

Oct. 24, 1939.

H. P. BOSWAU

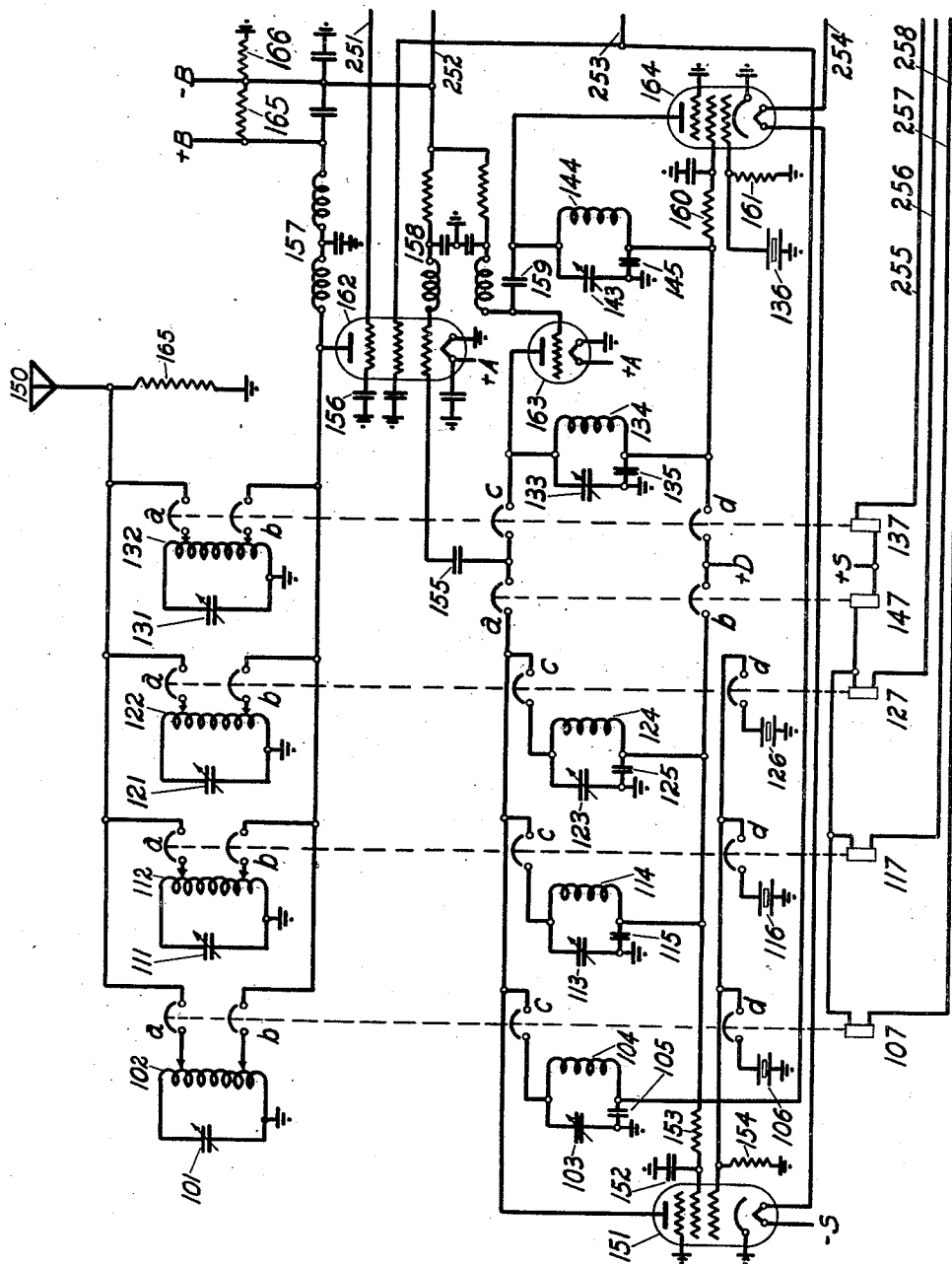
2,176,868

RADIO COMMUNICATION SYSTEM

Filed March 15, 1937

5 Sheets-Sheet 1

FIG. 1



INVENTOR:

HANS P. BOSWAU

Soulman & Soulman

by

ATTY.

Oct. 24, 1939.

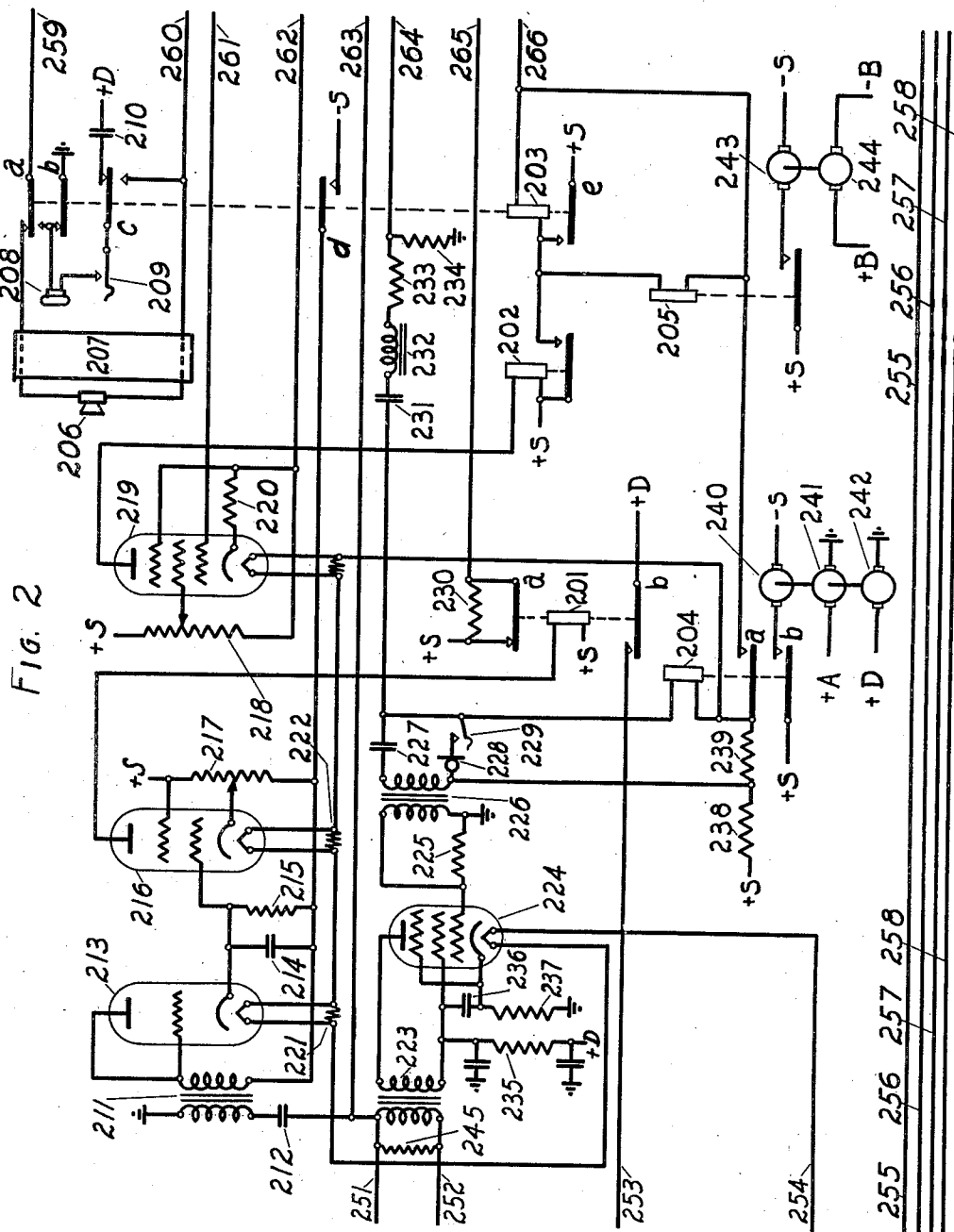
H. P. BOSWAU

2,176,868

RADIO COMMUNICATION SYSTEM

Filed March 15, 1937

5 Sheets-Sheet 2



INVENTOR:
HANS P. BOSWAU
by *Toulmin & Toulmin* ATT'Y.

Oct. 24, 1939.

