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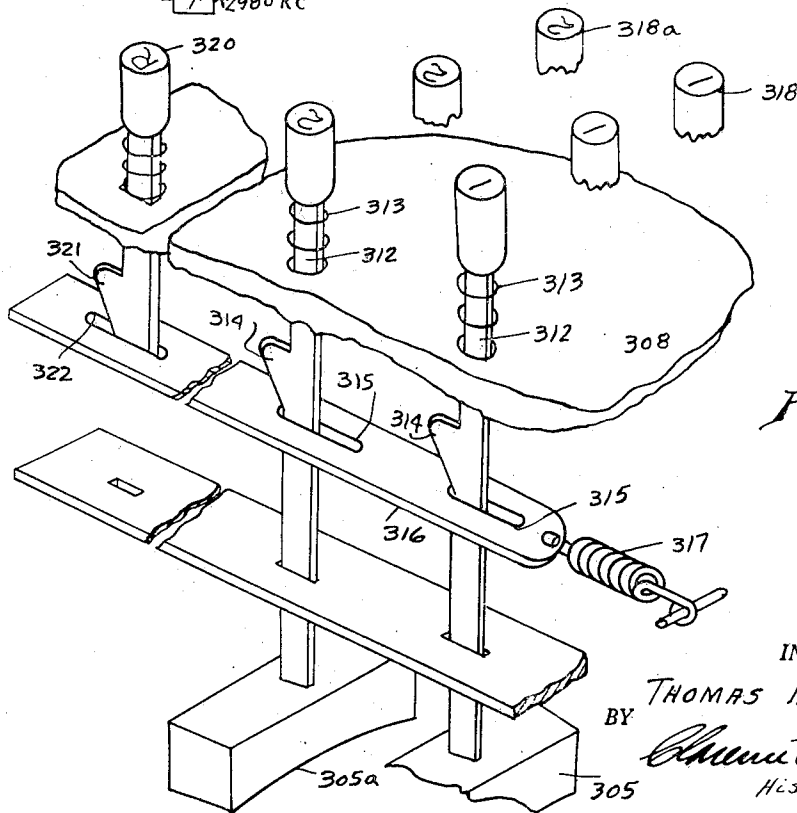
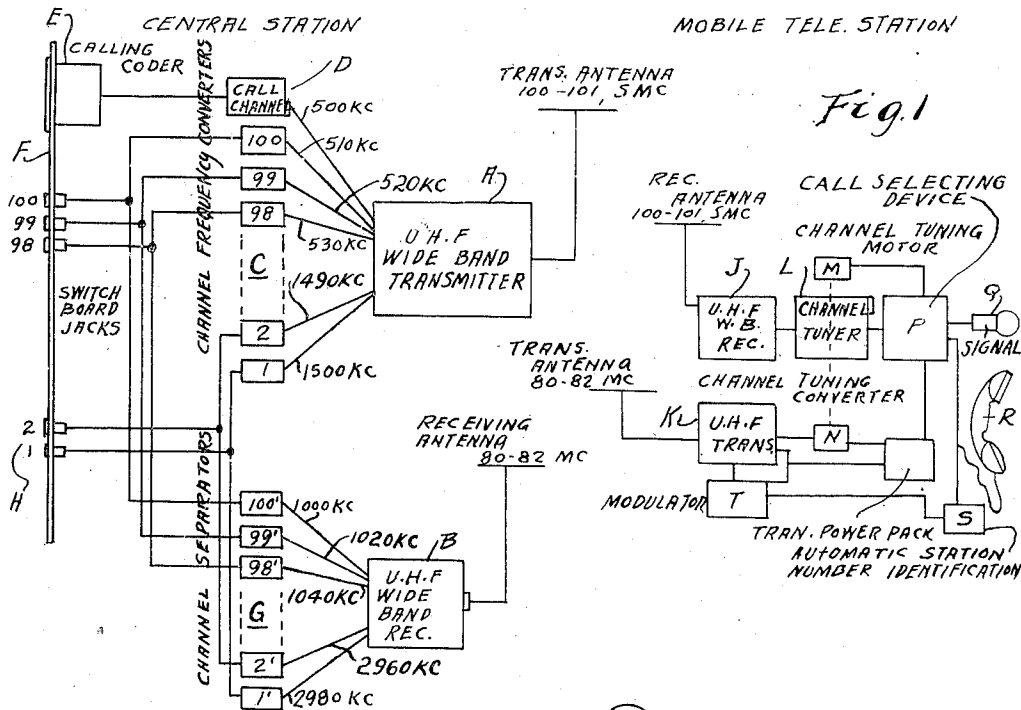
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2,479,701

TRANSMITTING SYSTEM

Filed Feb. 7, 1944

6 Sheets-Sheet 1



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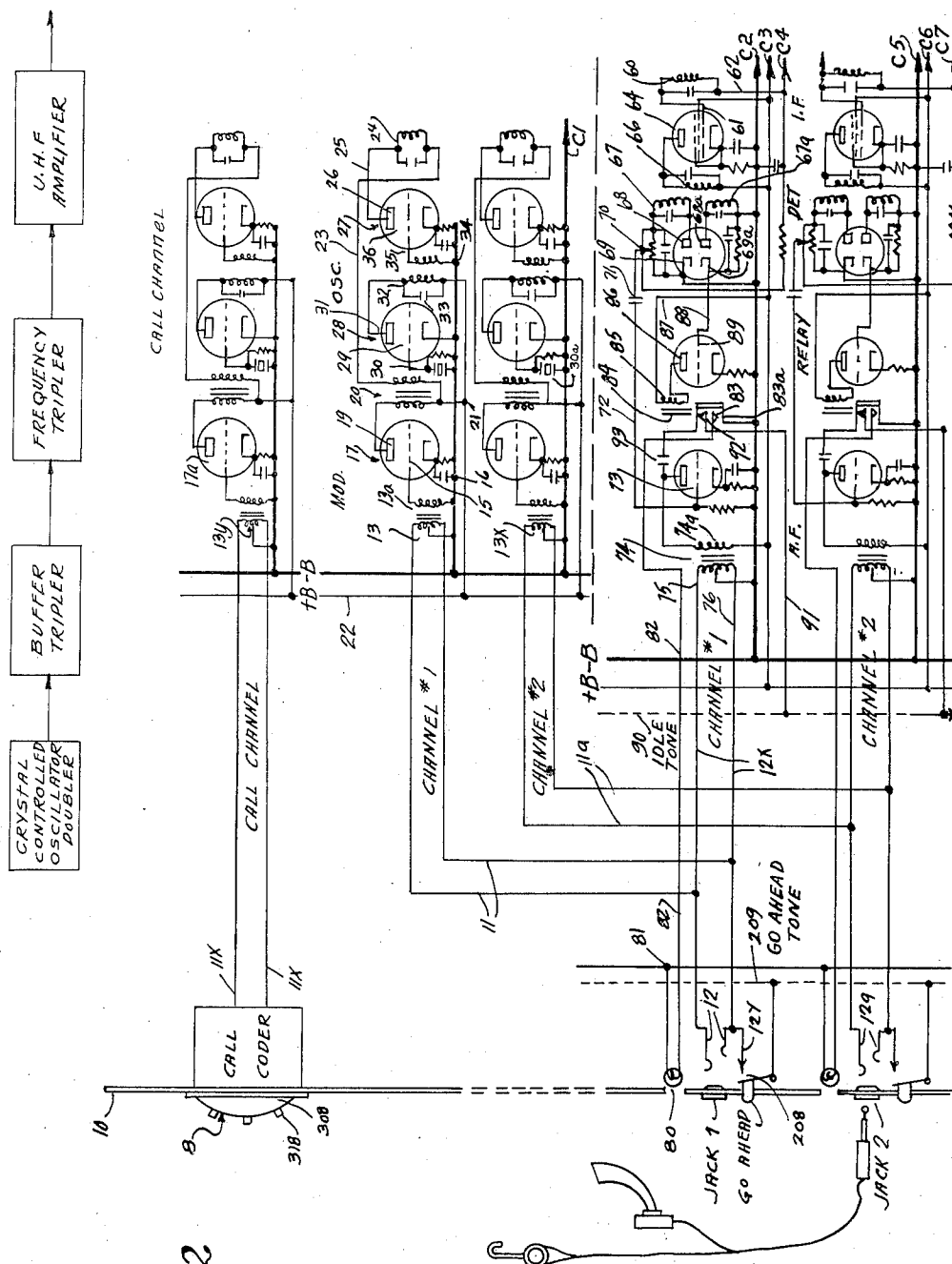
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TRANSMITTING SYSTEM

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6 Sheets-Sheet 2



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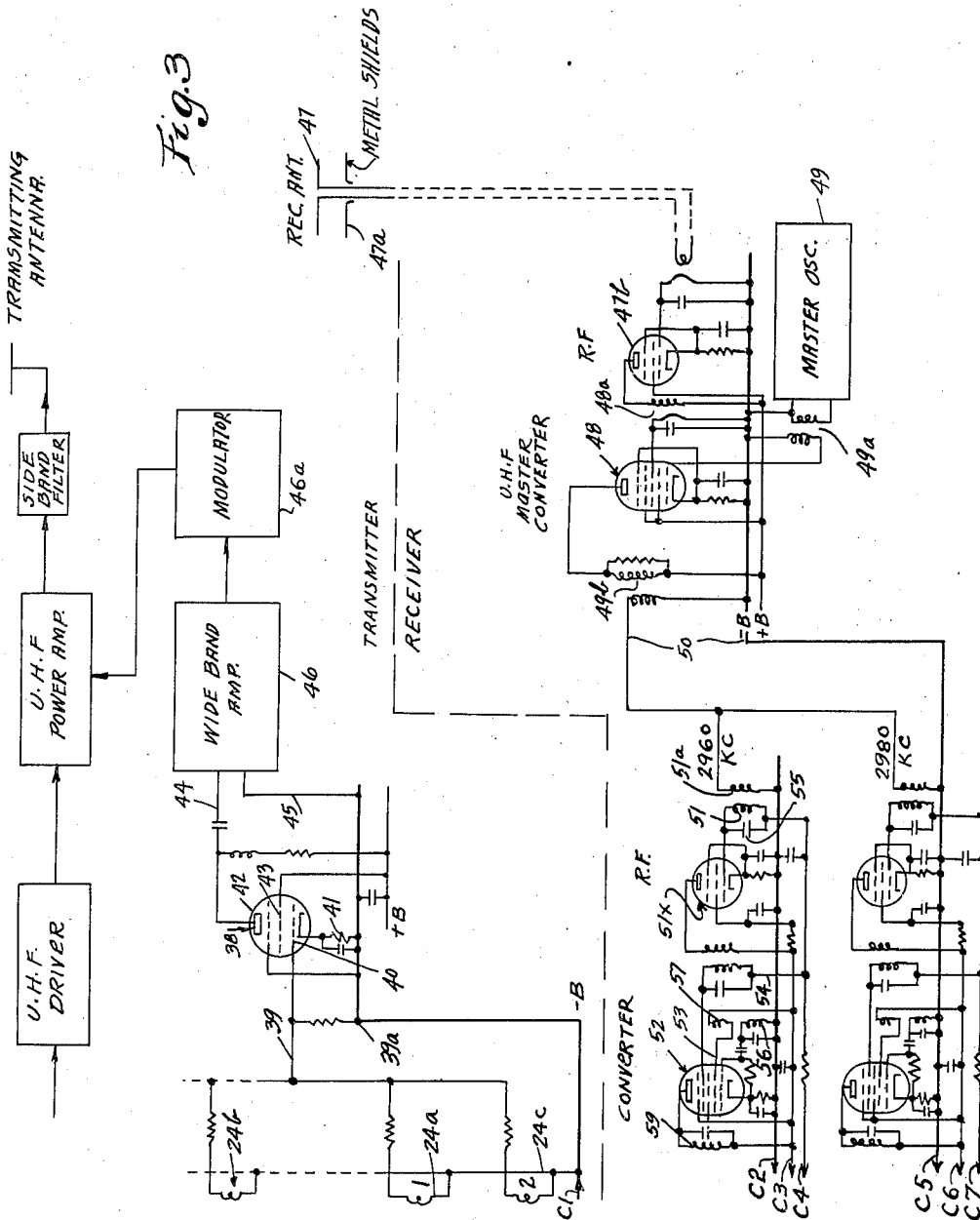
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TRANSMITTING SYSTEM

