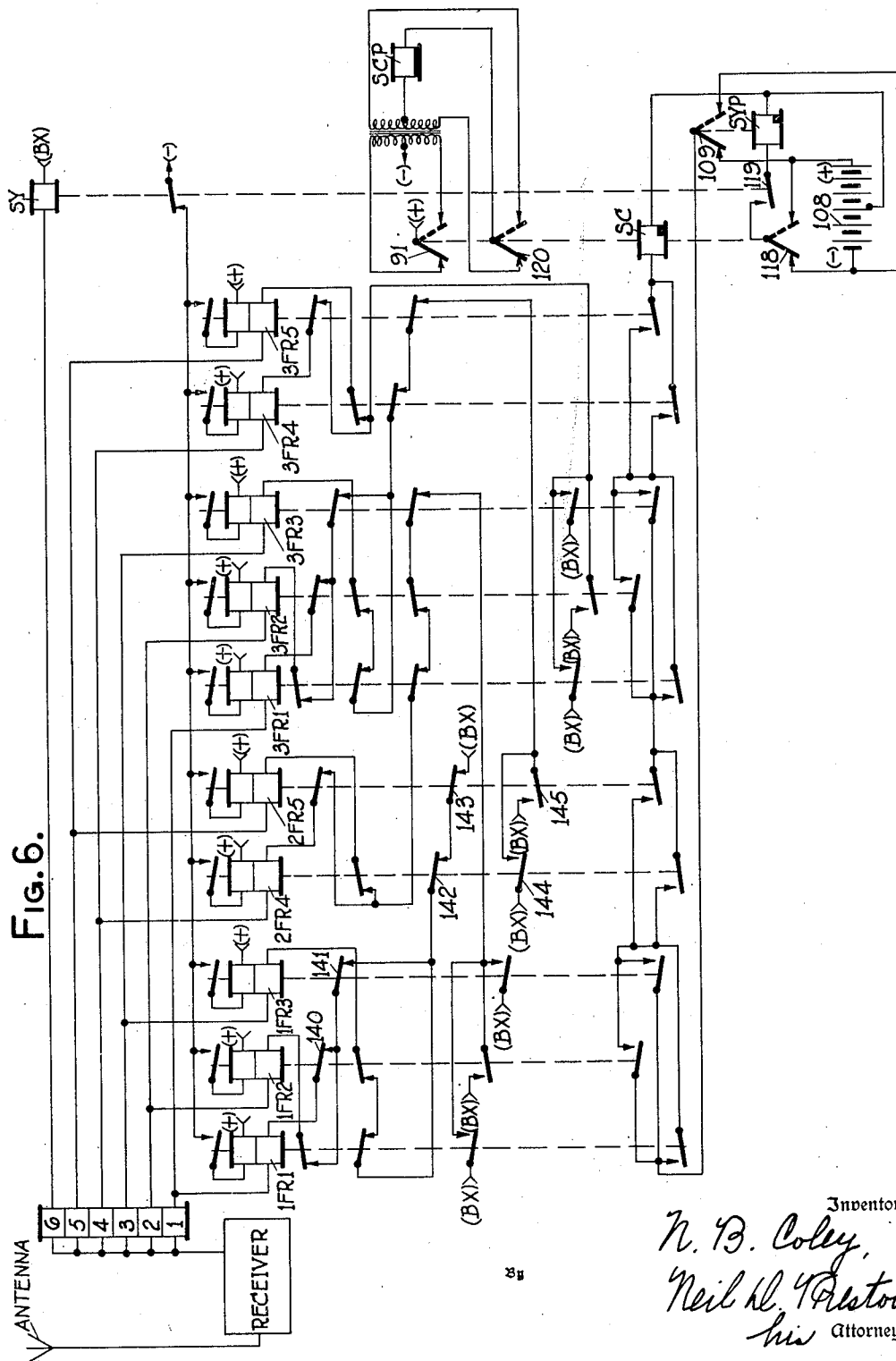
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Fig. 7.

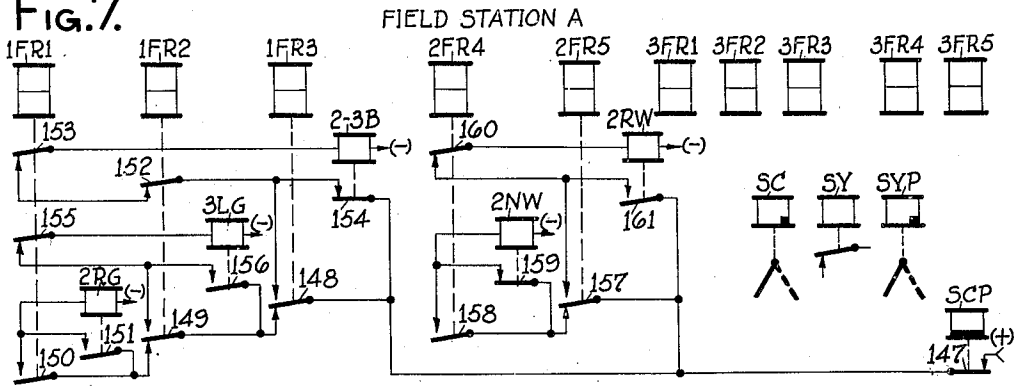


Fig. 8.

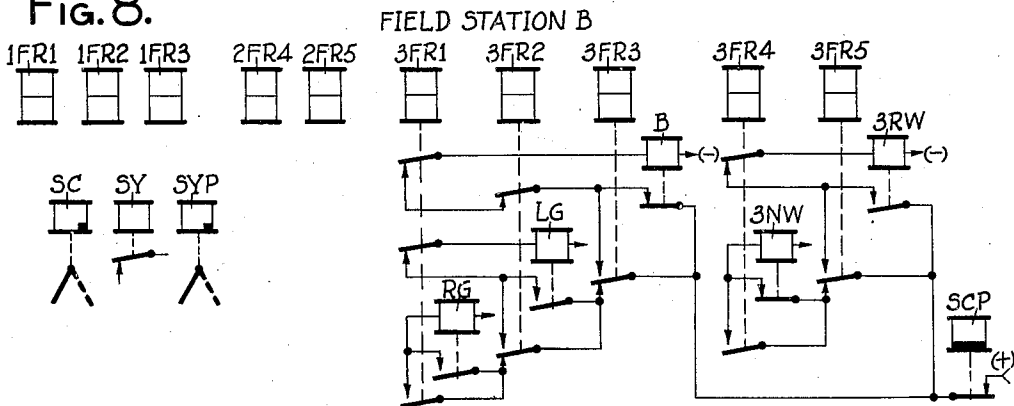


Fig. 9.

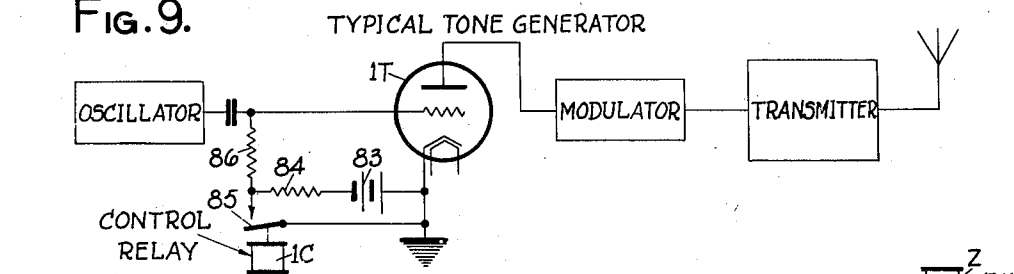
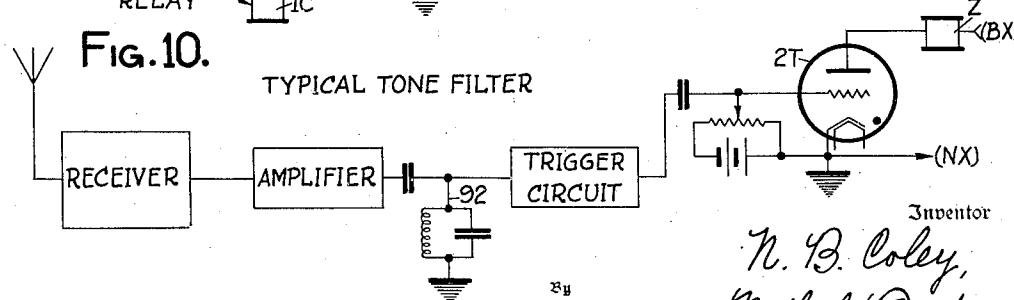


Fig. 10.



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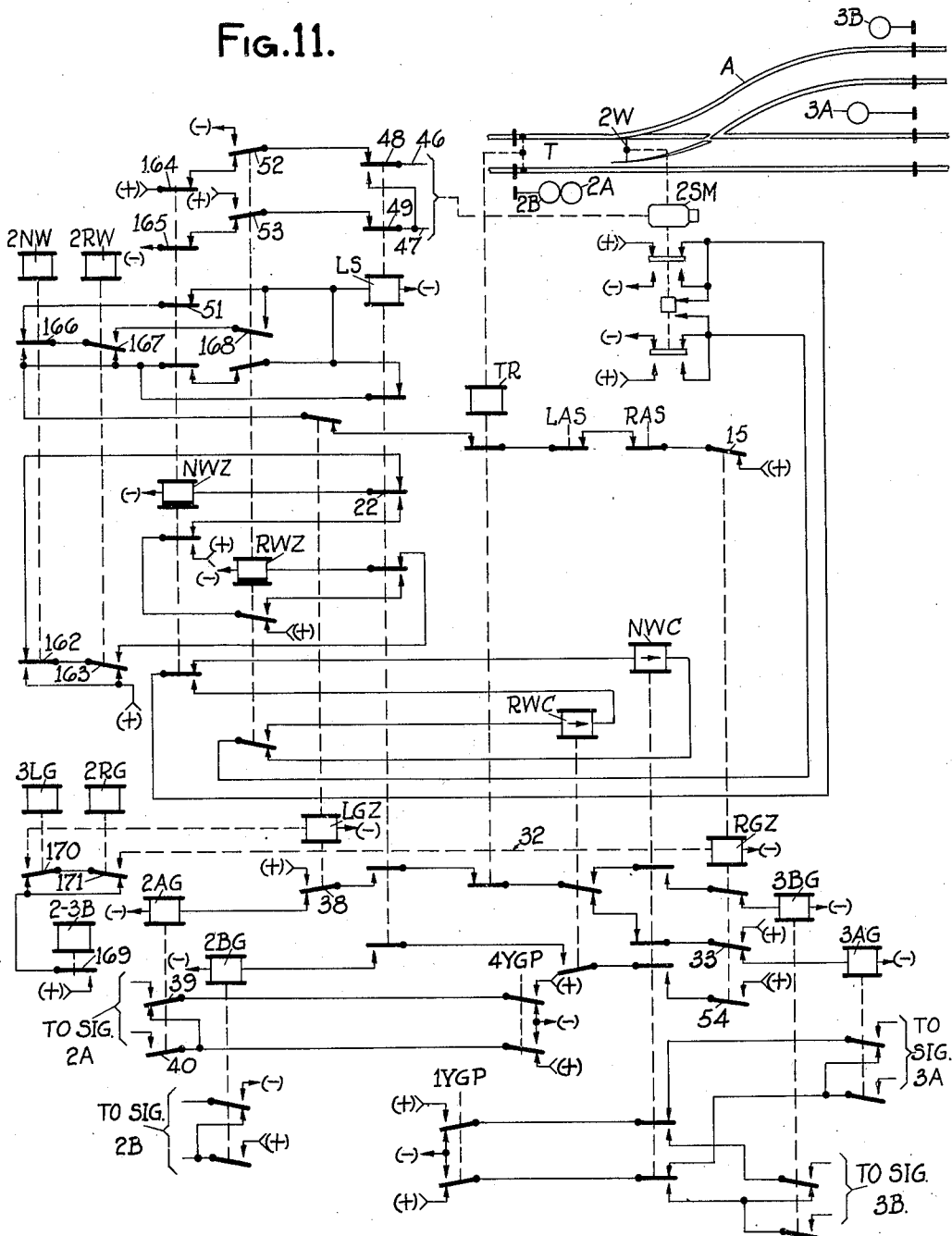
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FIG. 11.