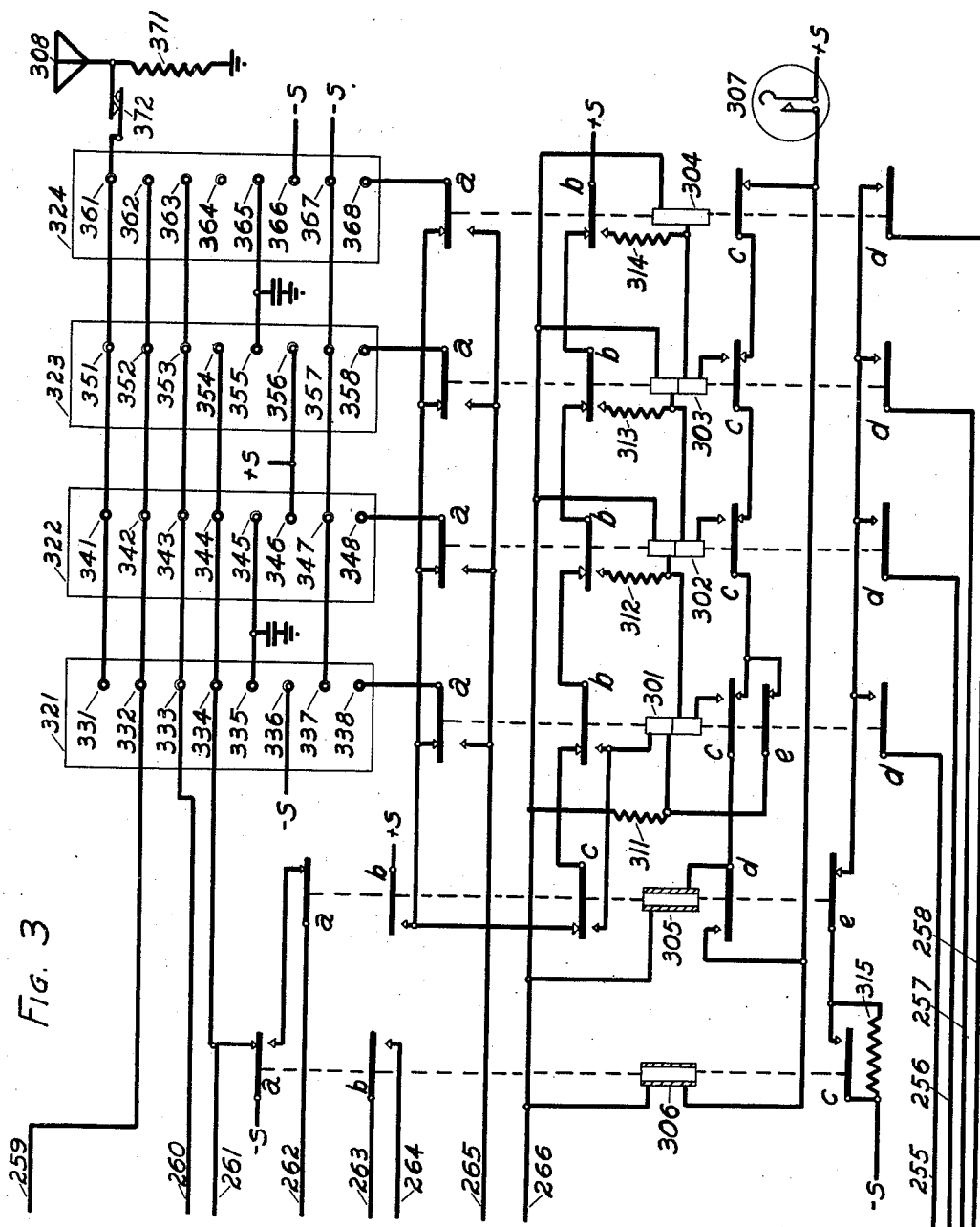
H. P. BOSWAU

2,176,868

RADIO COMMUNICATION SYSTEM

Filed March 15, 1937

5 Sheets-Sheet 3



INVENTOR:

HANS P. BOSWAU

Toulmin & Toulmin

by

ATT'Y.

Oct. 24, 1939.

H. P. BOSWAU

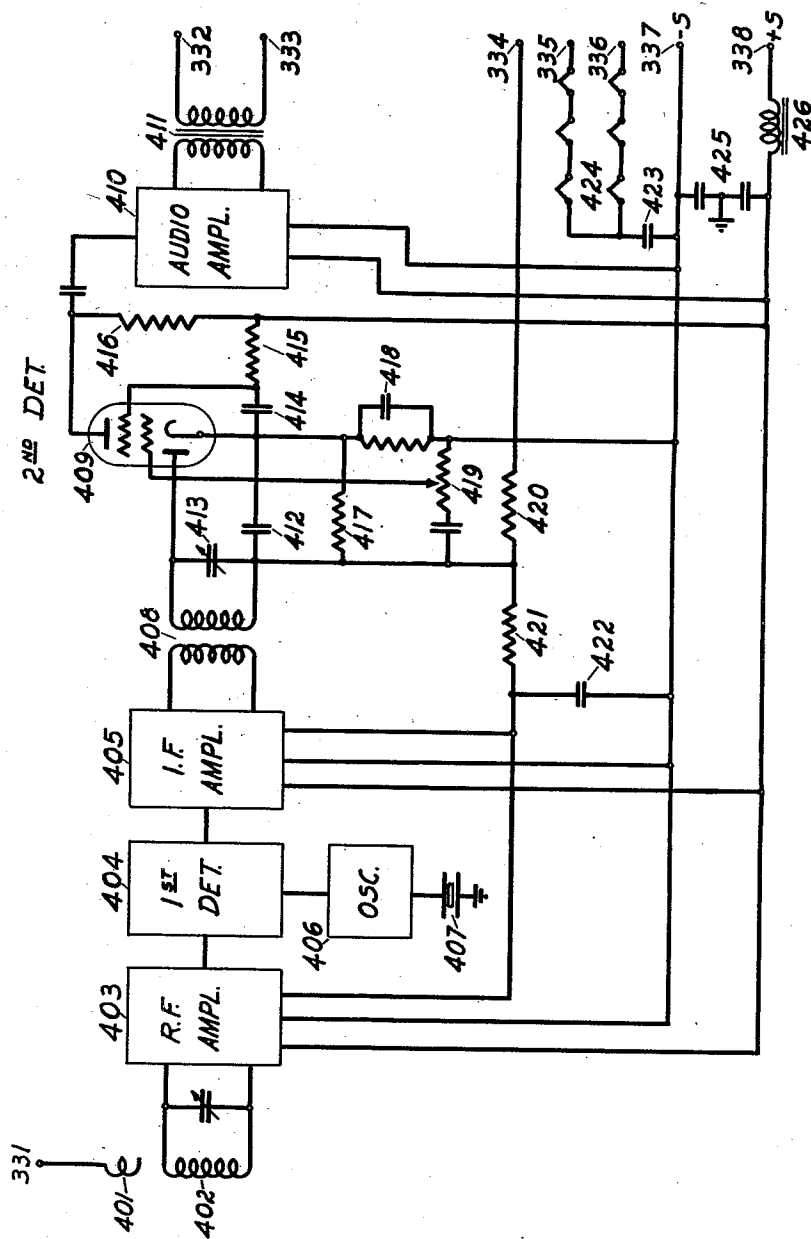
2,176,868

RADIO COMMUNICATION SYSTEM

Filed March 15, 1937

5 Sheets-Sheet 4

Fig. 4



INVENTOR:

HANS P. BOSWAU

Toulmin & Toulmin

by

ATT'Y.

Oct. 24, 1939.

H. P. BOSWAU

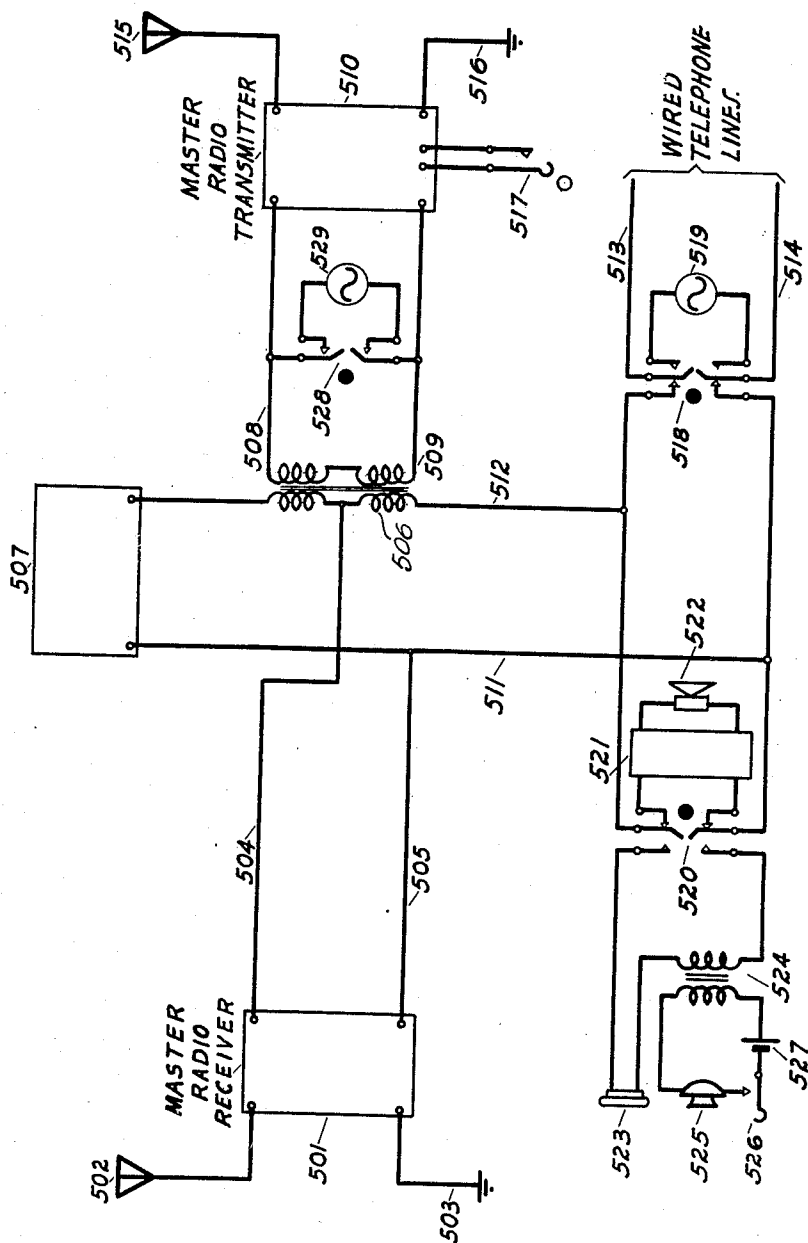
2,176,868

RADIO COMMUNICATION SYSTEM

Filed March 15, 1937

5 Sheets-Sheet 5

Fig. 5



INVENTOR:
HANS P. BOSWAU

Toulmin & Toulmin

by

ATTY

UNITED STATES PATENT OFFICE

2,176,868

RADIO COMMUNICATION SYSTEM

Hans P. Boswan, Lorain, Ohio, assignor to The
Lorain Telephone Company, Lorain, Ohio, a
corporation of Ohio

Application March 15, 1937, Serial No. 130,943

24 Claims. (Cl. 250-6)

This invention relates to radio communication systems, and in particular to such systems arranged for intercommunication between a master station and a plurality of subsidiary stations.

