

[54] TRANSMITTER-RECEIVER SYSTEM

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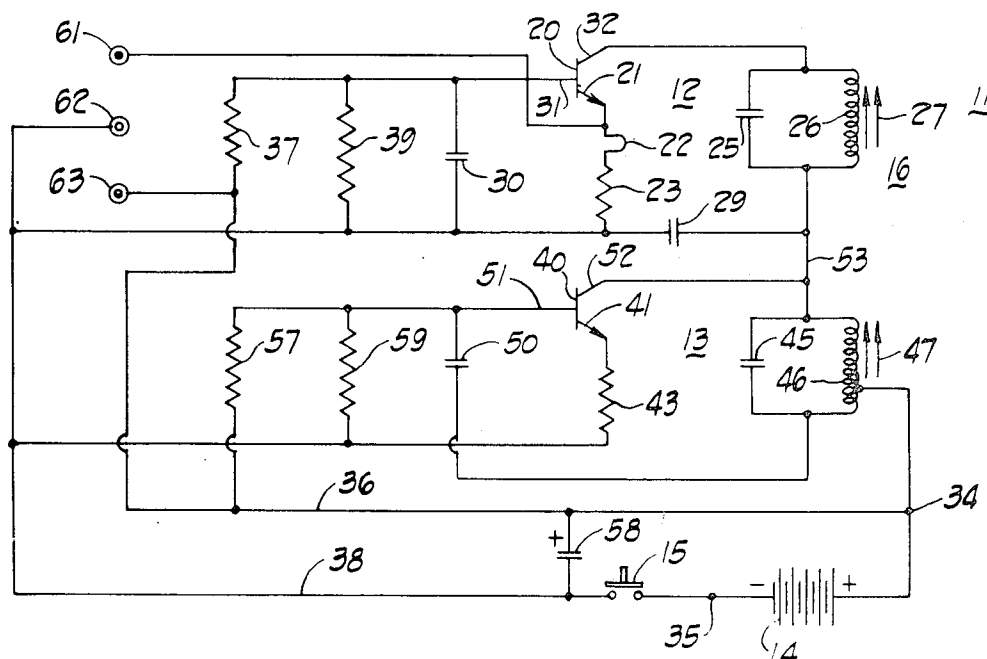
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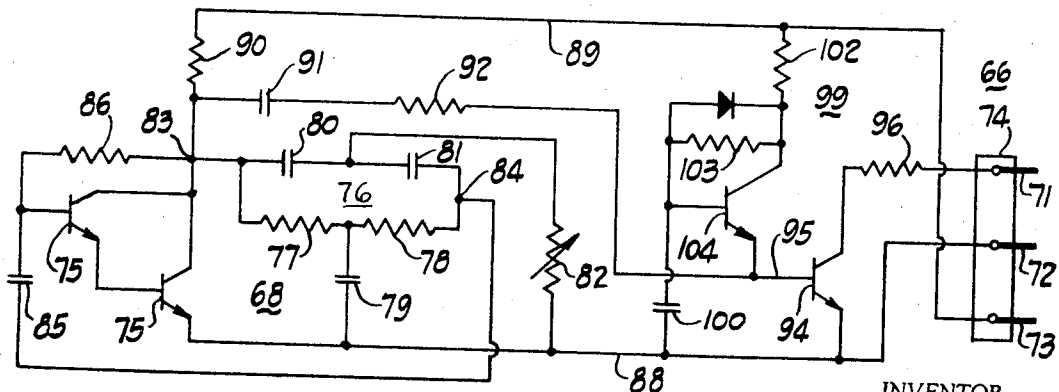
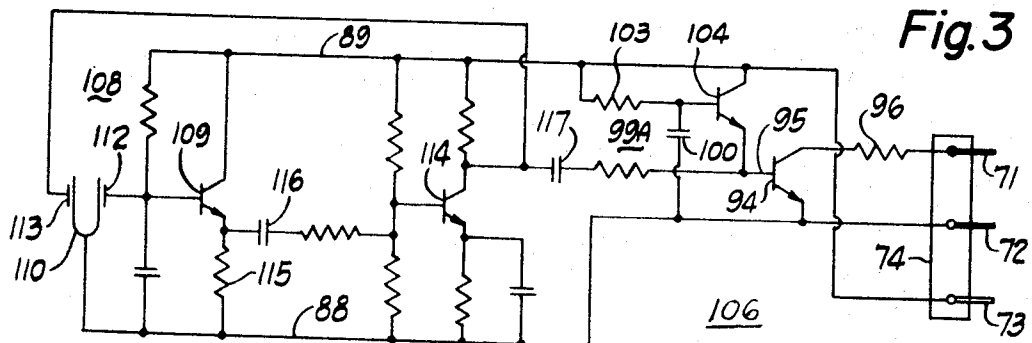
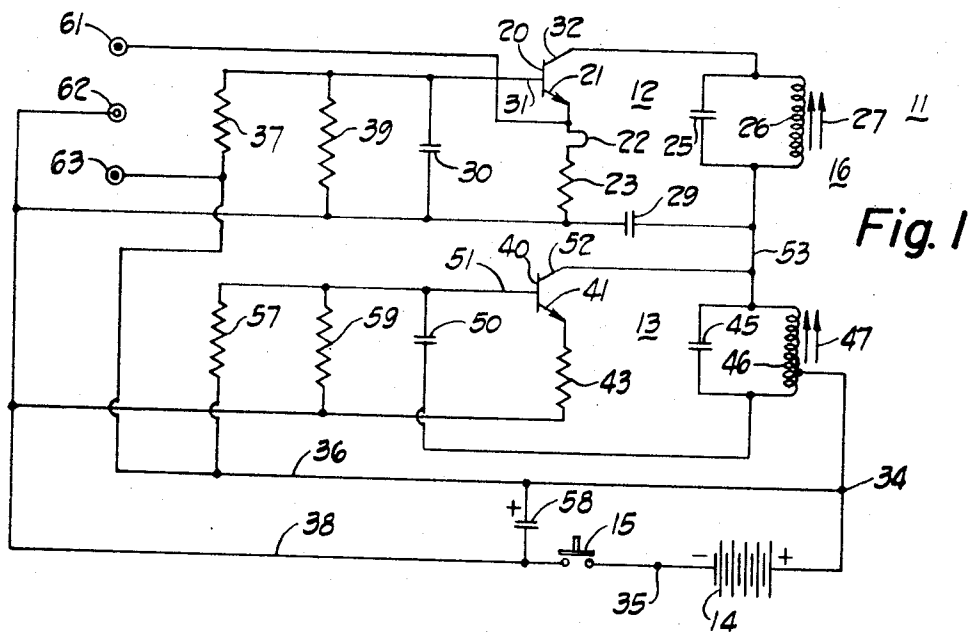
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ABSTRACT