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UNITED STATES PATENT OFFICE

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CODE COMMUNICATION SYSTEM

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Application May 2, 1947, Serial No. 745,673

15 Claims. (Cl. 177—353)

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This invention relates to communication systems and it more particularly pertains to systems for maintaining a plurality of independent channels between respective spaced locations.

In an air traffic control system of the general character disclosed, for example, in the application of Kendall et al. Serial No. 743,046, filed April 22, 1947, block stations are spaced along an airway for communicating information to aircraft in their respective vicinities as to the condition of occupancy in that block as well as the block in the rear and the block in advance, particularly for the altitudes at which each of such aircraft is flying. Over control means is also provided wherein a controller or a dispatcher in a central office can govern, through the respective block stations, suitable ascent, descent, and hold indicators in the aircraft at respective altitudes. Although these control office to block, and block to block, controls can be transmitted over line wires as disclosed in the above mentioned application, the large number of flight altitudes involved obviously requires a large number of independent circuits and a large number of line wires. There are also matters of safety involved in that the integrity of the circuits must be assured for safe aircraft operation along the airway.

The above described problems relative to communication between a controller's office and respective block stations will be recognized as being similar to problems involved in the control of railway track switches and signals located at respective field stations along a stretch of railway track from a control office in a centralized traffic control system. In such a centralized traffic control system, the large number of distinctive controls required to be transmitted from the control office to the field stations is such that a stepper organization is often employed wherein a large number of distinctive controls can be transmitted in sequence over a single pair of line wires to control respective switches and signals.

It is an object of the present invention to replace the above mentioned line wires in both an air traffic control system for airways and a centralized traffic control system for railroads with a radio link system of communication from block station to block station in case of the air traffic control system, and from control office to the respective field stations in case of a centralized traffic control system. In transmission from block station to block station, distinctive carrier frequencies are used in transmission as required so that no block station can receive carrier waves on the same frequency from two different transmitters.

Another object of the present invention is to provide the required number of channels for simultaneous distinctive control of a large number of relays by maintaining the transmission of

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a carrier wave constant and selectively applying modulations or tones at respective different frequencies to such carrier wave.

Another object of the present invention is to provide for the transmission of but one tone at a time by the use of a stepping organization for scanning the respective tones for transmission.

Another object in the use of a stepping organization is to reduce the number of distinctive tones required by providing an organization allowing a repeat of the same tones for alternate steps, such tones communicating distinctive controls by reason of the order in which they are transmitted.

Another object of the present invention resides in the operation of the steppers continuously to thereby maintain relays repeating conditions of unoccupancy continuously energized at respective block stations in accordance with the condition of energization of corresponding relays at an adjoining block station.

An object of the present invention in the receiving of the tones on the respective steps is to prevent against erroneous operation of relays controlled by the tones in case of failure of a tone to be received on any one step.

Another object of the present invention is by use of a stepping organization to scan the respective field stations for the reception of switch and signal controls, different stations being responsive to different steps in a cycle of operation of the stepping organization.

Other objects, purposes, and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference is made to the accompanying drawings in which similar reference characters designate corresponding or similar parts of the organization, and in which:

Fig. 1 illustrates a typical stepper and tone transmitter;

Fig. 2 illustrates a typical receiver and decoder organization actuated in response to tones selectively applied to a carrier wave as by the organization of Fig. 1;

Fig. 3 illustrates a radio link organization between a control office and the respective block stations in an air traffic control system;

Fig. 4 illustrates a typical control office transmitter for transmitting switch and signal controls by means of the selective application of tones to a steadily transmitted carrier wave;

Fig. 5 is a code chart illustrating a typical manner of assignment of tones to the respective steps for transmission according to the transmitter organization of Fig. 4;

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Fig. 6 illustrates a decoder unit such as is provided at each of the field stations to be responsive to the tones transmitted from the control office according to the transmitter of Fig. 4;

Fig. 7 illustrates the control of switch and signal application relays in response to tones received as decoded by the decoding unit of field station A;

Fig. 8 illustrates the control of switch and signal application relays in response to the decoding of tones received at field station B;

Fig. 9 illustrates the circuit organization of a typical tone generator;

Fig. 10 illustrates a typical tone filter circuit organization; and,

Fig. 11 illustrates typical switch and signal control circuits governed by the selective energization of the application relays at field station A.

For the purpose of simplification of the disclosure of the present invention, the drawings have been prepared in the conventional schematic manner, more particularly for the purpose of illustrating the circuit organization and the mode of operation involved than for the purpose of illustrating the specific structure and arrangement of parts that would be employed in practice. The symbols (+) and (−) are used to designate connection to the respective positive and negative terminals of suitable batteries or other sources of direct current while the symbols (BX) and (NX) are used to designate the respective instantaneous positive and negative terminals of a suitable source of alternating current. The symbols (B+) and (B−) are used to indicate connections to the respective positive and negative terminals of a suitable plate supply battery, the (B−) terminal of such battery being connected to ground.

To consider first the general organization of the typical tone transmitter shown in Fig. 1, such transmitter comprises stepping relays V1, V2, V3, and V4, and a synchronizing pulse relay SP for effecting the stepping continuously through successive cycles of operation to form channels including the wires C1, C2, C3, and C4 respectively, whereby the conditions of respective control devices 1C, 2C, 3C, and 4C can be effectively constantly transmitted, the conditions of the devices 1C, 2C, 3C and 4C being defined by tones selectively applied to a continually transmitted carrier wave.

The radio transmitter shown in block form in Fig. 1 is normally active when its control switch 2SW is closed to transmit a steady carrier wave at an assigned frequency, and such transmitter is adapted in a well-known manner to be modulated by any one of the tone generators 1, 2, 3, 4, or 5 which may be rendered effective for modulation of the carrier wave being transmitted. Because of the circuit organization in a manner to be hereinafter described, only one of the tone generators at a time is rendered effective to modulate the carrier wave being transmitted.

The transmitter of Fig. 1 is shown as having a circuit organization wherein it is rendered constantly active upon the closing of the control switch 2SW, and similarly the closing of switch 1SW renders the stepper continually active, such switches having been shown open primarily for the purpose of illustrating a starting point facilitating the explanation of the mode of operation and circuit organization of the transmitter and stepper organization.

To consider first the mode of operation of the

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stepper relays V1, V2, V3 and V4 and the synchronizing pulse relay SP, it will be assumed that the switch 1SW is closed, and upon the closure of that switch, the relay V1 is energized through back contact 60 of relay SP, and the relays V2, V3, and V4 are successively picked up in accordance with the closure of their pick-up circuits at front contacts 61, 62 and 63 respectively of the next preceding stepper relays.

When the picking up of relays V1, V2, V3 and V4 has been completed, the synchronizing pulse relay SP is picked up by the energization of a circuit extended from (+) including front contact 64 of relay V4, front contact 65 of relay V3, front contact 66 of relay V2, front contact 67 of relay V1 and winding of relay SP, to (−). The relay SP when picked up is maintained picked up by a stick circuit energized through front contacts 68, 69, 70 and 71 of relays V1, V2, V3 and V4 respectively connected in multiple and through its own front contact 72. By this arrangement, the relay SP is maintained energized until all of the stepper relays are dropped away.

The relay SP when picked up opens the energizing circuit for the relay V1 at back contact 60, and thus the relay V1 is dropped away to form the first channel of the stepper organization. The resistor 73 shunted across the winding of the relay V1 makes that relay slightly slow in dropping away as a means of timing the synchronizing pulse in a manner to be hereinafter more readily apparent.

Upon the dropping away of relay V1, the opening of its front contact 61 deenergizes relay V2, and the resistor 74 shunted across the relay V2 is effective to delay the dropping away of that relay sufficiently to govern the desired time of transmission through the channel of the first step of the transmitter before such step is terminated and the second step initiated.

The initiation of the third step of the transmitter is rendered effective when the relay V3 is dropped away subsequent to the opening of its energizing circuit at front contact 62, the dropping away of that relay being made slow by the resistance 75 shunted across its winding. The third step is terminated by the dropping away of the stepping relay V4, the energizing circuit for relay V4 having been opened at front contact 63 of relay V3. Relay V4 is made slightly slow in dropping away by the resistor 76 shunted across its winding to govern the duration of the third step.

The stick circuit for the relay SP is opened by the respective stepper relays when they are dropped away and the dropping away of the last of the step relays V4 by opening its front contact 71 deenergizes the synchronizing pulse relay SP, its pick up circuit having been opened by the dropping away of the respective stepper relays V. The relay SP is made to be slightly slow in dropping away for the purpose of governing the time during which the last control channel of the stepper is maintained closed. Upon the dropping away of the relay SP, the closure of back contact 60 of that relay in the energizing circuit for the relay V1 restores the initial conditions of the cycle of operation and thus initiates a second cycle of operation of the stepper. It will therefore be readily apparent that the stepper operates continually through successive cycles of operation as long as the control switch 1SW is maintained closed. A synchronizing tone is transmitted in a manner to be hereinafter considered when relay SP is dropped away to close

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back contact 77, and thus the aggregate pick up time of the relays V governs the duration of the synchronizing tone.

Having described the organization and mode of operation of the stepper unit, consideration will now be given to the circuits for selectively forming the respective channels for the various steps and the manner in which a tone is selected for transmission on each channel formed by the stepper. Upon the dropping away of the stepper relay V1 to form the first step, ground is connected to the first channel wire C1 through back contact, 78 of relay V1 and front contact 79 of relay V2. This circuit is opened upon the dropping away of the relay V2 at front contact 79, and the wire C2 is connected to ground on the second step through back contact 78 of relay V1, back contact 79 of relay V2 and front contact 80 of relay V3. Upon the dropping away of relay V3 at the beginning of the third step, the wire C2 is disconnected from ground at front contact 80, and the wire C3 is connected to ground for the third channel through back contacts 78, 79 and 80 of relays V1, V2 and V3 respectively and front contact 81 of relay V4. After the relay V4 has dropped away, the connection of the third channel wire C3 to ground is broken by the opening of front contact 81 of relay V4, and the channel wire C4 for the fourth step is connected to ground through back contacts 78, 79, 80 and 81 of the stepper relays V1, V2, V3 and V4 respectively and the front contact 82 of the synchronizing pulse relay SP. At the end of the cycle, the opening of front contact 82 of relay SP disconnects the channel wire C4 from ground, and the closure of back contact 77 of the relay SP connects ground directly to the tone generator for tone 5.