5 The invention is particularly adapted for intercommunication between a shore station and a plurality of ship stations.

One object of this invention is to provide a radio transmitting and receiving system employing a master station and a plurality of subsidiary stations utilizing a plurality of frequencies for transmitting and receiving, wherein a common means controls all the required functions at a given station, such as selection of the transmitting and receiving frequency, the starting of the various motor generators and the making of busy tests to ascertain whether the frequency is already in use, this common means, for example, being a dial device.

10 Another object is to provide a radio communication system employing a master station and a plurality of subsidiary stations, with a plurality of frequencies for intercommunication between the master station and the subsidiary stations, and an additional frequency for intercommunication between the subsidiary stations themselves, without the necessity of relaying the messages through the master station.

15 Another object is to provide a radio communication system of the above type for direct adaptation to marine use, between ship and shore stations, wherein a plurality of frequencies is provided for ship-to-shore use, and another frequency for ship-to-ship use so that the operator may utilize the frequency which is best adapted to the particular distance over which he is required to communicate with the shore station.

20 Another object is to provide a dial-operated multi-frequency radio telephone station having devices and circuits responsive thereto for selecting one of a plurality of transmitting frequencies, and an associated receiving frequency, by means of the same selecting devices.

25 Another object is to provide a circuit including dial-responsive means, preferably by the same dial, for causing a plurality of motor generators to start in succession at predetermined time intervals, these motor generators being required for supplying the various electrical voltages to the radio transmitter, such as the filament and plate voltages for the various vacuum tubes.

30 Another object is to provide a circuit including dial-responsive means, preferably by the same dial, for effecting a busy test involving a predetermined period of time, for the purpose of de-

termining whether or not the particular frequency desired to be used is already in use by another radio station of the system.

35 Another object is to provide a circuit including dial-responsive means, preferably by the same dial, for transmitting coded tone signals as well as for controlling the selecting devices, in the manner set forth above.

Another object is to provide a circuit including dial-responsive means, preferably by the same dial, for producing an audio tone suitable for coded tone signals, by closing a feed-back circuit on the modulator equipment of the radio transmitter.

40 Another object is to provide a circuit including dial-responsive means for placing the oscillator stage of the transmitter under the control of voice-operated devices on certain of the transmitting frequencies, but not on others.

Another object is to provide a circuit including selective means controlled by the dial to cut in additional amplifier stages on certain of the frequencies for the purpose of permitting the use of an oscillator crystal having a frequency lower than that of the transmitting frequency, as well as for selecting a transmitting frequency.

45 Another object is to provide means common to all frequencies for making the busy test circuit effective only on the selected receiving frequency, adapted to cut out other receiving frequencies controlled by other contacts on the same dial or selecting means.

Another object is to provide a busy test circuit employing a busy tone produced by the electrical commutator ripple of the motor generators already required for supplying the necessary voltages to the radio transmitter, thereby obviating the need for a separate generator for producing this busy tone signal.

50 Another object is to provide a circuit including means for utilizing the heater and filament circuits of the various vacuum tubes of the transmitter and control circuits for supplying various voltages for the operation of the microphone and selecting devices, this utilizing means being adapted also to maintain the heaters in a pre-heating condition during stand-by periods, as well as to raise these heaters to a full temperature for operation of the communication system.

55 Another object is to provide means for disabling the busy test circuits so as to enable the communication system to be employed in emergencies, regardless of the fact that the desired frequency may be already in use by another subsidiary station, such as by another ship.

In the drawings:

Figure 1 is a circuit diagram showing the radio transmitter including the selecting and control devices, according to the present invention.

5 Figure 2 is a circuit diagram of the radio telephone circuit and its associated elements, together with the control devices and motor generators according to this invention.

10 Figure 3 is a circuit diagram forming a continuation of Figure 2, and illustrating the radio receivers of different frequencies, together with the selecting relays and dial switch constituting the selecting means.

15 Figure 4 is a circuit diagram of one of the radio receivers of the plurality shown in Figure 3, illustrating in detail the electrical elements employed in the busy test circuit.

Figure 5 is a diagram of a transmitting and receiving circuit at the master station.

20 General arrangement

In general, the radio communication system of this invention consists of a master station, such as a shore station, and a plurality of subsidiary stations, such as ship stations, wherein a plurality of frequencies is provided for intercommunication between the master and subsidiary stations. An additional frequency is provided for intercommunication between individual subsidiary stations, such as between different ships, without the necessity of relaying the messages through the master or shore station. Each of the subsidiary stations is provided with a dial-responsive system for automatically bringing into play the various elements employed in intercommunication so that very little technical ability is necessitated upon the part of the operator. In this manner also the operation of the system closely simulates the operation of a land telephone system.

40 The operator, by dialing a given number, may select a given frequency for communication with the shore station, this frequency being chosen according to the distance between the ship and the shore. It is important to provide this plurality of frequencies in order to enable radio communication to be established between a shore station and ship stations over widely varying distances, at any time during the day or night. When the ship is relatively near the shore station a comparatively low frequency must be employed, yet this low frequency will not transmit messages over a very great distance during the daytime. As the distance between the ship and shore stations increases, the operator is required to employ higher frequencies for intercommunication. These higher frequencies cannot be employed over short ranges because high frequency radio waves pass over nearby points within a certain radius from the transmitting station, depending upon the frequency being employed. The waves reach the earth again at a great distance from the transmitting station, in accordance with the well known theory of deviation at the Heaviside layer in the stratosphere.

65 Hitherto, where a single frequency has been provided for intercommunication between master and subsidiary stations, it has not been possible to communicate efficiently over widely varying distances for the reasons given above. As a result of experiments, in accordance with this invention, it has been found that three frequencies are desirable for reliable intercommunication between ship and shore stations over distances ranging between one and six hundred miles. Accordingly, the present invention has been illustrated

in connection with the use of three frequencies for ship-to-shore communication, the fourth frequency being provided for ship-to-ship communication. It will be understood, however, that a greater or smaller number of frequencies may be employed in this multi-frequency arrangement.

Hitherto, also, voice-responsive means have been provided to render the transmitter operative only when the operator is speaking into the radio telephone instrument. Where the frequencies used for transmitting and receiving are different, however, it has been found desirable, according to the present invention, to maintain the oscillator stage of the radio transmitter in operation during transmitting pauses and to use the voice-responsive devices solely for controlling the final stage of the radio transmitter. Where, however, the same frequency is used, both for transmitting and receiving, as is most conveniently the case in ship-to-ship communication, it is obviously not possible to maintain the oscillator stage in operation during transmitting pauses because it would then interfere with reception of messages arriving on the same frequency from another station. According to the present invention, therefore, the same devices employed for selecting a given transmitting frequency are also utilized for placing the oscillator stage of the transmitter under the control of the voice-responsive devices on certain of the transmitting frequencies, but not on others.

Electrical circuits and elements in general

As the operation of the various circuits involved in the present invention is intimately tied up with the circuit arrangements, it will be sufficient to discuss the electrical elements in general and then to go into detail thereon during the discussion of the operation. In this manner duplication is avoided by describing the details of each circuit in connection with the operation thereof.

The numerals employed for the different elements are chosen so as to refer to the diagram upon which the particular element will be found. Thus, the numerals 100 to 199 will be found on the diagram of Figure 1; 200 to 299 will be found upon Figure 2; 300 to 399 on Figure 3 and 400 to 499 on Figure 4. It will be understood, of course, that not all of these numerals are employed in a given figure, and also that certain numerals applied to connecting lines will be found occasionally upon two figures.

The radio transmitter shown in Figure 1 consists broadly of an antenna 150, grounded through a resistance 165 for draining off static charges. Connected to this antenna are four tuning circuits, consisting of variable condensers 101, 111, 121 and 131, coupled with inductances 102, 112, 122 and 132. These various tuning circuits are connected to the antenna 150 and to the vacuum tube 162 by means of the make contacts 107a, 107b, 117a, 117b, 127a, 127b, 137a and 137b. These make contacts are operated by the windings of the frequency-selecting relays 107, 117, 127 and 137 through the mechanical connections indicated by the dashed lines.

75 An additional relay 147 with make contacts 147a, and 147b is provided in series with the relays 107, 117 or 127 for a purpose described below. Also provided for the radio transmitter circuit shown in Figure 1 are quartz crystals 106, 116, 126 and 136, oscillator tubes 151 and 164 and a doubler tube 163. Oscillator and doubler tuning circuits are provided in the lower part of Figure 1 and designated 103, 104, 105; 113, 114, 115; 123, 124, 125; 133, 134, 135.