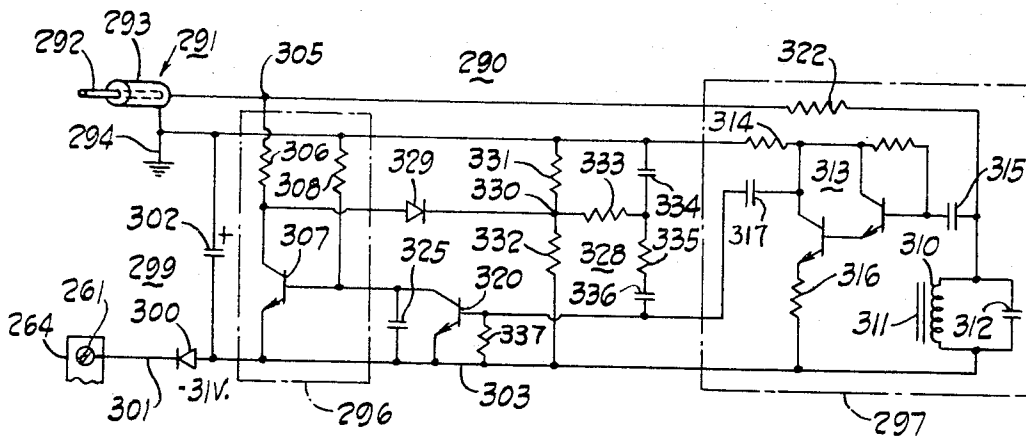
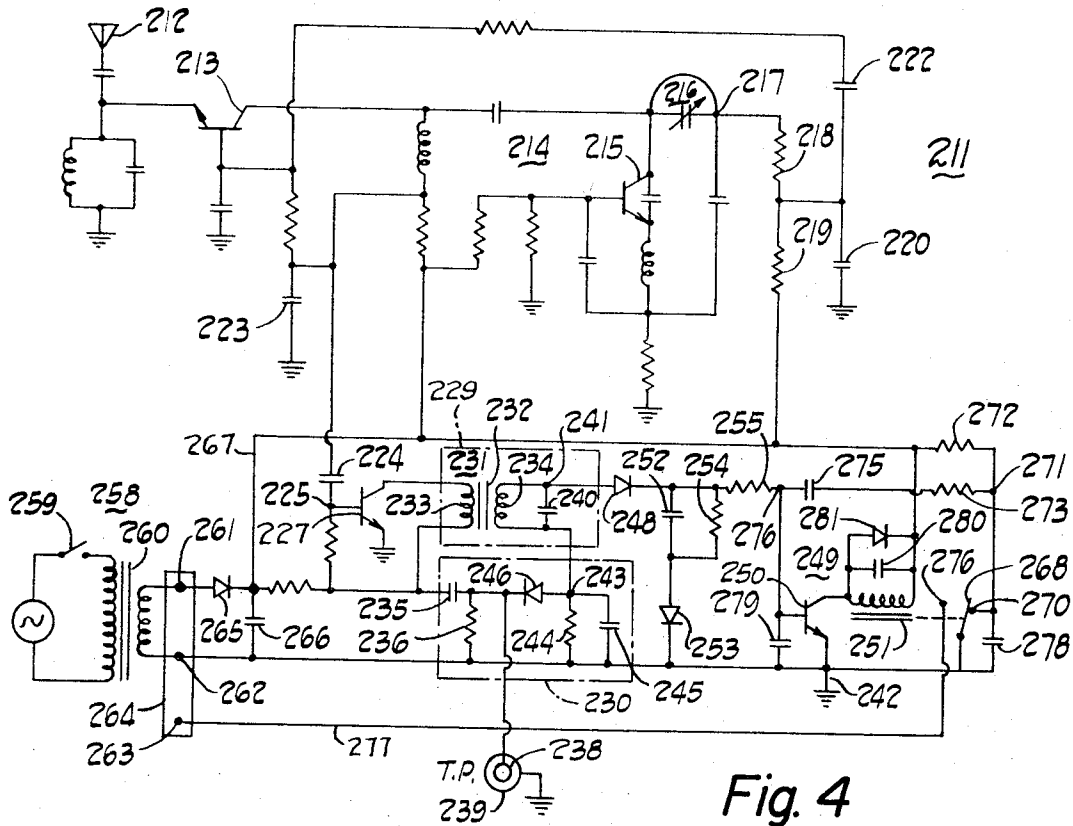
A transmitter-receiver system is disclosed which may be used for remote control purposes. The transmitter has a radiated signal with a first frequency carrier modulated with a second frequency. A subcoder may be selectively plugged into the transmitter and has a third frequency which influences or modulates the radiated signal at a third frequency rate. The receiver of the system has means responsive to the first and second frequencies and also has a decoder selectively plugged into the receiver which has a disabling bias means and a third frequency responsive means. The disabling means normally prevents any signal from reaching the load of the receiver and the third frequency responsive means has an output when the third frequency is present which terminates the disabling means so that the receiver is enabled and a signal is passed to the receiver load. Without the decoder plugged into the receiver, the receiver is completely operable on the first and second frequencies to supply a signal to the load.

17 Claims, 7 Drawing Figures





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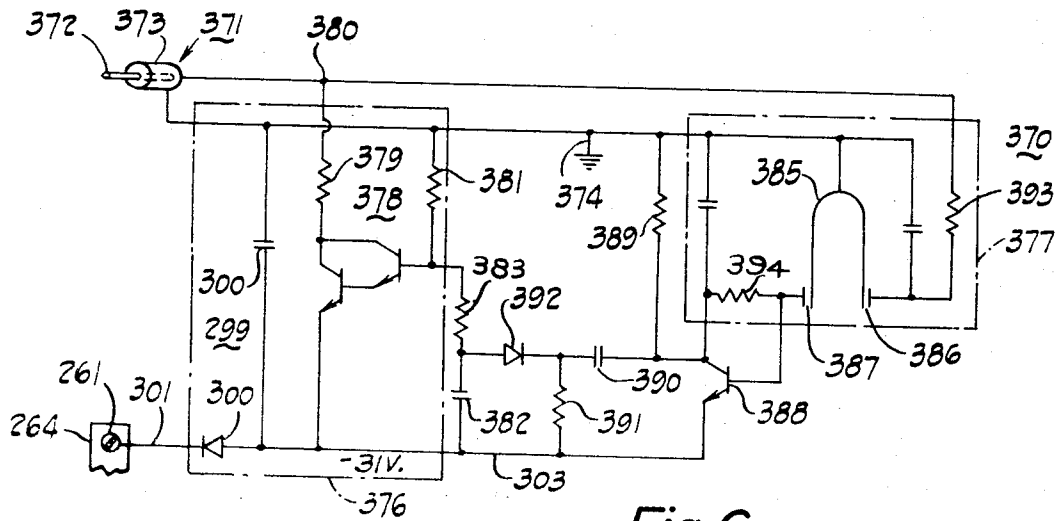


Fig. 6

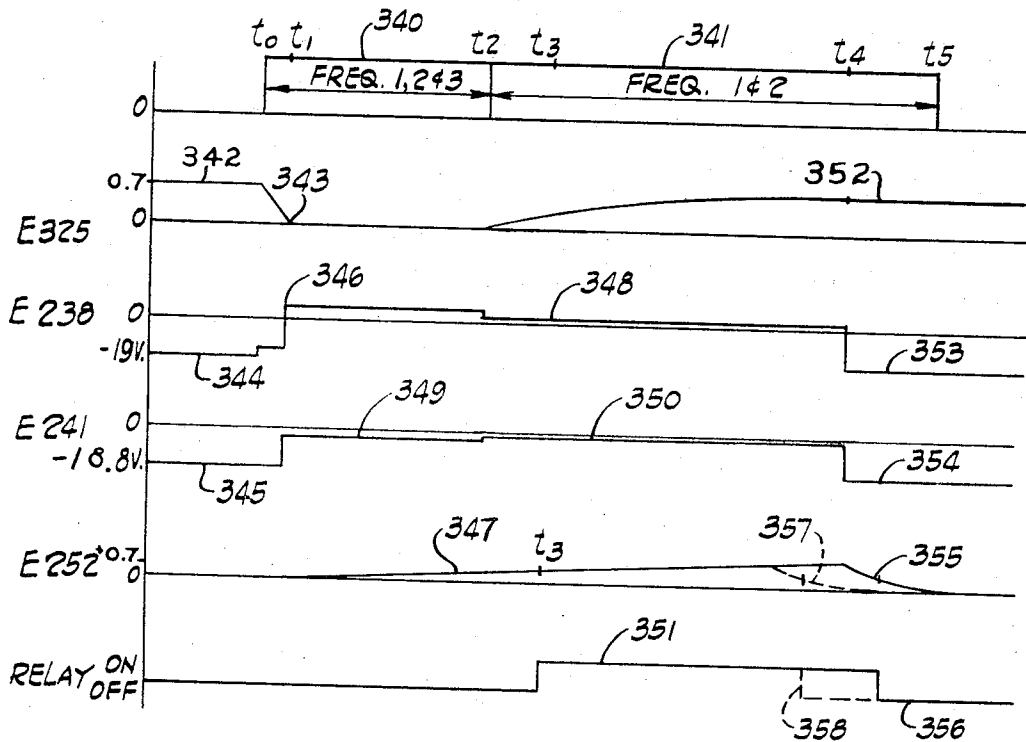


Fig. 7

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TRANSMITTER-RECEIVER SYSTEM

BACKGROUND OF THE INVENTION

The disclosed transmitter-receiver system may be used in remote control systems, for example, a remotely controlled garage door opener. In such use the transmitter may be a hand-sized battery powered low output power transmitter complying with Federal Communication Commission regulations as to radiated power. The carrier may be in the VHF range, for example, with modulation in the audio or super-audio frequencies.

The transmitter sends a signal to a corresponding receiver and if the proper carrier and modulation frequencies for that set of transmitter and receiver is received by the receiver, then an output signal is given. This output signal may be used to remotely control some particular device, for example, a garage door. In many cases the garage door being controlled is in a garage attached to the home and if unauthorized persons were able to easily operate the garage door operator receiver, then unauthorized access to the garage and to the home could be achieved. Thus a security problem occurs and it becomes increasingly important to increase the number of codes and the complexity of the codes in order to prevent unauthorized access to the garage and home. If there are only six different carrier frequencies and six different modulation frequencies, then this gives a total of six times six or 36 different possible codes. If there are 10 carrier frequencies and ten modulation frequencies, for example, then this would give a total possibility of 100 codes. However because of FCC regulations, the number of carrier frequencies which may be used without interference with each other is limited, thus limiting the total possible number of codes. Also, with only six or ten carrier frequencies plus a similar range of modulation frequencies, it is relatively easy for a law-breaker to gain access to the garage. For example, if such a person had six or ten different transmitters each on one of the assigned code of carrier frequencies, then each in turn could be turned on and gradually adjusted through the range of audio frequencies. Thus, all 36 or 100 possible codes could be swept through in a matter of 1 or 2 minutes and the lawbreaker could easily gain access to the garage or home.

