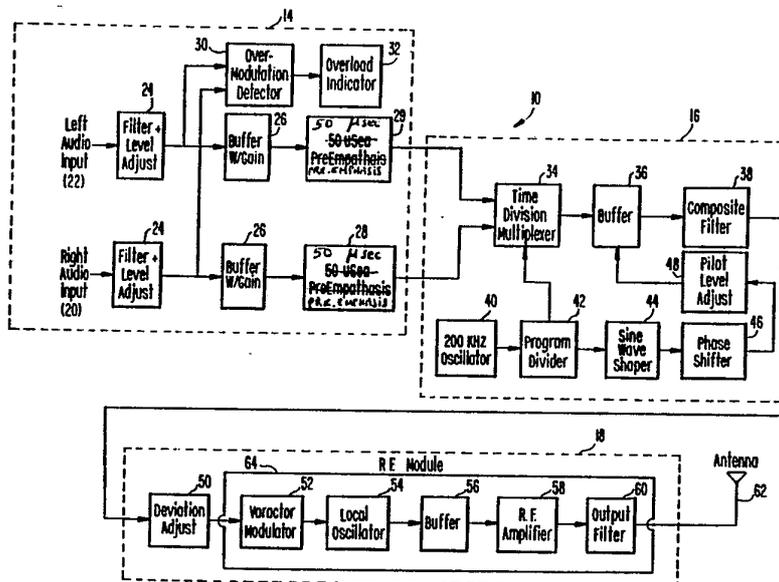




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(54) Title: SYSTEM FOR SHORT-RANGE TRANSMISSION OF SIGNALS OVER THE AIR USING A HIGH FREQUENCY CARRIER



(57) Abstract

A system is provided which transmits either analog or digital data signals over the air. The system includes a transmitter (10) and a receiver (12). The transmitter and receiver are arranged to transmit signals using a carrier signal having a high frequency such as in the range of 902-928 MHz. The transmitter and receiver are configured to provide for the transmission of two channels of stereophonic signals while maintaining high signal-to-noise ratios, good frequency response, and low distortion. To provide for the proper transmission of signals between transmitter and receiver, these devices include oscillating circuits (40, 102) having ceramic resonators which provide a base frequency which is readily modulated to facilitate proper transmission of either analog or digital signals between the transmitter and receiver. To further improve the transmission capability between the transmitter and receiver both include substantial buffering, isolation and shielding between selected circuit components to prevent unwanted areas of frequency modulation within the transmitter and receiver.

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SYSTEM FOR SHORT-RANGE TRANSMISSION OF SIGNALS
OVER THE AIR USING A HIGH FREQUENCY CARRIER

FIELD OF THE INVENTION

5 The present invention generally relates to the
transmission of information such as analog or digital data
signals over the air. More particularly, the present
invention relates to short-range transmission of information
over the air via the use of a high frequency carrier. The
system may be used for such applications as transmitting
10 signals to a high-fidelity speaker using a transmitter and
receiver where the transmitter and receiver may be separated
by a distance in the range of 10 to 300 feet.

BACKGROUND OF THE INVENTION

15 A number of systems have been developed to avoid wiring
stereo speakers directly to the source of signals used to
drive the speakers, e.g., phonographs, tape decks, CD ROM
players, or AM/FM tuners. By way of example, U.S. Patent
No. 4,829,570, issued to Larry Schotz on May 9, 1991,
discloses a system of this type. This system, while not
20 requiring direct wiring between the source of signals and
the speaker, transmits the signals over the A.C. electrical
conductors of the building in which the system is located.

The signals transmitted in this manner are subject to certain undesirable effects, such as filtering for computer systems. This type of filtering may eliminate or degrade the signals intended for transmission to the speakers.

5 An alternative to using any form of wiring between a speaker and the source of signals for driving the speaker is to transmit the signals over the air via electromagnetic waves such as radio waves. This type of system requires the use of a transmitter for transmitting the signals, a
10 receiver for receiving the signals at the speaker, and a power amplifier for amplifying the signals at the speakers to properly drive the speakers. The drawback with this type of system is that the FCC strictly regulates the frequencies at which information may be transmitted over the air without
15 the requirement of an appropriate license. Additionally, the number of frequencies at which transmission may occur is limited. Currently, the frequency bands available for transmitting information using low power transmission without a license are at high frequency ranges. For
20 example, the FCC currently allows the use of low power transmission in the range of 902 to 928 MHz, 2.4 to 2.483 GHz and 5.725 to 5.875 GHz.