Having thus described the stepper and circuit organization by which ground is successively connected to the channel wires C1, C2, C3, C4 respectively, consideration will now be given as to the manner in which the respective tone generators are selectively rendered effective to modulate the carrier wave of the transmitter. With reference to Fig. 9, a typical tone generator circuit organization is illustrated more specifically wherein a suitable type of oscillator generates the assigned frequency for modulation of the carrier wave for a particular tone, and the output of such oscillator is applied to the grid of an amplifier tube 1T which is normally biased negative beyond cut-off by the battery 83 so that the tube 1T is normally non-conducting, and thus there is normally no input to the modulator and normally no modulator output to the transmitter for modulation of the carrier wave being transmitted on the assigned frequency.

Because of the tube 1T being normally biased to cut-off, it will be readily apparent that the tube 1T can be made conductive by the shunting of the bias battery through a suitable resistor 84. It is thus provided that when it is desirable to render a particular tone generator effective to modulate the carrier wave being transmitted, the control relay governing the effectiveness of its associated tone generator upon the carrier, such as the relay 1C of Fig. 1 and Fig. 9, can selectively govern the modulation of the transmitter at the associated tone by shunting the bias of the grid of tube 1T and thus allowing that tube to conduct in its anode-cathode circuit. This is accomplished in Fig. 9 by the closure of front contact 85 of relay 1C which shunts the battery 83 through the resistor 84, and connects the grid of the tube 1T to the cathode of that tube through

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a suitable resistor 86. The output of the tube 1T is further amplified by a suitable modulator stage, and the output of such modulator is applied to the transmitter to modulate the carrier wave, such modulation of the carrier wave being accomplished in a suitable manner well known to those familiar with the art.

It is thus to be understood that each of the tone generators Nos. 1, 2, 3, 4 and 5 of Figs. 1 and 4 is of an organization similar to that which has just been described, each generator having an oscillator generating a distinctive tone which is rendered effective to modulate the carrier wave of the associated transmitter only if ground is connected to the block representing the associated tone generator. The tone frequencies chosen should be such that there will be no trouble from harmonics. A band of audio frequencies spaced about 300 cycles apart have been found to be satisfactory.

The relays 1C, 2C, 3C and 4C illustrated in Fig. 1 are assumed to be normally energized control relays that are subject to any particular type of a control circuit in accordance with the requirements of practice, and it is assumed that the conditions of these respective relays are required to be communicated to a distant receiver station by radio link transmission. It is to be understood that the contacts of the relays 1C, 2C, 3C and 4C could as well be contacts of manually operated control levers, or other devices, the conditions of which being desirable to be communicated by radio link to another station.

If the relay 1C is picked up as illustrated when ground is connected to the channel wire C1, the closure of front contact 87 of relay 1C connects that channel wire to the tone control wire T1 associated with the generator of tone No. 1. Thus by the connection of the wire T1 to ground through the channel wire C1, tone No. 1 is applied to the carrier wave transmitted by the transmitter during the first step of operation of the stepper organization. If, on the other hand, the relay 1C were dropped away during the first step, the closure of back contact 87 would have been effective to connect ground through the channel wire C1 to the tone control wire T2 and thus render the tone generator No. 2 effective to modulate the carrier wave transmitted during the first step of the stepper organization.

In a similar manner, during the second step, the closure of front contact 88 of the relay 2C as illustrated connects ground through the channel wire C2 to the tone control wire T3, and thus renders the tone generator No. 3 effective to modulate the carrier wave during the second step of the stepper organization. If the relay 2C were dropped away during that step, the closure of back contact 88 would have been effective to connect the tone control wire T4 to ground through the channel wire C2 and thus render the tone generator for tone No. 4 effective rather than the tone generator for tone No. 3 for modulation of the carrier wave during the second step of the stepper organization.

When the third channel formed by the stepper is selected, ground is connected through wire C3 and front contact 89 of relay 3C to the tone control wire T1 for rendering effective the tone generator No. 1 for modulation of the carrier wave during the third step, the closure of its back contact 89 would have been effective to connect ground through the channel wire C3 to the tone control wire T2, and thus render the tone gener-

ator No. 2 rather than the tone generator No. 1 effective to modulate the carrier wave.

The connection of ground to the channel wire C4 during the fourth step renders the tone generator No. 3 effective to modulate the carrier wave if the relay 4C is picked up as shown to close front contact 90 to connect channel wire C4 to the tone control wire T3. If, however, the relay 4C were in its dropped away position during the last step, the closure of its back contact 90 would have been effective to modulate the carrier wave being transmitted.

Upon the dropping away of relay SP at the end of a cycle of operation of the stepper organization, the closure of back contact 77 of that relay connects the tone control wire T5 to ground and thus renders the tone generator for tone No. 5 effective to modulate the carrier wave for transmission of a synchronizing tone characterizing the end of a cycle of operation of the tone transmitter. It will be noted that the synchronizing tone is always the same tone as compared to a selection of one or more tones for application during the other steps of the cycle of operation.

Having thus considered the manner in which tones are transmitted during respective cycles of operation of a stepping organization on a constantly radiated carrier wave, consideration will now be given to the means shown in Fig. 2 for receiving and decoding that which is transmitted according to the organization of Fig. 1. With reference to Fig. 2, the radio receiver is tuned to the carrier frequency transmitted by the radio transmitter of Fig. 1, and the output of such receiver is applied to a bank of tone filters which are tuned to the respective frequencies of the tone generators associated with the tone transmitter of Fig. 1.

The output of the tone filters is used for the control of decoding relays 1FR, 2FR, 3FR and 4FR which are provided for the respective steps of the decoding organization. There is a relay FR provided for each tone that can be selectively applied on each step received, and thus, according to the organization that has been described for selectively applying one of two tones to each step, there are two decoding relays FR provided for each step, one for each tone which can be received during that step.

In addition to the decoding relays FR for the respective steps, a synchronizing relay SY is provided to be responsive to the tone No. 5 which is the synchronizing tone. Magnetic stick relays SC and SYP which can be of the general character disclosed, for example, in the prior application of J. E. Willing et al., Ser. No. 697,452, dated September 17, 1946, are also associated with the clear-out at the end of the respective cycles of operation of the system in a particular organization for checking the completion of each cycle as will be hereinafter disclosed. The relay SCP is a slow acting relay controlled through a suitable decoding transformer in accordance with the pulsing of contact 91 of the relay SC as a means for indicating that the respective cycles of operation received are complete.

The relays 1Z, 2Z, 3Z and 4Z are application relays provided at the receiving station of Fig. 2 to be responsive to the respective controls that are transmitted by radio link from the transmitter station illustrated in Fig. 1. Thus the relay 1C of Fig. 1 governs the energization of the relay 1Z of Fig. 2, 2C the control of relay 2Z, etc.

As illustrated in Fig. 2 the output of the receiver, which is to be assumed as an audible fre-

quency output, if the tones employed are within the audible range, is applied to the respective tone filters Nos. 1, 2, 3, 4 and 5, and these filters govern the application of energy to the respective decoding relays. For convenience and for simplification of the drawings the respective tone filters are illustrated in block form, and each filter is assumed to be provided according to a suitable manner known to those skilled in the art, or according with the organization of the tone filter typically illustrated in Fig. 10.

The filter according to Fig. 10 is of the LC type in which the audio output of the receiver is amplified by the amplifier shown in block form, and the output of the amplifier is fed into an LC circuit 92 tuned to the tone frequency to which the associated relay Z is desired to be responsive. At the frequency to which the LC circuit is tuned, sufficient potential is applied to a suitable trigger circuit to so govern the bias of the grid of a suitable gas tube 2T as to trigger that tube and effect the energization of the winding of the relay Z in response to the reception of the particular tone for energization of that relay. It will be noted that the relay Z is connected in the anode-cathode circuit of the gas tube, and alternating current is used for energization of the anode-cathode circuit of the tube so as to provide for the cut off of the tube upon the cessation of the tone to which the filter is tuned. Direct current can be used for this circuit provided means such as the response of a relay FR for the following step is provided for extinguishing the gas tube as is inherent in the first three steps according to this embodiment of the present invention.

To consider the mode of operation of the decoding unit, it will be assumed that the clear-out period at the end of a cycle of operation has been completed and the relay SY dropped away at the termination of such period. On the first step of the following cycle of operation, as has been described, tone No. 1 or tone No. 2 is selected for transmission, and thus the reception of the carrier wave with one or the other of such tones during the first step of the cycle provides for the selective energization of the relay 1FR1 or 1FR2, dependent upon whether tone No. 1 or tone No. 2 is received.

If the tone No. 1 is received during the first step, the relay 1FR1 is picked up by the energization of its lower winding in the output circuit of filter No. 1 to which alternating current is applied, and which includes back contact 93 of relay 2FR4, back contact 94 of relay 2FR3, back contact 95 of relay 1FR2, and the lower winding of relay 1FR1. The picking up of relay 1FR1, by opening back contact 96, opens the circuit for relay 1FR2 to prevent the energization of that relay if by any chance the tone No. 2 were to be applied to the carrier from some extraneous source during the first step of the transmission of the cycle. If, the tone No. 2 were transmitted on the first step rather than the tone No. 1, the relay 1FR2 would have been picked up in preference to the relay 1FR1 because of its winding being included in the output circuit of the tone filter No. 2 in series with back contacts 93, 94 and 96 of relays 2FR4, 2FR3, and 1FR1 respectively.

The picking up of a relay 1FR1 or 1FR2 during the first step of the cycle of operation under consideration closes an obvious stick circuit including the upper winding of that relay and including back contact 97 of the synchronizing pulse receiver relay SY. Thus, the relay 1FR1 or 1FR2

that is energized during the first step of the cycle is maintained picked up until the cycle is completed, even though the pick up circuit of such relay is opened upon the picking up of the relay 2FR3 or relay 2FR4 during the next step of the cycle.

In a similar manner, the reception of tone No. 3 during the second step is effective to pick up the relay 2FR3, or the reception of tone No. 4 during the second step is effective to pick up relay 2FR4. The output circuit of the tone filter No. 3 in addition to including the lower winding of relay 2FR3 includes back contacts 98, 99 and 100 of relays 3FR2, 3FR1 and 2FR4 respectively and alternating current energy is applied to that circuit through either front contact 101 of relay 1FR1 or front contact 102 of relay 1FR2. If, on the other hand, tone No. 4 is received during the second step, the lower winding of relay 2FR4 is energized in the output circuit of the tone filter No. 4 by a circuit including front contacts 101 and 102 of relays 1FR1 and 1FR2 connected in multiple, and back contacts 98, 99 and 103 of relays 3FR2, 3FR1 and 2FR3 respectively. The circuits for relays 2FR3 and 2FR4 are to be considered as typical of the circuits that would be provided for additional intermediate decoder relays that may be required as a greater number of steps is provided in accordance with the requirements of practice.