In many areas of high saturation of garage door operators, there is an increasing problem of the transmitter of a neighbor operating the wrong garage door operator receiver. Thus the operator of an automobile driving along a street and depressing the transmitter push-button switch, could trigger receivers to open garage doors, which are the wrong garage doors, unless the carrier frequencies and modulation frequencies of the coding scheme have sufficient separation therebetween, and do not have a tendency to heterodyne to produce one of the carrier or modulation frequencies of the coding scheme.

In order to make the garage and home more secure, more codes have been suggested but this method of increasing the number of possible codes by increasing the number of carrier or modulation frequencies, runs into difficulty with the FCC regulations and runs into further difficulty with trying to select frequencies which do not interact with each other by heterodyning so as to produce one of the frequencies of the codes.

One prior art attempt at increasing the security was to produce a transmitter and receiver system wherein the transmitter had one carrier frequency out of a number of possible frequencies, for example, 6 or 10. Next, two separate modulation frequencies were provided in the transmitter with the transmitter first emitting a radiated signal of the carrier modulated by the first modulation frequency and then immediately afterward the first modulation frequency ceased and the second modulation frequency commenced for an additional time period. The receiver of that particular set would be tuned to that particular carrier frequency and would have a detector means to detect the first and second modulation frequencies with a time delay on drop out of detection of the first modulation frequency. This meant that the first modulation frequency had to be detected first, with a time delay hold-over of the relay contacts being held closed during the time that the second modulation frequency was detected, in order for an output signal to be developed by the receiver. This increased the security but required a considerably more complex receiver system and required a more complex transmitter system such that only the first and second modulation frequencies were transmitted and were transmitted in sequence but not simultaneously.

A serviceman has an extremely difficult time to locate the cause of spurious responses because the receiver is usually on 24 hours a day on a standby basis, awaiting the reception of a proper signal. The peculiar circumstances which cause a spurious signal to trigger the receiver will normally not occur when a serviceman is present and thus he seldom can find the cause. This is different from a complete breakdown of the equipment where he can use a signal generator or other serviceman's equipment to locate the break or short in the circuit and have it repaired.

Another disadvantage with this prior art system is the increased number of transmitters and receivers which must be manufactured and which must be stocked by a distributor. If there are ten different first carrier frequencies and ten different second modulation frequencies plus ten different third modulation frequencies, this is 10 times 10 times 10 or 1,000 different transmitters and receivers which must be manufactured and also 1,000 different transmitters and receivers which must be stocked by the manufacturer and the distributor. This is sufficiently burdensome that it becomes increasingly difficult to find a distributor who is willing to stock all of these units.

Accordingly, an object of the invention is to provide a transmitter-receiver system obviating the above-mentioned disadvantages.

Another object of the invention is to provide a transmitter subcoder such that the transmitter simultaneously transmits three different frequencies.

Another object of the invention is to provide a transmitter system wherein the security of a load actuated by a remotely controlled receiver is materially increased.

Another object of the invention is to provide a transmitter subcoder wherein the subcoder does not detune the transmitter circuit transmitting the modulation frequency.

Another object of the invention is to provide a receiver-decoder wherein the decoder does not detune the receiver circuit to its sensitivity to a second modulating frequency.

Another object of the invention is to provide a transmitter subcoder wherein a third frequency is provided for only a short length of time and then ceases to thus increase the security by requiring that the receiver be responsive to this third frequency and then responsive to the termination of the third frequency with only a modulated carrier wave.

Another object of the invention is to provide a transmitter system of increased security against spurious operation by requiring that the power supply switch be closed, and the carrier frequency, modulation frequency and subcoding frequency all be correct in order to transmit a proper signal which will operate a receiver system.

Another object of the invention is to provide a receiver-decoder wherein the presence of a third frequency is detected on a conductor and the receiver is disabled by a voltage condition on that same conductor.

Another object of the invention is to provide a receiver-decoder which may be plugged into an existing test point jack on an existing receiver which normally is used with only a first carrier and a second modulation frequency.

Another object of the invention is to provide a transmitter-receiver set which permits a customer to purchase a simplified transmitter-receiver operative on only first and second frequencies and later to add a subcoder and decoder with a third frequency response, if more security is desired or if spurious operating signals are encountered.

SUMMARY OF THE INVENTION

The invention may be incorporated in a modulated carrier system, comprising in combination, a transmitter and a receiver; said transmitter comprising output circuit means, means to develop a first frequency carrier in said output circuit means, means to develop a modulation frequency, and means connecting said modulation frequency developing means to said output circuit means to establish a carrier wave output from the transmitter influenced at said modulation frequency rate for a first time period and to terminate said modulation frequency thereafter; said receiver comprising first means responsive to said first frequency, a main load, disabling means connected to disable said main load and operative in the absence of a received signal containing said modulation frequency, and means responsive to said modulation frequency and having an output connected to terminate said disabling means output for at least a second time period to enable said receiver to thus pass current to said main load upon the presence of a received signal containing said modulation frequency and subsequently said first frequency.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of a transmitter circuit; FIG. 2 is a schematic diagram of a subcoder connectable to the transmitter of FIG. 1;

FIG. 3 is a schematic diagram of a modified form of subcoder;

FIG. 4 is a schematic diagram of a main receiver responsive to first and second frequencies;

FIG. 5 is a schematic diagram of a receiver decoder which may be connected to the receiver of FIG. 4 and which adds a third frequency capability;

FIG. 6 is a schematic diagram of an alternative receiver decoder which may be electrically connected to the main receiver of FIG. 4; and,

FIG. 7 is a graph of voltages obtainable in the circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a schematic diagram of a transmitter 11 which incorporates the invention. This transmitter has a means 12 to develop a carrier frequency and this is shown as a carrier frequency oscillator. The transmitter 11 also has a means 13 to develop a modulation frequency and this means 13 is shown as a modulation frequency oscillator. A power supply 14 is provided in the transmitter and this may be a primary battery, especially where the transmitter is of low power for example, a hand-sized VHF transmitter usable with remote control of garage door operator receivers. A switch such as a push-button switch 15 is provided as is output circuit means 16. Means is provided including the switch 15 to connect the power supply 14 to the frequency developing means 12 and 13 to establish an output from the output circuit means 16 which contains both the carrier and modulation frequencies. To this end, the carrier frequency oscillator 12 includes a transistor 20 having an emitter 21 connected through a jumper 22 and an output load impedance shown as an output load resistor 23. The resistor 23 is connected in the output circuit 16 and this output circuit means may include a parallel resonant circuit of a capacitor 25 and inductance 26. The inductance may have a movable permeable core 27 for tuning purposes. Capacitors 29 and 30 connect the lower end of the parallel resonant circuit 25-26 to the base 31 of transistor 20. These capacitors provide a feedback from the tank circuit 25-26 in order to sustain oscillations. The upper end of this tank circuit is connected to the collector 32 of the transistor 20 in order to complete the output circuit means 16.

The power supply 14 has first and second terminals 34 and 35, respectively, of different voltages. The first terminal 34 is the positive terminal of the power supply 14 and is connected to a conductor 36 and through a current limiting resistor 37 to the base 31 of transistor 20. The second power supply terminal 35 is connected through the push-button switch 15 to a conductor 38 and this may be considered the ground side of the power supply 14. This conductor 38 is connected through a bias resistor 39 to the base 31 of transistor 20. Conductor 38 is also connected to the interconnection of capacitors 29-30 and resistor 23. The transistor 20 with the connections as shown will oscillate at a frequency determined by the parallel resonant circuit 25-26 which may be in the VHF range, for example, 250-300 MHz.

The modulation frequency oscillator has a circuit quite similar to that of the carrier frequency oscillator except with different values of components to have the modulation frequency lower than the carrier frequency, for example, in an audio or super-audio range of 500-20,000 Hz. The modulation frequency oscillator 13 includes a transistor 40 with an emitter 41 connected through a resistor 43 to the conductor 38. A parallel resonant tank circuit is provided in this modu-

lation frequency oscillator 13 including a capacitor 45 and inductance 46. The inductance 46 may have a movable permeable core 47 for tuning to the desired modulation frequency. A feedback capacitor 50 connects the lower end of the tank circuit 45-46 to the base 51 of transistor 40. The upper end of the tank circuit 45-46 is connected to the collector 52 by a conductor 53 which also connects together the tank circuits of the two oscillators 12 and 13. A current limiting resistor 57 connects the conductor 36 to the base 51 and a resistor 59 connects the base 51 to the conductor 38. The transistor 40 will oscillate at the modulation frequency determined by the values of the parallel resonant circuit 45-46. A power supply capacitor 58 may be directed across the power supply 14.