Even though frequency bands are now available for the low power transmission of information at relatively high
25 frequencies (over 900 MHz), current transmitter and receiver arrangements for transmitting at lower frequencies are not readily modifiable for the purpose of transmitting at relatively high frequencies such as over 900 MHz. Attempts to modify existing transmitter and receiver arrangements to
30 transmit information have resulted in systems capable of transmitting information in a relatively crude manner. More specifically, the signal-to-noise ratio for signals transmitted using these modified systems is low, the frequency response of such systems is poor, the distortion

is typically unacceptable, and it is difficult if not impossible to transmit multiple channels simultaneously. Additionally, microphonics is a problem when a receiver is built into a speaker to which it is providing signals. More specifically, conventional inductive loops, which determine the frequency of the receiver's local oscillator, are subject to the vibrations of the speaker. These vibrations may adversely modulate the frequency of the local oscillator.

10 Wireless speaker systems are desirable, since wiring is not required between the speakers and source of signals for driving the speakers; however, an arrangement of this type is not practical if the quality of the information signal driving the speaker is poor. Stereo speaker applications require high signal-to-noise ratios, good frequency response, low distortion, and stereo capability (simultaneous transmission of two channels of information) to be practical. A wireless speaker system will not be a replacement for a system using wires unless the quality of information signals provided to drive the speakers results in a sound at the speakers comparable with the sound at similar speakers in a system using wires.

25 Accordingly, the need exists for a system capable of transmitting and receiving signals over the air using a high frequency carrier and also maintaining the quality of the signals.

SUMMARY OF THE INVENTION

30 The present invention provides for a transmitter and receiver used to transmit at least two transmitted signals carried by electromagnetic waves. The transmitter includes means for multiplexing the transmitted signals to produce a

5 multiplexed signal; means, including a first ceramic resonator, for producing a carrier signal having a carrier frequency determined by the first ceramic resonator; means for modulating the carrier frequency based upon the multiplexed signal to produce a first electric signal; and means for radiating electromagnetic waves in response to the first electric signal. The receiver includes means for converting the electromagnetic waves to a second electric signal; and means for mixing a local signal, having a local frequency, with the second electric signal to lower the frequency of the carrier signal from the second electric signal to produce a third signal. The local frequency is offset from the carrier frequency and is determined by a second ceramic resonator. The receiver also includes means for demodulating the third signal to produce a fourth signal, the multiplexed signal. The receiver also includes a means for demultiplexing the fourth signal to produce fifth and sixth signals representative of the transmitted signals.

20 The present invention further provides for a transmitter and receiver used to transmit first and second channel stereophonic signals carried by electromagnetic waves. The transmitter includes a multiplexer disposed to multiplex the signals to produce a composite signal; an oscillator including a first ceramic resonator disposed to produce a carrier frequency determined by the first ceramic resonator; means for modulating the carrier frequency based upon the composite signal to produce a first electric signal; and a first antenna coupled to the means for modulating to radiate electromagnetic waves in response to the first electric signal. The receiver includes a second antenna arranged to convert the electromagnetic waves to a second electric signal; a local oscillator including a second ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency

and determined by the second ceramic resonator; a mixer coupled to the second antenna and the local oscillator to remove the carrier signal from the second electric signal to produce a third signal; a demodulator coupled to the third
5 signal to produce a fourth signal representative of the composite signal; and a demultiplexer coupled to the demodulator. The demultiplexer demultiplexes the fourth signal to produce fifth and sixth signals representative of the first and second channel stereophonic signals,
10 respectively.

The present invention further provides a transmitter and receiver used to transmit digital signals carried by electromagnetic waves. The transmitter includes an oscillator including a first ceramic resonator disposed to
15 produce a carrier signal having a carrier frequency determined by a first ceramic resonator; a first varactor coupled to the oscillator to modulate the carrier signal based upon the digital signal to produce a first electric signal; and a first antenna coupled to the oscillator to
20 radiate electromagnetic waves in response to the first electric signal. The receiver includes a second antenna arranged to convert the electromagnetic waves to a second electric signal, a local oscillator including a second ceramic resonator disposed to produce a local signal having
25 a local frequency offset from the carrier frequency and determined by the second ceramic resonator; a second varactor coupled to the local oscillator to control the local signal; and a mixer coupled to the second antenna and the local oscillator to reduce the frequency of the carrier
30 signal from the second electric signal to produce a third signal, a demodulator coupled to the third signal to produce a fourth signal representative of the digital signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a transmitter using a high frequency carrier configured in accordance with an embodiment of the present invention;

