June 4, 1946. R. W. BUMSTEAD 2,401,333

RADIO RELAY SYSTEM

Filed Jan. 18, 1944 2 Sheets-Sheet 1

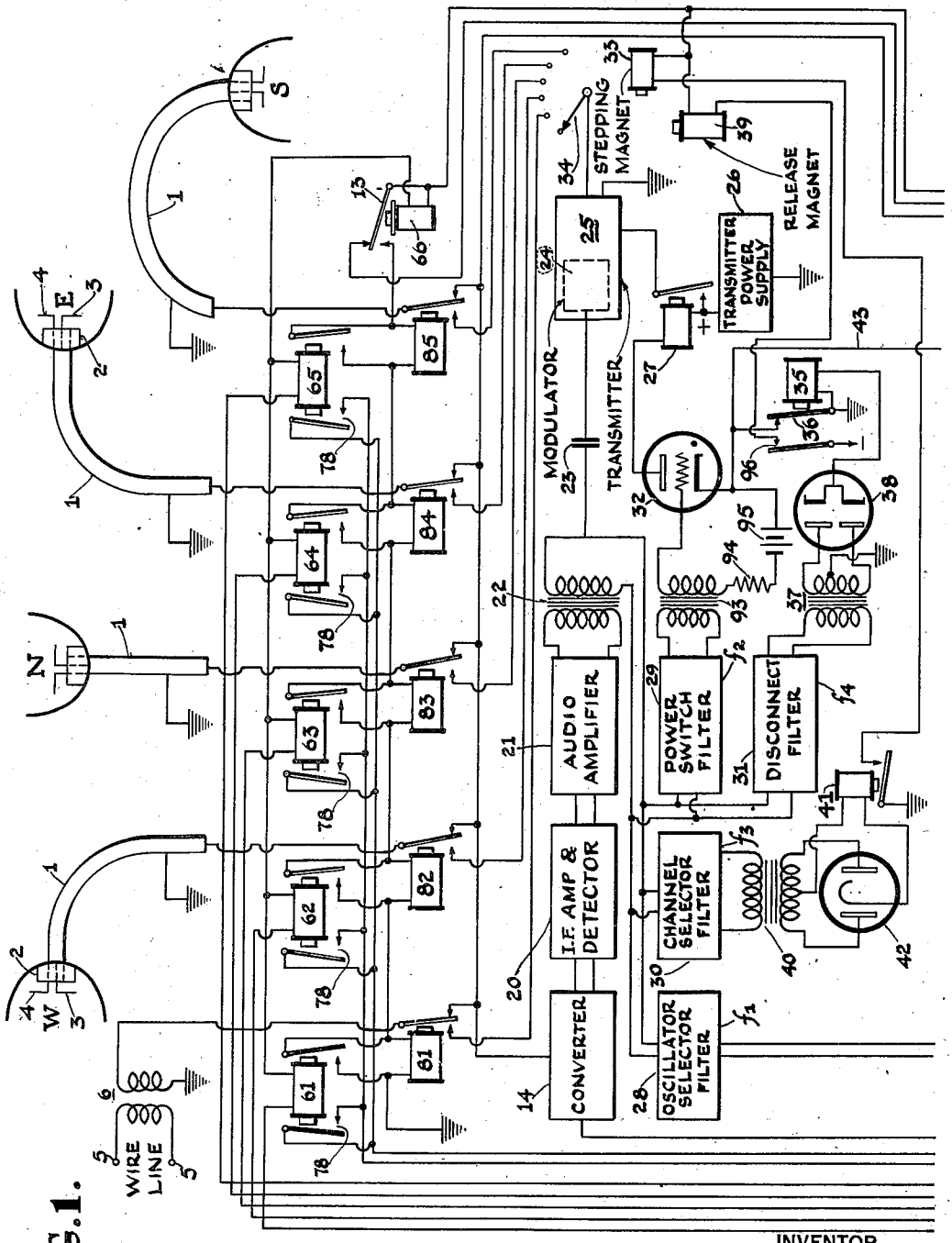


FIG. 1.