First, second and third junctions 61, 62 and 63, respectively, are provided in the transmitter 11. Junction 61 is connected to the interconnection of emitter 21 and jumper 22. The second junction 62 is connected to the ground conductor 38 and the third junction 63 is connected to the positive power supply terminal 34 via conductor 36. These junctions 61-63 provide a ready means for connection to a subcoder 66 shown in FIG. 2. This subcoder 66, together with the transmitter 11, has a means 68 to develop a third frequency. This third frequency may be a subcode and preferably is a frequency lower than either the carrier or the modulation frequency. The third frequency developing means 68 is at least partly in the subcoder 66 and in this preferred embodiment is shown as being incorporated in circuitry of the subcoder 66. The subcoder 66 has first, second and third terminals or connectors 71, 72 and 73. These connectors are connectable to the junctions 61-63, respectively, and for ease of this interconnection the subcoder 66 may simply be plugged into the transmitter 11 by having male connectors 71-73 on a terminal strip 74 receivable in female connections of the junctions 61-63. The transmitter 11 may be mounted on a printed circuit board as an example, and the subcoder may be mounted on another smaller printed circuit board with the terminal strip 74 an integral part thereof. This subcoder 66 in the preferred embodiment of FIG. 2 includes a Darlington transistor pair 75 connected to null resonant circuit means 76 to act as an oscillator which oscillator may be the principal component of the third frequency developing means 68. The circuit means may take one of several forms and in FIG. 2 is shown as including a bridge T filter network. Resistors 77, 78 and capacitor 79 form one T and capacitors 80, 81 and variable resistor 82 form another T which together form the bridge T 76. This bridge T network 76 has terminals 83 and 84. A feedback capacitor 85 establishes the transistor 75 oscillating at the null frequency of the bridge T circuit 76. A bias resistor 86 biases the transistor 75 into a proper operating condition.

The second connector 72 is connected to a ground conductor 88 and third connector 73 is connected to the positive power supply voltage in transmitter 11 and is connected to a conductor 89 in the subcoder 66. This conductor 89 is connected through a resistor 90 to the terminal 83 of the null resonant circuit means 76. This null resonant circuit means 76 is one which has a null at the desired frequency, hence a minimum output across terminals 84 and conductor 88. The output at terminal 83 is passed by a coupling capacitor 91 and resistor 92 to an output circuit which includes a transis-

tor 94. The resistor 92 is connected to the base 95 of this transistor 94. The emitter of transistor 95 is connected to the connector 72 and the collector of this transistor is connected through a current limiting resistor 96 to the connector 71. Accordingly, the conduction or non-conduction of transistor 94 gives an output signal on connectors 71 and 72.

A timing circuit 99 is provided in the subcoder 66 to provide a time delay period. This may be considered a second time delay period with the first time delay period that established by the resonant circuit means 76. Many such resonant circuit means take a certain finite time to "ring" or come up to full resonance. Such first time delay period may be quite short, for example, 0.01 seconds up to 0.1 seconds. The timing circuit 99 includes primarily a capacitor 100 and a transistor 104 to amplify the effect of capacitor 100. Resistors 102, 103 cooperate with capacitor 100 for an RC charging time delay network. This time delay may be any suitable value for example, 1/10 second to three seconds and after the capacitor 100 is charged, then the transistor 104 is turned on continuously. This turns on transistor 94 continuously for a minimum potential difference across terminals 71 and 72. This is after the second time delay period of perhaps 1/2 second and during that second time delay period, while capacitor 100 is charging, the transistor 20 is influenced at the third frequency rate by the output from Darlington transistor pair 75 appearing at terminal 83. This means that during this second time delay period the transistor 94 is turned on and off at the third frequency rate. When transistor 94 is not conducting, this means there is a high impedance condition between terminal 71 and 72. This turn on and off of transistor 94 interrupts the radiated modulated carrier at the third frequency rate. This is like 100% modulation with a square wave.

OPERATION

Now referring to FIG. 1, it may be observed how the subcoder 66 affects the transmitter 11. When the connectors 71-73 are plugged into the junctions 61-63, then the interconnection of connector 72 and junction 62 establishes a reference potential in the subcoder 66. This is the 0 volts or ground reference potential. The interconnection of junction 63 and connector 73 establishes another potential in the subcoder 66 at a potential different from that on terminal 72. Accordingly, an operating voltage is supplied to this subcoder 66. In the example shown this is plus nine volts applied to the subcoder 66. The interconnection of junction 61 and connector 71 establishes that the output of the subcoder 66 is applied to the transmitter 11. More particularly, the output of the subcoder 66 appears on connectors 71 and 72 and it will be seen in FIG. 1 that this output is applied to junctions 61 and 62 which is in parallel with the output load resistor 23. The jumper 22 may easily be formed from a U-shaped bend in the lead of this resistor as it is mounted on the printed circuit board. This jumper may easily be cut by a person plugging the subcoder 66 into the transmitter 11. With this jumper 22 cut, then the output of the subcoder is no longer in parallel with the resistor 23, instead it takes the place of this resistor 23. Preferably the effective impedance of the transistor 94 plus resistor 96 when this transistor 94 is conducting is the same as the resistance of resistor 23. In one practical embodiment of a circuit made in accordance with this invention, resistor 23 was 560

ohms, resistor 96 was 470 ohms and transistor 94 when conducting had the difference of about 90 ohms impedance. Accordingly, it will be seen that the transmitter 11 operation is virtually unaffected in its operation during the time transistor 94 is conducting, because there are no changes in impedance or circuit parameters. Thus, as the transistor 94 intermittently conducts at the third frequency or subcoding rate, this establishes the influence on the transmitter 11 at this third frequency rate. More specifically, the output circuit means 16 of this transmitter 11 will radiate a modulated carrier wave interrupted at the third frequency rate. In one actual embodiment of transmitter made in accordance with this invention, this third frequency was on the order of 300 to 15,000 Hz. The radiation is from the inductance 26 which acts as a radiating antenna.

The timing circuit 99 establishes the charging of capacitor 100 from the power supply source 14. This is the second time delay period and this might be 1/10 to 3 seconds, for example. After this second time period, the capacitor 100 is charged, which means that transistor 104 is turned fully on and this turns transistor 94 fully on. Accordingly, it is no longer influenced by the output from the oscillator 68. Also this continuous conduction of transistor 94 means that the transmitter 11 is no longer influenced at the third frequency rate. More specifically, the continuous conduction of transistor 94 means that the carrier wave is transmitted as a modulated carrier wave modulated only at the modulation frequency of oscillator 13 and is not influenced at any third frequency rate. This has the advantage that it does not detune the modulation frequency oscillator and hence the receiver of the transmitter-receiver set will be receiving a modulation frequency and a carrier frequency at the proper values.

SECOND EMBODIMENT

FIG. 3 shows an alternative subcoder 106 which may be used in place of the subcoder 66 of FIG. 2 and will also plug into the junctions 61-63 in the transmitter of FIG. 1. To this end the subcoder 106 again has the connectors 71-73 to be connected to the junctions 61-63. This subcoder 106 has a means 108 to develop a third frequency which includes a transistor 109 and resonant circuit means 110 shown as a tuning fork. This may be any of the usual forms of tuning fork oscillator circuits, with a capacitive plate 112 cooperating with the tuning fork 110 and supplying drive to the base of transistor 109. Another capacitive plate 113 cooperating with the tuning fork has a feedback from the output of a transistor 114 to sustain oscillation. The oscillation of transistor 109 is supplied to an emitter follower resistor 115 and this output is passed by a coupling capacitor 116 to the base input of transistor 114. The output of transistor 114 appears at the collector for the aforementioned feedback and is coupled through another coupling capacitor 117 to the base 95 of transistor 94. Again a timing circuit 99A is provided which includes transistor 104, resistor 103 and capacitor 100.

OPERATION

When the subcoder 106 is plugged into the transmitter 11 it operates in essentially the same manner as when subcoder 66 was plugged into transmitter 11. A first time delay period is established after push-button switch 15 is closed. This first time delay period is caused by the tuning fork 110 or resonant circuit

means building up the amplitude of oscillations to the normal value. This might be 1/100 to 1/4 of a second. The timing circuit 99A establishes a second time delay period during which the modulated carrier wave being radiated is influenced at the third frequency rate. During this second time delay period, the capacitor 100 is charging and also during this time the oscillator 108 is oscillating and affecting the base 95 of transistor 94 at this third frequency rate. Accordingly, transistor 94 is turned on and off at this third frequency rate which turns on and off the modulated carrier frequency radiated from the output circuit means 16 at this third frequency rate. At the completion of the second time delay period, the capacitor 100 is virtually charged which means that transistor 104 is turned fully on as is transistor 94, hence it is no longer influenced by the continuously running oscillator 108. Accordingly, after this second time delay period the radiated emissions are only of the carrier modulated at the modulation frequency of oscillator 13. The transistor 104 is an amplifier and also a buffer to prevent the continuous conduction of transistor 94, subsequent to the second time delay period, from influencing the oscillator 108. This has the advantage of not affecting the frequency of the oscillator circuit 108 and hence maintaining the same frequency in a particular transmitter-receiver set.