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6 Sheets-Sheet 3



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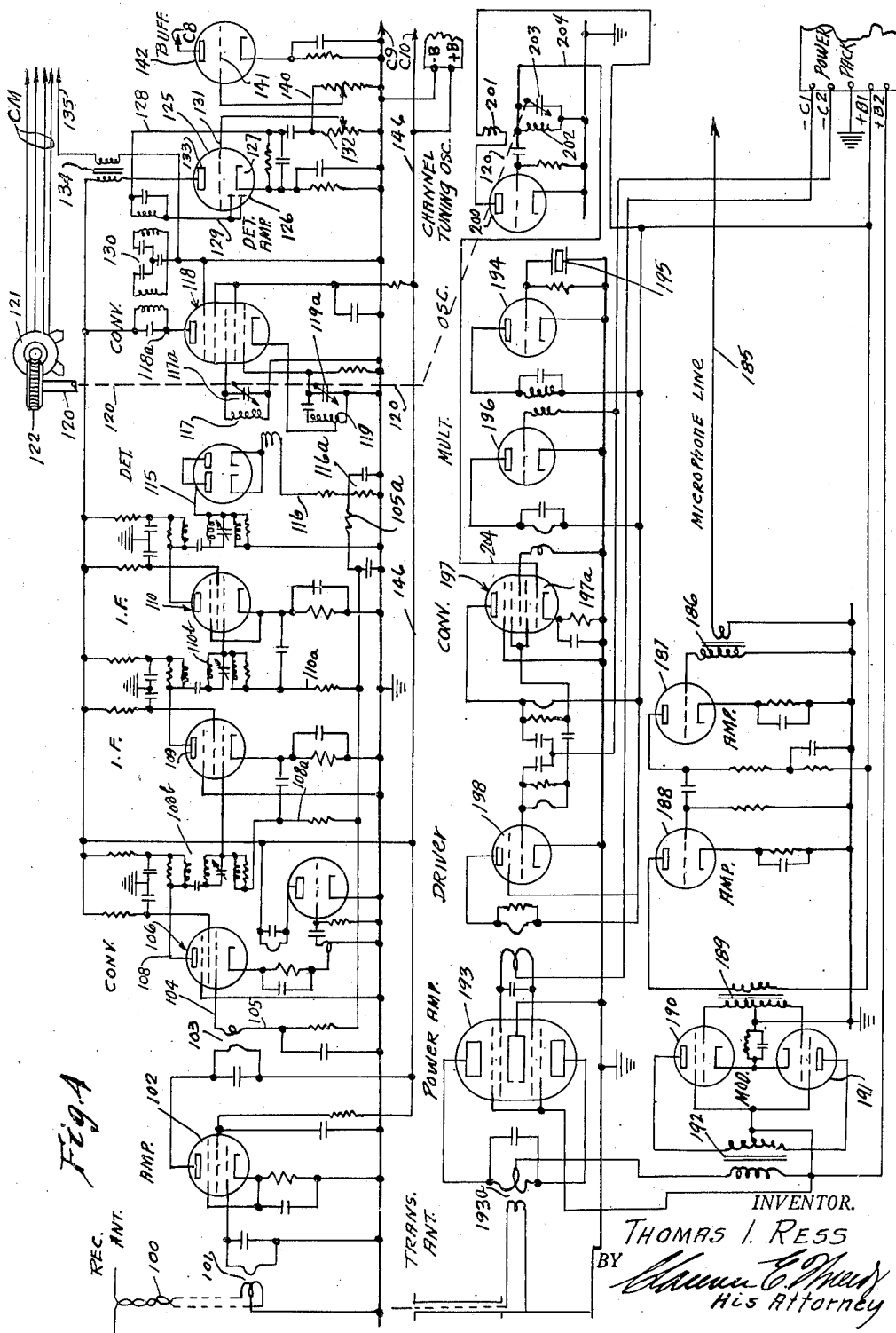
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TRANSMITTING SYSTEM

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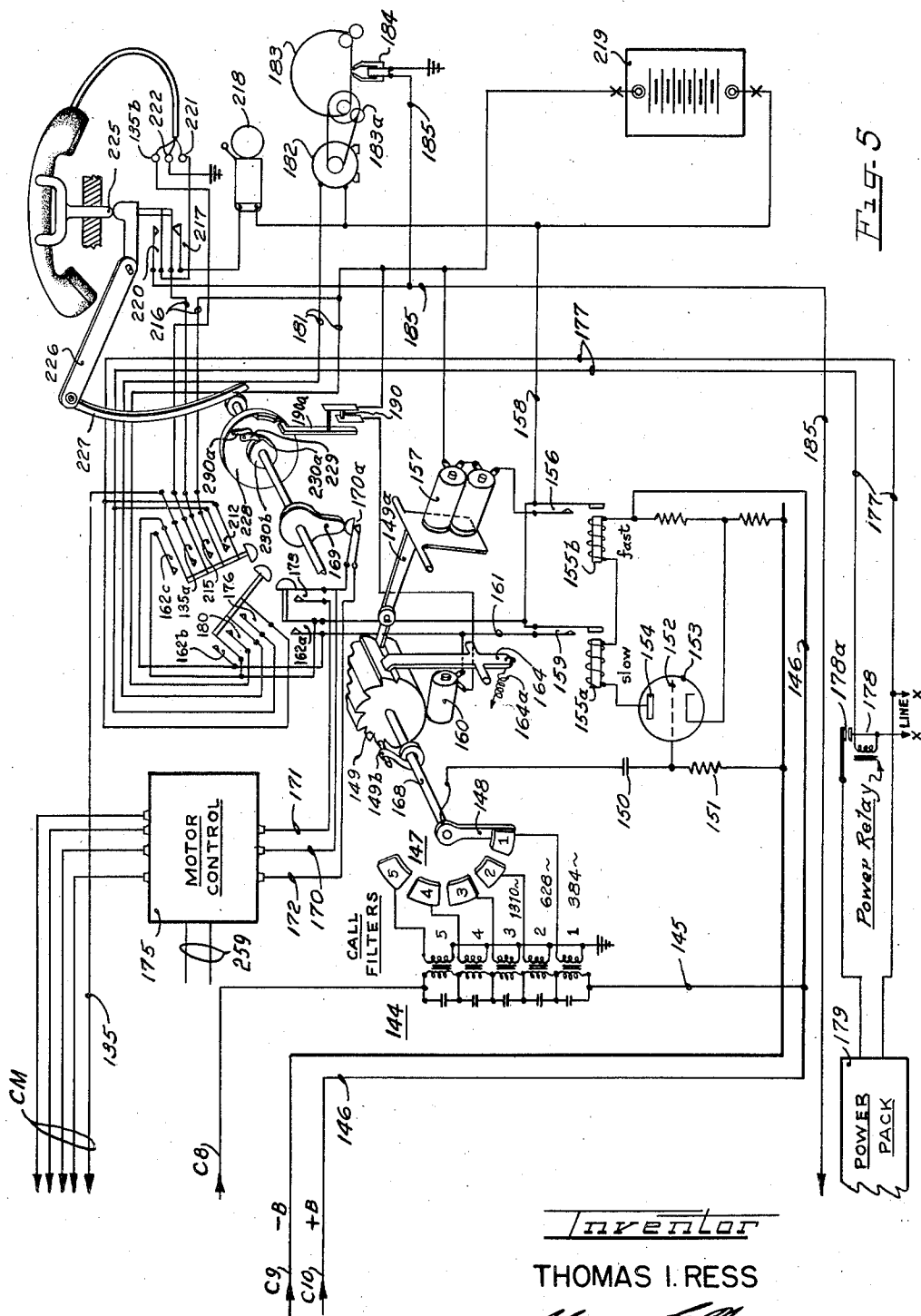
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6 Sheets-Sheet 5