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RADIO RELAY SYSTEM

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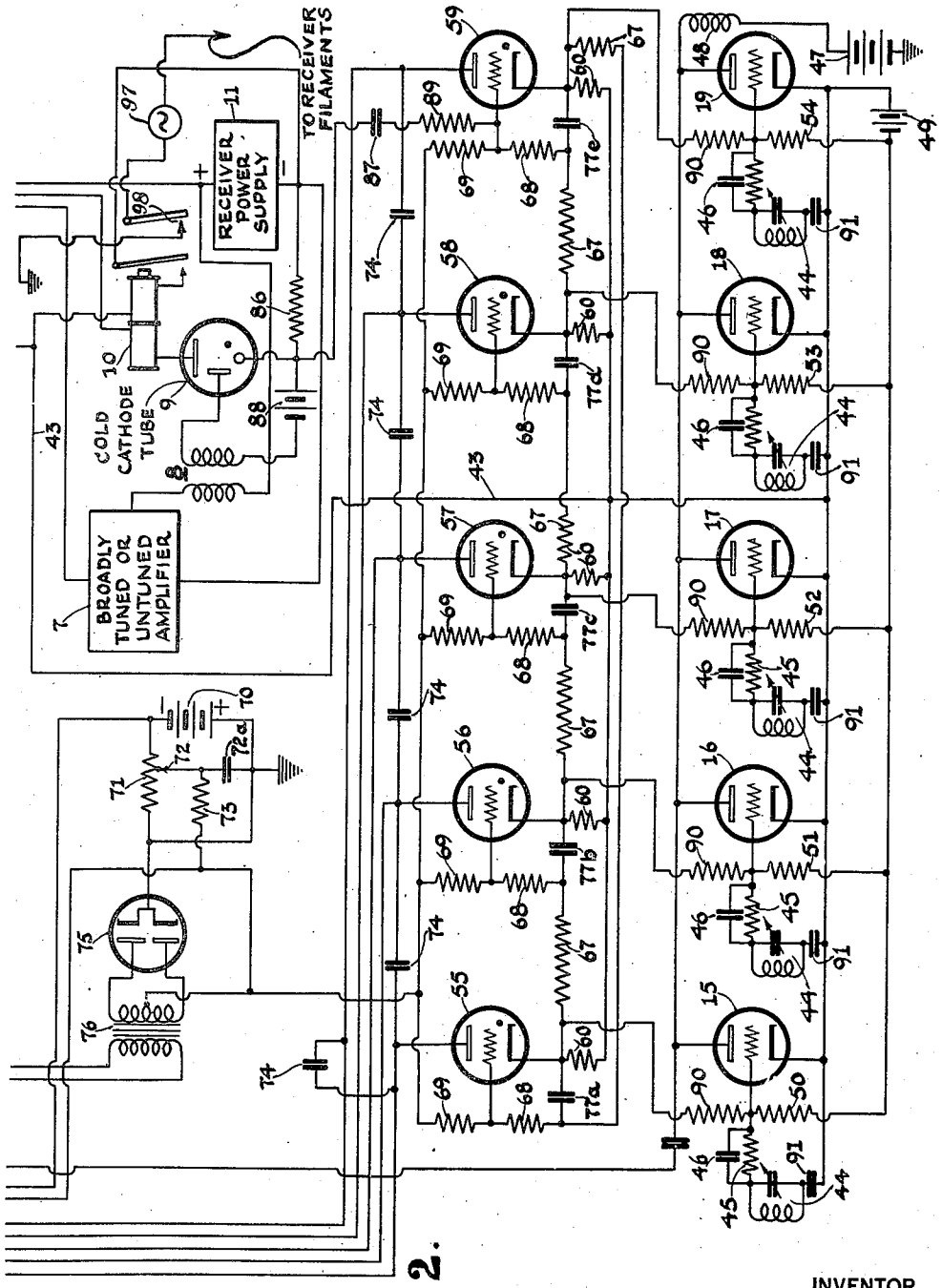


FIG. 2.

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UNITED STATES PATENT OFFICE

2,401,333

RADIO RELAY SYSTEM

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Application January 18, 1944, Serial No. 518,712

12 Claims. (Cl. 250—15)

1

This invention relates to radio relay systems and has particularly to do with unmanned radio relay stations which are remotely controlled. The system herein disclosed is particularly useful for transmitting intelligence over shortwave and ultra-shortwave radio channels. The intelligence to be transmitted from one station to another may be in the form of voice, telegraph, facsimile, or television signals. The modulations applied to a carrier wave may be varied in amplitude or in frequency, or the well-known interrupted carrier wave telegraph signalling system may be used either for code telegraphy or facsimile transmissions. The system may be used for point-to-point transmission of commercial traffic or for relaying between a point at which a broadcasting program originates and a point from which the program is to be broadcast.

Where ultra-high frequency carrier waves are to be used, it is preferable to employ directional antennae both for reception and for transmission. Various well-known types of antennae are available for use with my relay system. The invention itself, however, is more particularly concerned with apparatus and methods for remote control of a relay station which is used to interlink two radio channels.

Broadcasting networks for television and frequency modulation systems are particularly in need of improved equipment for the control of unmanned relay stations for the reason that the ultra-shortwaves used as carriers have a limited radius of effective transmission. Consequently, a nation-wide network must include a large number of relay stations which will interlink the main broadcasting stations so as to cover the widest possible areas of program reception. An unmanned relay station, therefore, is useful in extending the distances between manned stations of a radio network.

It is an object of my invention to provide apparatus in a relay station suitable for tying together channels of radio transmission which may extend in different directions and to provide switching means at such a station whereby incoming signals may be used to modulate a transmitter for sending out amplified signals in any desired direction.

It is another object of my invention to provide a relay station in which substantially all of the control operations for starting up the main receiving and transmitting apparatus, for rendering a particular antenna solely receptive to traffic signals, for rendering another antenna serviceable in directing outgoing signals, and for rendering the radio station unresponsive to undesired incoming signals while the relaying of a given program is in progress.

2

Other objects of my invention are to provide apparatus which will be economical of maintenance, particularly during standby periods, and which will be simple in construction.