114, 115; 123, 124, 125; 133, 134, 135; and 143, 144, 145. Each of these circuits contains a variable condenser, such as 103, a fixed condenser, such as 105, and an inductance such as 104. Also provided are grid bias resistors 154 and 161 and screen bias resistors 153, and 160 for the oscillator tubes, as well as the necessary radio frequency chokes and by-pass condensers associated therewith as at 152, 156, 157, 158, etc. Other details of the transmitter circuit will become apparent in the description of the operation thereof.

The voice-responsive circuit for controlling the various operations of the transmitter of Figure 1 and receivers of Figure 3, together with the busy tone test circuit of Figure 4, is shown in Figure 2. This circuit, in general, contains a plurality of relays 201, 202, 203, 204 and 205, operating contacts *a*, *b*, *c*, *d* and *e* through the mechanical connections indicated by the dashed lines. Certain of the relays have fewer than five contacts, as will be obvious from Figure 2. Relay 201 is a voice-controlled relay which operates whenever the operator talks into a microphone 228. In a manner subsequently set forth, this voice-controlled relay 201 makes the radio receiver inoperative and renders the radio transmitter operative when the station operator talks into the microphone 228.

Associated with the microphone 228 is a hook switch having a contact 229. A hook switch 209 is also provided for a telephone receiver 208 and operated by the removal thereof from the hook. A loud speaker 206 is provided for announcing the incoming signals from other stations, and a low pass filter 207 removes all frequencies required for intelligible speech, but passes a band of frequencies sufficient to provide a signalling tone in the loud speaker 206. The lifting of the receiver 208 from the hook switch actuates the hook switch contacts 209 and 229 to throw into the circuit the various elements necessary for the starting of operations. In particular, the actuation of this hook switch by the removal of the receiver 208 therefrom energizes and starts the motor 240 and generators 241 and 242 supplying the filaments and plates, respectively, of the various vacuum tubes. The motor 243 drives a generator 244 and is controlled by the energization of the relay 205. The generator 244 supplies plate voltage to the radio transmitter over the lines +B and -B. The circuit of Figure 2 also contains the vacuum tubes 213, 216, 219 and 224 with associated transformers 211, 223 and 226. The resistors 238 and 239 are provided to maintain the heaters of the vacuum tubes at a low temperature during stand-by operation, these resistors being shunted from the circuit automatically when communication is established in the manner set forth in connection with the operation. The other elements of Figure 2 will be disclosed in more detail in connection with the operation of this circuit.

The receiving circuit of Figure 3 includes a plurality of counting relays 301, 302, 303 and 304 for selecting one of the four transmitting and receiving frequencies or channels, according to the will of the operator, as expressed by his operating the dial switch 307 by dialing a predetermined number of impulses. Also associated with the counting relays 301 to 304, inclusive, are the slow releasing relays 305 and 306. These relays 305 and 306 are made slow releasing by having copper sleeves surrounding their cores so that the relays will remain in an operated condition during the pauses between impulses of the

dial switch 307. Each of these relays is provided with a plurality of make or break contacts, designated *a*, *b*, *c*, *d* and *e*, a mechanical connection being indicated by the dashed lines. As will be evident from Figure 3, certain of these relays have more contacts than others. Associated with these relays are resistors 311 to 315, inclusive. The usual antenna 308 is provided in connection with a resistance 371 for the discharge of static charges.

Shown at the top of Figure 3 are several receiving sets 321, 322, 323 and 324. These receiving sets are preferably tuned to different frequencies, sets 321 to 323 being employed for ship-to-shore use and set 324 for ship-to-ship use. The various terminals of these receiving sets are indicated for each set by the numerals 331 to 338, inclusive, 341 to 348, inclusive, 351 to 358, inclusive, and 361 to 368, inclusive. An antenna switch 372 is provided for disabling the busy tone test circuit, in a manner subsequently to be described, so that the ship station may in times of emergency be thrown into communication with the shore station, regardless of whether or not the particular frequency is already being used by another ship station. Normally, however, this switch is closed to permit the operation of the busy test signal circuit so that an operator is warned of the use of the circuit being tested.

An individual receiving set, such as is shown in Figure 4, is illustrative of any one of the receiving sets 321, 322, 323 or 324. The receiving set shown in Figure 4 is connected in the diagram of Figure 3 at the terminals 331 to 338, inclusive, but might also be connected between the terminals 341 to 348, inclusive, 351 to 358, inclusive, or 361 to 368, inclusive.

The receiver 321, chosen for the purpose of example, contains a coupling coil 401, a tuning circuit 402 and a radio frequency amplifier 403. Connected thereto is a superheterodyne receiving circuit containing a first detector 404, an intermediate frequency amplifier 405, an oscillator 406, a control crystal 407, a transformer 408 and a second detector 409. Connected to this circuit is an audio amplifier 410 and a transformer 411. The details of the other elements in the circuit of Figure 4 will be discussed individually in connection with the operation of this circuit.

Operation

The various circuits are placed in operation when the operator removes the telephone receiver 208 from its hook, and thereby actuates the hook switch contacts 209 and 229. For this purpose the circuit of Figure 3 is so connected that the heating elements 424 of the receiver vacuum tubes are connected to the terminals 335 and 336 in receiver 321 and to corresponding terminals in the other receivers. The heater circuits of 321 and 322, as well as 323 and 324, are connected in series to power lines designated -S and +S, representing the main power supply lines of the ship's generator. The power line -S supplies negative plate voltage to the four receivers 321, 322, 323 and 324 by way of the terminals 337, 347, 357 and 367. The power line +S conducts positive plate voltage to the receiver terminals 338, 348, 358 and 368 by way of the break contacts 304b, 303b, 302b, 301b, 305c and 301a, 302a, 303a, 304a, respectively.

The audio output terminals 332 and 333, 342 and 343, 352 and 353 and 362 and 363 are connected in parallel over conductors 259 and 260 (Figure 2) by way of break contact 203a and low

pass filter 207 to the loud speaker 206. As previously stated, the purpose of the low pass filter 207 is to remove all frequencies giving intelligible speech, but to pass a band of frequencies sufficient for signalling tones in the loud speaker 206. The line -S also energizes a tube heating circuit (Figure 1) extending, by way of the heaters of vacuum tubes 151 and 164, through conductor 254 (Figure 2) and the heaters of vacuum tubes 224, 213, 216, and 219, thence through the resistances 239 and 238 to the +S line. The resistances 221 and 222 are optionally connected in parallel with the heaters of certain of the vacuum tubes so as to provide the proper heater voltage when used in series with other tubes requiring a larger heater current. The resistances 238 and 239 cause the heater current supplied to be somewhat less than the full amount required for proper operation so as to preheat the heaters during stand-by periods, thereby enabling them to be brought more quickly to full temperature when the set is brought into operation for communication.

With the radio communication system in this condition, tone signals of suitable audio frequencies may be received by all four of the radio receivers 321, 322, 323 and 324 over the antenna 302, thereby operating the loud speaker 206 for calling the operator. When the shore station wishes to communicate with a particular ship, the shore operator sends out a distinctive coded tone signal on one of the ship frequencies, this signal being announced in the ship station by the loud speaker 206. Following the ship's calling signal, the shore station transmits a simple signal consisting of a series of impulses of one, two or three short tones so as to indicate on which frequency the ship's operator should answer the call.

When the ship's operator hears his calling signal coming in over the loud speaker 206, he lifts his telephone receiver 208 from its hook switch and dials the frequency indicated by the frequency signal by means of the dial switch 307 (Figure 3), which operates in a manner analogous to land telephone dial switches. For example, if the frequency signal received over the loud speaker 206 from the shore station is a single short tone, he dials the numeral one upon the dial switch 307. If two short tones are received he dials the numeral two, or if three short tones are received he dials the numeral three. After dialing the proper numeral upon the dial switch 307, the operator then dials the numeral 0 for the purpose of making a busy test to ascertain whether or not the particular frequency channel is already in use by another ship. The operation of this busy test circuit will be subsequently described.

Meanwhile, the lifting of the telephone receiver 208 from its hook switch automatically closes the hook switch contacts 209 and 229. The closing of the hook switch contact 229 closes the circuit for the microphone 228 in series with the relay 204 and across the resistance 239. The closing of this circuit thereby supplies current to the microphone 228, operates the relay 204 and causes an increase in the heater current of vacuum tubes 151, 164, 224, 213, 216 and 219. The energization of the relay 204 throws the power current supply devices into operation by connecting the generator motor 240 across the main power lines +S and -S of the ship's generator by way of the make contacts 204b. Thus, the energized motor 240 starts to drive the genera-

tors 241 and 242 coupled thereto. As previously stated, the generator 241 produces filament voltage for supplying the various vacuum tubes, this being supplied over the line +A to the filaments of the vacuum tubes 152 and 163 so as to prepare these tubes for operation.

On the other hand, the generator 242 produces plate voltage for the oscillator and modulator circuits of the transmitter (Figure 1) and for other purposes subsequently to be described. The generator 242 is also connected over the line +D to the fixed condenser 210, the break contact 203c and the switch contact 209 to the telephone receiver 208, returning over the break contact 203b and the ground to the generator 242. The fixed condenser 210 prevents the flow of direct current in this circuit, yet passes the commutator ripples of generator 242 there-through. These commutator ripples, therefore, pass into the telephone receiver 208 and produce an audible tone in this receiver utilized for a busy tone test signal. The closing of the make contact 204a of the relay 204 prepares the circuits for the operation of the selecting relays.