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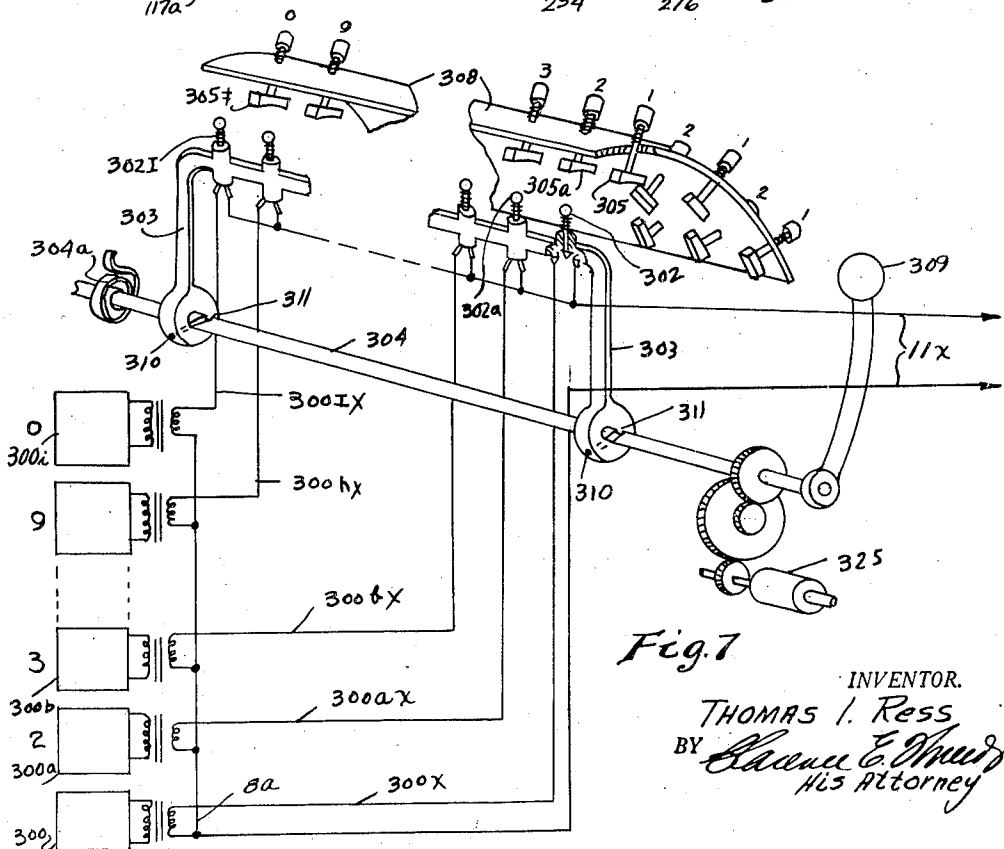
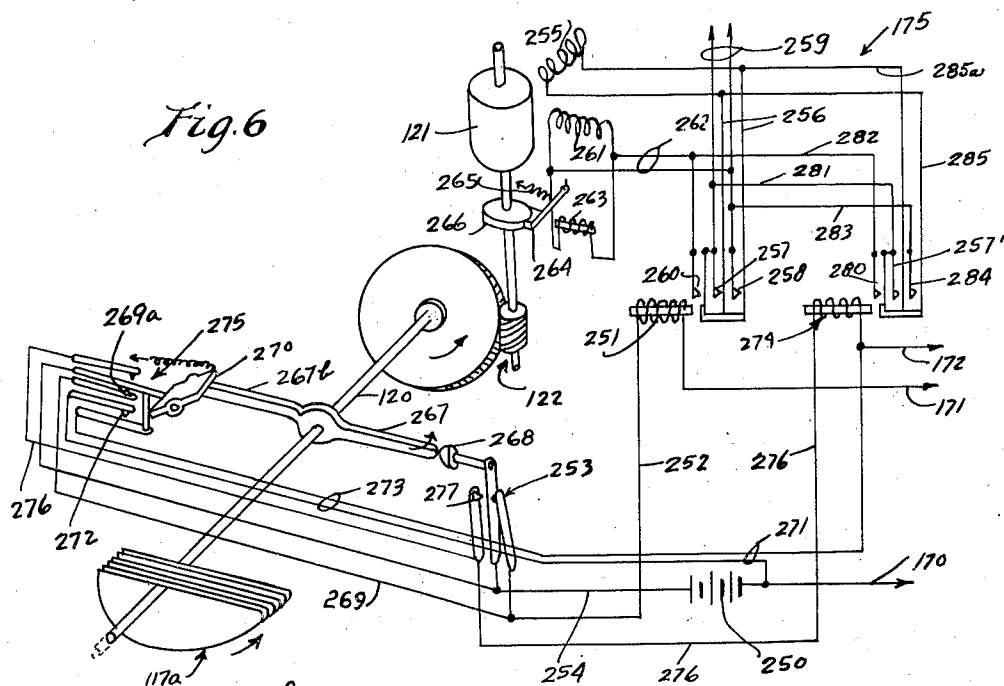
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TRANSMITTING SYSTEM

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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

2,479,701

TRANSMITTING SYSTEM

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Application February 7, 1944, Serial No. 521,340

16 Claims. (Cl. 250-9)

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This invention pertains to the communication arts, particularly radio telephony, and a system for interconnecting calling and called substations or subscribers, whether mobile or otherwise, through the medium of a central link or exchange station especially adapted to provide a number of two-way talking or trunk channels over the modulating band of a single ultra high frequency transmitter and over an ultra high frequency wide-band receiver, within the limits of a single broad-band carrier frequency.

It is a principal object of the invention to provide a radio telephone system which makes it possible for one subscriber or station, whether the same be fixed or mobile, as for example, automobiles, coastwise vessels, land stations, or aircraft, to call and be called by another such subscriber without the necessity of providing a multiplicity of radio frequency carrier channels equaling in number the total number of subscribers or substations to be served by the system.

It is a further important object to provide a system of the class described in which a relatively small band width of the available radio frequency spectrum provides a plurality of signalling and talking or trunking channels or carriers which are adapted, in conjunction with special circuit arrangements and selecting apparatus, to carry a predetermined traffic load for a relatively large number of subscribers; and further, to make possible the interconnection of subscribers with substantially the same facility as in ordinary telephone practice, notwithstanding that the subscriber stations may all be of the mobile type.

More detailed objects of the invention relate to the provision, in a system of the class described, of subscriber stations equipped with radio transmitting and receiving apparatus each capable of operating at any of a plurality of predetermined trunk carrier frequencies, constituting talking channels; to the provision at such stations of automatic means for testing and selecting idle channels over which communication may be established with the central station or exchange; to the provision of means at such stations for automatically setting the testing and selecting means into operation responsive to the reception of certain coded call signals; to the provision of means at said stations for the automatic transmission of station identification signals when calls are made, or answered; to the provision of means for automatically signalling the subscriber to announce an incoming call responsive to the reception of the aforesaid coded call signals.

Still further objects relate to the central or link

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exchange station and the provision thereof of a wide-band radio frequency transmitter capable of transmitting a principal carrier upon which is superimposed, in a manner of speaking, a plurality of trunking carrier frequencies; to the provision of means for allocating certain of the superimposed carrier channels as talking or trunk channels, and other such carrier channels as signalling channels; to the provision of central office switchboard supervisory and signalling means for establishing trunking "circuits" over said channels; to means for impressing voice-frequency energy upon the trunking carriers with relatively minimum amounts of equipment in comparison with the traffic load to be handled.

Other objects, advantages, and features of novelty and utility in the invention relate to the method of sub-frequency modulation disclosed for impressing and modulating trunking carriers upon a single wide-band main carrier frequency to afford a multi-channel radio telephone network adapted to serve a relatively large number of substations for two-way communication, all of which, together with ancillary and more detailed aspects of the invention pertaining to certain circuits and apparatus, will appear as the following description proceeds in view of the annexed drawings, in which:

Fig. 1 is a block diagram showing the basic operating units involved in a central or link station and one mobile sub-station;

Figs. 2 and 3 are circuit diagrams for a central exchange or link station and are to be read together;

Figs. 4 and 5 are circuit diagrams for one receiving or sub-station and are to be read together;

Fig. 6 is a circuit diagram detailing the tuning motor control unit employed at each sub-station;

Fig. 7 is a skeletonized perspective detail of the call signal transmitter and circuit connections therefor;

Fig. 8 is a fragmentary perspective detail of the automatic call signal transmitter.

General description

In general, the completion of connections over the novel system involves the calling, by the subscriber, of the central exchange, passing the desired number to the answering central operator, who then calls the desired subscriber, and the interconnection of the calling and called subscribers at the central exchange.

In calling the central exchange, the apparatus at the subscriber's station operates automatically to test the trunk carrier frequencies for idle

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ness by tuning the substation transmitter and receiver progressively over the frequency range of the system. A special signal or tone is placed upon idle channels at the central exchange, and the substation apparatus will automatically remain tuned to the first idle channel frequency encountered and marked by such tone in the aforesaid testing operation.

When an idle channel is seized by the substation, the identifying designation of the calling station is thereupon automatically transmitted until the central office operator answers and the called number is passed, whereupon the central operator sets a calling device into operation over a calling channel, and when the called subscriber responds, the operator interconnects the calling and called stations through jack terminals at the central switchboard, and the occupied trunking channel is blocked for the duration of the call.

Referring to the block diagram of Fig. 1, there is provided at the central or link station a wide-band ultra high frequency radio transmitter A adapted to transmit over a band preferably 1.5 megacycles wide, together with ultra high frequency receiving means B adapted to receive over a band of greater width than the transmitting band, the transmitter operating on frequencies from 100 to 101.5 megacycles and the receiver operating on frequencies from 80 to 82 megacycles, in the present embodiment.

Channel converter means, generally indicated at C, is utilized to provide at least one call channel D, operating in this instance on 500 kilocycles for transmitting call signals from a calling device E located at a central control or switchboard F. In addition to the call channel or channels (several may be required), there are provided a number of talking or trunk channels numbered consecutively from 1 to 100, and each separated by a band width of 10 kilocycles, preferably.

The wide-band receiver B is connected to a plurality of channel separators, generally indicated at G, and numbered consecutively from 1' to 100', and each separated in frequency from the other by intervals of 20 kilocycles.

Drop connections from each of the channel converters and separators are brought out at the switchboard F in jacks H, also numbered from 1 to 100, to correspond to the talking channels, so that the operator's telephone set may be plugged into any of the 100 talking channels for two-way communication thereover.

At the right-hand side of Fig. 1 are shown the instrumentalities of one substation, which include an ultra high frequency wide-band receiver J operating on a band width of 1.5 megacycles, that is, from 100 to 101.5 mc., and a U. H. F. transmitter K operating on a band 2 megacycles wide, that is, from 80 to 82 mc.

The substation receiver is tuned by a channel tuner L, actuated automatically by a channel tuning motor M, which simultaneously actuates a channel tuning converter N for tuning the transmitter K to any of the trunking frequencies included within the principal link carrier frequency. The automatic tuning means is so arranged that when the channel tuning motor M is set into operation, the substation transmitter and receiver will be tuned simultaneously over their respective trunking channel frequency bands for two-way communication with the central station unit over the idle channels selected thereby.

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The substation receiver is normally kept tuned (with the channel tuning motor means at a starting position) to one of the call channels D of the central station, and when a certain sequence of call code signals of pre-arranged frequency is received thereby, a call selecting device P sets the channel tuning motor means M into operation, so that the substation transmitter and receiver will automatically begin to tune over the range of the aforesaid operating band, testing for an idle trunking or talking channel.

Means is provided for rendering idle channels selectively distinguishable from busy channels, the preferred form of such means being the transmission of a characteristic idle tone over the various idle channels, such that when the substation receiver is automatically tuned, as aforesaid, over its operating band and the first idle tone is received, the call selector will be actuated at once to stop the automatic tuning means or channel tuning motor M, so that the substation will be conditioned to operate on the particular frequency of such idle channel.