Still another object of my invention is to provide radio relay apparatus including a single heterodyne receiver of high quality and a single transmitter in combination with a plurality of directional antennae any two of which may be remotely selected for reception and transmission respectively.

The foregoing and other objects of my invention will be made clear in the description to follow. Certain advantages will also be brought out. This description is accompanied by drawings, in which:

Figs. 1 and 2 show diagrammatically a preferred circuit arrangement. It will be understood that Fig. 1 should be placed above Fig. 2 in order to completely trace the circuits which extend from one figure to the other.

In the drawings, I show illustratively four directional antennae, which are labelled N, E, S, and W respectively, to indicate that they are suitably oriented for reception from different points to the north, east, south, and west. These directional indications are merely illustrative, and in practice, it will be understood that the antennae are accurately aimed toward the stations with which communication is to be established regardless of their compass directions. While I have illustrated a conventional type of antenna having a dipole in the focal region of a parabolic reflector, it will be understood that other types of directional antennae may be used if desired. I have also indicated as a preference the use of coaxial transmission lines 1 which are terminated at the antenna end by a quarterwave resonance element 2, the outer conductor being grounded near the radio apparatus end. One of the dipole arms 3 is connected to the inner conductor and the other dipole arm 4 is connected to the tubular conductor of the transmission line. This construction, however, is not part of the instant invention, but is in accordance with the teachings of Patent No. 2,238,904, granted April 22, 1941, to Nils E. Lindenblad.

For the purpose of receiving incoming signals or transmitting signals outgoing over a wire line, the terminals 5 of such a wire line are indicated. The wire line signals traverse the windings of a transformer 6.

Method of starting

In order that power may be conserved during non-operating periods, I preferably provide a separate monitoring receiver which includes a broadly tuned or untuned amplifier 7, the tube or tubes of which consume no current during standby periods except for filament heating. The unit 7 is arranged to amplify incoming signals (regardless of their source) for control of a relay tube 9. This tube is preferably of the cold cathode gaseous type, such as an RCA tube OA4–G which consumes no power except when ionized. Tube 9 has in its anode circuit the left hand winding of a relay 10 and the back contact which engages with armature 13 of a slow-acting relay 66. Anode potential is supplied to tube 9 from the positive terminal of the receiver power supply 11. The negative terminal of this power supply is connected through a resistor 86 to the cold cathode of tube 9. The input circuit for this tube includes the secondary winding of transformer 8, and a threshold biasing battery 88. When an incoming carrier wave is amplified by the unit 7 the output energy therefrom, if sufficient to overcome the threshold bias of source 88 produces a triggering action whereby tube 9 becomes ignited, and remains conductive until its anode circuit is broken by operation of relay 66.

The slow-acting relay 66 has a retardation period which is sufficient to delay the energization of relays in the group 81 to 85 inclusive until one of the relays 61 to 65 has been selected for operation. When the armature 13 is pulled up, the left hand winding of relay 10 becomes deenergized, but the right hand winding of this relay has already functioned as a locking winding to maintain closure of contacts 12. This locking winding carries substantially the full load current of the receiving apparatus and associated relays, and is preferably of very low resistance. It is in series with contacts 12 of the relay and serves to ground the receiver power supply 11. The cold cathode of tube 9 is connected through resistor 86 to the negative terminal of source 11. When tube 9 becomes ionized the potential drop through resistor 86 impresses a surge impulse across capacitor 87 for the purpose of selecting a gaseous tube 59 as the first of a series of such tubes in the group 55—59 to be successively ionized. These gaseous tubes are used to select appropriate tubes of the group 15—19 to be actuated as oscillation generators, as will presently be explained.

The ground connection for the negative terminal of the receiver power supply 11 may be traced through contacts 12, the right hand winding of relay 10, conductor 43 and the normally closed contacts 36 of relay 35. The positive terminal of the power supply 11 is connected through contacts 13 when closed by the energization of relay 66, and feeds current to all relays and tubes of the receiving apparatus which are to be actuated.

The filament heating circuit for the receiver tubes may be connected to any suitable source 97 and is preferably closed by a second pair of contacts 98 on relay 10.

General arrangement of the receiver and transmitter

The usual components of a heterodyne receiver are indicated as comprising a converter stage 14 which is supplied with local oscillations from one or another of several oscillators 15, 16, 17, 18, and 19. The receiver also includes an intermediate frequency amplifier 20 and an audio amplifier 21. The usual detector is indicated to be comprised in the unit 20.

For the purpose of relaying incoming traffic signals, the output from the audio amplifier 21 is fed across a transformer 22 and also across a capacitor 23 to the modulator 24 in a transmitter unit 25. Transmitter unit 25 has associated therewith an independent power supply unit 26. Although only one positive terminal connection is shown as being relay-controlled, it will be understood that the relay 27 may possess a plurality of contact pairs sufficient to simultaneously close the necessary circuits for supplying all of the usual potentials to the various tubes in the transmitter unit 25.