From the above it will be noted that either subcoder 66 or 106 may be used interchangeably with the transmitter 11 and prior to plugging a subcoder into the transmitter, the transmitter is a completely operable unit radiating a modulated carrier wave and usable with a receiver tuned to the same carrier and modulation frequencies. If security is required in addition to that afforded by the possible carrier frequencies and possible modulation frequencies, then the subcoder 66 or 106 may easily be added to the transmitter and a complementary decoder added to the receiver. For example, if 10 possible transmitter frequencies are usable and 10 possible modulation frequencies are usable, this would give 100 possible codes. Adding a subcoder with another 10 possible frequencies, this gives 1,000 possible codes. Actually it has been found that the security achieved by the addition of this third frequency is considerably more than merely a 10-fold increase in security. Referring to FIG. 3 with the tuning fork 110, it will be observed that this tuning fork could be induced into oscillation by a physical shock. However, this alone does not establish a third frequency output. Before the right combination of carrier, modulation and subcoding frequencies occur, five things must be properly established:

1. The push-button switch 15 must be closed;
2. The carrier frequency oscillator 12 must be at the right frequency;
3. The modulation frequency oscillator 13 must be at the right frequency;
4. The third frequency oscillator 108 must be at the right frequency; and,
5. The capacitor 100 must not be charged. This fifth criteria above is accomplished by the timing circuit 99 and takes only 1/10 to three seconds to accomplish. Accordingly, a lawbreaker would have a very short time in order to try to fulfill these five criteria. This is why the security is increased much more than 10-fold by the addition of a third frequency.

FIG. 4 illustrates a preferred embodiment of the receiver 211 incorporated in the transmitter-receiver sys-

tem. The radio receiver 211 is adapted to be operative on a received signal of a predetermined first frequency carrier modulated by a lower second modulation frequency, and also subject to receiving random noise signals. The receiver 211 includes a receiving antenna 212 supplying an input to a transistor 213 which is an isolation stage. The signal is then passed to a superregenerative circuit 214 which includes a transistor 215 with a parallel resonant output circuit 216. This parallel resonant output circuit 216 is tuned to a predetermined first frequency carrier, which for example, might be in the order of 250 MHz. The output of the superregenerative circuit 214 appears at a terminal 217 and contains the carrier frequency, the modulation frequency and also a squelch frequency intermediate these two frequencies. In this example, the modulation second frequency may be an audio or super-audio frequency.

The squelch frequency depends upon the constants of the circuit 214 and may be 600 KHz., for example. This output is applied to resistors 218 and 219 in series and to a capacitor 220 which presents a low impedance to ground for the squelch frequency and accordingly the modulation frequency signal is passed by a capacitor 222 to the transistor 213 in a reflex circuit for amplification of such modulation frequency signal. This amplified output appears across a capacitor 223 and it is passed by a coupling capacitor 224 to an input terminal 225 of a lower frequency amplifier 227. The amplifier 227 is shown as a transistor supplying an output to a detector circuit which includes a tuned load 229 and an untuned load 230.

The parallel resonant circuit 216 is tuned to resonance to the first or carrier frequency and hence is a first means responsive to this first frequency. The tuned load 229 is tuned to resonance at the second or modulation frequency and hence is a second means responsive to this second frequency. The tuned load 229 includes a transform 231 with a movable slug core 232 and the transformer has a primary and a secondary winding 233 and 234, respectively with the primary winding connected to the output of the transistor 227. The output from the transistor 227 is through the primary winding 233, a capacitor 235 and a resistor 236 to ground. Each of the output signals of the transistor 227 appear across the resistor 236, and accordingly, a center conductor 238 of a test point jack is connected to this junction of the capacitor 235 and resistor 236. The outer conductor 239 of this test point jack is connected to ground. With all of the audio signals including the random noise appearing across resistor 236, this may be considered the input to the untuned load 230 and it is stated as being untuned to distinguish it from the tuned load 229.

In this tuned load 229 capacitor 240 is connected across the secondary winding 234 to tune it to resonance which is reflected into the primary winding 233. The upper terminal of capacitor 240 is a first terminal 241 relative to ground 242 which may be considered a second terminal. The lower end of capacitor 240 is connected to a junction 243 at the untuned load 230 and passes from there through a resistor 244 to ground. A capacitor 245 is connected in parallel with resistor 244 and a diode 246 is connected with a polarity to conduct current from junction 243 to the test point center conductor 238.

A unidirectional conducting device shown as a diode 248 is connected to the first terminal 241 to pass current to a main load 249. This main load includes a transistor 250, a relay 251 and a time delay capacitor 252. A diode 253 connects the capacitor 252 between diode 248 and ground 242. A discharge resistor 254 is connected across the capacitor 252. When the time delay capacitor has been sufficiently charged positive, then current is passed through a resistor 255 to the base of transistor 250. This occurs when the voltage of the capacitor 252 exceeds the forward voltage drop from base to emitter of the transistor 250.

A power supply 258 is provided such that when a switch 259 is closed, a step-down transformer 260 is energized and the secondary thereof energizes first and second terminals 261 and 262 of a terminal strip 264 which also has a third terminal 263. The AC voltage between terminals 261 and 262 is supplied through a rectifier 265 to a filter capacitor 266 so that a supply conductor 267 is positive relative to ground 242. The relay 251 is connected to this DC supply conductor 267. The relay controls single pole double-throw contacts with a contact blade 268 connected to ground 242. The normally closed contacts 270 are connected to a terminal 271 at the junction of first and second bleeder resistors 272 and 273. A capacitor 275 is connected in series with resistor 273 between terminal 271 and a terminal 276, which is connected to the base of transistor 250. The normally open contacts 276 are connected by a lead 277 to the third terminal 263 on the terminal strip 264. This provides an external connection controlled by the energized or de-energized condition of the load 249. Protective capacitors 278 and 279 are connected between terminal 271 and ground and terminal 276 and ground and a filter capacitor 280 is connected across the relay 251. A protective diode 281 is also connected across this relay 251.

OPERATION

The radio receiver 211 conveniently may be used in a remote control of a physical device, for example, the remote control of a garage door operator from a low powered transmitter. As the user approaches the garage in driving his automobile, he presses a button on the transmitter to place it in operation. The transmitter emits a signal which is a selected one of a plurality of carrier first frequencies and one of a plurality of second modulation frequencies. As explained above, it may also contain a third lower frequency, however, the main receiver as described so far in FIG. 1 is usable with just a singly modulated carrier frequency. The tuned circuit 216 is responsive to the first frequency and if the received signal on the antenna 212 is one having a carrier at this frequency, then the signal is passed to the lower frequency amplifier 227. Normally noise being received on the antenna 212 is passed and is further amplified by the amplifier 227. The untuned load 230 is that which is more responsive to this noise and off-frequency signals than the tuned load 229, for example, there may be four times as much voltage across resistor 236 as across the primary winding 233 due to this noise. The polarity of the diode 246 is such that junction 243 will be negative as caused by the audio frequency noise on this resistor 236. In a practical circuit this may be 1 to 3 volts negative at junction 243 relative to ground 242. The conduction by diode 246 makes the test jack conductor 238 positive by a

small amount due to this rectification of the audio frequency noise.

When a received signal of the proper first and second frequencies is received, then it is passed by the super-regenerative circuit 214 and the tuned load 229 resonates at this second frequency. This means a high voltage appears across the secondary winding 234 and hence across the primary winding 233. Diode 248 is poled to conduct when the first terminal 241 is positive. However, it will be noted that diodes 246 and 248 are in effect poled in opposite directions. This means that the outputs of the tuned and untuned loads 229 and 230 are effectively connected in opposition. The output of the untuned load 230 appears across terminal 243 and 242 and is negative on terminal 243 relative to ground terminal 242. The output of the tuned load 229 is positive on the first terminal 241 relative to the ground 242. Accordingly, under normal stand-by conditions, the output from the noise from the untuned load 230 predominates and no current is passed to the main load 249. When the proper second frequency signal is received however, then the output from the tuned load 229 at terminal 241 predominates and exceeds the negative voltage at terminal 243. Under this condition the output of the tuned load 229 is more positive than a given value to pass current to the main load 249. The given value in this case is a voltage, for example, 2/10ths of a volt to cause the diode 248 to conduct. Upon conduction the time delay capacitor 252 will be charged. At the threshold of received signal, diode 248 conducts only on the crests of the positive half cycles but as the received signals grow stronger, the diode 248 may conduct for practically the entire positive half cycles. Resistor 254 is connected to continually discharge capacitor 252 but at some point the charge on capacitor 252 will reach a voltage value exceeding the forward bias on transistor 250. This may be 7/10ths of a volt, for example, for silicon transistors and hence transistor 250 will conduct to energize relay 251. When this happens the normally closed contact 270 is opened and the normally open contact 276 is closed. This places an output signal on the third terminal 263, which may be used for any desired purpose, for example, in a garage door operator this may be used to control a power relay energizing a motor which drives the garage door. The operation of this particular part of the circuit is more fully described in my previous U.S. Pat. No. 3,579,240.

FIG. 5 shows a preferred embodiment of a decoder 290 having a test plug 291 which may be plugged into the test jack 238-239 of the main receiver 211 to add a third frequency capability thereto. The decoder 290 may be made on a printed circuit board and may be practically small and lightweight to support itself physically when plugged into the test point jack 238-239. Electrical connections are also made at the same time of this physical support. The test plug 291 includes a center conductor 292 connecting to the center conductor 238 and an outer conductor 293 connecting to the outer conductor 239 of the test jack. The outer conductor 293 is connected to an internal ground 294 of the decoder 290.