Upon automatic selection of an idle channel by the called station, the transmitter K thereat is operated to radiate a carrier wave and an automatic station identification device S, cooperating with the transmitter modulator T, will cause the call number of that subscriber to be transmitted over said carrier to the central exchange or link station operator. The reception of this carrier at the central station causes a relay in the corresponding channel separator circuit to operate and turn on a "busy" or "line" lamp located over the corresponding channel jack on the switch board. The attention of the operator is thus called to the answering channel and by connecting the operator's telephone set to this channel, the answering subscriber can be identified. Upon completing the connection, a "go ahead" signal is transmitted from the central station to the mobile station. The reception of the "go-ahead" signal at the mobile station operates a local signal or buzzer thereat to announce the call to the subscriber.

Should the subscriber wish to place a call, in the diagrammatic arrangement of Fig. 1, he removes his hand-set in the usual manner, setting the automatic call selector device P into operation, and thereby causes the aforesaid channel testing operation to go forward until an idle channel is found, whereupon the station identification device S causes the call number of this particular substation to be transmitted to the central station, with a resultant illumination of a signal lamp over the jack terminal of the calling channel at the central switchboard; when the operator answers, the subscriber passes the desired number, and the operator completes the call in the manner heretofore described.

Detailed description

At the top of Figs. 2 and 3 (read together) there are shown by block symbols, appropriately designated, the major unit components of a conventional ultra high frequency (U. H. F.) radio transmitter, such apparatus including a crystal-controlled oscillator doubler unit, a buffer-tripler stage, a frequency tripling stage, an U. H. F. amplifying unit, an U. H. F. driver stage (Fig. 3) the output of which is amplified by an U. H. F. power amplifier unit, which has its output modulated by the unit so-designated, in cooperation with the channel converter system shown in detail to the left thereof in Fig. 2.

For purposes of this specification, it may be

pointed out here that the individual instrumentalities of the foregoing transmitter components indicated by block units are well understood in the art, so that a detailed description and illustration of these parts is deemed unnecessary.

The principal apparatus interposed between the central office switchboard and the transmitter therefor, is the channel conversion means, the function of which is the provision of a plurality of sub-frequency carriers or trunking and signaling channels, the term sub-frequency being utilized here to designate the various carrier frequencies which are additively contained within the modulation band of the ultra high frequency (U. H. F.) carrier of the central office transmitter.

Since the apparatus and circuit connections for one channel conversion unit differ from those of another unit only in the frequency at which it is capable of operating, only one such unit need be described in detail.

Beginning at the central exchange switchboard 10 (Fig. 2), conductors 11 lead from the tip and sleeve terminals 12 of the jack terminal for channel No. 1 to the primary 13 of an input transformer whose secondary winding 13a connects respectively to the control grid 15 of tube 17 and to ground.

The output of the modulator tube 17 is passed through a coupling transformer 20 connecting with the plate 19 of the modulator stage and at junction 21 with the positive plate power lead 22. The secondary winding of transformer 20 has one terminal connected to plate power lead 22, and its other terminal connected via conductor 23 through the primary winding 24 of a radio frequency injector coupling transformer and thence via conductor 25 to the plate 26 of a radio frequency amplifier tube 27.

An oscillator tube 28 has its control grid 29 connected to a crystal oscillator unit 30, the plate 31 of this tube being connected to power lead 22 through the primary winding 32 of a coupling transformer tuned by condenser 33. The secondary winding of this coupling transformer connects at 34 with the ground 16 and at 35 to the control grid 36 of the R. F. amplifier tube 27.

The frequency of the trunking channel carrier afforded by the foregoing converter unit is determined by the crystal control means 30, and the voice frequency energy from the talking circuit is picked up at the jack terminals of the switchboard and impressed upon the trunking channel carrier through the modulator stage or tube 17.

The channel carrier, thus modulated, is impressed upon the main transmitting carrier through the injector coil secondary winding 24a (Fig. 3), there being a plurality of such injector coils 24b, etc., corresponding in number to the number of call channels and trunking carrier or sub-frequency channels used, preferably one hundred, as heretofore stated.

All the injector coils 24a, 24b, etc., are connected in parallel and feed into a channel mixer 42 via conductor 39, leading to the control grid 40 of the mixer tube, and conductor 39a leading to the cathode lead 41 of this tube. Mixer tube 42 has its output connected from its plate 38 and second grid 43 condenser-coupled via leads 44 and 45 to a wide-band amplifier 46, which in turn passes its output into the modulator unit, so-designated for impression upon the main carrier through the U. H. F. amplifier unit, and it should be observed here that a side band of this main carrier is cut-off by a side-band filter so designated ahead of the radiating antenna, in

order to reduce the overall frequency band (which would otherwise be occupied) to nearly one-half.

For purposes of illustration, a second channel converter unit is shown in Fig. 2 connected via conductors 11a to switchboard jack terminals 12a, and this unit has its output coupled through another of the injector coil windings 24c to the channel mixer, such converter unit being identical to that just described excepting that it is tuned, as by its oscillator crystal control unit 30a, to a frequency about 10 kilocycles away from the frequency of the first-described unit, so as to provide a second voice trunking channel distinct from the others, it being understood that addition converter units of this type are included in the actual installation for the transmitting side of the required one hundred trunking channels.

The same kind of converter means is employed for call channel purposes, one such channel unit being shown on Fig. 2 connected from a call signal control unit 8 at the switchboard via conductors 11x to the input transformer 13y for a call channel modulator tube 17a. The output of this call channel converter unit is coupled with the injector coil 24b (Fig. 3). Thus, a call channel carrier of 500 k. c., modulated by special call signals under control of the call coding device 8, as will be more fully explained hereinafter, is impressed upon the control station transmitter through the channel mixer stage 38 and associated instrumentalities, in the same manner as the voice-modulated trunking carriers.

In order to afford two-way communication for each trunking channel, there are provided, as shown in Fig. 2 (read with Fig. 3), a plurality of channel separators, which are essentially special individual receiving circuits provided with frequency converter means and certain control relay means, and respectively picking up their input energy from a master frequency converter 48 (Fig. 3), having its output connected via conductors 50 through the parallel primaries of a plurality of injector coils 51a, 51b, etc.

The master frequency converter receives energy from an U. H. F. receiving antenna 47, which is provided with metal shield means 47a to reduce the field strength of nearby mobile stations, and this incoming energy is passed through an amplifying stage 47b having its output coupled to a mixing and converting stage 48 via coupling transformer 48a. A crystal-controlled master oscillator 49 (tuned to 79 mc., for example) coupled via transformer 49a with the mixing converter stage 48, and the resultant intermediate frequency, including the mixed trunking carriers, is passed through coupling 49b and conductors 50 to the several injector coils 51a, 51b, etc., for selective distribution to the several channel converter units.

Considering the converter circuit for channel No. 1, for example, the mixed-frequency energy from the main control office master frequency converter is picked up by the winding 51 (Fig. 3) of the corresponding injector coil, amplified by radio frequency amplifier 51x, then coupled to the input of a converter 52 via conductors 53 and 54, the injector coil being tuned by condenser 55 for selective response to the incoming trunking carrier frequency of this particular channel.

Converter 52 includes an oscillator circuit including a parallel condenser and inductance 56 and feed-back coil 57, setting up local oscilla-

tions which beat with the incoming injector frequency, giving a resultant intermediate frequency which is passed via windings 59 (Fig. 3) and 60 (Fig. 2) of a coupling transformer and conductors 61 and 62 to the input of an intermediate frequency amplifier tube 64.

The output of the intermediate frequency amplifier is passed to coupling coil 66, from which it is transferred in part via tuned winding 67 to plate 68 and cathode 69 of a twin diode detector, and demodulated, this portion of the demodulated energy being coupled via drop resistor 70, condenser 71, conductor 72 to the control grid 73 of an audio frequency amplifier, and the amplified voice component is then transferred through output transformer 74 and conductors 75 and 76 to conductors 12x leading to the jack terminals of channel No. 1 at the switchboard.

Since there is a wide variation in the signal strength from the substations, automatic volume control (A. V. C.) is provided at the central station for each converter unit, such A. V. C. being derived from the drop across resistor 70 in diode circuit 68—69, and acting to vary the grid bias voltage applied to the preceding amplifier tubes 64, 52 and 51x.

A feature of the foregoing channel separator circuit is the "idle channel" signal control means, which includes (lower Fig. 2) a "busy" lamp 80 above the corresponding channel jack on the switchboard, one terminal of which lamp connects with power supply line 81, and the remaining terminal of which connects via conductor 82 to the normally open "make" contact 83 of the "idle channel" relay 84. The coil 85 of this relay is in series with plate 86 of the D. C. amplifier tube and the positive plate or "B" power supply line 87.

This "idle channel" relay 84 is actuated by the second diode unit of the detector, which includes tuned coupling coil 67a connected in a rectifying circuit with plate 68a and cathode 69a of the diode, the D. C. control component from which connects via conductor 88 to control grid 89 of the "idle channel" relay tube. If channel No. 1 is busy, relay coil 85 is energized through the plate circuit 86—87 by virtue of the control voltage applied to grid 89 from the diode detector circuit 67a, 68a, 69a, 88, causing contact 83 to "make" with its companion contact 83a and complete circuit to illuminate the "busy" lamp 80.

A further important function of the "idle channel" control relay circuit is the application or removal thereby of an "idle channel" buzz signal from source conductor 90, via conductor 91 and normally closed contacts 92 on the "idle channel" relay and through coupling condenser 93 to primary winding 74a of the output transformer leading to the channel jack 12. Thus, the "idle channel" buzz signal is normally applied by closed contacts 92 to the switchboard jack circuit, through transformer 74, and also via conductors 11 to the input side 13 of the corresponding channel converter unit, so that the "idle" signal is transmitted constantly over this channel so long as it remains idle; but so soon as the channel is seized or busy, relay coil 85 becomes energized to open contacts 92 and disconnect the "idle" tone, while at the same time closing relay contacts 83—83a to illuminate the "busy" lamp.

The circuit for additional channel separator units, such as that shown for channel No. 2, is identical to that just described for channel No. 1 excepting, of course, that the tuning components

thereof are principally resonated to the particular frequency of channel No. 2.

Subscriber station equipment

Considering now Figs. 4 and 5 together, the receiving equipment at the substation consists generally of a superheterodyne type circuit with a demodulator for the modulation band, and certain automatic call selector, filter and switching means.

The broad band carrier with its mixed trunking or sub-frequency carriers is picked up by the antenna 100 (Fig. 4) and passed through input coupling means 101 to a conventional U. H. F. amplifier stage 102, whose output is transferred via coupling transformer means 103 to the input leads 104, 105 of an U. H. F. frequency converter stage 106, and the output of this stage is passed via conductor 108 and a tuned coupling unit 108b to the input side of a first intermediate frequency amplifier 109, which in turn passes its output to the input of a second intermediate frequency amplifier 110 through a tuned coupling unit 110b.