Arrangements for remote control

The use of tone frequency modulations for remote control of the various functions to be performed is illustratively indicated by the provision of a number of frequency-selective filters 28, 29, 30, and 31 all of which have input circuits connected to receive control energy from the secondary winding of audio output transformer 22. Filter unit 28 passes a tone frequency represented as f_1 and is used for selecting one of a plurality of oscillators 15–19 inclusive which will provide a suitable local oscillator frequency for heterodyning with the incoming carrier wave. The method of selection will presently be described. The power switch filter 29 passes a tone modulation f_2 and controls relay apparatus including a gaseous discharge tube 32, the space path of which is in circuit with the winding of relay 27. The tone frequency f_2 when filtered through unit 29 is impressed on the input circuit of tube 32 and ignites this tube. The input circuit includes the secondary winding of transformer 93, the grid resistor 94, and a threshold bias battery 95 the potential of which must be overbalanced by a desirably strong signal in order to start the discharge in tube 32. Hence the arrival of tone frequency f_2 ionizes tube 32 and closes the winding circuit of relay 27. This relay now remains energized until the transmitter 25 is to be shut down. During operation, however, relay 27 connects the transmitter power supply 26 to the transmitter 25.

The channel selector filter 30 passes a tone frequency f_3 which may be transmitted as a series of control impulses for the purpose of actuating a stepping magnet 33 in a rotary switch of well-known type. The wiper 34 of this switch may, therefore, be advanced any number of steps for connecting the transmitter output circuit to different ones of the antennae or to the wire line having the terminals 5.

The channel selector signals as filtered by unit 30 are impressed across a transformer 40, the secondary winding of which has a centertap connected to one terminal of a relay 41. The other terminal of this relay winding is connected to the common cathode of a full-wave rectifier tube 42. Relay 41 is, therefore, actuated by the rectified tone modulation signals of frequency f_3. The armature of relay 41 is grounded and when this relay is energized, it impresses a ground potential on one terminal of magnet winding 33, the other terminal of which is connected to the positive lead from supply source 11.

A disconnect filter 31 responds to a tone frequency f_4 and is provided for the purpose of actuating a relay 35, the contacts of which are arranged to perform two functions. The pulling

up of the armature 36 opens the common return circuit for substantially all of the receiver apparatus and self-locking relays (whether magnetic or electronic) which are fed from the receiver power supply unit 11. All relays are, therefore, returned to normal and tube filaments are allowed to cool. The winding of relay 35, however, is energized only momentarily from rectified tone frequency potentials which are developed in the secondary of transformer 37 and are rectified by the twin diode tube 38. The closing of contacts 96 completes a circuit through the winding of a release magnet 39 which is used to restore to normal the wiper 34 of the channel selector switch. The power for energizing magnets 33 and 39 is shown in the drawing to be derived from source 11, but it could optionally be taken from source 26, in which case relay 35 would need only one movable contact 36 in cooperation with a back contact as shown and a front contact connected to the winding of release magnet 39.

The heterodyne oscillators

It is optional what type of heterodyne oscillator shall be used. I have, however, shown a conventional type which is quite suitable for ultra-high frequency systems. Each of the triode tubes 15, 16, 17, 18, and 19 is an oscillator having its cathode grounded through the common return conductor 43 and through the armature 36 which is controlled by relay 35. The resonant input circuit 44 for tube 15 comprises an inductance and a capacitance adjusted to provide a local oscillator frequency which will heterodyne suitably with an incoming carrier wave fed into the relay station over the wire line. The resonant circuit 44 is coupled to the control grid in tube 15 through the usual grid leak resistor 45 and shunt capacitor 46. Each of the tubes 16—19 has its resonant circuit 44 tuned to a frequency which will suitably heterodyne with an incoming carrier wave collected by a respective one of the antennae W, N, E, and S.

Anode potential is supplied to each of the anodes in the tubes 15 to 19 inclusive as indicated by the source 47, the positive terminal of which is connected to the anodes of these tubes through an inductive choke 48. Anode potential may, of course, be supplied from the receiver power supply unit 11, but the separate source 47 is indicated merely in order to simplify the circuit diagram.

A negative biasing source for the grids in tubes 15–19 inclusive is indicated at 49. This negative bias is used to maintain the oscillator tubes normally inactive. The biasing circuits include grid resistors 50, 51, 52, 53, and 54.

Oscillator selecting means

The selection of an individual oscillator in the group 15—19 for heterodyning its generated oscillations with the incoming carrier wave is predicated upon producing such heterodyning in the converter stage 14, whereby the intermediate frequency amplifier 20 will accept the difference frequency and convey to the audio amplifier 21 the tone modulation f_1 which will be passed by filter 28. If, therefore, the oscillator tubes 15—19 are caused to be excited in rapid succession and in cyclic rotation, this operation will serve to seek a step in the cycle at which the control signal of frequency f_1 will be rectified in tube 75, and will be made effective to arrest the progress of a rotary switching means comprising tubes 55—59. I will now explain the operation of the gaseous discharge tubes 55—59 which constitute a rotary electronic switch.