The relays 3FR1 and 3FR2 are provided for decoding purposes during the third step of the cycle, and such relays are selectively energized in accordance with whether tone No. 1 or tone No. 2 is received during the third step. If tone No. 1 is received, the lower winding of relay 3FR1 is energized in the output circuit of the tone filter by a circuit similar to that which has been described for the energization of the lower winding of the relay 2FR3; and similarly, if tone No. 2 is received on the third step of the cycle, the lower winding of the relay 3FR2 is energized in the output circuit of the tone filter No. 2 by a circuit comparable to that which has been described for the energization of the lower winding of relay 2FR4 in the output circuit of tone filter No. 4.

During the fourth step in the cycle of operation, the relays 4FR3 and 4FR4 are selectively governed in accordance with whether tone No. 3 or tone No. 4 is received during that step. The lower winding of relay 4FR3 is energized during the fourth step in the output circuit of tone filter No. 3 when that tone is received through back contact 104 of relay 4FR4 and front contact 105 of relay 3FR1 or front contact 106 of relay 3FR2 of the preceding step. Similarly, if the tone No. 4 is received during the fourth step, the output circuit of the tone filter for that tone causes the picking up of the relay 4FR4 by the energization of its lower winding in a circuit including back contact 107 of relay 4FR3 and front contact 105 of relay 3FR1 or front contact 106 of relay 3FR2.

After a relay FR has been picked up for each of the steps of the cycle, the magnetic stick relay SC is energized with a polarity to actuate its contacts from their left hand to their right hand positions by a circuit extending from the positive terminal of the center tap battery 108 including contact 109 of relay SYP in its left hand position, front contact 110 of relay 1FR1 or front contact 111 of relay 1FR2, front contact 112 of relay 2FR3 or front contact 113 of relay 2FR4, front contact 114 of relay 3FR1 or front contact 115 of relay 3FR2, front contact 116 of relay 4FR3 or front contact 117 of relay 4FR4, and

winding of relay SC to the center tap of the battery 108. The shifting of the contact 118 of relay SC to the right conditions a circuit by which the magnetic stick relay SYP can be energized with a polarity for the actuation of its contacts to their right hand positions, such circuit being closed only upon reception of tone No. 5 for the picking up of the synchronizing pulse relay SY.

The picking up of a decoding relay on the fourth step completes the decoding, and the tone responsive relays that have been picked up during the cycle are all maintained picked up by their respective stick circuits, dependent upon back contact 97 of relay SY. The reception of tone No. 5, designating the clearout period, provides for the picking up of the relay SY which is connected directly in the output circuit of the tone filter No. 5, and the picking up of that relay by opening back contact 97 provides for the restoration of the decoding relays FR to thereby condition such relays for the next cycle of operation.

The relay SY in picking up, closes a circuit for energizing the magnetic stick relay SYP with a polarity to operate the contacts of that relay from their left hand to their right hand positions. Such circuit extends from the positive terminal of the center tap battery 108 including contact 118 of relay SC in its right hand position, front contact 119 of relay SY and winding of relay SYP to the center terminal of the battery 108.

The shifting of the contacts of relays SYP to their right hand position in response to the above described energization of that relay, pole changes the circuit for the relay SC, but the circuit for that relay has been opened by the dropping away of the decoding relays so that it is not responsive to such change in polarity until the circuit for the relay SC is again closed at the end of the next cycle of operation. It is thus provided that under normal operating conditions, as long as the cycles of operation of the decoder are complete, the relay SC shifts its contacts at the end of each cycle of operation, and thus in accordance with the pulsing of contact 91 of that relay, the primary winding of the decoding transformer is energized with first one polarity and then the other to provide for the energization of the relay SCP by the output of that transformer through the rectifying contact 120. The relay SCP is made sufficiently slow in dropping away to be maintained steadily picked up as long as the contacts are pulsed for each cycle of operation.

Having thus considered specifically the organization of the decoder, consideration will now be given to the utility and attributes of the organization as described. In general, the decoding organization is such as to have the ability to keep in step, to distinguish between complete and incomplete cycles of operation, to restore itself to normal after an incomplete cycle so as to be ready for the next cycle, and to maintain continuous energization of a remotely controlled relay, such as a relay Z, for example, on a closed circuit principle.

The decoder organization as shown is kept in step by each pair of decoding relays FR for each step have their energizing circuits checked through a front contact of a relay FR for the preceding step, except for the relays FR associated with the first step of the decoding bank. Thus, for example, relay 2FR3 or relay 2FR4 cannot be energized during the second step of a cycle of operation unless a relay 1FR1 or 1FR2 has been picked up on the preceding step to close

front contact 101 or front contact 102 respectively.

By use of different tones for successive steps, it is provided that if step 2, for example, is not received, the tones of step 3 cannot energize the relays FR for step 2 which have not been energized because of failure to receive tones on the preceding step. Assuming the third step to be received properly, the tones of the fourth step cannot energize a relay of the second step because the relays of the second step have their circuits open by a relay of the third step. If the second and third steps are both not received during a cycle, one of the tones of the fourth step can energize a decoder relay FR of the second step only momentarily because of the creation of a short cycle.

Provided that complete cycles are received by the decoder organization shown in Fig. 2, the magnetic stick relay SC shifts its contacts at the end of each cycle, and thus an energizing pulse is applied to the relay SCP at the end of each cycle. If, however, a relay FR fails to be picked up in response to its associated tone for any one step of the cycle, the circuit as described for the relay SC cannot be closed at the end of the cycle to provide for the shifting of the contacts 91 and 120 of that relay, and thus by failure of the relay SC to shift these contacts relay SCP becomes dropped away, and by the dropping away of that relay, a suitable indication is provided as, for example, by the energization of the indicator lamp SCK upon the closure of back contact 121. It will be readily apparent that this indication can be used in accordance with the requirements of practice to merely indicate to an operator that there is something wrong at that receiving station, or the dropping away of relay SCP can be used to automatically govern the controlled relays Z of the receiver organization at that station to provide for more restrictive control in cases where controls which are communicated involve safety circuits.

If, because of a failure of the decoder to respond to a tone on a particular step, although a distinctive indication of an under-step is provided as above described, it is also provided by the circuit organization that has been described that the reception of a subsequent synchronizing pulse at the end of a short cycle or at the end of any other cycle, is effective in the manner which has been described to restore the relays FR at the end of that cycle by the opening of back contact 91, and thus condition the decoder for the reception of the next cycle of operation. In this way, as soon as the trouble originally causing the short cycle is repaired, the decoding unit is automatically conditioned to be responsive to complete subsequent cycles of operation.

It will be readily apparent from the organization as it has been described that application relays to be governed by the tones received can be governed by contacts of the respective decoding relays FR in accordance with the requirements of practice for the particular application to which the stepper and decoder organization is to be applied. For this embodiment of the present invention, it is assumed that it is desired to control a relay Z of Fig. 2 in correspondence with each of the relays C at the transmitter station of Fig. 1. By this arrangement it is provided that the relay 1Z is picked up in response to tone No. 1 on the first step as selected by the relay 1C in its picked up position at the transmitter station. The tone No. 2 when received on the first step is not shown

in Fig. 2 as governing the energization of any particular application relay, but such tone is effective to govern the dropping away of the application relay 1Z for the first step in a manner to be more readily apparent as the description progresses. In a similar manner the relays 2Z, 3Z and 4Z are provided to be energized in correspondence with the relays 2C, 3C and 4C at the control office.

To consider the energization of the application relays Z more specifically, it will be noted that the picking up of any of such relays, and the sustained energization of any of such relays is dependent upon the closure of front contact 122 of the relay SCP, which relay is maintained picked up only in response to complete cycles of operation. It is therefore required that a cycle be completed so as to actuate the relay SC, assuming the system to be initiated from a deenergized and inactive condition, before a pick up circuit can be closed for the respective application relays Z.

Thus, when the system is in operation, the relay 1Z is picked up in response to the picking up of the relay 1FR1 by the energization of a circuit extending from (+) including front contact 122 of relay SCP, back contact 123 of relay 1FR2, front contact 124 of relay 1FR1 and winding of relay 1Z, to (-). The picking up of relay 1Z by closing its stick contact 125 shunts the front contact 124 of relay 1FR1 out of the circuit that has been described and thus maintains that relay steadily energized, dependent upon the contacts 122 and 123 of relays SCP and 1FR2 respectively being maintained closed. It is therefore provided that the relay 1Z can be dropped away upon the reception of tone No. 2 when it is transmitted during the first step of a subsequent cycle, such tone being selected for transmission by the dropping away of the relay 1C at the transmitter station shown in Fig. 1. Under such conditions, the relay 1FR2 is picked up in preference to the relay 1FR1 during the first step of the cycle, and by opening back contact 123 in the stick circuit for the relay 1Z, the relay 1Z is dropped away. In case of a short cycle at the end of which relay SC fails to shift, the failure of contacts 91 and 120 to be pulsed provides for the dropping away of relay SCP and the opening of the circuit for relay 1Z at front contact 122. The circuit governing the mode of operation of the relay 1Z as it has been described is to be understood as typical of the circuit organization provided for the control of the similar relays 2Z, 3Z and 4Z associated with the respective second, third and fourth steps of the system.

Because of its being assumed that the energization of the respective relays Z is used to indicate safety conditions in a system of the general character of that shown in Fig. 3 and to be hereinafter described, it is provided that the integrity of the picked up condition of the relays Z is dependent upon the reception of complete cycles. In case of the failure to receive a tone on a particular step in the cycle, it is provided that the opening of front contact 122 of the relay SCP because of the short cycle causes the dropping away of all of the application relays Z and thus prevents all of such relays from providing erroneous information involving safety because of their being maintained picked up during times of abnormal operation of the decoder organization. It is to be understood, however, that the energization of the application relays Z could as well be provided independent of the relay SCP, if this feature of the present invention is not desired.

Radio link for air traffic control

In an air traffic control system of the general nature of that disclosed in the above mentioned Kendall et al. application, the airway is divided into successive blocks of predetermined limits, and each block has a block station for transmitting intelligence to and receiving intelligence from aircraft at respective altitudes within that block. Lines of demarkation of these blocks are drawn by time-distance characteristics in a pulse technique system such as is disclosed in the above mentioned Kendall et al. application and is of little consequence to the present invention in that the present invention is more particularly related to the communication of block occupancy and over controls (controls from a central office) from station to station rather than dealing with problems involving block demarkation and communication of intelligence between the block stations and the respective aircraft. As part of the block demarkation organization, however, the adjoining blocks are of slightly different character as identified by the character of pulses transmitted to the aircraft from the associated stations, and thus a given block of a character A has adjoining blocks at each side thereof of a character B. With reference to Fig. 3, for example, the block station A' has to its left block station B' and to its right block station B'', the blocks B' and B'' being of the same general character but distinctive from station A'.