The mixed channel trunking carriers are next passed via conductors 115, 116 to a diode detector, which delivers the mixed modulated side bands of channel trunking carriers to a special tuning radio frequency converter 118 through coupling 117. This converter by beating selectively variable frequencies generated by its own tunable oscillator circuit 119 with the output of the diode or second detector in coupling circuit 117, makes possible the selection of a particular one of the trunk carriers, and to this end, coupling circuit 117 is provided with a variable condenser 117a, which is ganged with a variable condenser 119a of the converter oscillator circuit for joint tuning by connection with a drive shaft 120 actuated by channel tuning motor 121 through reduction gear means 122.

Any trunking carrier frequency selected by the aforesaid converter means, is demodulated and amplified as to its voice component in a combination detector and amplifier 125 having detector diodes 126 and cathode 127 connected to the converter output via conductors 128, 129, a sharply tuned band filter circuit 130 being inductively coupled with circuit 129 to the output or plate circuit 118a of the converter. The rectified component in the diode plate circuit is impressed upon a control grid 131 in tube 125 via a potentiometer 132, thus controlling the amplifier current flow to plate 133, this plate circuit being coupled via transformer 134 and conductor 135 to the telephone receiver of the sub-station hand-set, as will presently be explained.

Automatic volume control is provided for the converter 106 and intermediate frequency amplifiers 109, 110, by the drop across resistor 116a in the cathode lead of the diode detector, from which the bias voltage is passed via filter resistor 105a, conductors 105, 104 to the control grid of the converter, and via conductors 108a and 110a, respectively, to the control grids of the two intermediate frequency amplifiers.

The voice frequency output of the detector-amplifier 125 is also impressed, via conductor 140 upon the grid 141 of a buffer stage 142 (Figs. 4 and 5 together) for the purpose of energizing certain call selector means, which includes a plurality of tuned band pass filter circuits generally indicated at 144, and numbered serially from 1 to 5, all in series via conductor 145 with plate voltage supply lead 146.

Each of the individual call selector filters 144 is connected to one of the contacts numbered serially from 1 to 5 on a stepping switch generally indicated at 147, and having a movable wiper contact 148 adapted to be rotatively stepped by a ratchet mechanism 149 into engagement with any of said contacts. The stepping switch wiper contact 148 is connected via condenser 150 to the grid 152 of a selector relay tube 153, which has the coils 155a, 155b, of a slow and fast relay in series with its plate 154 and plate voltage supply lead 146 for control of the stepping ratchet mechanism.

Calling of subscriber stations is effected by transmission of a series of coded or predetermined call signals at audio frequencies, and the first three of the call filters 144 are each peaked or sharply tuned to one of these frequencies. For example, the filter connected to contact #1 may be peaked at 300 cycles, filter #2 at 492 cycles, and filter #3 at 2750. Ten frequency intervals are considered practical for such a call filter system, and will afford possible combination and permutation groupings of frequencies taken three at a time, which will give 1000 call signals each consisting of three consecutive call frequencies.

The subscriber stations are preferably each assigned a call number consisting of digits or groups of digits from 1 to 9 and zero, and to each such call digit (inclusive of zero) is assigned a particular audio frequency for selective signalling purposes. In one arrangement, the digits are assigned the frequencies tabulated hereafter:

	CYC.
1 -----	300
2 -----	384
3 -----	492
4 -----	628
5 -----	803
6 -----	1025
7 -----	1310
8 -----	1680
9 -----	2150
0 -----	2750

Assuming, by way of example, that the assigned call of a substation were "130," the operator would set up the digits 1-3-0 on a call coding device (8 in Fig. 2) hereinafter more fully referred to, and would thereby cause the call channel carrier to be modulated by three successive signals, the first of which would be at 300 cycles, the second, at 492 cycles, and the third at 2750 cycles.

If the substation illustrated in Fig. 5, particularly, were intended to respond to such call, filter #1 in group 144 would be peaked or tuned to the frequency of the first call signal or 300 cycle; filter #2 at 492 cycles; and filter #3 at 2750 cycles.

A call signal at 300 cycles would be sufficiently passed through filter section #1 to impulse the grid 152 of the selector relay tube and cause a current flow through the windings of slow and fast relays 155a, 155b, and such energization of the latter relay would effect closure of fast relay contacts 156 to energize the selector switch ratchet magnets 157, causing ratchet pawl 149a to advance the ratchet and associated contact arm 148 to contact #2, thus connecting filter #2 in the grid circuit of the selector relay tube 153.

The next incoming call signal, being at the proper frequency of 492 cycles, will be passed by filter #2 to cause another impulsing of the slow

and fast relays, so as to effect advance of the selector switch contact arm 148 to contact #3; and the next call signal at 2750 cycles will pass filter #3 to cause a further advance of the selector contact arm 148 to contact #4 in the same manner.

It may be pointed out at this juncture that the function of the slow-acting relay, which is of the slow-to-release variety, is to control the locking of the ratchet mechanism to prevent return of the wiper contact arm 148 to normal or starting position by its spring 149b so long as proper call signal impulses continue to be received and corresponding impulses traverse the plate circuit of relay tube 153. This is accomplished by reason of the fact that each call signal impulse which actuates the ratchet relay to advance the selector switch, also effects closure of slow relay contact 159 to energize locking magnet 160 from the main power source or battery 219, via conductor 158, said contact 159, conductor 161, resulting in attraction of locking dog 164 to engage the ratchet means 149 so that the latter is held against retrograde movement to starting position by spring 149b.

Since relay 155a is slow to release, it will tend to hold up and lock the ratchet mechanism against return so long as the call signal impulses continue to come in in proper sequence.

However, should an improper call signal traverse the filter means 144-145, the selector relay tube 153 would fail to deliver further impulses to the relays 155a, 155b, and slow relay 155a would release, breaking the circuit to holding magnet 160 at contacts 159, allowing locking or holding dog 164 to be withdrawn by its spring 164a, so that spring 149b would restore the selector contact arm 148 to starting position.

When the contact arm 148 arrives at contact #4, cam 169, among other things, closes contacts 162a. The purpose of this is to hold up the selector switch at position 4 while the "idle" channel test goes forward.

Driven jointly with the selector switch wiper 148 by drive shaft 168, is a switch cam 169, which normally rests upon and closes motor control normalizing contacts 170a to energize channel tuning motor 121 through motor control means 175 for operation to normal or starting position, via conductors 170-172, said motor being reversible, the control means 175 for this motor being described in detail hereinafter in connection with Fig. 6.

When the call selector stepping switch moves to position #4, as by reception of the proper sequence of call signal frequencies, cam 169 closes contacts 173 and energizes the tuning motor in the reverse direction via conductors 170-171 and control means 175, hereinafter explained, and the gang tuning condensers 117a, 119a, 203, begin progressive tuning of both the substation receiver and transmitter over the trunking carrier frequency range, as heretofore described. When an idle channel is tuned in (modulated as heretofore explained by the "idle channel" buzz signal) which is of a predetermined characteristic frequency, for example, 200 cycles, to which call filter #4 is tuned, then the selector relay 155b will be actuated again to cause the stepping switch to advance to position #5, thus causing cam contacts 173 to open and stop the channel tuning motor 121 with the gang condensers tuning the receiver and transmitter to the frequency of the idle channel over which the "idle channel" buzz tone was thus received.

At position #5, the stepping switch cam 169 will close contacts 176, causing energization of the station transmitter via conductors 177, actuating power relay 178 to connect power through contacts 178a from the line to the transmitter power pack 179 (Figs. 4 and 5), so that the substation transmitter (Fig. 4) is conditioned for operation. In addition, cam 169 at position #5 also closes contacts 180 to energize the automatic station identification transmitter motor 182 via conductors 181. As in position 4, contacts 162b keep the locking magnet 160 energized and prevent falling back of the selector.

The automatic station identification transmitter shown is of the magnetic tape type, in which a magnetizable wire loop 183, on which is magnetically impressed a vocal (or other) recording of the identification call or "telephone number" of this particular station; and this wire loop is driven, by drive wheels 183a and motor 182, through the field of a pick-up coil 184, which causes the station transmitter to be modulated with the call identification recording via microphone lead 185.

At this juncture the substation transmitter may be conveniently described. Apart from the novel channel tuning means, this transmitter may be of conventional U. H. F. design, including (Fig. 4) a microphone input transformer 186 controlling voice input amplifiers 187, 188, coupled by modulator input transformer 189, to a pair of modulator tubes 190, 191, whose output is impressed upon the antenna coupling coil 193a through modulation transformer 192 to modulate the U. H. F. output of the transmitter power amplifier stage 193. The remaining transmitter instrumentalities include an oscillator 194, tuned by a crystal control unit 195, and having its output frequency modified by a frequency multiplier stage 196, the resultant frequency being subject to variation over the range of the trunking carrier frequencies in an U. H. F. converter stage 197, which controls a driver stage 198 ahead of a power amplifier stage 193.

The transmitter channel tuning means includes (Fig. 4) a variable oscillator 200 having a plate inductance 201 coupled with a grid inductance 202 tuned by a variable condenser 203 which is driven from the channel tuning motor drive shaft 120, along with receiver condensers 117a, 119a. The output of this channel tuning oscillator is passed via conductor 204 to injector grid 197a in the U. H. F. converter stage to produce a selectively variable resultant transmitter frequency corresponding to the several trunk carrier frequencies.

Resuming the foregoing description, wherein the call signal step switch had come to rest at position #5, in which the transmitter power pack was energized by relay 178, as described, and the automatic station identification transmitter started, consequent upon the reception of the proper incoming call code signals, with the result that the subscriber's transmitter would then be radiating at one of the idle trunking carrier frequencies determined by the aforesaid channel testing operation. The reception of this trunking carrier frequency (assume it to be that of channel #1) at the control exchange (Fig. 2) causes the D. C. "idler channel" relay means 84-85 to close contacts 83, 83a, illuminating lamp 80 at the switchboard to show the trunk channel "busy," at the same time opening contacts 92 to remove the free or "idle channel" buzz signal from this channel.

Upon ascertaining the call number of the station answering over this channel by listening to the call emitted by the station identification means 183-184, to determine if the proper station is answering, the operator interconnects the calling and call stations at the jack terminals and closes a "go-ahead" signal switch 208 (Fig. 2) connecting a "go-ahead" tone of distinct frequency, for example, 100 cycles, momentarily to the central station transmitter from tone source line 209 via one of the jack contacts 12y.

The "go-ahead" tone received at the called substation (Figs. 4 and 5) will be passed by selector filter #5 to contact #5, causing the step switch to advance to position #6 in the manner heretofore described, at which cam 169 will close contacts 212 across conductors 177 to hold up the power supply relay 178. Cam 169 will at this sixth position also close contacts 135a, connecting the audio output of the receiver amplifier from line 135 to the station telephone receiver at terminals 135b. Cam 169 at this position will also close contacts 215, energizing the station signal or buzzer 218 via conductors 216 and main battery or power source 219 through the normally closed telephone set contacts 217, which will open to stop the signal 218 when the subscriber lifts the set to answer. In addition, contact 162c is closed and keeps locking magnet 160 energized.