These tubes are embodied in a circuit arrangement similar to that which is disclosed in Patent No. 2,136,621, granted November 15, 1938, to A. P. King et al. The King patent relates to a diversity receiving system and shows a plurality of geographically spaced antennae which are rendered singly operable by means of a rotary electronic switch. A fading condition at one antenna causes it to lose control of the receiver. The rotative action of the electronic switch is automatically started. Switching stops when an antenna is found which delivers a stronger signal. In the instant case, however, the gaseous tubes 55—59 are used to remove a blocking bias from each of the oscillator tubes 15—19 in succession so as to cause different frequencies to be generated.

Each of the gaseous tubes 55–59 inclusive is provided with an anode circuit which includes the winding of one of the relays 61, 62, 63, 64, and 65 respectively. These relays do not operate during the rapid switching function of the gaseous tubes. Anode potential is derived from the receiver power supply unit 11 and is fed through the winding of the slow-acting relay 66.

The battery 70 has its positive terminal connected to ground and supplies a potential across adjustable potentiometer 71. The grounded end of this potentiometer is connected to a common cathode in the twin diode rectifier 75. The potentiometer tap 72 is coupled to ground across a capacitor 72*a* and is connected through a resistor 73 to each of several resistors 69 which are individual to the grid circuits of the gaseous tubes 55—59. These resistors 69 are also connected to the center tap on the secondary winding of transformer 76.

A cathode resistor 60 is interposed between each cathode of the tubes 55—59 and the normally grounded conductor 43 to which, under operative conditions, the negative terminal of the receiver power supply 11 is connected by closure of contacts 12 but through the low resistance right hand winding of relay 10.

Resistors 67 and 68 interconnect the cathode of one tube, say tube 55, with the grid in an adjacent tube 56. Each of these resistive connections enables a tube to the right in the series to be controlled by the ignition state which occurs in the left hand tube of each pair. Similarly, resistive connections are made between the cathode of tube 59 and the grid in tube 55 so as to complete the cycle of interaction between these tubes. Capacitors 77*a*, 77*b*, 77*c*, 77*d*, and 77*e* serve to store a charge and to provide a time constant for the interaction between successive tubes 55—59.

In the foregoing chapter captioned "Method of starting" I have shown how the receiver power supply 11 is to be applied in response to an incoming control signal of frequency f_1 regardless of the incoming carrier frequency which is used and regardless of the particular antenna which collects the incoming signal. The potential which is developed across cathode resistor 86 produces a surge impulse through capacitor 87 and a potential drop through resistors 89, 68, 67, and 60 such as to cause the gaseous tube 59 to ignite. This starts the rapid cyclic succession of ignitions in the series of tubes 55—59. The rise of potential on the cathode of tube 59 produces a potential drop through the adjoining resistor 67 and through capacitor 77*a* which removes the blocking bias from the grid in tube 55, this blocking bias having been supplied by source 70. Tube 55, therefore, ignites. The consequent lowering of

positive potential on the anode of tube 55 produces a surge impulse through that capacitor 74 which intercouples the anodes in tubes 55 and 59. This surge impulse is of such voltage as to extinguish tube 59. The ignition state in tube 55 now removes a blocking bias from the grid in tube 56 and this tube becomes ignited. The same action takes place with successive tube ignitions, each tube extinguishing the previously ignited tube and igniting the next succeeding tube. A point is reached, however, where the rotative switching operation is arrested. This point is determined by the rectification of the control tone frequency signal f_1 in tube 75. The negative potential derived from the center tap in the secondary of transformer 76 is added to the blocking bias from source 70, and counteracts the positive bias derived from the potential drop in one of the cathode resistors 60 when the corresponding tube is ignited. Therefore, the ignition of this tube fails to ignite the next tube. The continuation of the ionization state in one of the tubes 55—59 now causes a corresponding continuation of the oscillatory condition in the appropriate one of the oscillator tubes 15—19. This will be seen from the fact that each of the grids in the oscillator tubes 15—19 is resistively connected to a respective one of the cathodes in tubes 55—59. These resistive connections include the resistors 90. Thus tube 15 oscillates while tube 55 is ignited. Oscillator tube 16 is rendered operative by the ignition state in tube 56. Tubes 56 and 16 operate in response to a signal received on the W antenna which is oriented to receive from a station to the west of the relay station. Accordingly, it will be seen that the arrest of the cyclic action in the rotary switching means of tubes 55—59 provides continued excitation of the selected oscillator tube in the group 15—19.

The locking-out relay system

One of the relays of the group 61—65 attracts its armature as soon as a steady flow of current is established through a selected one of the tubes 55—59. During the rapid sequence of operations of the several gaseous discharge tubes, the successive intervals of ignition of the individual tubes was such that not one of the relays 61—65 would have time to respond. The left hand contacts 78 are used to apply a still more negative bias direct from the negative terminal of battery 70 to the grid biasing circuits for the gaseous tubes 55–59 inclusive. This action prevents the resumption of the sequential switching operation of the gaseous tubes until the communication is to be ended, at which time a disconnect tone frequency signal is to be transmitted.