The information to be communicated from block station to block station is primarily that of the occupancy of respective flight altitudes of the adjoining block stations. The occupancy condition of such altitudes is received from the respective aircraft by the block station nearest such aircraft and such information governs block occupancy relays BO (provided with preceding numerals indicative of the altitudes with which such relays are associated, and also provided with a preceding letter indicative of the particular block for which that relay is provided. For example, the relay A'1BO is the block occupancy relay for the first flight altitude in block A', and the relay A'2BO is the block occupancy relay for the second flight altitude in block station A'. These relays are so controlled as to be normally energized, and are dropped away in response to the presence of aircraft in that block and at the associated altitude.

Inasmuch as each block station must have information relative to the occupancy of each altitude of the block at each side thereof, it is required that the conditions of occupancy for the respective flight altitudes be transmitted to the block station to the left and to the block station to the right from each of the block stations receiving the occupancy indications from planes within that block. It is therefore required that the relays A'1BO and A'2BO, for example, be repeated by radio link both to station B' to the left and to station B'' to the right.

It is also desirable to be able to communicate certain over controls from a control office to the respective block stations to be relayed by the respective block stations to aircraft in the respective blocks with which such stations are associated. These over controls may be controls instructing aircraft at any selected altitude to ascend or descend, or instructing the aircraft to hold within the particular block within which it is flying. In this manner, a controller at a central control office who has for his information

certain indications as to the location of aircraft along the airway, can intelligently govern the dispatching of aircraft in congested areas to the best advantage. Thus, it may be desirable to provide respective ascent, descent and hold control levers at the control office for each block station, and for each flight altitude governed by that block station that is desired to be governed in the above described manner. The disclosure of a means for the communication of one of the above described types of controls to the respective blocks can be considered typical of the manner provided for the communication of the other types of controls to such blocks, and thus, for the purpose of simplification of the disclosure of the present invention, only levers and control circuits relative to the communication of an over control to descend for a given altitude for each of the blocks illustrated is shown. It is thus provided that the levers B'DS, A'DS, and B''DS are provided on a suitable control panel at a control office as a means by which the controller at such office can designate descent controls for transmission to the respective block stations B', A' and B''.

For the communication of the above described over controls and block occupancy controls between respective blocks and the control office, it is provided that a radio transmitter is continually active at the control office and at each of the block stations for transmitting its particular assigned carrier frequency, such carrier frequency to be received as indicated by the dotted lines of Fig. 3 at the respective block stations to the left and to the right of the particular block station transmitting.

To prevent interference in transmission by the respective transmitters, it is provided that the carrier wave transmitted from the control office is for a carrier frequency F3, and the next two block stations to the right have their transmitters tuned to the distinctive frequencies F1 and F2. By this arrangement, it is provided that the receiver F3 at block station B' is the only receiver within range of the transmitter F3 at the control office that is tuned to the frequency F3. This is desirable because the receiver F3 at block station B' is intended to be responsive only to controls transmitted from the next station to the left which is the control office. Similarly, the receiver F1 at block station A' is responsive only to controls transmitted by the transmitter F1 of block station B', and receiver F2 at block station B'' is responsive only to controls transmitted by the transmitter F2 of block station A'.

The receiver F1 at block station B'' receives from the next block station to the right (not shown), block station B'' being assumed to be out of range of the transmitter F1 at block station B'. The receiver F3 of block station A' is responsive only to controls transmitted by the transmitter F3 of block station B'', and similarly the receiver F2 of block station B' is responsive only to controls transmitted from the transmitter F2 of block station A' to the right thereof.

It is to be understood that all of these transmitters and receivers are continually active, and communicate controls through respective successive cycles of operation of a stepper and decoder organization of the character shown, for example, in Figs. 1 and 2 which has been heretofore described. More specifically, the channel wires C1, C2, C3 and C4 of Fig. 3 correspond to wires similarly designated in the stepper organization of Fig. 1, and the tone control wires T1, T2, T3 and

T4 of Fig. 3 correspond to the tone control wires similarly identified in Fig. 1.

It is thus provided, for example, that the contact 126 of the descent lever B'DS selects the transmission of tone T2 with the lever in its left hand position during the first step of each cycle of operation of the stepper at the control office, and the actuation of that lever to the right hand position is effective to render the transmission of tone T1 effective during the first step of each cycle of operation of the stepper organization. In a similar manner, the tone control wires T3 and T4 are selectively energized during the second step in accordance with the contact 127 of the lever A'DS, and the tone wires T1 and T2 are selectively energized during the third step by the contact 128 of lever B'DS for governing the tone to be applied to the carrier wave transmitted from the control office.

In accordance with the reception of the tone No. 2 during the first step by the receiver F3 and decoder at block station B', a decoder relay corresponding to relay 1FR2 of Fig. 2 is picked up, and the picking up of that relay is effective to open the control circuit for the relay B'DR for that step, the relay B'DR of Fig. 3 corresponding to the relay 1Z of Fig. 2, relay B'DR being controlled by the wire C1—T1 which corresponds to the wire C1—T1 associated with the relay 1Z of Fig. 2. It has thus been illustrated that the lever B'DS at the control office in its left hand position provides for the relay B'DR at block station B' to be dropped away and thus to be ineffective for selecting a control to energize a descent indicator (not shown) in an aircraft flying at the particular altitude for which the descent control under consideration is provided.

In a similar manner, the relays A'DR and B''DR at block stations A' and B'' respectively are maintained in their dropped away positions in accordance with the respective left-hand positions of the levers A'DS and B'DS at the control office, and such relays are picked up, as is the relay B'DR, at anytime the respective associated control levers at the control office are actuated to their right-hand positions to thereby change the selection of tones transmitted from the control offices.

The relays A'DR and B''DR at block station B' must repeat their controls through to the next block station to the right, and thus such relays selectively govern tones transmitted during assigned steps by the transmitter F1 at block station B'. It is thus provided that the back contact 129 of relay A'DR at block station B' when closed selects the connection of the tone wire T2 to the channel wire C3 for rendering effective the transmission of tone No. 2 during the third step of the respective cycles transmitted by the transmitter F1 of block station B'. If the relay A'DR is picked up, the shifting of contact 129 selects the transmission of tone No. 1 during that step in accordance with the lever A'DS at the control office having been actuated to its right-hand position. In a similar manner, the contact 130 of relay B''DR selects between tones No. 3 and 4 for transmission during the fourth step of each cycle of operation of the stepper at the block station B'.

It has been pointed out that it is also desirable to transmit conditions of the block occupancy relays BO for the respective flight altitudes to the next station to the right, and thus it is illustrated that the contacts 131 and 132 of relays B'IBO and B'2BO respectively at block station B' select tones to be transmitted during the respective first and second steps of the stepper at

that station. Assuming the blocks to be normally unoccupied at the respective altitudes under consideration, the relays B'IBO and B'2BO at station B' are normally picked up, and thus select respectively the transmission of tone Nos. 1 and 3 on the respective first and second steps of each cycle of operation of the stepper at that block station.

Upon reception of controls at block station A' in response to the transmitter F1 at block station B', it is provided that the relays B'IBO and B'2BO at block station A' are maintained steadily picked up in accordance with the tone Nos. 1 and 3 received on the respective first and second steps from the block station B', and it is also provided that the over control relays A'DR and B''DR at station A' are maintained dropped away according to the tones T1 and T3 transmitted during the respective third and fourth steps of each cycle. The relay A'DR is used at block station A' to govern the descent control transmitted to aircraft in the block A', the contacts of that relay being substituted in the control circuit for the relay 2AR of Fig. 6 of the above mentioned Kendall et al. application for the switch 530 shown normally open in the circuit for that relay. A contact of the relay A'DR replacing the switch 530 should be a front contact so as to allow the relay 2AR to be normally dropped away as illustrated, and to be picked up in response to the actuation of the lever A'DS at the control office to its right hand position.

The relay B''DR at block station A' must repeat its position through the radio link from block station A' to block station B''. Thus the contact 133 of that relay governs the application of tone No. 1 or tone No. 2 to the channel wire C3 during the third step of the stepper at block station A'.

The conditions of the relay A'IBO and A'2BO at block station A' are transmitted during the respective first and second steps of each cycle of the stepper at that station because of the respective contacts 134 and 135 selectively governing the respective tones applied during those steps, the tone No. 1 being applied during step No. 1, and tone No. 3 being applied during step No. 2 if the respective first and second altitudes of block A' are unoccupied.

It is therefore provided, as above described, that the transmitter F2 of block station A' transmits controls of distinctive devices on steps 1, 2, and 3, such transmission being received both by the station to the right and the station to the left. Inasmuch as the station to the left is not interested in the conditions of relay B''DR as transmitted by the transmitter F2 of block station A', the receiver F2 at block station B' provides for the control of only the relays A'IBO and A'2BO at block station B' to correspond with the conditions of similarly identified relays governing the tones transmitted by the transmitter F2 of block station A'.

At the block station B'', however, such station is interested in receiving controls on all 3 steps transmitted from the block station A' and therefore the relays A'IBO, A'2BO and B''DR at block station B'' are positioned in correspondence with the relays bearing similar reference characters used in selection of the tones for application to the transmitter F2 at block station A'.

From the typical condition of link transmission as it has been described, it will be noted that at times the full complement of steps according to

Fig. 1 is used for the communication of controls from station to station, and at other times only two or three steps are required. In accordance with the organization of the stepper employed as illustrated and described with reference to Figs. 1 and 2, the number of steps required is dependent upon the number of distinctive controls required to be transmitted. It is required that the respective decoders complete each cycle as a check against faulty operation because of failure to transmit a tone during a step on account of dirty contacts, or other conditions affecting tone transmission. It is therefore required that although a smaller number of application relays are controlled in certain cases than one for each step transmitted, that each of the decoder units is adapted to be responsive to a tone for each step, the tones for the steps not used for the control of application relays serving merely as phantom tones to effectively complete the count of the number of tone pulses transmitted during each cycle.

Consider for example the transmitter F2 at block station A' which has three distinctive controls to transmit on three successive steps. The intelligence transmitted from block station A' during the three steps is used only in part at block station B', and thus the decoder associated with receiver F2 at block station B' provides only for the control of relays A'1BO and A'2BO on respective first and second steps of each cycle of operation, the third step of the cycle stepper being assigned to the transmission of a descent control intended only for block station B'. Under these conditions, the decoder at block station B' is adapted to receive tone 1 or tone 2 during the third step, only for the purpose of completing the cycle, there being no application relay such, for example, as the relay 3Z of Fig. 2, providing for that step of the decoder.

The organization of the system therefore is such that the number of steps employed by the transmitter is determined by the number of distinctive controls to be transmitted, and each station which receives from that transmitter must have a decoder unit including a relay responsive to the tone transmitted on each step, irrespective of whether or not the associated step is used in that receiver for the reception of a control which has been transmitted.