Lifting of the telephone set to answer also closes transmitter microphone contacts 220 at the phone set, so that the microphone of the latter is connected with the transmitter at terminals 221, 222 to conductor 185.

When the telephone hand-set is lifted to answer the call, the cradle plunger 225 (Fig. 5) rocks lever 226 thereby causing arm 227 to move downwardly to rotate wheel 228 in a clockwise direction. During the clockwise rotation of wheel 228 the upper end of arm 190a is engaged by a cam projecting from the face of wheel 228 and is moved thereby towards the shaft 168. When wheel 228 is fully rotated this cam passes beyond the tip of arm 190a permitting it to restore to normal. When the call is finished and the hand-set is restored, wheel 228 is rotated counterclockwise by arm 227. During the return movement of wheel 228 the upper end of arm 190a is again engaged by the cam projecting from the face of wheel 228, but this time arm 190a is moved away from shaft 168 causing contacts 190 to open and release locking magnet 160 so as to permit shaft 168 to be restored by spring 149b. When wheel 228 reaches its normal position the cam projecting therefrom passes beyond the tip of arm 190a permitting it to restore and reclose contacts 190.

Should the call be outgoing from the substation shown in Fig. 5, the subscriber lifts the hand-set in the usual manner, which sets the selector switch on position #4 through the agency of levers 225, 226, 227 turning wheel 228 so that dog 229, which is engaged in ratchet tooth 230a, will turn the ratchet 230b and cam 169 to position #4; causing the channel tuning motor to start the testing operation for an idle channel, which, when located, will by its idle tone, cause the selector switch to be advanced to position #5 in the manner explained, energizing the transmitter and signalling the central exchange operator as heretofore described.

In Fig. 6 are shown details of the motor control unit 175, wherein a common lead 170 from battery 250 is connected (in Fig. 5) through cam 75 switch contacts 173 and conductor 171 to close

an operating circuit for a "forward" relay 251 via normally closed starting position contacts 253 and conductor 254 to battery 250. This circuit actuates "forward" relay 251, energizing motor starting coil 255 via conductors 256, contacts 257, 258, closed, with power line contacts 259 on this relay, which also serves to close its contacts 260 to energize the main motor field coil 261 via conductors 262 from the same power line, at the same time, thus starting motor 121, which rotates the gang condenser drive shaft 120 slowly through reduction gear means 122.

Energization of the main motor coil 261 as aforesaid also simultaneously energizes the solenoid 263, in shunt therewith, of a brake 264, which is normally urged by spring 265 against brake drum 266 on the motor shaft, to hold the latter against rotation. As soon as the "forward" relay coil circuit is de-energized, the solenoid 263 is likewise de-energized and brake 264 drops back instantly and stops the motor 121 and the associated rotors of the gang tuning condensers 117a, etc.

When the gang condensers are disposed at starting position, tuned to the call channel, an end-position cam arm 267 on shaft 120 holds the starting switch contacts 253 closed at 268, but as soon as the shaft begins turning the condensers through the tuning range, contacts 253 open and their circuit is shunted via conductors 254, 269 and toggle switch contacts 269a held closed by toggle 270, so that the "forward" relay will hold up until the condenser rotor drive shaft 120 is turned through the entire tuning range (assuming it does not stop for an idle channel beforehand), whereupon the cam arm 267 will trip toggle 270 into the opposite position, thus opening "forward" relay shunt contacts 269a and dropping out this relay 251.

Such action of the toggle closes reverse supervisory contacts 272, closing circuit via conductors 273 from battery 250 to one terminal of the reverse relay 274, the power circuit from battery 250 being completed via conductor 254, toggle switch contacts 275 closed, conductor 276 to the remaining terminal of the coil of relay 274. Also, conductors 254 and 276 are shunted by contacts 277 closed (as by cam arm 267 leaving starting position) to complete the carry-over necessary to permit cam arm 267b to pass the toggle as it approaches normal starting position after reversal, cam arm 267 opening the shunt supervisory contacts 277 when the drive shaft, and hence cam arms 267, 267b, actually reach starting position.

Assuming that the reverse relay 274 has been energized as aforesaid, reversal of the motor is effected through closure thereby of contacts 280, power line lead 281, conductor 282, for the main motor winding, and power line lead 283, contacts 284 closed, conductor 285, coil 255, conductor 285a, contacts 257' closed to power lead 281, for the starting coil 255.

It will be observed that alternate forward and reverse motion of the tuning motor 121 will continue so long as contacts 173 at the selector switch (Fig. 5) remain closed, as in the case where no idle channel is encountered during the first tuning transit of the gang condenser means in testing for an idle channel.

However, should selector cam 169 (Fig. 5) be restored to starting position, to close contacts 170a, then circuit would be closed through conductors 170, 172, relay 274, and either toggle switch contacts 275 closed, or supervisory start-

ing position contacts 277 closed, whichever of said contacts 275, 277, happened to be closed at the time, since they open and close in reverse relation, whereby the motor will always be stopped at its normal starting position whenever cam contacts 170a (Fig. 5) are closed, as by return of the call signal selector means to normal starting position.

In Fig. 7, there are disclosed certain details of the automatic, central exchange, call coding transmitter which is generally indicated at 3 in Fig. 2. This device includes a plurality of audio frequency signal tone sources, 300, 300a, 300b... 300i, there being ten such tone sources corresponding to the ten digits (counting zero as a "digit"), each generating a call signal frequency ranging from 300 cycles to 2750 cycles, as heretofore explained.

One output terminal of each signal frequency generator aforesaid is connected in common to one of the two call channel leads 11x. The remaining tone source output leads 300x, 300ax... 300ix, each terminate in a corresponding set of brush contacts 302, 302a, 302b... 302i, all carried on a bail 303, which in turn is shiftably carried on a rock shaft 304, urged into the normal position shown by spring means 304a, wherein each of the said brush contact sets 302, 302a, etc., is shifted axially of the rock shaft (toward the left, Fig. 7), with respect to a corresponding number of operating cams 305, 305a... 305i, arranged in three horizontal rows or sets on an arcuate mounting panel 308, such that each brush contact, when aligned as heretofore explained, can engage any one or all of three cams disposed along its arc of travel.

In the normal position shown in Fig. 7, the brush contacts 302, etc., are shifted or offset with respect to their respective columns of cams 305, 305a, etc., so as not to engage the latter when the rock shaft 304 is rocked downward, by depressing handle 309, but when said handle is released by the operator, spring 304a urges shaft 304 in an anti-clockwise (upward) direction.

The bail 303 is coupled to the rock shaft by pin means 310 engaging in spiral grooves or worm tracks 311 on the shaft, so that downward or clockwise motions of the shaft tend to shift the pins 310, and hence bail 303, and hence brush switches 302, etc., toward the left out of alignment with cams 305, but upon reverse or upward motion of the shaft, the worm coupling 310-311 shifts the bail and contacts back into alignment with the cams.

The cams 305 consist (Fig. 8) essentially of arcuate shoes carried on plungers 312, normally urged by individual springs 313 to raised position with shoes or cams 305, etc., out of the path of the corresponding brush contacts 302, etc.

By depressing any of the plungers 312, the same will be locked by a catch 314 in the slot 315 of a lock bar 316, which is shiftable laterally of the axis of the plungers against its normalizing tension spring 317.

As depicted in Fig. 8, there are three of the same digits, "1," "2," etc., shown in each column of keys or plungers, as indicated on the knobs 318, 318a, etc., there being ten digits (inclusive of zero) in each horizontal row across the unit, and three of the same digits in each vertical column, from which selection of numbers, as heretofore stated, one thousand combinations of three digits at a time may be made.

After a call number has been set up on this coding device, the plungers may be normalized

or released by depressing a clearing button 320 (Fig. 8) having a non-latching cam nose 321 which engages edge 322 of a corresponding slot to shift the latch bar 316 to the left and free all depressed plungers.

Operation

The exemplary installation shown in the drawings, particularly Fig. 2, contemplates 100 trunking channels, and one call channel, and therefore there would be provided 100 channel converter units each identical (excepting as to operating frequency) to the converter units shown to the left of the input transformers 13, 13x, in Fig. 2. In addition, there will be at least one more such channel converter for call signalling purposes to transmit substation call signals from the coding device 8 at the switchboard via conductors 11x and input transformer 13y to modulate the frequency of the call channel carrier.

In addition to the aforesaid channel converters, there will be individual receiving circuit units called "channel separators" corresponding in number to the number of channel converter units, not counting the call channel converter.

Each channel converter provides a transmitting channel, and has a corresponding channel separator unit, providing a receiving channel, looped in with it to the same switchboard jack terminal.

The frequency of the call channel is selected at 500 kc., and the remaining 100 channel converters operate on frequencies separated by an interval of 10 kc. (see Fig. 1). Thus, channel No. 100, for example, would operate at 510 kc., channel No. 99 at 520 kc., and so on, so that channel No. 1 would accordingly operate at 1500 kc.

The operating frequency of each channel separator unit is likewise separated from the other by a frequency interval of 20 kc., and, as depicted in Fig. 1, channel separator unit No. 100 may operate at 1000 kc., channel No. 99 at 1020 kc., and channel No. 1, accordingly, at 2980 kc.

The control link station operator plugs the usual telephone set into any of the jacks 12 and is thereby connected for two-way communication over the corresponding channel converter and separator section of any of the 100 trunking channels.

If it is assumed that a regular non-mobile telephone station has called in for connection to a mobile substation whose assigned call number is 130, the central operator sets up the number by pushing the plunger knob 318 numbered "1" in the lower or "hundreds" column on the call selector shown in Fig. 7, and in the "tens" row the knob numbered "3" is depressed, and finally in the "units" or top row the knob numbered "0" would be depressed, thus lowering the corresponding operating cams generally indicated at 305 into operative position, whereupon the operator would pull handle 309 (Fig. 7) downward and release it for return by spring 304a at a rate regulated by conventional governor means 325.

The return motion of the associated shaft 304 shifts the brush contact bail 303 to the right so that the brush contacts generally indicated at 302 will be operated by engagement with such of the cams 305 as have been depressed by the operator. In this example, the brush switches corresponding to the frequencies assigned to the call numbers 1-3-0 would be so actuated in succession, connecting tone momentarily from the tone sources 300 via conductors 300x, brush contact 302 to leads 11x which connect with input

transformer 13y (Fig. 2), thereby modulating the call channel converter with a first call signal tone at 300 cycles.