Relays 81, 82, 83, 84, and 85 are individual to each of the channels. Their operation is obtained by closure of the slow-acting relay 66 in response to the continuous discharge current flowing through any one of the gaseous tubes 55–59 inclusive. The retardation constant in tube 66 is made such that relays 81–85 inclusive will not be energized until after the stable operating condition of a gaseous tube and its associated oscillator tube is established.

The right hand contacts of relay 61 may be closed to short-circuit the winding of lock-out relay 81. Similar short-circuiting contacts on each of the relays 62, 63, 64, and 65 are connected respectively across the windings of lock-out relays 82, 83, 84, and 85. This arrangement is adopted in order to energize all but one of the relays 81–85 inclusive, depending upon which incoming signal channel has been used to control the relay station. In other words, assuming that a signal comes in from the south and is received on the S antenna, relay 65 will be energized, since this signal produces a response such as to continue the ignition state in tube 59 and to continue the generation of oscillations in tube 19. Relay 65 draws up its armature contacts, the right hand contacts of which are caused to short-circuit the winding of relay 85. Relays 81, 82, 83, and 84 will then be energized when relay 66 is operated, but relay 85 will not operate. Hence, reception is now continued from antenna S. Signals are fed through the back contact of relay 85 and thence to the converter stage 14. Note, however, that the energization of relays 81–84 inclusive renders it impossible for an incoming signal from any other source to break in on the communication which has been established through antenna S.

Transmitter power supply switch

It has previously been mentioned that the transmitter power supply 26 may be connected to the transmitter 25 by means of relay 27. Remote control of this relay is obtained by the transmission of a tone frequency f_2 acceptable to the power switch filter 29. Output from the filter 29 is fed across transformer 93, the secondary of which is in the input circuit of the gaseous discharge tube 32. This input circuit includes a resistor 94 and a grid biasing battery 95, providing a threshold bias so that tube 32 will be ignited only in the presence of a tone frequency signal of suitable amplitude. The anode circuit of tube 32 includes the power supply source 26 and the winding of relay 27. When tube 32 ignites, it acts as a switch to close the circuit for relay 27 and this circuit will be maintained until the ground connection from the cathode of tube 32 is opened by operation of the disconnect relay 35.

Outgoing channel selection

In order to select the out-bound channel by remote control, I preferably provide a rotary step-by-step operated switch conventionally indicated as comprising a wiper 34 which contacts with a series of switch contacts individually connected to the front contacts of relays 81–85 inclusive. The wiper 34 is stepped along an arcuate bank of contacts by means of the stepping magnet 33. The rotary switch has a homing position at which the wiper 34 is shown. A single impulse directed through the winding of stepping magnet 33 moves this wiper to the first selecting contact so as to connect the output circuit of the transmitter 25 to the transformer 6 at the terminals of the wire line. Active step #2 on the rotary switch makes connection of the transmitter to the westerly-aimed antenna W. Active step #3 connects the transmitter to the northerly-directed antenna N. Step #4 correspondingly directs the outgoing signals into antenna E. Step #5 directs the signals into the southerly-directed antenna S. No connection can be made between the transmitter and the incoming channel, due to the short-circuiting of the appropriate relay in the group 81—85.

Assuming that the receiver has responded to control signals of tone frequencies f_1 and f_2, as heretofore explained, so as to establish a steady flow of current through a selected one of the gaseous discharge tubes 55—59, then the corresponding local oscillator of the group 15—19 will

continue to serve the receiver. Channel selection for outgoing signals may then be made upon reception of a predetermined number of impulses of tone frequency f_3 as passed by the channel selector filter **30**.

Relay **41** operates in response to each stepping-pulse of the control frequency f_3, as previously explained. The contacts of relay **41** when closed cause the stepping magnet **33** to be energized. Wiper **34** on the rotary switch is, therefore, stepped to a selected position according to the number of control pulses of frequency f_3 which are transmitted from the control station. Each position of the rotary switch provides an outlet for transmitter **25** over a different channel, including either the wire line or an antenna which is not engaged for reception.

Assuming now that it is desired to relay the signals which come in from the south outgoing in a westerly direction, relay **65** will be operated, but relay **85** will not be operated. Relays **81—84** will operate, thereby giving the rotary channel selector switch an opportunity to feed the outgoing signals into any one of the antennae except antenna S, depending upon the position which is assumed by the rotary switch. Antenna W is connected by relay **82** to the second active segment of the rotary switch. Therefore, two impulses of frequency f_3 are necessary to establish this connection.

In a similar manner switching operations may be performed in order to direct the outgoing signals into any one of the antennae or into the wire line.

Disconnection of the circuits

After completing the transmission of a message or broadcast program normal conditions at each relay station must be restored. The control station then sends a tone signal of frequency f_4 which is accepted by filter **31**. This signal is rectified by the diode rectifier **38**, energy being translated thereto across transformer **37**. The centertap is grounded. One terminal of relay winding **35** is also grounded. The other terminal of this relay is connected to the common cathode of the twin diode **38**. Relay **35** is energized by rectified output of frequency f_4 from filter **31**. Operation of relay **35** pulls up its armature **36** thereby to remove ground potential from conductor **43**. This breaks the ground connection for the negative terminal of the receiver power supply unit **11** and causes all of the operating tubes to become inactive.