Having thus described specifically typical conditions of operation of the radio link system of Fig. 3, it is believed to be readily apparent to those skilled in the art as to the manner in which controls are communicated under other combinations of occupancy and office controlling conditions other than those which have been described, and it is to be understood that the stepper and tone transmitter F3 at block station B'' is effective to communicate block occupancy controls to the block station A' at the left and to the next block station to the right (not shown) in a manner similar to that which has been specifically described for the communication of block occupancy controls from block station A' to the respective adjoining block stations.

Radio link for centralized traffic control

In a centralized traffic control system of the general character disclosed in the patent to W. D. Hailes et al. No. 2,399,734 dated May 7, 1946, a stretch of single track is provided with passing sidings and power switches and signals at the respective ends of the passing sidings governed

from a control office by means of a code communication system, whereby an operator at the control office can designate respective switch and signal control on a suitable control panel for transmission to respective field stations at which such switches and signals are located. The controls are communicated in general during respective control cycles of operation wherein a single cycle of operation is transmitted in response to the actuation of a start button at the control office. According to the present invention, it is contemplated to use the stepper organization of the general character heretofore described with reference to Figs. 1 and 2 for the communication of similar switch and signal controls to the respective field stations in a centralized traffic control system, such stepper organization being preferably continuously active and thereby effective to maintain at all times the respective controlled switches and signals substantially directly responsive to the actuation of the respective switch and signal control levers at the control office, irrespective of the order in which such switch and signal control lever can be actuated, and irrespective of whether or not several switch and signal control levers are simultaneously actuated. In other words, the centralized traffic control system according to the present invention can be said to be in effect, a code communication system providing the advantages of a unit wire switch and signal control system without requiring a large number of line wires which reaches prohibitive proportions where a substantial number of respective switches and signals are to be controlled from a control office.

The organization of the centralized traffic control system of the embodiment illustrated in Figs. 4, 5, 6, 7 and 8 is such as to provide for the control of switches and signals at the respective A and B ends of a crossover which is illustrated by the track diagram 136 of Fig. 4. Such diagram is assumed to be provided on a suitable control panel at the control office as a typical part of a centralized traffic control system. Also disposed on the control panel are suitable respective switch and signal control levers SML and SCL for the track switches and signals generally provided at the respective ends of a passing siding, such switches and signals being associated with the ends of the passing siding in a manner well known to those familiar in the art as is disclosed for the left hand end A of the passing siding A, for example, in Fig. 11.

With reference to Fig. 11, the switch 2W is illustrated as being a power switch governed by a suitable switch machine 2SM, and the OS track section T including the switch 2W has signals 2A and 2B associated with the left hand end thereof for governing eastbound traffic (to the right) and signals 3A and 3B for governing entrance to that track section for westbound traffic (to the left). It is to be understood that the present invention is not limited to the use of any particular types of signals, and that signals of the search light, semaphore, position light or color lamp types can be employed. The signals illustrated are assumed to be of the search light type such as is disclosed, for example, in the patent to O. S. Field No. 2,376,534, dated May 22, 1945. The organization of the apparatus more directly governing the switches and signals as illustrated in Fig. 11 in accordance with application relays controlled by the radio link system will be readily identified as corresponding to apparatus disclosed in the prior application of W. L.

Livingston Ser. No. 703,173 dated October 14, 1946 to which reference can be made for a detailed description of its organization and mode of operation.

With reference to Fig. 4, the stepper for this embodiment of the present invention is illustrated in block form, as it is to be understood that the stepper disclosed in Fig. 1 can be employed for selectively connecting ground to the respective channel wires C1, C2, C3 and C4. It will be readily apparent however that stepping organizations other than that disclosed in Fig. 1 which are effective to provide respective channels C1, C2, C3 and C4 can be employed within the scope of the present invention.

The respective contacts of the signal and switch control levers 2—3SGL, 4—5SGL, 2SML and 3SML selectively govern the connection of the tone control wires T1, T2, T3, T4 and T5 to the channel wires C1, C2, C3 and C4 in a manner to be hereinafter considered, and the connection of ground through the respective channel wires to selected tone wires T is effective to selectively render the tone generators Nos. 1, 2, 3, 4 and 5 selectively effective to modulate a carrier wave assumed to be continually transmitted at an assigned frequency by the transmitter shown in block form. Each of the respective tone generators can be of the character shown, for example, in Fig. 9 and heretofore described.

With reference to Fig. 5, a code chart is shown illustrating the manner in which the different steps are used in the control of the respective switches and signals. It will be noted according to this chart that the steps 1 and 2 having the channel wires C1 and C2 are used in the control of the switch and signals at station A, and the steps 3 and 4 involving the channel wires C3 and C4 are used in the control of the switch and signals at station B. In a similar manner, steps can be added for additional stations in accordance with the requirements of practice.

The tones Nos. 1, 2 and 3 are used for governing the respective signal right, signal left, and signal stop controls when applied to the channel C1, for the signals at field station A, and the tones 4 and 5 are used for the respective switch normal and switch reverse controls for governing the switch machine at field station A through the channel C2. In a similar manner, the tones Nos. 1, 2, and 3 govern the signal right, signal left, and signal stop controls respectively through channel C3 for field station B, and the tones Nos. 4 and 5 govern switch normal and switch reverse controls respectively for the control of the track switch at field station B through the channel C4.

It will be noted that the assignment of the tones as above described follows the general principles of the organization heretofore described in that the same tones are never repeated on adjoining steps, but are repeated on alternate steps, thus providing for the transmission of ten distinctive controls during the four steps with the use of only five distinctive tones. Because of their being substantially no limit to the number of distinctive tones that can be assigned to a single step of the organization, it is to be understood that various arrangements of tone assignment can as well be applied in accordance with the requirements of practice. Although it is desirable to limit transmission to only one tone at a time per step, with slight modifications in the decoding circuits the organization may be adapted to the transmission of more than one tone at a time if such is the requirement of practice.

Because of the use of five distinctive tones for control purposes as compared to four distinctive tones as used in Fig. 1, it is necessary to employ a sixth tone according to the organization of Fig. 4 for a synchronizing tone, such tone being applied and used for purposes corresponding to that of tone No. 5 of Figs. 1 and 2.

The tone control wires T1, T2, T3, T4 and T5 (see Fig. 4) are selectively connected to the channel wires C1, C2, C3 and C4 in correspondence with the requirements according to the code chart of Fig. 5. For example, the channel wire C1 is selectively connected to either tone wire T1, T2, or T3 by the positioning of the signal control lever 2—3SGL. With such lever in its center position as shown, the tone wire T3 is connected through contact 137 of lever 2—3SGL in its center position to the wire C1; thus causing the radiated carrier wave to be modulated by the tone generator No. 3 during the first step of a cycle of operation transmitted from the control office. The actuation of the lever 2—3SGL to its right hand position opens the connection of wire C1 to the wire T3 at contact 137, and closes the connection from the channel wire C1 to the tone wire T1 to render the carrier wave modulated by tone generator No. 1 during the first step. If, however, the lever 2—3SGL is operated to its left hand position for designating the clearing of a signal governing westbound traffic, the channel wire C1 becomes connected to the tone wire T2 to render the tone generator No. 2 effective to modulate the carrier wave during the first step of the cycle.

The switch control lever 2SML when in its left hand position connects the channel wire C2 to the tone wire T4 through contact 138 and thus provides for the modulation of the carrier wave during the second step by tone generator No. 4 for governing the operation of the switch machine 2SM at station A (see Fig. 11) to its normal position. The actuation of the lever 2SML to its right hand position opens the connection of the channel wire C2 to the tone wire T4 and connects the channel wire C2 to the tone wire T5 for rendering the carrier wave modulated by tone No. 5.

In a similar manner, the application of tones Nos. 1, 2 and 3 during the third step is selected by the lever 4—5SGL for governing the signals at station B, and the tones 4 and 5 are selected by lever 3SML for governing the modulation of the carrier wave during the fourth step of the cycle. The completion of the cycle provides for the deenergization of the synchronizing pulse relay SP, and the dropping away of that relay by closing its back contact 139 renders the modulation of the carrier wave by tone No. 6 effective for marking the clear out period at the end of the cycle.

A decoding bank for the decoding of the tones transmitted on the respective steps according to the tone transmitter of Fig. 4 is shown in Fig. 6, and this decoding unit will be readily recognized as corresponding in most respects with the organization of the decoding unit of Fig. 2, the principal difference being that three relays are used for each of the first and third steps, one for each tone to be received on that step, as compared to two relays for each of these steps in the organization of Fig. 2. It is therefore believed unnecessary to describe specifically the mode of operation of the decoding bank of Fig. 6, and the description of Fig. 6 will be in general limited to

the manner in which the decoding bank of Fig. 6 differs from that of Fig. 2.

Assuming the first step of a control cycle to be received by the apparatus of Fig. 6, which is typical of the decoding unit at each of the field stations A and B, the relay 1FR1 is picked up if the carrier wave is modulated by tone No. 1 by a circuit checking the back contacts 140 and 141 of relays 1FR2 and 1FR3 for that step, and the back contacts 142 and 143 of relays 2FR4 and 2FR5 associated with the next step. This is in accordance with the principles as described with reference to Fig. 2, wherein the energization of each tone responsive relay checks that the tone responsive relay for that step and for the following step are dropped away, and if the step under consideration is an intermediate step, the circuit also checks that a decoding relay is picked up for the preceding step. It is believed to be readily apparent that if a tone No. 2 or a tone No. 3 is received on the first step rather than the tone No. 1, its corresponding relay 1FR2 or 1FR3 is picked up by a circuit checking contacts of other decoding relays in a manner similar to that which has been specifically described with reference to the circuit organization for the relay 1FR1. The circuit organization for the control of the relays 3FR1, 3FR2 and 3FR3 will be recognized as being comparable to that described for the relays 1FR1, 1FR2 and 1FR3 except that, because of such relays being provided for an intermediate step in the cycle, the pick up circuits for such relays check through the front contacts 144 and 145 of relays 2FR4 and 2FR5 respectively to insure that a relay for the preceding step has been properly conditioned.

The circuit for the magnetic stick relay SC will be recognized as being similar to that of the relay SC of Fig. 2 except that the contact groups for the steps 1 and 3 in its pick up circuit have 3 contacts in multiple, one for each tone responsive relays as shown in Fig. 2. This obviously does not alter the mode of operation of the relay SC and its associated relays SXP and SCP of Fig. 6 as compared to the mode of operation of corresponding relays according to the organization which has been specifically described with reference to Fig. 2.

With reference to Fig. 7, the control circuits for switch and signal control application relays at field station A are illustrated whereby such relays are rendered responsive to the respective codes used for their control according to the code chart of Fig. 5. The relays 3LG and 2RG are signal control application relays for controlling the clearing of signals governing westbound and eastbound traffic respectively at field station A. A stop control application relay 2-3B is used in insuring the putting to stop of whichever of the signals at field station A may have last been cleared in accordance with a stop control designated by an operator at the control office. The relays 2NW and 2RW are switch control application relays provided for governing the respective normal and reverse operations of the switch machine 2SM which is provided for the operation of the power switch 2W (see Fig. 11).

Assuming the relays FR to be controlled in a manner which has been described, according to the circuits of Fig. 7, it is provided that the relay 2RG is picked up in response to the reception of tone No. 1 during the first step of a control cycle in accordance with the lever 2-3SGL at the control office being actuated to its right-hand position.