The decoder 290 includes generally a disabling means 296 and a third frequency responsive means 297. The disabling means 296 may also be considered a bias means to bias the main receiver 211 so that no current is passed to the main load 249. The third frequency responsive means 297 may also be considered

a tuned circuit resonant to the third frequency, which is lower than the carrier frequency. The decoder 290 includes a power supply means 299 including a rectifier 300 poled to conduct current through a flexible lead 301 to the first terminal 261 on the terminal strip 264. This flexible lead 301 may readily be connected on the terminal 261 when the decoder is plugged into the test jack. The power supply 299 also includes a filter capacitor 302 connected between the voltage supply conductor 303 and ground 294. This polarity of the rectifier 300 makes supply conductor 303 negative relative to ground 294, for example, -31 volts. The ground 294 of decoder 290 is connected to the ground 242 of the main receiver and with the first terminal 261 connection, this provides an operating voltage to the decoder 290 and also provides a reference potential; namely, ground.

The test plug center conductor 292 is connected to a terminal 305 and the disabling means 296 is connected between this terminal and the supply conductor 303. This disabling means 296 includes generally a voltage dropping resistor 306 and a transistor 307. A bias resistor 308 is connected between ground 294 and the base of transistor 307 and since ground is positive of the supply conductor 303 in this decoder 290, this biases the transistor 307 normally into conduction. The circuit may be traced considering FIG. 5 in conjunction with FIG. 4. Starting with ground 294 or 242, which is positive, the current flows upwardly through resistor 244, the diode 246, the test point center conductor 238, test plug center conductor 292, down through resistor 306 and transistor 307 to the negative supply conductor 303. This current flow makes the upper end of resistor 244 at junction 243 negative with respect to ground. In a practical circuit constructed in accordance with this invention, this was made to be about 20 volts negative relative to ground. This is sufficient negative bias voltage supplied by the biasing or disabling circuit 296 such that the main receiver is disabled. By this is meant that no current may be passed to the main load 249. The super-regenerative circuit 214 is a sensitive circuit with a gain in the order of one million, yet irrespective of the strength of the signal on the antenna 12, for example, even if the proper first and second frequencies are present there will not be sufficient positive voltage at terminal 241 relative to ground 242 such that the output of the tuned load 229 can overcome this negative voltage output of the untuned load 230 plus the bias from the decoder 290. This is why the circuit is described as being disabled by the negative bias supply from the decoder 290.

The decoder 290 also includes the third frequency responsive means 297 which in this preferred embodiment is a tuned circuit resonant to this third frequency. The tuned circuit includes an inductance 310 with a tunable core 311. A capacitor 312 is connected in parallel with the inductance 310 for parallel resonance. This circuit is tuned to resonance at the third frequency which is lower than the first or carrier frequency and in this preferred embodiment is also lower than the second or modulation frequency. For example, in one practical circuit this might be in the range of 500 to 5,000 Hz. Upon parallel resonance the voltage across this inductance 310 rises and this establishes turn-off of the transistor 307 to terminate the negative bias on the junction 243 and thus enable the receiver 211. Since the receiver is at that time enabled, this means that if

the signal is received containing the proper first and second frequencies, then current is passed to the main load 249 at that time.

The third frequency responsive means 297 includes in this preferred embodiment a buffer amplifier 313 shown as a Darlington transistor pair. Power is supplied to this amplifier through a resistor 314 from the positive operating voltage which in this case is ground 294. The input base of the Darlington pair is connected by a coupling capacitor 315 to the upper end of the tank circuit 310-312. The emitter output of the Darlington pair is fed through a resistor 316 to the negative operating voltage at conductor 303. The AC output of the Darlington pair is supplied through a coupling capacitor 317 to the input base of a driver transistor 320. A high impedance isolating resistor 322 connects the input terminal 305 to the upper end of the tank circuit 310-312 to have supplied thereto the low frequency signals present on the test jack center conductor 238. An accelerator circuit 328 is provided in the subcoder or decoder 290. This accelerator circuit includes a diode 329 connected from the lower end of resistor 306 to a junction 330 between voltage divider resistors 331 and 332 connected between ground and the negative supply conductor 303. A resistor 333 and a capacitor 334 are connected in series between junction 330 and ground. A resistor 335 and capacitor 336 are connected in series between the junction of resistor 333 and capacitor 334 and the base of the transistor 320. A resistor 337 is connected from the base of transistor 320 to conductor 303.

OPERATION

When a signal is received, correct in the first frequency, this is passed by the superregenerative circuit 214 and the tuned circuit 216 thereof to the lower frequency amplifier 227. During normal operation the voltage across resistor 236 is approximately four times as great as the voltage across the secondary 234. This is because the noise and off-frequency signals generate a much larger output from the untuned load 230 than from the tuned load 229. However, during those periods when the correct second frequency is applied to the amplifier 227, then the parallel resonance of the detector circuit 229 assures that up to about 90% of the total output of the detector appears across the secondary winding 234 and only about 10% across the resistor 236. Also present across resistor 236, in this example, will be the aforementioned proper third frequency. This third frequency is applied to the decoder 290.

During the initial period that the decoder 290 is powered, there will be a small leakage current through the high resistance 308 to charge the large capacitor 325 so that the base of transistor 307 is positive relative to conductor 303 and transistor 307 is made conducting. Now, when the proper third frequency is passed along the center conductor 292 of test plug 291, it will be passed to the third frequency responsive means 297. The voltage across the parallel resonant circuit 310-312 thus increases considerably and the AC signals at this third frequency are passed by the coupling capacitor 315 to the Darlington transistor pair 313. This transistor pair has an output at the collector of the last transistor which is passed through the AC coupling capacitor 317 to drive the base of the transistor 320 at this third frequency rate. The Darlington transistor pair 313 has a high impedance input to not load the induc-

tance 310 and has a low impedance output to drive the transistor 320. The turn-on of the transistor 320 on half wave positive pulses at the third frequency rate, rapidly discharges the capacitor 325, perhaps in about 10 milliseconds.

FIG. 7 shows a graph of voltages available at different parts of the receiver circuit 211. A curve 340 illustrates the signal received at the antenna 212 which as an example includes the proper first, second and third frequencies between a time t_0 and a time t_2 . Also a curve 341 shows the time period of a received signal containing only the proper first and second frequencies, the third frequency being missing. Prior to this time t_0 , the voltage across the capacitor 325 is shown by a curve 342 and this shows a voltage of 0.7 volts positive with respect to conductor 303 across this capacitor 325. From time t_0 to time t_1 ; namely, about 10 milliseconds, the capacitor 325 discharges to have essentially zero voltage thereacross at time t_1 as shown at a point 343 on this curve 342. Prior to this the transistor 307 was conducting and this caused a large DC negative bias voltage to appear on the center conductor test point 238. In the aforementioned circuit this might be a -19 volt DC bias established on the curve 344 showing the voltage at this conductor 238. During this same period prior to time t_0 this large negative voltage at this conductor 238 causes conduction of the diode 246 so that junction 243 and first terminal 241 is at a minus voltage, for example, -18.8 volts as shown by curve 345 of the potential at this terminal 241. Now at time t_1 when the transistor 307 has stopped conducting, the potential at test point 238 goes up to about +5 volts as shown at a point 346. The reason for this positive voltage is that the third frequency signal is now an off frequency signal as far as the tuned load 229 is concerned. Accordingly, a large proportion of the total output of transistor 227 appears across the resistor 236. This will be positive at the center conductor 238. This positive voltage partially biases off diode 246 so that the potential at the first terminal 241 remains at about -4.8 volts.

The curves of FIG. 7 assume a condition wherein small hand-sized transmitters may be far away from the receiver and hence be emitting a relatively weak signal, not much more than the threshold of sensitivity of the receiver. This might be 5 microvolts of signal at the antenna 212, for example. During this condition the very crests of the positive half cycles at the second frequency rate are resonated by the tuned circuit 234-240 sufficiently so that these crests are passed by the diode 248. These charge the capacitor 252 relatively slowly and this capacitor is being continuously discharged by the paralleled resistor 254. Under these conditions the charging of capacitor 252 may be sufficiently slowly achieved, as shown by a curve 347, so that the plus 0.7 volt charge condition on this capacitor 252 is not reached until a time t_3 which is subsequent to time t_2 . The time t_2 is that at which the third frequency disappears from the received signal. When the third frequency disappears, the noise, in this case an off frequency signal, on resistor 236 decreases to a lower level, perhaps +2 volts as shown at a portion 348 of the curve of voltage on this center conductor 238. During this same time period from time t_1 to time t_2 , the voltage at terminal 241 is about 4 to 5 volts negative because of conduction of diode 246 on the negative half cycles of voltage on the resistor 236. This is shown by a portion 349 on the curve of the potential at terminal

241. This negative voltage at terminal 241 makes it difficult for the proper second frequency to be passed by the diode 248 during positive half cycles.