As the bail 303 continues its upward movement, brush switch 302a would then momentarily connect tone from source 300a via conductor 300ax to the call channel input leads 11x, so that the call channel converter would transmit a signal at 492 cycles, and finally brush contact 302i would be actuated to connect tone from source 300i via conductor 300ix to leads 11x, causing a call signal at 2750 cycles to be transmitted.

Referring to Fig. 2, the foregoing call signal frequencies would be impressed in succession upon the 500 kc. call carrier generated by the call channel converter associated with leads 11x, and the call carrier, thus modulated, would be impressed in turn (Figs. 2 and 3 read together) upon the central station U. H. F. transmitter through the injector coil 24b, channel mixer 42, wide-band amplifier 46, modulator 46a, and thence upon the main U. H. F. carrier through the U. H. F. amplifier designated in the block diagram.

All mobile substations being tuned to their normal stand-by call channel of 500 kc., the main carrier would be received and demodulated by the means heretofore described, at all stations, and the call signal frequencies ultimately caused to traverse the filter circuit means 144 (Fig. 5) at each such substation.

Assuming that filters 144, numbered 1-2-3 in Fig. 5, were peaked or tuned to audio frequencies at 300, 492, and 2750 cycles, respectively, then the selector tube 153 would have its grid 152 excited by three successive call signal impulses, the first of which would cause relays 155a, 155b, to pull up at once, but whereas relay 155b would quickly release at the cessation of such first impulse, relay 155a, being slow to release, would tend to hold up long enough for the next or second signal impulse to arrive. Meanwhile, actuation of relay 155b would energize ratchet magnets 157 to advance the ratchet means 149 one step, causing contact arm 148 to lodge on filter contact #2.

If the second call signal is of proper frequency to pass filter #2 and arrives at its properly timed interval, before relay 155a has had time to release, then both relays 155a, 155b are again impelled, causing slow relay 155a to continue to hold up, and causing the ratchet mechanism to advance contact arm 148 to filter contact #3.

When the slow relay 155a first pulls up, its contacts 159 energize the locking magnet 160 to pull locking dog 164 into locking position so that the ratchet mechanism cannot return to normal position. If, however, the second or third call signal impulses are not properly received thereafter, as explained, then relay 155a releases, de-energizing the locking magnet 160 so that spring 164a restores the locking dog and frees the ratchet means 149 for return to normal starting position by spring 149b.

Assuming that the three call signal impulses are, however, properly received, the selector arm 148 will be lodged upon contact #4, and selector cam 169 will close contacts 173, thus energizing the "forward" tuning motor relay 251 (Fig. 6) via conductors 170-171 thus connecting power to the starter and main windings 255, 261 for motor 121 at relay contacts 257, 258, 260, whereupon gang condenser shaft 120 rotates the rotors of

condensers 117a, 119a, 203 (Fig. 4), thus progressively tuning both the transmitter and receiver of the called substation over the trunking frequency range, as heretofore explained in detail. Meanwhile, locking magnet 160 holds up by closure of cam contacts 162a and relay contacts 159a on the slow relay.

At the central office (Fig. 2), "idle channel" tone from source conductors 90 is impressed via conductor 91 and relay contacts 92, normally closed, condenser 93, transformer windings 74a, 74, upon the drop or jack connections 75—76 for channel No. 1, and consequently upon the input transformer 13 for the corresponding channel converter, and filter #4 (Fig. 4) at the substation being tuned to the frequency of this "idle" tone causes the selector relay tube to be excited so that relays 155a, 155b are again impulsed, resulting in a further advance of contact arm 148 to contact #5, at which position cam contacts 173 are again open, dropping out the "forward" motor relay 251 (Fig. 6), stopping motor 121 instantly, through the agency of brake 264, whose solenoid winding 263 is de-energized at this time since it is in parallel with motor winding 261.

Thus, the substation is now tuned to an idle trunking carrier frequency.

As a result of cam 169 (Fig. 5) reaching fifth position as aforesaid, cam contacts 176 are now closed, connecting power via conductors 177 to energize transmitter power relay 178, closing contacts 178a to connect power to the transmitter power pack 179, thus conditioning the substation transmitter for operation. In addition, the closing of contact 162b keeps the locking magnet energized and locks the selector in position 5.

Cam 169 also at this time closes cam contacts 180, energizing motor 182 of the automatic identification transmitter via conductors 181, and this causes the magnetic recording loop 183 to be passed through the field of pick-up coil 184, so that the substation transmitter is modulated with the recorded identification data via microphone lead 185, input transformer 186 (Fig. 4) and the associated amplifying and modulating stages 187, 188, 190, 191 for impression of the identification recording on the trunking carrier generated by the oscillator means 194—198, and antenna coupling 193a, for radiation from the substation antenna.

The central link station operator receives the substation carrier over the channel separator unit No. 1 (Fig. 2) in this example, the trunking carrier being picked up by antenna 47, amplified through radio frequency stage 47b, mixed in converter stage 48 with the frequency of the master oscillator 49 to provide a first intermediate trunk carrier frequency, distinct from the other trunking carrier frequencies but still bearing the voice modulations from the identification device of the substation.

The aforesaid intermediate or trunking carrier is then transferred via injector coil 51a to the converter stage 52 for channel No. 1, providing a further intermediate frequency which is amplified in stage 64, demodulated in diode circuit 67a, 68a, 68, and the D. C. component of the rectified carrier impressed upon the grid 89 of the "idle channel" relay tube (Fig. 2).

As a result of voltage thus applied to relay tube grid 89, "idle channel" relay winding 85 is energized, causing contacts 92 to open, lifting the "idle" tone from the channel, and closing contacts 83, 83a, to illuminate "busy" lamp 80 via

conductor 82, thus signalling the central operator that a call is incoming, whereupon the operator plugs in on channel No. 1, listens to the identification data, which will preferably be a vocal recording of the substation call number, in this example "1—3—0," and thereby ascertains that the proper station has responded. The trunk carrier is demodulated to deliver the voice component to the jack terminals by the diode circuit 67, 68, 69, and transferred via condenser 71, conductor 72, to grid 73 of the audio amplifier tube whose output is connected through transformer means 74—74a to the jack terminals 12.

The central station operator having thus determined that communication is established with the proper substation, interconnects the calling and called stations at the jack terminals and closes switch 208 at the switchboard, thus connecting a "go ahead" or connecting signal of audio frequency from source conductor 209 via jack contact 12y to the input leads 11 of this channel, and this frequency passes filter #5 (Fig. 5) at the substation, causing the selector contact arm 148 to be advanced to sixth and final position.

When thus advanced by "connecting" tone, the selector switch contacts 212 shunt the contacts 176 (now open again) to hold up the transmitter power relay 178, contacts 135a connect the hand telephone set receiver with the output of the audio-detector amplifier stage 125 via conductor 135, and terminal 135b while contacts 162c shunt contacts 162b and contacts 215 close an operating circuit, through telephone set contacts 217, normally closed, to the signal or buzzer 218 to summon the subscriber, who lifts the instrument, causing contacts 217 to open and stop the buzzer, as an incident to raising cradle plunger 225, which also actuates selector switch levers 226, 227, without effect at the time, since notch 230a on ratchet wheel 230b is away from dog 229. However, clockwise motion of lever-wheel 228 upon lifting of the hand-set, brings the cam projecting from the face of wheel 228 into position relative to the arm 190a so that when the hand-set is finally restored and cradle plunger descends, lever-wheel 228 will rotate anti-clockwise, causing this cam to operate arm 190a to the right to open contact 190 temporarily and thereby de-energize the locking magnet 160. Locking dog 164 is retracted by spring 164a and the selector returns unopposed to position 1.

As a further incident to raising of the cradle plunger 225, microphone contacts 220 close, connecting the hand-set microphone at terminals 221, 222 in circuit with microphone lead 185. The called subscriber is now ready to talk.

When the substation hangs up by reseating the hand-set to depress cradle plunger 225, the lever means 226, 227, 228, 229 will reset the selector cam to starting position as heretofore described, normalizing or restoring all circuits theretofore set up, and closing tuning motor normal contacts 170a to actuate the motor reverse relay 214 via conductors 170, 172, causing a return of the gang condensers to starting position with the substation receiver tuned again to the call channel frequency of 500 kc.

Channel No. 1 will again be designated "idle" by extinction of "busy" lamp 80 and application of "idle" tone to this channel by dropping out of "idle channel" relay 84 (Fig. 2) opening contacts 83, 83a, and closing contacts 92.

In the event the substation initiates the call, raising of the hand telephone set actuates (Fig.

5) lever means 225, 226, 227, wheel 228, to cause dog 229 to engage in notch 236a and rotate ratchet wheel 230b clockwise to move selector contact arm 148 and cam 169 to fourth position, at which cam switch contacts 173 close to start the tuning motor, under control of means 175, heretofore described, to test for an idle channel. Locking magnet 160 would also be energized through contact cam switch 162 to hold up the selector switch in fourth position by closure of contacts 162a.

The operation from this point on, goes forward as in the case of the call just previously described. When an idle channel is found, the selector switch advances to position "five," causing transmission of the identification data of this substation; the central operator, upon responding, effects transmission of the "connecting" signal by operating switch 208 (Fig. 2), which sets the selector and cam switch contacts to the condition of sixth position, and the substation is ready for communication with the central operator and any called station connected through the central board.

While I have illustrated and described the preferred form of construction for carrying my invention into effect, this is capable of variation and modification without departing from the spirit of the invention. I, therefore, do not wish to be limited to the precise details of construction set forth, but desire to avail myself of such variations and modifications as come within the scope of the appended claims.

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

1. In a communication system of the class described, in combination, an ultra high frequency transmitter and receiver, a plurality of channel converters generating a plurality of transmitting trunk carriers and each having operatively associated therewith a channel separator for receiving an incoming trunk carrier of frequency different from the corresponding transmitting trunk carrier, whereby each said channel converter and corresponding channel separator comprises means for two-way communication, means for modulating each channel converter individually with voice frequency energy, said channel separators including means for demodulating the trunk carriers received through said channel separators, means coupling said channel converters with said high frequency transmitter, means coupling said channel separators with said high frequency receiver, means cooperable with said channel converters for modulating the same with an "idle" signal, means controlled by the trunk carriers received by said channel separators for rendering said idle signal modulating means ineffective for the corresponding channel converter when the trunk carrier is received by the corresponding channel separator.