Assuming the respective cycles of operation to be complete so as to maintain the relay SCP (see Fig. 7) steadily picked up in a manner which has been described, the relay 2RG is picked up in response to the picking up of relay 1FR1 during the first step of a cycle by the energization of a circuit extending from (+) including front contact 147 of relay SCP, back contact 148 of relay 1FR3, back contact 149 of relay 1FR2, front contact 150 of relay 1FR1 and winding of relay 2RG, to (-). When relay 2RG is picked up, the closing of its front contact 151 establishes a stick circuit to shunt front contact 150 of relay 1FR1 out of the circuit that has been described so as to maintain the relay 2RG steadily picked up, dependent upon the back contacts 149 and 148 of relays 1FR2 and 1FR3 remaining closed, and the front contact 147 of relay SCP being maintained closed as an indication that complete cycles of operation are being received.

At a time when it is desired to put a signal to stop which is controlled by the relay 2RG, the stop control relay 2-3B can be picked up and the relay 2RG dropped away in accordance with the actuation of the control lever 2-3SGL at the control office from its right-hand position to its center position, which operation selects the tone No. 3 for transmission during the first step of the respective control cycles.

The reception of the tone No. 3 during the first step at field station A provides for the picking up of the relay 1FR3 at that station during the first step of the cycle and in accordance with the picking up of relay 1FR3, the opening of back contact 148 in the above described circuit for the relay 2RG opens the stick circuit for that relay and causes the relay 2RG to be dropped away. In addition, the shifting of contact 148 of relay 1FR3, is effective to pick up the relay 2-3B by the energization of a circuit extending from (+) including front contact 147 of relay SCP, front contact 148 of relay 1FR3, back contact 152 of relay 1FR2, back contact 153 of relay 1FR1, and winding of relay 2-3B, to (-). The closing of front contact 154 upon the picking up of relay 2-3B establishes a stick circuit to shunt the front contact 148 of relay 1FR3 out of the circuit that has been described so as to maintain the relay 2-3B steadily picked up as long as the decoding unit at field station A is continuously responsive to complete cycles of operation, and as long as the levers 2-3SGL at the control office is maintained in its center position.

Similarly, when the control machine operator at the control office desires to permit the clearing of a signal for governing westbound traffic, the actuation of the lever 2-3SGL to its left-hand position selects the transmission of tone No. 2 during the first step of the next cycle of operation. The reception of that tone at field station A provides for the picking up of relay 1FR2, and the picking up of that relay according to Fig. 7, is effective by the opening of back contact 152 to release the relay 2-3B. The relay 1FR2 in being picked up provides for the picking up of relay 3LG for governing the clearing of a signal governing westbound traffic by the energization of a circuit extending from (+) including front contact 147 of relay SCP, back contact 148 of relay 1FR3, front contact 149 of relay 1FR2, back contact 155 of relay 1FR1 and winding of relay 3LG, to (-). When relay 3LG is picked up, the closing of its front contact 156 establishes a stick circuit to shunt front contact 149 of relay 1FR2

out of the circuit which has been described and thereby maintain the relay 3LG picked up until a change in tone is effected on the first step of some subsequent control cycle.

The application relays 2NW and 2RW for governing the operation of the track switch 2W illustrated in Fig. 11 at field station A are controlled in accordance with whether tone No. 4 or tone No. 5 respectively is transmitted during the second step of the respective control cycles transmitted from the control office. It is therefore provided that the actuation of the switch control lever 2SML at the control office to its left hand position causes the transmission of tone No. 4 during the second step of the respective control cycles of operation, and in accordance therewith, the decoding relay 2FR4 at field station A is picked up. The picking up of relay 2FR4 closes a pick up circuit for the relay 2NW (assuming the relay SCP at field station A to be picked up) extending from (+) including front contact 147 of relay SCP, back contact 157 of relay 2FR5, front contact 158 of relay 2FR4, and winding of relay 2NW, to (-). The closure of front contact 159 of relay 2NW shunts the contact 158 of relay 2FR4 out of the circuit just described and maintains the relay 2NW steadily picked up until a change in the tone applied to the carrier wave during the transmission of the second channel of the respective control cycles. The picking up of the relay 2NW governs the operation of the track switch 2W to its normal position in a manner to be hereinafter considered.

Similarly, the relay 2RW can be picked up when the lever 2SML at the control office is actuated to its right hand position so as to apply tone No. 5 to the carrier wave transmitted during the second channel of the respective control cycles. The reception of such tone at field station A, by picking up the decoder relay 2FR5 at that station, is effective to pick up the relay 2RW and release the relay 2NW in accordance with the shifting of its contact 157. The pick up circuit for relay 2RW extends from (+) including front contact 147 of relay SCP, front contact 157 of relay 2FR5, back contact 160 of relay 2FR4, and winding of relay 2RW, to (-). The front contact 161 of relay 2RW establishes a stick circuit to shunt front contact 157 of relay 2FR5 out of the circuit just described and thus maintain the relay 2RW steadily energized until a change in the tone transmitted during the second step of a subsequent control cycle.

Having thus described specifically the circuit organization by which switch and signal control application relays are conditioned in response to the decoding of codes received during the first and second steps of respective control cycles of operation, it is to be understood that this description as set forth is readily applicable to the control of similar application relays at field station B as illustrated in Fig. 8 except that such relays are controlled during the respective third and fourth steps of the control cycles transmitted rather than the first and second steps as is the case of the application relays of field station A. This is because of the assignment of the third and fourth steps of the cycle for the control of these application relays at field station B as distinguished from the transmission of corresponding tones for corresponding purposes during the first and second steps of the cycle for governing the switch and signal control application relays at field station A.

Inasmuch as a means has been described

whereby respective switch and signal control application relays for a plurality of field stations can be effectively directly controlled through radio transmission from a distant control office, all on a single assigned carrier frequency, it is to be understood that the use of the application relays in the field which have been described as being conditioned from the control office can be made in controlling the respective switches and signals at those field stations in accordance with safety control circuits varying in their organization according to the requirements of practice. For the purpose of illustrating specifically how a typical switch and typical signals can be controlled in response to the above described application relays, it is illustrated in Fig. 11 how the application relays at field station A can govern the operation of the track switch 2W and the control of the signals 2A, 2B, 3A and 3B.

For the purpose of simplification of this disclosure of the present invention, the switch and signal control circuits of Fig. 11 have been made to correspond with the circuits shown and specifically described in the above mentioned application of W. L. Livingston Ser. No. 703,173 dated October 14, 1946, to which reference is to be made for a description in detail as to this circuit organization. The circuits in Fig. 11 correspond to those of Fig. 1 of this Livingston application except that the respective normal and reverse switch control relays 2NW and 2RW the control of which has been described herein as being controlled from the control office, are substituted for the switch control lever SML of Fig. 1 of the above identified Livingston application. Similarly the office controlled relays 3LG and 2RG and 2-3B of the present application have been substituted for the signal control lever SGL in Fig. 1 of the above identified application of Livingston.

It is therefore provided that when the relay 2NW is picked up for operating the track switch 2W to its normal position, the closing of front contact 162 establishes a circuit including back contact 163 of relay 2RW and front contact 22 of relay LS for the energization of the normal switch control relay NWZ. Relay NWZ by closing its front contacts 164 and 165, applies energy to the wires 46 and 47 through front contacts 48 and 49 respectively of lock relay LS for governing the operation of the switch machine 2SM to its normal position. In a similar manner, it is provided that the relay 2RW when picked up, with the relay 2NW dropped away, provides for the energization of the reverse switch control relay RWZ, which by closing its front contacts 52 and 53 applies energy to the switch machine control wires 46 and 47 of a polarity to operate the switch machine 2SM to its reverse position.

The function of lock relay LS is of a general character well known to those familiar with the art relative to permitting the operation of the switch machine SM only under safe conditions, and permitting the clearing of a signal only when the track switch 2W is locked in its operated full normal or full reversed position. The pick up circuit for the relay LS is closed through either relay 2NW or relay 2RW in its picked up position in correspondence with the corresponding relay NWZ or relay RWZ. Thus the pick up circuit of the relay LS includes front contact 166 of relay 2NW in series with front contact 51 of relay NWZ, and similarly the relay LS can be picked up through front contact 167 of relay 2RW and front contact 168 of relay RWZ.

Assuming the radio communication system to

be normally active for transmitting controls selected at the control office by the levers in the positions in which they are shown in Fig. 4, the relay 2-3B for the stop position of the lever 2-3SGL which is associated with station A is picked up, and thus energy is removed from the circuits for the signal control relays LGZ and RGZ at back contact 169 of relay 2-3B to insure that the signals are all at stop. It will be apparent that the signals would be at stop with the relays 3LG and 2RG dropped away under such conditions without the use of the stop control relay 2-3B, but the use of the relay 2-3B positively removes energy from the signal control circuits, and thus relay 2-3B would be effective to prevent a false clear indication in case either of the relays 3LG or 2RG were to fail to drop away when the associated signal control lever 2-3SGL were restored to its center position.

When the lever 2-3SGL at the control office is actuated to its right hand position to clear a signal for eastbound traffic, the relay 2-3B is dropped away and the relay 2RG at field station A is picked up. The picking up of such relay applies energy to the signal control relay RGZ through back contact 169 of relay 2-3B, back contact 170 of relay 3LG, front contact 171 of relay 2RG, and other suitable selections that may be required in practice as indicated by the dotted line 32. The picking up of relay RGZ, by opening back contact 15, locks the track switch 2W and the closing of front contacts 33 and 54 of relay RGZ conditions the circuits for the energization of relays 2AG and 2BG, one or the other of such relays being energized as selected by the position of the track switch 2W. If the relay 2AG is picked up, for example, the closing of front contacts 39 and 40 establishes a signal control circuit for the energization of the mechanism of the searchlight signal 2A with a polarity as selected by the condition of the next signal in advance.

Similarly if the signal lever 2-3SGL is actuated to its left hand position, the relay 3LG is picked up at field station A for permitting the energization of the relay LGZ. The relay LGZ in picking up, by closing its front contact 38, conditions circuits whereby the relay 3BG or the relay 3AG can be energized, as selected by the position of the track switch 2W.

Although the present invention according to the embodiments which have been specifically described is assumed to be applied to the communication by space radiation of the respective controls transmitted from the respective transmitters to the receivers, it is to be understood that the invention is not necessarily limited to space radio, in that the respective frequencies or tones could be superimposed directly, or by limited space radiation, upon existing line circuits without interference with such existing circuits. It will be readily understood that it is merely a matter of selection of a proper band of frequencies which is least susceptible to interference and attenuation in line circuit transmission in accordance with the requirements of practice.

It will be readily understood that a controller at a central office, in the case of the air traffic control system, must necessarily have suitable indications of the presence of aircraft within the respective blocks of his controlled airway in order to intelligently dispatch the aircraft at congested areas. Although the means for the communication of such indications to the controller is not herein disclosed, it is to be understood that such indications can be readily communicated by the

radio link communication system provided by the present invention, by line wire, or voice radio, in accordance with the requirements of practice. Similarly, it is to be assumed that indications are communicated to the control office in the centralized traffic control system herein described as to the locations of the respective trains and the conditions of the switch and signal control apparatus in the field in a suitable manner such, for example, as is described above.