When the ship's operator dials the dial switch 307 to select a particular circuit, the selecting relays will be operated in accordance with the particular numeral dialed. For purposes of illustration, let it be assumed that the shore station has indicated by four short tones, following the ship's call signal, that the fourth frequency channel is to be used for communication. Accordingly, the ship's operator dials the numeral four upon the dial switch 307, this being so arranged that it closes its normally open contact the number of times indicated by the dialed numeral. Accordingly, the dial switch 307 closes its contact four times when the operator dials the numeral four.

In the following discussion, for purposes of brevity, it is found most convenient to trace the various energization circuits of the relays 301 to 306, inclusive, merely as far as the line 266 running horizontally across the middle of Figure 3. Beyond Figure 3 this line runs to Figure 2, through the make contact 204a, the heaters of the vacuum tubes 219, 216, 213 and 224, and thence by the line 254 (Figure 1) through the heaters of the vacuum tubes 164 and 151 to the -S line of the ship's generator system used for energizing the motors 240 and 242. As the relay 204 is energized and its contacts closed by the action of the operator in lifting his telephone receiver 208 from its hook switch, the circuit from the line 266 (Figure 3), through Figures 1 and 2, to the line -S will therefore be closed and energized when the circuit is closed through the dial switch 307 and the various relays 301 to 306, inclusive. The energization of each relay circuit, therefore, will be terminated at the line 266.

When the contact of the dial switch 307 closes for the first time, assuming it to be dialed for four impulses corresponding to the dialing of the numeral four, the slow release relay 306 is energized from the line +S, seen in the lower right-hand corner of Figure 3, through the dial switch 307, the winding of the relay 306 and the line 266, the energization of which has just been described. The slow releasing relay 306 operates in parallel with the resistances 239 and 238 (Figure 2) which, it will be recalled, are utilized for maintaining the vacuum tube heaters at a low temperature for stand-by purposes. Similarly, relays 301, 302, 303, 304, 305, 203 and 205 also

operate in parallel with resistances 239 and 238. This arrangement provides a lower voltage than the ship's generator voltage for operating these relays, yet enables the heater elements of these vacuum tubes to receive full current for full operation when the selection of the various circuits is completed, in the manner described below. When the relay circuits are described as connected to the line 266, which is energized in the manner previously set forth, it will therefore be understood that these relay circuits are connected in parallel with the resistances 239 and 238 over the make contact 204a of the relay 204, which is energized by the raising of the receiver 208 from its hook.

The first closure of the dial contact 307, besides energizing the slow releasing relay 306, also energizes the slow releasing relay 305 from the +S line, through the dial switch 307 (Figure 3), the break contacts 304c, 303c, 302c, 301c, the winding of the relay 305 and the line 266. The energization of the slow releasing relay 305 prepares the energization circuit for the counting relay 301 from the +S line, seen immediately above the dial switch 307 in Figure 3, by way of the break contacts 304b, 303b, 302b and 301b, the make contact 305c, the upper winding of the counting relay 301, the resistance 311 and the line 266, which is energized from the -S line, in the manner previously described.

As long as the switch contacts of the dial switch 307 are closed, however, the upper winding of the relay 301 is shortcircuited across the dial switch contacts by way of the relay break contacts 304c, 303c, 302c and 301c. When the contacts of the dial switch 307 open, after the first impulse thereof, this shortcircuit is opened and the counting relay 301 consequently becomes energized. The energization of the counting relay 301 closes a locking circuit for itself from the +S line, by way of the relay break contacts 304b, 303b and 302b, the make contact 301b, the upper winding 301, the resistance 311, the line 266, and thence to the -S line, as previously described. The opening of the contacts of the dial switch 307 also interrupts the energization circuits of the slow releasing relays 305 and 306, but their delay action causes them to remain in an operating condition during the pauses between dial impulses.

When the contacts of the dial switch 307 close for the second time, the energization circuit for the slow releasing relay 306 is again completed, in the manner previously described. The circuit for the slow releasing relay 305 is now completed from the +S line, through the dial switch 307, the make contact 305d and the relay winding 305, the original energization circuit thereof having been opened by the opening of the break contact 301c, through the energization of the counting relay 301. At the same time, the counting relay 302 is energized by the closing of a circuit from the +S line, the dial switch 307, the make contacts 305d and 301c, the lower winding of the counting relay 301, the upper winding of the counting relay 302 in series therewith, and the line 266, the energization of which has been previously described.

When the relay 302 operates, it opens the previously described locking circuit for the winding of the counting relay 301 at break contact 302b. The latter, however, remains in an operated condition over its lower winding as long as the contacts of the dial switch 307 are closed. The counting relay 302 in closing, also closes a locking

circuit for itself from the +S line, through the break contacts 304b and 303b, the make contact 302b, the resistance 312, the upper winding of the counting relay 302 and the line 266, which has been energized in the previously described manner. As the dial switch 307 opens its contacts, for the second time, the circuit is thereby opened through the lower winding of the counting relay 301, thereby causing the latter to open while relays 305 and 306 remain closed, due to their slow release action.

When the contacts of the dial switch 307 close for the third time, a circuit is completed from the +S line by way of the dial switch 307, the make contact 305d, the break contact 301c, the make contact 302c, the lower winding of the counting relay 302 in series with the upper winding of the counting relay 303, and thence to the line 266, the energization of which has been previously described. The energization of the counting relay 303 in this manner opens the locking circuit of the relay 302 through its upper winding, and closes a locking circuit for itself by way of the make contact 303b and the resistance 313. While the dial switch contacts are closed the relay 302 is held closed by means of its lower winding. When the contacts of the dial switch 307 open, after the third impulse, the counting relay 302 opens.

When the contacts of the dial switch 307 close for the fourth time, the counting relay 304 is energized by the circuit including the +S line, the dial switch 307, the make contact 305d, the break contacts 301c and 302c, the make contact 303c and the lower winding of the relay 303 in series with the winding of the relay 304. The consequent energization of the relay 304 opens the previously described locking circuit of the counting relay 303 and closes a locking circuit for itself by way of the make contact 304b and the resistance 314. When the contacts of the dial switch 307 now open after the fourth impulse, the counting relay 303 is deenergized and opens. As no further dial impulses follow the slow releasing relay 306 opens, followed by the opening of the slow releasing relay 305 after a predetermined interval of time obtained by an adjustment of these relays.

Thus, it will be seen that when four impulses are dialed on the dial switch 307, the only relay remaining in operation after the dial has come to rest is the relay 304. If three impulses had been dialed upon the dial switch 307, the relay 303 would have been the last relay to operate and would have remained the last relay still in operation. In a similar manner, after dialing two impulses, the relay 302 alone would remain in operation, and after dialing one impulse the relay 301 alone would remain in operation. At this stage the energization circuit of the relay 305 is opened by way of the break contacts 301c, 302c, 303c or 304c of whatever relay remains operated. Accordingly, once the slow releasing relay 305 has released its contacts, thereby opening the make contact 305d, it cannot be operated again by the dial switch 307, nor will additional dial impulses have any effect upon the counting relays 301, 302, 303 or 304.

As a result of dialing the first numeral on the dial switch 307, one of the counting relays 301, 302, 303 or 304 is energized to select one of the four transmitting and receiving channels. If it be assumed that the counting relay 301 is so operated, the plate supply terminal 338 of the receiver 321 is connected to the +S line by way of

the make contact 301a, the line 265 and the break contact 201a. At the same time the plate supply circuit for the other three receivers 322, 323 and 324 is opened by the opening of the break contact 301b, thereby rendering these three receivers inoperative. While the dialing is in progress the relay 305 remains in operation by reason of its slow release characteristics, so that the plate supply circuit of all the receivers 321 to 324, inclusive, is closed by way of the make contact 305b. In this manner the interruption of the plate supply current to the desired receiver during the dialing is prevented, thereby preventing interruption of the automatic volume-control circuit of the selected receiver. The latter possesses a certain time lag characteristic, and is required for making a busy signal test immediately after the dialing of the first numeral.

After the dialing of the selected numeral, corresponding to the particular channel which the shore station has indicated in its signal arriving over the loud speaker 206, the operator now dials the numeral 0 in order to complete the procedure. This action energizes the relay 306 for the period of time required by the dial switch 307 for sending ten impulses over the +S line. As previously described, the relays 301 to 305, inclusive, will not be affected by this dialing operation. The energization of the slow releasing relay 306 short-circuits the resistance 315 in the circuit of one of the four frequency selecting relays 107, 117, 127 and 137 (Figure 1) of the transmitter, according to which of these relays has been previously selected by the operation of one of the counting relays 301 to 304.

If it be assumed that the numeral one has been dialed, the relay 137 is energized through the circuit including the make contact 301d and the line 255. As the transmitter frequency-selecting relays 107, 117, 127 and 137 require large armature travels, in order to reduce capacity effects, it is necessary to employ a relatively large current in the windings of these relays. The resistance 315 is provided to reduce the current in these relays so as to prevent over-heating, this resistance 315 being shortcircuited by the slow releasing relay 306 when the second numeral is dialed in order to obtain a large operating current. When the slow releasing relay 306 is deenergized, thereafter the resistance 315 is restored in the circuit so as to reduce the current in the coil of the frequency-selecting relay 137 to an amount sufficient to hold the relay in an operated condition, yet insufficient to cause over-heating thereof.