2. In a communication system, means for generating an ultra high frequency main carrier, means for generating a plurality of outgoing sub-frequency trunk carriers, their frequency being a small fraction of the main carrier frequency, and spaced approximately 10 kilocycles apart, means for modulating said trunk carriers with voice frequency energy, means for superimposing all outgoing trunk carriers upon said main carrier, means for receiving an incoming ultra high frequency carrier, means cooperable with said receiving means for selecting incoming trunk carrier frequencies at 20 kilocycle intervals within the range of said ultra high frequency carrier and for demodulating said incoming trunk car-

riers, means for modulating said main carrier with various call signal frequencies, and with an idle signal frequency, and with a connecting signal frequency, means for connecting an operator's telephone set selectively with one each of said outgoing and incoming trunk carriers in pairs for two-way communication thereover, together with substation apparatus including a transmitter and a receiver respectively adapted to operate at frequencies corresponding to any said pair of trunking frequencies, means for tuning said substation receiver and transmitter successively to any said pair of trunk frequencies, means actuated under control of said call signal frequencies received by the substation receiver for automatically tuning said substation receiver and transmitter to a pair of said trunk frequencies, one of which is modulated by said idle signal frequency, and means at said substation actuated under control of said connecting signal frequency received over one of the pair of trunk carriers to which the substation receiver is automatically tuned as aforesaid, for establishing connections at said substation for two-way communication over said pair of trunk carriers.

3. In a communication system of the class described which includes means for transmitting a plurality of outgoing trunk carriers and receiving a plurality of incoming trunk carriers, means modulating said transmitting trunk carriers with an idle tone, means coupling said outgoing and incoming transmitting and receiving means in pairs for two-way communication, indicating means associated with each said pair of transmitting and receiving means operable to indicate the same as "busy," and means under control of an incoming trunk carrier for effecting operation of the corresponding indicating means and rendering said idle tone modulating means ineffective for the corresponding outgoing trunk carrier when the corresponding incoming trunk carrier is received.

4. In a communication system of the class described which includes a broad-band ultra high frequency transmitter operable over a first frequency band, and a broad-band ultra high frequency receiver operable over a second frequency band different from the first band, the combination of a plurality of means generating a plurality of outgoing trunk carriers of distinct frequency, means for separately modulating said trunk carriers and modulating said transmitter with all trunk carriers, means cooperable with said receiver for selectively demodulating a plurality of incoming trunk carriers received thereby, means linking an outgoing trunk carrier generator means with an incoming trunk carrier demodulating means to provide two-way communication channels, means normally modulating outgoing trunk carriers with an "idle" signal, and means actuated by incoming trunk carriers to effect removal of the "idle" signal from the corresponding outgoing trunk carrier.

5. In a communication system of the class described, substation apparatus comprising an ultra high frequency receiver operable on a first frequency, an ultra high frequency transmitter operable on a second frequency different from the first, means for simultaneously tuning said receiver and transmitter to operate at any of a plurality of sub-frequencies differing respectively for the receiver and transmitter, means actuated by a combination of predetermined received call signals for starting said tuning means, means actuated by a predetermined received "idle" sig-

nal for stopping said tuning means, at a tuning frequency at which said "idle" signal was received; and means actuated by a predetermined received "connecting" signal for giving a signal at the substation.

6. A radio communication system comprising: a central station including an ultra high frequency transmitter and an ultra high frequency receiver each operating on a distinct ultra high frequency band; means providing a plurality of outgoing trunk carriers all superimposed upon said transmitter carrier, means providing a plurality of incoming trunk carrier demodulators each tuned to a frequency distinct from that of any outgoing trunk carrier and all energized from said receiver, means providing a call channel carrier superimposed upon the transmitter carrier, means modulating each outgoing trunk carrier with an idle signal, together with a plurality of substations each including a transmitter progressively tunable over the frequency range of said incoming trunk carriers, a receiver progressively tunable over the frequency range of said outgoing trunk carriers and said call channel carrier, means actuated by a call signal received at said substation at said call channel carrier frequency for starting said tuning means of the receiver and transmitters; means actuated by said idle signal received at the frequency of one of said outgoing carriers for stopping said tuning means of the receiver and transmitters with the substation receiver tuned to said last-mentioned frequency, and the substation transmitter tuned to the corresponding distinct transmitter frequency, means at the substation for modulating the transmitter thereof with station identification data automatically upon tuning by idle signal as aforesaid, means at said central station for transmitting a connecting signal at the frequency to which the substation receiver is tuned by said idle signal; means at said substation actuated by reception of said connecting signal to stop said identification modulation, to give a signal at the substation, and to connect said substation transmitter and receiver for two-way communication with said central station at the tuned frequencies determined by the idle signal as aforesaid.

7. Apparatus as defined in claim 6 in which said central station transmitter is further provided with means for modulating said first frequency with a plurality of sub-frequencies, and means for modulating the sub-frequencies with idle tone and connecting tone of predetermined frequency; and said substation apparatus is further characterized by the provision of means cooperable with said selective means responsive to the reception of said idle tone for actuating said selector switch means to still further advanced position to disable said tuning means of the receiver and transmitter with the substation receiver tuned to the sub-frequency at which said idle tone was received, and thereafter to effect still further advance of said selector switch means, responsive to reception of said connecting tone by said selective means, to connect said substation transmitter and receiver with substation telephone equipment for two-way communication thereover.

8. In a communication system of the class described including a central station receiver and a transmitter emitting a main carrier modulated by a call channel carrier and a plurality of sub-frequency trunk carriers each of the latter in turn modulated by an idle trunk tone, means for removing said idle tone, and means for modulat-

ing said trunk carriers with connecting tone, substation apparatus including: a transmitter, a local telephone set, receiving means tunable to the frequency of any said trunk carrier, means for tuning said receiver over the range of said trunk carriers, means including frequency-selective apparatus cooperable with said receiver and operable by reception of certain call frequencies over said call channel carrier for actuating said tuning means to start the tuning of said receiver over the range aforesaid and to stop said tuning means by reception of said idle tone over one of said trunk carriers, and means actuated by reception of said connecting tone to connect said transmitter, said receiver, and said telephone set for two-way communication with said central station at frequencies lying within the range of said main carrier, said substation transmitter at all times being tuned to a non-interfering frequency different from any frequency to which the substation receiver is tuned.

9. In an ultra high frequency carrier communication system, a central office ultra high frequency main carrier generator; means for generating and modulating a multiplicity of sub-carriers, means for modulating the main carrier with said sub-carriers; means modulating idle sub-carriers distinctively; substation apparatus including a tunable receiver and transmitter; modulation controlled means for starting a tuning operation of said substation apparatus to locate an idle sub-carrier; modulation controlled means for stopping said tuning operation when the substation apparatus is tuned to a said distinctively modulated sub-carrier; means operating automatically at the substation to transmit an identifying signal to the central office when said tuning operation is stopped as aforesaid; modulation-controlled means at the substation for interrupting said signal transmission and giving a subscriber's signal; and means at said central office for modulating said sub-carriers with control modulations for actuating the aforesaid modulation-controlled means.

10. Improvements in communication systems of the class which include a central office ultra high frequency emitter and receiver modulated with sub-frequencies to provide a multiplicity of two-way communication channels with mobile and fixed substations, said improvements comprising: substation transmitting and receiving apparatus including means for tuning said apparatus over the frequency range of said channels, means normally tuning said apparatus to a call frequency channel, means actuated by signals over said call channel for setting said tuning means into operation, means actuated by idle signal on a selected idle communication channel to which said substation apparatus becomes tuned as aforesaid for stopping said tuning means with the substation apparatus tuned to said last-mentioned channel; means actuated automatically upon stopping of the tuning aforesaid to effect transmission of an identification signal from said substation over said selected channel; central-office controlled signal means for stopping transmission of said identification signal and giving an incoming call signal at said substation and for further conditioning said substation apparatus for two-way subscriber communication over said selected channel; means at said central office for impressing an idle signal on all idle channels; means at said central office providing at least one said call frequency channel; and means at said central office for impressing on a said call chan-

nel signals as aforesaid for starting said substation tuning means.

11. In a communication system employing ultra high frequency carrier with sub-frequency, trunking carriers thereon, improvements comprising: central office means modulating idle trunking carriers with an idle signal; substation transmitting and receiving apparatus tunable to any said trunking carrier; substation means actuated by predetermined call signal from said central office for tuning said substation apparatus successively to each said trunking carrier; substation means for automatically causing said substation apparatus to remain tuned to the first idle signal encountered during said successive tuning; and substation means for automatically signalling over said last-mentioned trunking carrier seized by the substation as aforesaid to designate at the central office which trunking carrier has been seized by the substation.

12. Improvements as defined in claim 11, further characterized by the provision of means at said substation for initiating said tuning operation at the substation to seize an idle trunking carrier, for actuating said designating means, and for transmitting a substation identifying signal over said seized carrier to the central office.

13. In a radio communication system, a plurality of stations each having receiving means tunable to any one of a plurality of communication channels, the receiving means of each station being normally tuned to a call signal channel, a further station having means for transmitting a marking signal over one of the communication channels and having means for transmitting a signal, characteristic of one of the first stations, over the call signal channel, means controlled by the receiving means at the station corresponding to said characteristic signal and responsive thereto for causing the receiving means thereat to scan the plurality of communication channels, said last means being responsive to the marking signal transmitted over said one channel by said further station for stopping the scanning of the communication channels by the associated receiving means when said one channel is reached.

14. In a carrier wave communicating system, means for generating and radiating a main ultra high-frequency carrier, a plurality of channel converters and a plurality of channel separators connected in pairs, each channel converter producing a different sub channel carrier frequency and having means for modulating the main carrier therewith, a wide band receiver adapted to receive a second ultra high-frequency carrier modulated by still different sub channel carrier frequencies, said channel separators coupled to said receiver and means for connecting each pair of converters and separators in connections whereby simultaneous two way transmission may be had over the main carrier modulated by any plurality of its sub channel carrier frequencies, and over the second ultra high-frequency carrier modulated by its different sub channel carrier frequencies.

15. In a radio communication system, a main

station and a plurality of substations, a plurality of transmitting and receiving channels at the main station, each transmitting channel producing a different carrier frequency from the others and each receiving channel tuned to a different carrier frequency from the transmitting channels, a pair of transmitting and receiving channels at each substation, means at each station responsive to a particular signal transmitted from the main station over one of the transmitting channels to successively tune the transmitting and receiving channels thereat in steps, each step tuning said last channels to one of the transmitting and one of the receiving carriers of the main station, means in the substation responsive to a particular signal over one of said carriers for stopping said tuning means when tuned to a pair of said carrier frequencies corresponding to a transmitting and receiving channel of the main station and for indicating in the main station the pair of channels selected, and means in the main station for thereafter completing a communication channel between said main station and the selected substation over the selected pair of channels.

16. In a radio communication system, a central office, a plurality of substations, a plurality of communication channels in the central office, each channel including a path over which a carrier of a particular frequency is transmitted and a receiving path tuned to a carrier of another frequency, the frequencies of each channel differing from each other channel, means at each station for selecting any one of said channels and signaling the central office thereover, means at the central office for establishing a connection to another substation over any other of said channels and for linking the two channels at the central office to provide a two way conversation link from the first to the second substation including both of said channels.

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