Having thus described specific embodiments of the present invention relative to a step by step communication organization, it is desired to be understood that these forms have been selected primarily for the purpose of facilitating the disclosure of the invention rather than for the purpose of defining the number of forms which the invention may assume, and it is to be further understood that various adaptations, alterations and modifications may be applied to the specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention except as limited by the appending claims.

What I claim is:

1. In a communication system, decoding apparatus for the reception of a pulse at a selected one of any plurality of distinctive frequencies during each of a plurality of successive steps comprising, a filter for each of said frequencies having its input energized by the respective pulses received, a group of decoding relays for each step, one relay for each frequency to be received on that step, and circuit means for energizing each of said decoding relays in response to the output of its associated frequency filter during the step for which that relay is provided, said circuit means being effective for intermediate steps only provided that one of said group of decoding relays for the preceding step is picked up and only provided that each of said group of decoding relays for the following steps is dropped away.

2. In a communication system, decoding apparatus for the reception of a pulse at a selected one of any plurality of distinctive frequencies during each of a plurality of successive steps and for receiving a clear-out pulse at a given frequency characterizing the end of each cycle of stepping operation comprising, a filter for each of said frequencies having its input energized by the respective pulses received, a group of decoding relays for each step, one for each frequency to be received on that step, circuit means for energizing each of said decoding relays in response to the output of its associated frequency filter during the step for which that relay is provided, a clear-out relay energized in response to the output of said filter for said given frequency, irrespective of the picked up or dropped away condition of said decoding relays, and stick circuit means effective to maintain each of said decoding relays energized subsequent to its being picked up, said stick circuit means being rendered ineffective in response to the energization of said clear-out relay.

3. In a communication system of the character described, decoding apparatus for the reception of any selected one of a plurality of respective distinctive modulation frequencies selectively applied to a carrier wave during each of a plurality of successive steps comprising, a filter for each of said frequencies having its input energized in response to the modulations received, a group of decoding relays for each step,

one relay for each frequency to be received on that step, circuit means for energizing each of said decoding relays in response to the output of its associated frequency filter during that step, said circuit means being effective on each intermediate step only provided that one of said group of decoding relays is picked up for the next preceding step and only provided all of said group of decoding relays are dropped away for the following step, and stick circuit means for maintaining each of said decoding relay energized until the reception of a distinctive frequency characterizing the end of a stepping cycle.

4. In a communication system, decoding apparatus for the reception of a pulse at any selected one of a plurality of distinctive frequencies during each of a plurality of successive steps constituting a cycle of operation, a filter for each of said frequencies having its input energized by the respective pulses received, a group of decoding relays for each step, one for each frequency to be received on that step, and circuit means for energizing each of said decoding relays in response to the output of its associated frequency filter during the step for which that relay is provided, said circuit means being effective only provided that all other decoding relays of that group are dropped away.

5. In a communication system, decoding apparatus for the reception of pulses during respective successive steps and for the reception of a distinctive clear-out pulse at the end of each of several stepping cycles, decoding relays for the respective steps energized in response to the pulse received during that step, a clear-out relay energized in response to said clear-out pulse at the end of each cycle, irrespective of the condition of energization of said decoding relays, a cycle checking relay, circuit means for energizing said cycle checking relay at the end of each cycle only provided that one of said decoding relays has been energized for each step during that cycle, and electro-responsive means maintained normally active during the reception of successive cycles in accordance with the joint energization of said clear-out and said checking relays at the end of each cycle, said electro-responsive means being rendered inactive upon failure of either said clear-out or said checking relays to be energized at the end of a cycle of operation.

6. In a communication system of the character described, decoding apparatus for the reception of a pulse at a selected one of a plurality of distinctive frequencies during each of a plurality of successive steps and during a clear-out period for each of several successive cycles, said decoding apparatus comprising a filter for each of said frequencies having its input energized by the respective pulses received, a group of decoding relays for each step, one for each frequency to be received on that step, circuit means for energizing each of said decoding relays in response to the output of its associated frequency filter during the step for which that relay is provided, electro-responsive means maintained normally active during the reception of successive cycles of pulses only provided a pulse characterizing said clear-out period is received at the end of each cycle, and only provided that one of said decoding relays is energized during each step of that cycle, and devices governed by the respective decoding relays, said devices being conditioned in response to said decoding

relays only provided said electro-responsive means is active.

7. In a normally active communication system, the combination with decoding relays energized on successive steps of each of several successive cycles in response to pulses characterizing such steps, of electro-responsive means maintained normally active during the reception of successive cycles only provided one of said decoding relays is energized during each step of each cycle, an application relay for each step, circuit means for energizing said application relay in response to the energization of a predetermined decoder relay for that step, and stick circuit means for maintaining each of said application relays energized until a different decoder relay is energized for that step, and only so long as said electro-responsive means is maintained active.

8. In a normally active communication system, the combination with decoding relays energized on successive steps of each of several successive cycles in response to pulses of selected characters received during such steps, of electro-responsive means maintained normally active during the reception of successive cycles only provided that one of said decoding relays is energized for each step of each cycle received, application relays for the respective steps, circuit means for energizing each of said application relays in response to the energization of a predetermined decoder relay for that step, said circuit means being rendered effective only provided that said electro-responsive means is active, thereby indicating that the preceding cycle has been completed.

9. A traffic control system for the continuous communication of respective designated controls for devices between two stations by the constant transmission of pulses at selected frequencies in correspondence with the respective designated controls during continuously successive cycles of operation comprising in combination, a generator at one of said stations for generating each of said frequencies, control devices at said one station for selecting a particular one of said frequencies to be transmitted for each designated control, stepping means at said one station governing the transmission of said pulses during each of said successive cycles, said stepping means permitting the transmission of but one frequency per pulse, and said stepping means permitting the transmission of similar frequency pulses during a single cycle of operation but not as consecutive pulses, and electro-responsive means at the other of said stations for each pulse of the cycle distinctively responsive to the respective frequencies that may be transmitted to characterize that pulse, said electro-responsive means for each pulse being rendered active only provided that the electro-responsive means for the next succeeding pulse is inactive and providing that the electro-responsive means for the next preceding pulse has been rendered active during that cycle.

10. A centralized traffic control system for the continuous communication of respective designated distinctive controls for signals from a control office to respective field stations with which such signals are associated by frequency pulses selected in accordance with designated signal controls and transmitted during respective cycles of a continuous series of cycles of operation comprising in combination, a generator at the control office for generating each of said frequencies, manually operable means at the control office for selecting respective distinctive signal control frequencies for transmission in accord-

ance with distinctive designated controls for each of said signals, said manually operable means being effective to select the same frequencies for the control of signals at different stations for transmission during a single cycle, and step-by-step means permitting the transmission of similar frequency pulses to each of the field stations during a single cycle of operation of said step-by-step means and on separate steps, but not as consecutive pulses.

11. A centralized traffic control system for the continuous communication of respective designated distinctive switch and signal controls from a control office to each of a plurality of field stations with which such switches and signals are associated comprising in combination, a generator at the control office for generating a distinctive frequency for each distinctive switch or signal control that can be manually designated, manually operable means at the control office for selecting a particular one of said frequencies for transmission during a cycle of operation to each of said field stations, said manually operable means being effective to select the same frequencies for the control of switches and signals at different stations during a single cycle, and step-by-step means governing the transmission of control pulses during each cycle to cause the pulses to be transmitted for the respective field stations in a predetermined order during a single cycle of operation, said step-by-step means permitting the transmission of pulses at the same frequencies during a single cycle to each of the field stations but not as consecutive pulses in the cycle, and electro-responsive means at each of the field stations for each pulse that can be transmitted during a cycle distinctively responsive to the respective frequencies that can be transmitted to characterize that pulse, said electro-responsive means for each pulse being rendered active only provided that the electro-responsive means for the next succeeding pulse is inactive and the electro-responsive means for the next preceding pulse has been rendered active during that cycle.

12. In a centralized traffic control system for the communication of respective switch and signal controls from a control office to respective field stations by applying selected modulation frequencies to a constantly transmitted carrier wave, a generator at the control office for generating each of said frequencies, stepping means operable step-by-step through a cycle of operation, manually operable means at the control office for each of said field stations for designating a selected one of a plurality of respective switch and signal controls for transmission to that field station, and circuit means governed by said manually operable means and said stepping means for rendering a selected one of said generators effective to modulate said carrier wave during one step in accordance with said designated signal control for communication to a given field station during that step and for rendering another of said generators effective to modulate said carrier wave during another step in accordance with said designated switch control for communication to said field station, whereby respective switch and signal controls for each field station are transmitted on two separate steps, said carrier wave being modulated only by a single frequency during any one step.

13. In a centralized traffic control system of the character described for the communication of respective manually designated switch and signal

controls from a control office to respective field stations, the combination with means for transmitting selected switch and signal controls for a plurality of field stations during each cycle from a control office by distinctive frequency pulses during successive steps of a control cycle, of decoding apparatus at the respective field stations comprising a plurality of decoding relays for each step, one of said relays being provided for each distinctive frequency to be received during that step, a filter for each of said frequencies having its input energized by the respective pulses received, circuit means for energizing each of said decoder relays in accordance with the output of said filter for its associated frequency, switch and signal control relays at the respective field stations, said relays being provided only for the respective steps of said cycle corresponding to those assigned at the control office to the control of such relays at that station, and means governing the energization of said switch and signal control relays in response to said decoding relays for associated steps, and means effecting the de-energization of said switch and signal control relays if at any time during the reception of continuous successive cycles there is an incomplete cycle.

14. In a link communication organization of the character described for the effectively constant control of a plurality of devices at one station in accordance with conditions of corresponding devices at another station, a frequency pulse transmitter at said another station normally active through successive cycles to transmit pulses at selected frequencies determined by the conditions of said corresponding devices, said transmitter being effective to transmit but one frequency pulse at a time during successive steps, each step being assigned to the control of one of said devices, decoding means at said one station comprising frequency responsive means conditioned in response to the respective pulses received during each cycle, and circuit means responsive to said frequency responsive means for maintaining said devices at said one station conditioned in accordance with said corresponding devices at said other station, such circuit means being effective only so long as said pulses are received in continuous successive complete cycles.

15. In a link communication organization of the character described for the effectively continuous control at one station of a plurality of devices in accordance with conditions of corresponding devices at another station, the combination with a frequency pulse transmitter at said another station normally active through successive cycles each cycle comprising a predetermined number of pulses to transmit pulses, at selected frequencies determined by the conditions of said corresponding devices at said another station, of decoding means at said one station comprising frequency responsive means conditioned in response to the respective pulses received during each cycle, and circuit means responsive to said frequency responsive means at said one station for maintaining said devices at said one station governed in accordance with said corresponding devices at said other station, said circuit means being continuously effective dependent upon the continuous reception of complete successive cycles of pulses.

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