During the dialing of the second numeral and during the actuation of the slow releasing relay 306, a busy test is automatically made to ascertain whether or not the selected frequency channel is already in use in intercommunication between the shore station and another ship, this being determined by the presence or absence of radio signals from the shore station. For this purpose the receiving antenna 308 is connected by way of the emergency antenna switch 372 to the terminal 331 of the selected receiver, thereby permitting radio signals from the shore station to pass from the antenna 308, through the switch 372, to the terminal 331 of the selected receiver, and thence by way of the coupling coil 401 and the tuning circuit 402 to the radio frequency amplifier 403. From the radio frequency amplifier 403 the signals are received by the superheterodyne receiving circuit comprising the first detector 404, the oscillator 406, the control crystal

407, the intermediate frequency amplifier 405 and the transformer 408.

From this superheterodyne receiving circuit the signals received are rectified by the diode portion of the second detector tube 409 (Figure 4), thereby causing a negative voltage to be applied to the left-hand end of the resistance 417, the amount of which depending upon the strength of the radio signals being received. This voltage increases the grid bias of the radio frequency amplifier 403 and intermediate frequency amplifier 405 by way of the circuit including the resistance 421, and filter condenser 422. This negative voltage resulting from the rectification of the radio signals by the diode portion of the second detector tube 409 also passes through the resistance 420 to the terminal 334 of the radio receiver 321, and thence to the busy test circuit. The latter is connected to be effective in conjunction with receivers 321, 322 and 323, which are used for receiving signals from the shore station, but does not operate in connection with the receiver 324 which is employed for receiving signals from other ships. This results from the fact that the terminals 334, 344 and 355 are interconnected between the receivers 321, 322 and 323, but the terminal 364 of the receiver 324 is not connected in this manner.

In the normal condition of the system the terminals 334, 344 and 354 are connected to the -S line by way of the break contact 306a of the slow release relay 306 for the purpose of avoiding interference between the automatic volume-control circuits of the three receivers 321, 322 and 323 by way of the resistances 420. When the second numeral is dialed, however, the operation of the set, as previously described, removes the plate voltage from all but one of these receivers, and no interaction between the automatic volume controls of the different receivers is possible. This obviates the necessity for additional contacts on the counting relays 301 to 304 for controlling the automatic volume control circuits.

When the slow release relay 306 is energized it disconnects the terminals 334, 344 and 354 of the receivers 321, 322 and 323 from the -S line at the break contact 306a, and then closes the circuit from the -S line, through the make contact 306a, the break contact 305a, the line 262 to the vacuum tube 219 (Figure 2), thereby rendering the latter operative.

The line 261 connects the control grid of the vacuum tube 219 to the terminals 334, 344 and 354 of the receivers 321, 322 and 323. The vacuum tube 219 is adjusted by means of the cathode bias resistor 220 and screen bias potentiometer 218 to such a condition that the plate current is sufficient to operate the relay 202 if no negative bias voltage is impressed upon its control grid. Accordingly, when signals are not being received, no negative voltage will be applied to the resistance 417 (Figure 4), nor through its subsequent connection by way of the resistance 420, the terminal 334 of the receiver 321 and the line 261 to the control grid of the tube 219. Under these conditions the relay 202 will be operated by the plate current of the vacuum tube 219. When radio signals arrive over the receiving antenna 308, however, the negative voltage applied as a result thereof to the resistance 417 is carried by way of the resistance 420, the terminal 334 and the line 261 to the control grid of the tube 219, whereupon the latter is

biased into a condition where its plate current is not sufficient to cause the operation of the relay 202.

When the dial switch 307 returns to its normal position the slow release relay 306 opens, after its delay time expires, so that the busy test period is terminated. If the desired frequency channel is already in use by another station at the time the busy test is made, the control grid of the tube 219 is biased at the point where its plate current is insufficient to operate the relay 202. As a consequence, therefore, the system remains in its previous condition, and the commutator ripple of the generator 242, which serves as a busy tone signal, will continue to be heard in the telephone receiver 208, thereby indicating the busy condition of the system. If the selected frequency channel is free at the time the busy test is made, however, the relay 202 is operated by the plate current of the vacuum tube 219 in such a manner as to close the circuit for the relays 203 and 205 in parallel. As a consequence thereof, the relay 203 closes a locking circuit for both of the relays 203 and 205 from the +S line, through the make contact 203e. This locking circuit holds both relays 203 and 205 in an energized condition after the relay 202 opens at the end of the busy test.

The relay 205 when energized connects the motor 243 across the power lines +S and -S of the ship's generator, thereby starting the motor 243 and driving the generator 244. The latter, when driven, supplies plate voltage to the radio transmitter by way of the lines +B and -B. On the other hand, the motor generator set 240-241-242, which is started by the lifting of the telephone receiver 208 from the hook switch, supplies filament voltage for the transmitter vacuum tubes. By the operations set forth above the motor generator set 243-244 is not started until two digits have been dialed upon the dial switch 307. This provides a sufficiently long interval of time between the starting of the two motor generator sets to insure that the filaments of the transmitting tubes have reached their full operating temperatures before the plate voltage is applied thereto. At the same time also this arrangement separates the starting surges of the motors.

The energization of the relay 203 disconnects the telephone receiver 208 from its ground connection across the break contact 203b, and likewise disconnects it from its connection through the break contact 203c with the +D line, thereby stopping the busy tone in the receiver 208. The stopping of this busy tone indicates that the selected frequency channel is free for use, and that no other station of the system is operating over this frequency. The energization of the relay 203 causes the telephone receiver 208 to be connected through the make contacts 203a and 203c and the lines 259 and 260 (Figure 2) to the audio output terminals of the radio receivers 321, 322 or 323, depending upon which receiver is selected for use. Consequently, all radio signals being received on the selected frequency over the receiving antenna 308 will thenceforth be heard in the telephone receiver 208. The shifting of the break contact 203a, however, by reason of the energization of the relay 203, disconnects the loud speaker 206 and the low pass filter 207 from the circuit. The closing of the make contact 203d of this relay 203 causes the -S line to transmit current to the vacuum tubes 213 and 216, which operate the voice-responsive relay 201.

As the disappearance of the busy tone following the dialing of the second numeral, indicates to the operator the free condition of the system, the ship's radio station is now in a condition to communicate with the shore station. The ship's operator now speaks into the microphone 228, whereupon the voice frequency currents produced thereby are applied by way of the transformer 226 upon the audio frequency amplifier tube 224 (Figure 2), the output of which is connected to the transformer 223 having the resistance 245 thereacross for loading the vacuum tube 224. A portion of the output of the transformer 223 is diverted through the fixed condenser 212 to the transformer 211, to a rectifier tube 213, the latter charging the fixed condenser 214 in accordance with the amplitude of the voice frequency currents. The fixed condenser 214, in turn, is connected to the control grid of the amplifier tube 216, the latter being biased by means of the potentiometer 217 into a condition wherein no plate current flows through the relay 201 in the normal condition of this control grid.

When the condenser 214 is charged as a result of the rectified voice frequency currents, however, the resultant voltage alters the grid bias of the vacuum tube 216 so that the resulting flow of plate current operates the voice-responsive relay 201. The resistance 215, connected across the condenser 214, discharges the condenser, but its value is so chosen that the relay 201 remains in an operated condition during short intervals between words, but is released after a long interval when the ship's operator stops talking. In this manner the voice-responsive relay 201 operates whenever the ship's operator talks into the microphone 228.

Meanwhile, if either of the transmitter frequency selecting relays 117 or 127 is energized, after the first digit is dialed, the associated quartz crystal 116 or 126 becomes thereby connected to the grid of the oscillator tube 151 by way of the make contact 117d or 127d, respectively.

The transmitter relay 147 operates in series with any one of the three transmitter frequency-selecting relays 107, 117 or 127 to apply oscillator plate voltage from +D line to the plate of the oscillator tube 151 by way of the make contact 147b, the coil 114 and the make contact 117c, or else by way of the coil 124 and the make contact 127c. Accordingly, the oscillator tube 151 begins to function after this occurrence. The make contact 147a serves, when closed, to connect the oscillator circuit through a coupling condenser 155 to the control grid of the final amplifier tube 162, although the latter remains inoperative until its screen circuit is closed by the closing of the make contact 201b in the line 253.

The relay 201 when so operated renders the radio receiver inoperative by inserting the resistance 230 in the positive plate supply line 265, the break contact 201a shortcircuiting this resistance being opened by the energization of the voice-responsive relay 201. At the same time voltage from the +D line is applied through the make contact 201b and the line 253 to the screen element of the vacuum tube 162 in the transmitter. The consequent actuation of the vacuum tube 162 generates radio signals which are emitted by the transmitting antenna 150. The voice frequency output of the transformer 223 is connected by way of the line 251 to the suppressor grid element of the tube 162, thereby modulating the radio signal in accordance with the voice signals impressed upon the microphone 228. The

voltage drop across the resistor 166 resulting from the plate current of the vacuum tube 162 serves to supply the proper bias to the suppressor grid thereof by way of the line 252, the resistance 245 and the conductor 251. The same bias voltage is used for the control grids of the vacuum tubes 162 and 163 through the filter networks 158.

When the ship's operator ceases talking into the microphone 228, the voice-responsive relay 201 becomes deenergized and opens the make contact 201b, thereby opening the screen circuit of the vacuum tube 162 and stopping the emission of radio signals. At the same time the closing of the break contact 201a reapplies plate voltage to the radio receiver by shorting out the resistance 236 in the +S line, thereby placing the radio receiver in condition for receiving any signals transmitted by the shore station in reply to the ship operator's message.