Residual magnetism in the relay **35** holds its contacts **96** closed for a sufficient length of time to actuate the release magnet **39** and hence to restore the stepping switch wiper **34** to its homing position. The entire system is, therefore, restored to normal so as to be in readiness for the establishment of any other relaying operations.

It will be apparent that after connections have been set up for the relaying of messages through a number of unmanned relay stations, the disconnect signals must be transmitted in such order that the station most remote from the manned transmitting station will be the first to respond to a disconnect signal and successive disconnect signals will be transmitted, each having a tone-frequency selectively acceptable to the disconnect filters **31** of stations closer and closer to the manned transmitting station. Such disconnect frequencies may, therefore, be designated f_{12}, f_8, f_4 and will be sent out in that order from the west terminal to disconnect relay stations C, B, and A which are intermediate between the west and east terminals. Furthermore, if a call were to be initiated by the east terminal and sent through stations C, B, and A to the west terminal, then the disconnect tone signals would be sent in the order f_4, f_8, f_{12}.

Recapitulation

Among the principal advantages of the relay system herein disclosed are the following:

1. The directive antennas are useful either for reception or for transmission.

2. Once a connection has been established by incoming signals fed to one of the antennae or through the wire line no interruption of the connection so established can result from stray signals fed through any of the remaining channels.

3. The establishment of connections is not upset in case the carrier wave of the incoming signal fades or is momentarily interrupted. This is true for the reason that maintenance of the connections is dependent upon continued ionization of the selected gaseous tube in the group **55—59** and the consequent continued energization of one of the relays of the group **61—65**.

4. The converter stage, the intermediate frequency amplifier stage, and the audio amplifier stage of the receiver are not necessarily duplicated despite the availability of the receiving apparatus for reception of incoming signals on different assigned carrier waves. Only the local oscillators are multiplied in order to provide a suitable choice of frequencies for heterodyning with the assigned carrier frequencies of different channels.

5. The transmitter has its assigned carrier frequency and is available for sending out signals on any one of the directive antennae or on a wire line, if desired.

6. From the moment when a control station wishes to utilize a given relay station until the termination of traffic signalling, no interference from extraneous sources is capable of disturbing the circuit connections which are established at the relay station.

7. A chain of relay stations may be interlinked from point to point by utilizing different control tone frequencies, four of which would be assigned to each relay station. Each relay station in the chain then has a different assignment of four such tone frequencies. Thus, if it is desired to relay from a west terminal through relay station A and through relay station B to an east terminal, the west terminal will first condition station A by the use of tone frequencies f_1, f_2, and f_3. Relay station B is then conditioned by receipt of tone signals of frequencies f_5, f_6, and f_7 which are sent out by the west terminal and relayed through station A. Through traffic from the west terminal to the east terminal is then possible and may be continued until the disconnect signals f_8 and f_4 are sent—and in that order.

If, on the other hand, communication is to be established from the west terminal through stations A and B, and thence to the wire line terminating at station B, the set-up of connections would then be suitable for utilization of the incoming traffic signals by any device to which the wire line would be connected. The wire line, for example, may lead to an omni-directional antenna of a broadcasting station. If the wire line is to serve for incoming signals, then the remote end would naturally be connected to suitable transmitting equipment. Furthermore, if desired,

facilities may well be established for two-way communication by using two wire lines and a pair of antennas for each direction in which signals are to be beamed.

My invention is capable of modification in numerous ways without departing from the spirit thereof as will be well understood by those skilled in the art.

I claim:

1. In a radio relay station, a receiver comprisprising a converter stage, an intermediate frequency amplifier, a detector stage connected to the output terminals of said amplifier, and local oscillator means for producing a frequency to be heterodyned in said converter stage with an incoming radio wave, thereby to produce an intermediate frequency acceptable to said amplifier; means for producing a cycle of stepwise variations in the frequency of output from said oscillator means; means responsive to a predetermined tone modulation of said incoming radio wave for interrupting the cycle of said frequency variations and for causing the oscillator means to continue generating a single selected frequency; a transmitter; and means operable during the continuance of single frequency generation by said oscillator means for causing said transmitter to be modulated by signals conveyed through said amplifier and said detector stage.

2. A system in accordance with claim 1 and including an electronic distributor in said means for producing said cycle of frequency variations, the function of said distributor being to rapidly switch different components of said oscillator means into successive operation.

3. A system in accordance with claim 1 and including a plurality of directional antennae all normally connected to said converter stage, means for causing all but one of said antennae to be disconnected from said converter stage when the selected frequency of said oscillator means is obtained, and means responsive to a selecting signal for connecting one of said antennae to said transmitter.

4. The method of establishing operative conditions for the reception and relaying of intelligence at a remotely controlled radio relay station, said method comprising generating a cyclic succession of different local oscillator frequencies, causing an incoming wave to be heterodyned with each of said frequencies until a predetermined intermediate frequency response is obtained, amplifying and detecting said response, using the products of detection to terminate said cyclic succession and to cause the continued generation of a single local oscillator frequency, producing selective responses at said station to incoming signals which are differently characterized for each control function, one of said responses being effective to select a single one out of a plurality of available directions in which outgoing signals are to be beamed, and causing an outgoing wave to be modulated by a derivative of reception.