Now at the time t_2 when the third frequency has disappeared from the incoming received signals, this third frequency which is noise insofar as the tuned circuit 229 is concerned, has now disappeared and hence the negative bias at terminal 241 has about disappeared as shown by a portion 350 of the curve of potential at this terminal 241. This means that the positive half cycles of the second frequency will be more readily passed by diode 248 to more quickly charge capacitor 252 and hence the relay will be energized at a time t_3 by conduction of transistor 250. This relay energization is shown by a curve 351 as occurring at the time t_3 . It will be understood that with a stronger signal containing frequencies one, two and three, then the energization and pull-in of the relay 251 may occur prior in time to the time t_2 ; namely, prior to the time when the third frequency disappears from the incoming signal.

At the time t_2 when the third frequency has ceased, the decoder 290 will be conditioned so that the third frequency voltage across the tank circuit 310-312 disappears. This causes transistor 320 to cease conduction and hence the capacitor 325 starts to charge as shown by portion 352 of the curve of voltage across this capacitor. This charge is relatively slow because of the high resistance of resistor 308. At some point in time t_4 , not necessarily related to the time t_3 when frequencies one and two cease, the capacitor 325 will charge to about 0.7 volts positive on the upper plate thereof so that transistor 307 again starts to conduct. This establishes the aforementioned large negative bias on center conductor 238 and on the terminal 241 as shown by portions 353 and 354 of the voltage curves on these terminals, respectively. This disables the receiver 211 so that no further signals may be passed to the relay 251. The capacitor 252 is now being discharged rather rapidly by resistor 254 as shown by curve portion 355 and when the potential thereacross falls below 0.7 volts, the transistor 250 ceases conduction and relay 251 drops out as shown by curve portion 356. The above description is with the frequencies one and two ceasing at a time t_3 which is subsequent to the time t_4 . However, should the frequencies one and two cease prior to the time t_4 , then capacitor 252 ceases charging and starts to discharge along a line 357. This would cause dropout of the relay at a point 358 on the relay energization curve.

The accelerator circuit 328 makes certain that once transistor 307 starts to turn off, it actually does turn off and quickly. Resistors 331 and 332 form a voltage divider, and the potential of junction 330 may be half way between ground and conductor 303, for example, at a potential of -15.5 V. At some time during turning off of transistor 307, the collector thereof will rise in potential to a point exceeding -15.3 volts, at which time diode 329 will conduct. This supplies a momentary current through resistors 333 and 335 and capacitor 336 to help drive the base of transistor 320 more positive and hence assure turn on thereof.

FIG. 6 shows an alternative decoder circuit 370 which may be used in place of the decoder 290 and which has a test plug 371 with a center conductor 372 and an outer conductor 373. This test plug 371 may be plugged into the test point jack 238-239 of the receiver 211. The decoder 370 has the same power supply 299

to establish a negative voltage, for example, -31 volts on a negative power supply conductor 303. This is again established by a flexible conductor 301 which may be connected to the terminal strip terminal 261.

The power supply 299 establishes this negative voltage on conductor 303 relative to a ground 374 to which the outer conductor 373 of test plug 371 is connected. The decoder 370 includes generally a disabling means 376 and a third frequency responsive means 377. The disabling means 376 is quite similar to the disabling means 396 of the circuit of FIG. 5. This disabling means 376 includes a Darlington transistor pair 378 connected in series with a resistor 379 between the negative supply conductor 303 and a terminal 380 which is connected to the test plug center conductor 372. Normally, this transistor pair 378 is biased into conduction by the bias resistor 381. This bias resistor is a large value impedance and through a resistor 383 charges a capacitor 382 connected in series therewith between negative supply conductor 303 and the ground connection 374. Accordingly, normally during non-receipt of third frequencies, the capacitor 382 will be charged enough to bias transistor pair 378 into saturation.

The third frequency responsive means 377 is a means tuned to be responsive to this frequency and is shown in this embodiment as a tuning fork 385. This tuning fork may vibrate or be in resonance at the selected third frequency rate which again may be in the order of 300 to 5,000 Hz. The input to the tuning fork 385 is from the terminal 380 through a high resistance 393 and a coupling capacitor 386 and upon receiving the proper third frequency this forces the tuning fork 385 into vibration at its resonant frequency. The output from the tuning fork is from the other fork leg at a coupling capacitor 387 which drives the base of the transistor 388 at this third frequency rate. This transistor 388 is normally biased partly on by current through resistors 389 and 394. Transistor 388 amplifies the third frequency voltage and the output appears across the resistor 389. The third frequency rate is passed by a capacitor 390 to a resistor 391. During the negative excursions of the upper end of resistor 391, a diode 392 will conduct, again at this third frequency rate. This rapidly drives the upper plate of capacitor 382 more negative so that the transistor pair 378 ceases conduction. This stops the bias previously developed by conduction of this Darlington transistor pair. Accordingly, with the bias stopped, this enables the receiver 211 so that if the received signal on antenna 212 contains a proper first and second frequencies, then the diode 248 passes this second frequency output to energize the relay 251. This is essentially the same operation as the circuit of FIG. 5 and as described by the aid of the curves of FIG. 7. Again when the third frequency ceases, the tuning fork 385 will cease oscillation, the transistor 388 will cease amplifying, diode 392 will cease conduction and capacitor 382 will again be permitted to charge slowly through the large value resistor 381. When about 1.4 volts forward bias appears across capacitor 382, this will again establish forward conduction of the transistor pair 378 to again start the negative bias which disables the receiver 211.

The decoder 290 or 370 is responsive to the third frequency which may be received on the antenna 212 of the receiver 211. The decoder by itself has a terminal 305 or 380 which may be considered a first terminal,

ground 294 or 374 may be considered a second terminal and input terminal 261 may be considered a third terminal of this decoder. The bias means or disabling means 296 or 376 develops a bias voltage and the transistor 307 or 378 is a switch means connected to this bias means to selectively connect and disconnect the bias voltage from the first terminal 305 or 380. The frequency responsive means 297 or 377 is responsive to a given frequency input; namely, the third frequency, on this first terminal 305 or 380. In each decoder there is a means connecting the output of the frequency responsive means to the switch means to actuate this switch means to change the bias voltage condition on the first terminal upon the incoming presence of the given or third frequency. This connecting means includes the transistor 320 in FIG. 5 and the transistor 388 and diode 392 in FIG. 6. In the preferred embodiment of FIG. 5, this change of the bias voltage condition on the first terminal is a disconnection of the bias voltage from this first terminal. In both FIGS. 5 and 6 there is a power supply means with a rectifier and filter so that the bias voltage is a DC voltage. The DC bias voltage appears between the first and second terminals 305 and 294 and the second and third terminals 294 and 261 are adapted to have an AC voltage applied thereto. The capacitor 325 or 382 provides a time delay of reapplying the bias voltage to terminal 305 or 380 upon cessation of third frequency input to said first terminal 305 or 380.

The time period 340 during which the first, second and third frequencies are being transmitted, as shown in FIG. 7, is a first time period. The third frequency is terminated thereafter. In the receiver circuit the third frequency responsive means is enabled during at least a second time period. This second time period is portions 349 and 350 of the voltage curve on the terminal 241. The receiver is enabled during this period, because the disabling bias means has been terminated during this time.

The aforementioned receiver circuit 211 and decoders 290 or 370 establish a circuit which accomplishes many objectives.

An additional advantage is achieved by having the subcoder 66 or 106 as a plug-in module rather than permanently wired into the transmitter 11. If a customer wants only a minimum security of one of a range of carrier frequencies and one of a range of modulation frequencies, then the transmitter 11 is completely usable as part of a transmitter-receiver set. However, let us assume that after the consumer has purchased the transmitter receiver set, he desires (1) either more security or (2) increased freedom from spurious interference which might be operating his garage door on spurious signals. In such a case, the serviceman or dealer may simply plug the subcoder into the transmitter 11, cut the jumper 22, place a similar decoder in the receiver of that set and the customer has accomplished both things; namely, increased security and increased freedom from spurious signal operation of his garage door. The transmitter 11 at that time is one which has not only the two frequencies originally built into it, but it also has the third frequency of the subcoder.

Still another advantage is gained by the dealer or distributor because he does not need to stock nearly as many parts as he did before. Considering only the transmitter of the transmitter-receiver set, and if one assumes ten possible carrier frequencies, 10 possible

modulation frequencies and ten possible subcoding frequencies, the dealer or distributor does not need to stock one thousand different transmitters. He needs to stock only ten different transmitters of different carrier frequencies, plus ninety more transmitters for the ten different modulation frequencies of each of the ten carrier frequencies, plus ten different subcoders 66 or 106. This is a stocking of 110 parts rather than 1,000 parts. Actually, the stocking of the 90 additional transmitters to cover the possible 100 codes of modulation and carrier frequencies, may be eliminated if the dealer or distributor wishes to tune the movable cores 47 for the particular modulation frequency desired. These are continuously movable tuning slugs and with some frequency standard these modulation frequencies may quickly be set by a simple screwdriver adjustment. In such case, one would need to stock only 10 transmitters for the 10 different carrier frequencies, plus 10 subcoders for the 10 different subcoding frequencies for a total of stocking only twenty parts rather than one thousand parts. A similar saving in the stocking of receivers of the transmitter-receiver set is also effected and hence this is a tremendous saving in cost and convenience to the dealer and distributor who needs to stock such a materially reduced number of units.