When the conversation between the ship station and the shore station is finally terminated, the ship's operator hangs up the telephone receiver 208 upon the hook switch, thereby opening the hook switch contacts 209 and 229. This action opens the energization circuit of the relay 204, consequently deenergizing the generator-driving motor 240 and opening the energization circuits of the relays 203, 205, 301, 302, 303 and 304. The deenergization of the relay 205 accordingly deenergizes the generator-driving motor 243. The deenergization of the relays 301, 302, 303 and 304 deenergizes the relay 107, 117, 127, 147 and 137 in the transmitter, thereby restoring the entire ship's station equipment to its normal condition.

When the ship's operator desires to establish direct communication with another ship, he dials the numeral four upon the dial switch 307. By thus dialing numeral four the transmitter is brought into operation, in the manner previously described, except that plate voltage is not applied to the oscillator until the voice-responsive relay 201 is energized, the coil 104 being connected across the make contact 201b by way of the line 253. This slightly altered arrangement makes direct ship-to-ship communication possible, with transmission and reception upon the same frequency, which is of great advantage. As the automatic volume-control terminal 364 of the ship-to-ship receiver 324 is not connected to the conductor 261, by which the other receivers 321, 322 and 323 are connected to the busy test circuit of Figure 4, the ship-to-ship frequency channel can be selected at any time, regardless of whether or not it is being used by other ships. In this manner any number of ships in the system can establish intercommunication so as to exchange information of common interest, such as relaying navigation conditions or in case of distress.

If, however, the ship's operator dials the numeral one to select relay 137 of the transmitter, the relay 147 will not operate. Under such conditions plate voltage is applied to the oscillator tube 164 and to the doubler tube 163 of this frequency by way of make contact 137d, the output of the doubler being connected through make contact 137c to the final amplifier tube 162. It will be understood that the tube 163 may be used as a tripler instead of a doubler, if it is so desired.

If the ship's operator, in an emergency, desires to establish communication with the shore station, even though the desired frequency channel is already in use by another ship, he may

disable the busy tone test system by opening the switch 372 in the circuit of the antenna 308 (Figure 3). The opening of this switch prevents the reception of radio signals, and thereby disables the busy test signalling system. The operator then dials the desired frequency to transmit his message, after which he closes the switch 372 in order to receive the answering signals from the shore station.

The presence of the low pass filter 207 in the circuit of the loud speaker 206 prevents the calling of other ships by voice, hence, the dial switch 307 may be used for transmitting coded tone signals to other ships. In consequence, whenever the dial switch 307 is operated after the dialing of the first digit, the sole result is to energize the slow release relay 306 during the time required by the dial switch 307 to return to rest. The closing of the relay 306 closes a feed-back circuit from the output transformer 223 of the voice frequency amplifier tube 224 by way of the line 263, the make contact 306b, the line 264 and the tuning circuits 223, 232 and 231 to the input transformer 225 of the voice frequency amplifier 224. The fixed condenser 231, inductance 232, resistance 233 and shunt resistance 234 in this tuning circuit serve to produce an audio tone of the desired volume and frequency by causing the amplifier 224 to act as an audio oscillator. In this manner coded tone signals can be transmitted by means of the dial switch 307. For example, the numeral eight may be dialed for a long tone, and numeral two for a short tone, the calling signals of the ships consisting of combinations of long and short tones. When one ship calls another, however, no frequency designating signal will follow the ship's calling signal, as in the case of the shore station operation. This absence of a frequency-designating signal at once informs the operator on the called ship that he should select the ship-to-ship frequency channel in which the oscillator functions only when the operator talks into the microphone 228, enabling the same frequency to be used for receiving and transmitting.

The ship's operator may call the shore station in the same procedure as in answering calls from the shore station. Using the dial switch 307, however, he will dial a suitable frequency channel, depending upon his distance from the shore station, instead of dialing a frequency channel indicated by the calling signal received from the shore station.

Arrangement of master station

Figure 5 shows a master station which may be used for communication with the subsidiary stations. One such master station is provided for each of the frequency channels used.

The master station comprises a master radio receiver 501 connected to a receiving antenna 502 and ground 503. This receiver is tuned to one of the transmitting frequencies of the subsidiary stations and its output is connected by the lines 504 and 505 to a hybrid circuit 506 including an artificial balancing line network 507. The hybrid circuit is also connected by the lines 508 and 509 to a master radio transmitter 510 and by the lines 511 and 512 to the wired telephone lines 513 and 514.

The master radio transmitter 510 is connected to a transmitting antenna 515 and to ground 516 and is tuned to one of the receiving frequencies of the subsidiary stations. The master radio transmitter is placed in operation by the switch

517, which causes the transmitter to emit radio waves from the antenna 515.

The wired telephone lines 513 and 514 lead to a telephone switchboard where the radio connection may be extended to any telephone subscriber.

The hybrid circuit 506 with the balancing network 507 transmits speech from the wired telephone lines 513 and 514 to the transmitter 510. However, speech fed to the hybrid circuit 506 from the receiver 501 is transmitted to the wired telephone lines 513 and 514, but is balanced out and not transmitted to the transmitter 510. It will be understood that the action of the hybrid circuit may be assisted by carrier or voice controlled relays.

A key 518 is provided in the wired telephone lines 513 and 514 for connecting a ringing current generator 519 to these lines for the purpose of calling the operator at the telephone switchboard.

The lines 511 and 512 are connected over the normally closed contacts of a key 520 to an amplifier 521 which feeds a loudspeaker 522. Thus any speech or other audio signals received either on the receiver 501, or over the telephone lines 513 and 514 will be heard in the loudspeaker 522.

When the key 520 is operated, the amplifier 521 and loudspeaker 522 are disconnected, while the radio operator's talking set comprising a telephone receiver 523, induction coil 524, microphone 525, switch-hook 526 and battery 527, is connected to lines 511 and 512, enabling the operator to receive speech from the receiver 501 as well as from the telephone lines 513 and 514 and to transmit speech to the radio transmitter 510 and to the telephone lines 513 and 514.

A key 528 is provided for connecting the audio frequency generator 529 to the radio transmitter 510 for the purpose of calling the subsidiary stations. The frequency of the generator 529 is such as to pass readily through the low-pass filters 207 at the subsidiary stations.

Operation of master station

When a subsidiary station calls one of the master stations, the signals are received on the antenna 502, operating the receiver 501, which in turn actuates the loudspeaker 522. The operator at the master station upon hearing the call places the transmitter 510 in operation by closing switch 517, operates key 520, disconnecting the loudspeaker and connecting his talking set, and answers the call, the speech passing from the microphone 525 through induction coil 524, key 520, lines 511 and 512, hybrid circuit 506, lines 508 and 509 to the transmitter 510 and thence from antenna 515 to the subsidiary station. The signals from the subsidiary station are now received in the operator's telephone receiver 523.

If the operator at the subsidiary station wishes to talk to a telephone subscriber over the wired telephone system, the operator at the master station calls the telephone switchboard by operating the key 518. When the switchboard operator answers, the connection is completed in the usual manner.

When the switchboard operator wishes to complete a call from a telephone subscriber to one of the subsidiary stations she calls the master station operator by voice over the wired telephone lines 513 and 514. The master station operator hears the call on the loudspeaker 522 and

answers after operating the key 520. Having ascertained which subsidiary station is wanted he places the transmitter 510 in operation by closing switch 517 and then actuates the key 528 to transmit the coded tone signals assigned to the wanted station, following it by the frequency signal to indicate on which frequency the subsidiary station should answer. When the operator at the subsidiary station answers, the connection is completed to the calling telephone subscriber. When a call is in progress, transmitter 510 is in continuous operation, emitting radio waves from antenna 515 so that other subsidiary stations attempting to call on this frequency will receive the busy signal.

The operator at the master station supervises the call either on his telephone receiver 523 or by means of the loudspeaker 522 and, when the call is finished, opens the switch 517 thereby stopping the emission of radio signals from antenna 515 so as to enable other subsidiary stations to call the master station.

The master stations for the other frequencies function in the same manner, making it possible to handle calls on all three frequency channels at the same time.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims and the invention.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a radio station, a plurality of radio transmitting and receiving circuits tuned for a plurality of frequency channels, a manually operated dial for effecting a sequence of circuit changes connected to said circuits, means responsive to a specific number of circuit changes by said dial for operatively selecting a particular one of said transmitting circuits and for disabling certain of said receiving circuits, said receiving circuits including a signal announcer, a busy signal circuit responsive to incoming signal voltage in said selected receiving circuit for indicating a busy signal in said announcer, a generator, and means including connections between said generator and said busy signal circuit for transmitting the commutator ripple of said generator to said busy signal circuit for use as a busy tone signal in said announcer.

2. In a radio station, a radio transmitting circuit, a radio receiving circuit, a motor generator for supplying filament voltage to said transmitting circuit, an energizing circuit connected to said motor generator, a motor generator for supplying plate voltage to said transmitting circuit, means connected to said energizing circuit and responsive to the placing of said receiving circuit in receptive condition for energizing said filament supply generator motor, and switch means connected to said energizing circuit for subsequently energizing said plate supply generator motor.

3. In a radio station, a radio transmitting circuit, a radio receiving circuit, a motor generator for supplying filament voltage to said transmitting circuit, a motor generator for supplying plate voltage to said transmitting circuit, an energizing circuit connected to said motor generators, means connected to said energizing circuit and responsive to the placing of said receiving circuit in receptive condition for energizing said filament supply generator motor, and a dial switch circuit responsive to a predetermined motion of the dial

for subsequently energizing said plate supply generator motor.

4. In a radio station, a radio transmitting circuit, a radio receiving circuit, a motor generator connected thereto, an energizing circuit connected to said motor generator, said receiving circuit including a signal announcer, means connected to said energizing circuit and responsive to the placing of said signal announcer in signal-announcing condition for energizing the motor of said motor generator, and means responsive to incoming signal voltage for preventing the energization of the motor of said motor generator.