5. The method of establishing operative conditions for reception and relaying of intelligence at a remotely controlled radio relay station, which comprises cyclically heterodyning an incoming carrier wave with different frequencies which are locally generated in rapid succession until a predetermined intermediate frequency amplifier response is obtained, fixing the locally generated frequency in response to the detection of a tone signal borne by said incoming carrier wave, and producing selective responses to different tone signals for performing the steps of (*a*) isolating the receiving section of said relay station from the effects of other incoming signals, (*b*) energizing the transmitting section of said relay station, and (*c*) beaming the output of said transmitting section in a desired direction.

6. In a remotely controlled relay station, a plurality of differently oriented directional antennae, a local oscillator individual to each antenna, a heterodyne receiving circuit having a mixer stage arranged to be fed with signal energy collected by any one of said antennae and with oscillations generated by a selected one of said local oscillators, switching means operable to apply an operating bias to the input circuit of each said oscillator in rapid succession, means responsive to an incoming control signal for arresting the operation of said switching means when the carrier wave of said signal is heterodyned with oscillations generated by the oscillator appropriate to the antennae which collects said signal, means for sustaining the oscillations of that oscillator during reception of traffic signals, means for locking out reception through others of said antennae, a transmitter subject to modulation by said traffic signals, means operable after the arrest of said switching means for causing the output from said receiving circuit to be delivered to said transmitter for modulating the same, and means selectively operable by a remote control signal for assigning the output from said transmitter to a predetermined one of said antennae.

7. A system in accordance with claim 6, and including in said switching means a gaseous discharge tube circuit arrangement appropriate to each said oscillator and circuit components for producing sequential ignition of said tubes, and for causing each tube, when it ignites, to extinguish the tube previously ignited, said gaseous tube circuit arrangement being arranged and adapted to control the operation of said switching means until a predetermined oscillator is selected, and to cause that oscillator alone to be conditioned for continued operation subsequent to the arrest of the switching means.

8. In a relaying system, a plurality of communication channels radiating in different directions from a relay station, radio receiving and transmitting apparatus at said relay station arranged to re-transmit incoming signals, a plurality of directional antennae individually oriented to collect or emit energy over respective ones of said channels, means responsive to a first remote control signal for appropriating the antenna which collects said signal for further reception, means responsive to a second remote control signal for empowering said transmitting apparatus, means responsive to a third remote control signal for connecting a selected antenna to the output terminals of said transmitter, and means responsive to a fourth remote control signal for terminating said connections and for shutting down said relay station.

9. In a relaying system according to claim 8, a power supply for feeding operating potentials to said radio receiving apparatus and to the several said responsive means, a monitoring receiver, and means including a relay under control of said monitoring receiver for completing the main feeder circuit of said power supply.

10. In a radio network comprising a plurality of control stations, a plurality of controlled relay stations, and at least one station for the ultimate reception of intelligence, a monitoring receiver at each relay station, means rendering said receiver responsive to control signals originated at

any one of said control stations, a heterodyne receiver, a transmitter having its modulator coupled to the output side of said heterodyne receiver, signal responsive means operable initially through said monitoring receiver and thereafter through said heterodyne receiver for conditioning the latter to accept incoming signals from one channel exclusively, other signal responsive means operable through said heterodyne receiver for selecting an outgoing channel on which to relay intelligence exclusively, and means enabling one relay station to repeat control signals which are so characterized as to be effective in conditioning another station exclusively.

11. In a system for controlling a radio relay station by signals initiated at any one of a plurality of remote points, means at said station responsive to a modulated carrier wave for performing a control function, an electronic distributor switch arranged and adapted to selectively operate said control function performing means a plurality of signal collecting means selectively connectable by said electronic distributor switch to said responsive means in accordance with the source of the control signals, means for locking out the reception of signals other than by the signal collecting means first selected, means controlled by a train of impulses for selecting one of said signal collecting means as a means for directionally beaming outgoing signals, and means

responsive to a "disconnect"-signal for restoring said station to a condition in which it becomes responsive to incoming signals from any one of said remote points.

12. The method of establishing radio communication through a plurality of channels which are interlinked by relay stations, said method comprising sending out control signals from a point of origin of the intelligence to be communicated, producing a succession of different testing responses in each of the relay stations to be interlinked, said responses being of a character such that said point of origin is identified by the nature of its signals and the step of identification causes the testing responses to cease, causing certain of said control signals to be effective in conditioning each relay station in succession for exclusive reception of said intelligence, causing certain others of said control signals to be effective at each relay station in succession for determining the orientation of directional signal energy radiation therefrom, and causing control signals of distinctive characterization to initiate other functional operations at each of said relay stations whereby the selected interlinkage of said channels is maintained throughout the period of transmission of said intelligence and said channels are uncoupled at the termination of said period.

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