The decoder 290 or 370 easily may be plugged into an existing test point jack 238 on any one of several existing receivers. Prior to the plug-in of this decoder, the receiver is completely operative on two frequencies; namely, the first carrier frequency and the second or modulation frequency. The test point jack is a valid test point so that a serviceman in the field may readily check for proper carrier frequency and proper modulation frequency. It is recognized that many servicemen in the field will not have complete laboratory test equipment, and in fact, may have only a small DC voltmeter. Accordingly, the test point 238 has been selected with this in mind. To test the proper operation of the receiver 211 in the field, the serviceman merely connects a DC voltmeter from the test point center conductor 238 to ground 239 or 242. First, the modulation frequency is tuned considerably away from the proper point by moving the adjustable core slug 232. Next, the variable capacitor in the tank circuit 216 is adjusted to get a maximum reading on the voltmeter. This will be because the super-regenerative circuit 214 is passing a maximum of audio frequency signals, primarily noise, when the receiver carrier tuned circuit 216 is correctly tuned to the carrier of the transmitted signal. Second, the modulation frequency is adjusted by the movable core slug 232 until the voltmeter gives a minimum reading. The reason why the voltmeter gives a minimum reading at the proper modulation frequency is that the proportion of output voltage from the tuned load 229 relative to the untuned load 230 is a maximum at the second or modulation frequency. Since the test point center conductor 238 is effectively measuring the voltage output of the untuned load 230, this is then a minimum at the time that the second frequency received signal is a maximum. Accordingly, it will be seen that the decoder 290 or 370 plugs into an existing test point jack which is a valid and operable test point for determining the proper condition of operation of the receiver 211.

This plug-in to the test point jack establishes that the decoder 290 or 370 is operable with a minimum of electrical connections to the receiver. The plug-in es-

establishes two electrical connections and additionally provides physical support for the small lightweight decoder. A third electrical connection by means of the flexible conductor 301 is easily made to the terminal strip 264 by merely a screwdriver to fasten the conductor lug to this terminal 261. These minimum electrical connections provide not only an operating voltage to the decoder but also provide a reference potential in this case ground 242 or 294.

The above description illustrates that the decoder 290 or 370 has three different electrical conditions all on the same test point center conductor 238: (1) the third frequency signal is supplied to the decoder 290 or 370; (2) the entire receiver 211 is disabled by a bias voltage applied on this center conductor; and, (3) the entire receiver 211 is enabled by a changed electrical condition on this semiconductor 238.

The present invention is also greatly advantageous to the user. It enables the user to select one simplified system at a lower cost and later if the location of this remote control receiver is in an area wherein spurious electrical disturbances are encountered and the garage door goes up and down undesirably and due to spurious electrical disturbances, then the user may merely purchase an easily added decoder 290 or 370 to convert his receiver into one responsive to three frequencies rather than to only two frequencies.

Another important objective of the present invention is that it does not change the effective band width of the receiver in order to add the third frequency. One reason for this is that the third frequency remains on the incoming signal for only a short time, for example, a tenth of a second from time t_0 to t_2 as shown in FIG. 7. As described above when the third frequency is present, this acts generally as noise on the untuned load 230 to increase the signal thereof. This is shown at the portion 349 of the voltage at the first terminal 241 on FIG. 7. This is an establishment of a negative bias which means that the output from the tuned load 229 must be in excess of this bias in order to have current passed to the time delay capacitor 252. However, the existence of this proper third frequency is received in the decoder which then terminates the bias; namely, the disabling means, and hence the receiver is enabled after time t_2 without any change in bandwidth reception characteristics of the entire receiver 211.

The present disclosure includes that contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of the circuit and the combination and arrangement of circuit elements may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A modulated carrier system, comprising in combination, a transmitter and a receiver, said transmitter comprising output circuit means, means to develop a first frequency carrier in said output circuit means, means to develop a modulation frequency, and means connecting said modulation frequency developing means to said output circuit means to establish a carrier wave output from the transmitter influenced at said modulation frequency rate for a

first time period and to terminate said modulation frequency thereafter;

said receiver comprising a main load,

first means responsive to said first frequency to pass a signal toward said main load,

disabling means having an output connected to said main load,

means responsive to said modulation frequency,

a conductor common to said disabling means and to said modulation frequency responsive means,

means establishing said modulation frequency on said conductor,

means establishing a disabling voltage from said disabling means on said conductor and operative in the absence of a received signal containing said modulation frequency to disable the signal from actuating said main load,

and said means responsive to said modulation frequency having an output connected to terminate said disabling means output for at least a second time period to enable said receiver.

2. A modulated carrier system as set forth in claim 1, wherein said modulation frequency responsive means establishes said second time period overlapping said first time period.

3. A modulated carrier system as set forth in claim 1, wherein said modulation frequency developing means develops second and third frequencies,

and said connecting means includes separable connections for said third frequency developing means.

4. A modulated carrier system as set forth in claim 3, wherein said modulation frequency responsive means is responsive to said second and third frequencies,

means permanently connecting said second frequency responsive means into said receiver to supply a signal to said main load in response to the proper first and second frequencies,

and means establishing said third frequency responsive means selectively disconnectable and connectable to the said receiver to establish said receiver operative to pass a signal to said main load upon the presence of a received signal containing said first, second and third frequencies and subsequently said first and second frequencies.

5. A modulated carrier system as set forth in claim 3, wherein said modulation frequency responsive means is responsive to said second and third frequencies.

6. A modulated carrier system as set forth in claim 1, including means establishing at least part of said modulation frequency developing means selectively connectable with said transmitter.

7. A modulated carrier system as set forth in claim 1, including means establishing at least part of said modulation frequency responsive means selectively connectable with said receiver.

8. A modulated carrier system as set forth in claim 1, wherein said modulation frequency developing means develops second and third modulation frequencies,

means permanently wiring said second frequency developing means into said transmitter to establish a modulated frequency output from said output circuit means,

and means establishing plug-in connection of said third frequency developing means to permit opera-

tion of said transmitter with only two frequencies or selectively with three frequencies.

9. A modulated carrier system, comprising in combination, a transmitter and a receiver;

said transmitter comprising output circuit means, means to develop a first frequency carrier in said output circuit means,

and modulation frequency developing means selectively connectable to said output circuit means to establish a modulated carrier wave output from the transmitter for a first time period and to terminate said modulation frequency thereafter;

said receiver comprising a main load, first means responsive to said first frequency to pass a signal toward said main load,

modulation frequency responsive means and disabling means selectively connectable to said main load with said disabling means operative in the absence of a received signal containing said modulation frequency to disable the signal from actuating said main load,

a first connector as a part of said selectively connectable means,

means establishing said modulation frequency on said first connector,

means establishing a disabling voltage from said disabling means on said first connector to disable the signal from actuating said main load,

and said modulation frequency responsive means having an output connected to terminate said disabling means output for at least a second time period to enable said receiver to thus pass current to said main load upon the presence of a received signal containing said carrier and modulation frequencies.

10. A modulated carrier system as set forth in claim 9, including means supplying an operating voltage from said receiver to said selectively connectable modulation frequency responsive means and disabling means.

11. A modulated carrier system as set forth in claim 9, including means supplying operating voltages from said transmitter to said selectively connectable modulation frequency developing means.

12. A modulated carrier system as set forth in claim 9, wherein said modulation frequency responsive means terminates said disabling voltage on said first

connector to enable said receiver during said second time period.

13. A modulated carrier system, comprising in combination, a transmitter and a receiver;

said transmitter comprising output circuit means, means to develop a first frequency carrier in said output circuit means,

means to develop in said output circuit means a second frequency modulating said carrier frequency, and third frequency developing means selectively connectable to said output circuit means to establish a second frequency modulated carrier wave output from the transmitter influenced at said third frequency rate for a first time period and to terminate said third frequency thereafter;

said receiver comprising a main load, first means responsive to said first frequency to pass a signal toward said main load,

second means responsive to said second frequency to pass a signal toward said main load,

third frequency responsive means and disabling means having an output and selectively connectable to said main load with said disabling means operative to disable said main load in the absence of a received signal containing said third frequency, and said third frequency responsive means having an output connected to terminate said disabling means output for at least a second time period to enable said receiver to thus pass current to said main load upon the presence of a received signal containing said first, second and third frequencies and subsequently said first and second frequencies.

14. A modulated carrier system as set forth in claim 13, wherein said third frequency developing means includes a bridge T filter tuned to said third frequency.

15. A modulated carrier system as set forth in claim 13, wherein said third frequency developing means includes a mechanically vibratable tuning fork.

16. A modulated carrier system as set forth in claim 13, wherein said third frequency responsive means includes a parallel resonant circuit resonant to said third frequency.

17. A modulated carrier system as set forth in claim 13, wherein said third frequency responsive means includes a mechanically vibratable tuning fork.

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