5. In a radio station, a radio receiving circuit for receiving intelligence from a distant station, a radio transmitting circuit for sending intelligence to said distant station, one of said circuits having electronic tubes with heating elements, means for supplying electricity to said heating elements, means for reducing the current supplied to said heating elements to a definite value but less than the operating value for stand-by service, a telephone receiver in said receiving circuit for translating the received intelligence into auditory form, a telephone receiver support, and means responsive to the shifting of said telephone receiver relatively to said support on the reception of intelligence for increasing the current supplied to said heating elements from the less-than-operating value to the operating value whereby the said one circuit is placed in an operating condition.

6. In a radio station, a radio receiving circuit for receiving intelligence from a distant station, a radio transmitting circuit for sending intelligence to said distant station, said transmitting circuit having electronic tubes with heating elements, means for supplying electricity to said heating elements, means for reducing the current supplied to said heating elements to a definite value but less than operating value for stand-by service, a telephone receiver in said receiving circuit for translating the received intelligence into auditory form, a telephone receiver support, a microphone in said transmitting circuit, and means responsive to the shifting of said telephone receiver relatively to said support on the reception of intelligence for supplying current to said microphone and for increasing the current supplied to said heating elements from the less-than-operating value to the operating value whereby said transmitting circuit is placed in an operating condition.

7. In a radio station, a radio receiving circuit for receiving intelligence from a distant station, a radio transmitting circuit for sending intelligence to said distant station, said transmitting circuit having electronic tubes with heating elements, means for supplying electricity to said heating elements, means for reducing the current supplied to said heating elements to a definite value but less than the operating value for stand-by service, a telephone receiver in said receiving circuit for translating the received intelligence into auditory form, a telephone receiver support, and means responsive to the shifting of said telephone receiver relatively to said support on the reception of intelligence for increasing the current supplied to said heating elements from the less-than-operating value to the operating value, said current-reducing means comprising resistance means in circuit with said heating elements, said shift-responsive means when actuated being arranged to permit current to flow around said resistance means.

8. In a radio station, a circuit for sending intelligence to a distant station, a receiving circuit for receiving intelligence from said distant station, said receiving circuit being tuned to a plurality of substantially fixed frequency channels, extending between the stations a busy test circuit responsive to incoming signal voltage for signalling the busy condition of said frequency channels, and means for connecting said busy test circuit selectively to all but one of said receiving circuits, said busy-signal-free circuit being adapted for reception on one of the frequency channels even though the channel indicates an otherwise busy condition, and means for transferring the busy frequency channel to the busy-signal-free circuit.

9. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a motor generator set connected thereto, a busy signal circuit at each subsidiary station, and means including a switch adapted to produce a series of electrical impulses in predetermined succession for selecting a given channel for communication, for starting said motor generator and for operating said busy signal circuit to ascertain the operating condition of the selected frequency channel.

10. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a motor generator set connected thereto, a busy signal circuit at each subsidiary station, and a dial switch circuit with a single dial switch for selecting a given frequency channel for communication, for starting said motor generator set, and for operating said busy signal circuit to ascertain the operating condition of the selected frequency channel.

11. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits including telephone receivers for establishing radio communication upon a plurality of frequency channels, a motor generator set connected thereto, a busy signal circuit at each subsidiary station, and means responsive to the shifting of the telephone receiver relatively to its support and to the motion of said dial switch for selecting a given channel for communication, for starting said motor generator set and for operating said busy signal circuit to ascertain the operating conditions of the selected frequency channel.

12. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a plurality of motor generator sets connected thereto, a busy signal circuit at each subsidiary station, and manually controlled means including a single dial switch for selecting a given frequency channel for communication for starting said motor generator sets in a predetermined sequence and for operating said busy signal circuit to ascertain the operating condition of the selected frequency channel.

13. In a radio communication system, a group of radio stations having a plurality of transmitting and receiving circuits for establishing

radio communication upon a plurality of frequency channels, said circuits including radio tubes, manually controlled means at said stations for selecting one of said frequency channels for communication between stations and dial-responsive means for transmitting coded tone signals over the selected frequency channel and for causing the energization of said radio tubes.

14. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a dial switch circuit with a dial switch at each of said subsidiary stations for selecting the circuit of one of said frequency channels for communication, and means associated with said dial switch circuit responsive to a predetermined motion thereof for transmitting coded tone signals.

15. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a dial switch circuit with a dial switch at each of said subsidiary stations for selecting one of said frequency channels for communication, at least one of said transmitting circuits having a modulation circuit including a feed-back circuit, and means responsive to said dial switch for closing said feed-back circuit for transmitting coded signals.

16. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, said transmitting circuits having oscillator stages, voice-responsive devices for placing the output of one of said transmitting circuits in a transmitting condition, and dial-responsive means for placing at least one of said oscillator stages under the control of said voice-responsive devices upon a part only of said transmitting frequency channels.

17. In a radio communication system, a master radio station, a group of subsidiary radio stations having a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, a dial switch circuit with a dial switch at each of said subsidiary stations for selecting one of said frequency channels for communication, said transmitting circuits having oscillator stages, voice-responsive devices for placing the output of one of said transmitting circuits in a transmitting condition, means responsive to said dial switch for placing said oscillator stage under control of said voice-responsive devices upon a part only of said transmitting frequency channels and excluding at least one of said frequency channels in each station.

18. In a radio station for communicating with a master radio station and a group of subsidiary radio stations, a plurality of radio transmitting and receiving circuits for establishing radio communication upon a plurality of frequency channels, said transmitting circuits having at least one amplifier stage, dial controlled means for selecting one of said channels for communication, and means responsive to said dial controlled means for cutting in said amplifier stage on certain of said frequency channels.

19. In combination, a radio transmitting circuit,

a radio receiving circuit having thermionic devices which require filament and plate energy, a plurality of motor-generator sets, one of which provides filament energy and the other provides plate energy for said thermionic devices, said receiving circuit including a signal announcer, means connected to said energizing circuit and responsive to the placing of said signal announcer in signal-announcing condition for energizing the motor of the set which provides filament energy, switch means connected to said energizing circuit for subsequently energizing the motor-generator set which provides plate energy, and means responsive to incoming signal voltage for preventing the energization of the motor-generator set which provides plate energy.

20. In a radio station, a plurality of radio receiving circuits tuned for a plurality of frequency channels, a plurality of radio transmitting circuits tuned to corresponding frequency channels, a manually operated dial switch, means responsive to a predetermined motion of said dial switch for selecting a transmitting circuit and a receiving circuit for one of said channels, a busy signal circuit responsive to incoming signal voltage for announcing the busy condition of a frequency channel selected by said dial switch, and means for connecting said busy signal circuit to the receiving circuit selected by said dial switch except one of said selected receiving circuits whereby the busy signal ascertains whether the selected receiving circuit is busy except the said one selected receiving circuit, and means for connecting the said one selected receiving circuit to the selected frequency channel regardless of its busy condition.

21. In a radio station, radio receiving and transmitting circuits including radio tubes, said receiving circuits including a signal announcer, said transmitting circuit including a dial switch for transmitting electrical impulses over the circuit, a plurality of sources of current for the filament and plate circuits respectively of the radio tubes, means responsive to the placing of the signal announcer in signal announcing condition for causing the energization of said filament circuits by their source of current, and means responsive to the operation of the dial switch for causing the energization of said plate circuits by their source of current.

22. In a radio station, radio receiving and transmitting circuits including radio tubes, said receiving circuit including a signal announcer, said transmitting circuit including a dial switch for transmitting electrical impulses over the transmitting circuit, a plurality of motor generator sets, an energizing circuit for the motor of each set, the generator of one of said sets serving to energize the filaments of said radio tubes, and the generator of another motor generator set serving to energize the plates of said radio tubes, means responsive to the placing of said signal announcer in signal-announcing condition for energizing the motor of the motor generator set which provides the filament energy, and means responsive to the operation of said dial switch for energizing the motor of the motor generator set which provides the plate energy.

23. In a radio station, radio receiving and transmitting circuits including radio tubes, said receiving circuit including a signal announcer, said transmitting circuit including a dial switch for transmitting electrical impulses over the transmitting circuit, a plurality of motor generator sets, an energizing circuit for the motor

- of each set, the generator of one of said sets serving to energize the filaments of said radio tubes, and the generator of another motor set serving to energize the plates of said radio tubes, means responsive to the placing of said signal announcer in signal-announcing condition for energizing the motor of the motor generator set which provides the filament energy, and means responsive to the dialing of not less than two digits on said dial switch for energizing the motor of the motor generator set which provides the plate energy whereby the application of plate voltage to the radio tubes is delayed until after the filaments of the tubes have been energized.
24. In a radio station, radio receiving and transmitting circuits including radio tubes, said receiving circuit including a signal announcer, said transmitting circuit including a dial switch

for transmitting electrical impulses over the transmitting circuit, a motor generator set having a pair of generators, an energizing circuit for said motor, one of the generators serving to energize the filaments of the radio tubes, the other of the generators serving to provide a test signal for determining the busy status of a frequency channel for the transmitting and receiving circuits, means responsive to the placing of the signal announcer in a signal announcing condition for causing the energization of said motor, a second motor generator set, the generator of which serves to energize the plates of said radio tubes, and means responsive to the operation of said dial switch for energizing the motor of the motor generator set which provides the plate energy.

HANS P. BOSWAU.