5 FIGURE 2 is a block diagram of a high frequency receiver usable with the transmitter configured in accordance with an embodiment of the present invention;

10 FIGURE 3 is the circuit diagram for input circuitry of the transmitter configured in accordance with an embodiment of the present invention;

FIGURE 4 is the circuit diagram for multiplexing circuitry of the transmitter configured in accordance with an embodiment of the present invention;

15 FIGURE 5 is the circuit diagram for radio frequency circuitry of the transmitter configured in accordance with an embodiment of the present invention;

20 FIGURE 6 is the circuit diagram for antenna matching and intermediate frequency circuitry of the receiver configured in accordance with an embodiment of the present invention;

FIGURE 7 is the circuit diagram for frequency demodulation circuitry of the receiver configured in accordance with an embodiment of the present invention;

25 FIGURE 8 is the circuit diagram for local oscillator circuitry for the receiver configured in accordance with an embodiment of the present invention; and

FIGURE 9 is the circuit diagram for demultiplexing and audio output circuitry of the receiver configured in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5 The presently preferred embodiment of the invention will be described below in reference to the transmission of stereophonic audio signals (such as left-channel and right-channel signals) from a source to a destination, where the signals are transmitted over the air via frequency modulated
10 electromagnetic (EM) waves (e.g., radio waves). Examples of suitable sources include phonographs, tape decks, CD ROM players and AM/FM tuners, where the destination is typically a speaker.

15 While the presently preferred embodiment of the invention is described below in reference to the transmission of stereophonic audio signals which conventionally have been analog signals, the system is also usable for the transmission of digital stereophonic audio signals which may eventually replace analog audio signals
20 for purposes of transmitting audio information. Furthermore, the system may be modified for purposes of transmitting digital data signals, without the use of data transmission wires, for such applications as transmitting digital data over short distances between computers such as
25 personal computers. By way of example, the system may be modified for the purpose of replacing the costly wiring in a computer network system with the ability to transmit digital data signals over the air.

30 In general, the system includes a transmitter 10 and a receiver 12. Transmitter 10 transmits signals over the air to receiver 12 using modulated electromagnetic (EM) waves as

a carrier, where the frequency of the carrier is in the range of 902-928 MHz. While this frequency range has been selected for the carrier of the presently preferred embodiment, it should be understood that the circuitry of the presently preferred embodiment may be modified to operate at frequencies outside of the 902-928 MHz range, depending upon the requirements of the specific application.

Referring to FIGURE 1, transmitter 10, shown in block diagram form, includes audio input circuitry 14, multiplexing circuitry 16, and radio frequency (RF) circuitry 18. The circuitry for transmitter 10 is illustrated in FIGURES 3, 4 and 5, and described in further detail below.

Audio input circuitry 14 includes a right audio input channel 20 and a left audio input channel 22. The right and left channels of a stereophonic audio signal source are applied to channels 20 and 22, respectively, via an appropriate arrangement such as conventional plug-in jacks (not shown). Circuitry 14 also includes a filter and level adjust circuit 24, a buffering and gain circuit 26, and a pre-emphasis circuit 28 associated with each of channels 20 and 22.

The audio signals at channels 20 and 22 are first applied to filter and level adjust circuits 24. Circuits 24 include circuitry for filtering the audio signals. This circuitry provides a 20 KHz low pass filter for the audio signals. The low pass filter is used to attenuate high frequency noise, such as digital noise, present at the output jacks of such devices as low cost CD players. Circuit 24 also includes level adjust circuitry which allows the level of the audio signals to be adjusted so that different output levels of various audio sources may be accommodated. The signals from circuits 24 are applied to

buffering and gain circuits 26. Buffering and gain circuits 26 buffer the output of circuit 26 from the input of pre-emphasis circuit 28, and also amplify the output of circuit 24 by a gain of, for example, 10. This amplification is provided to produce signals at the output circuits 28 having appropriate amplitudes to drive the remaining circuitry of transmitter 10.

The output signals of buffering and gain circuits 26 are applied to pre-emphasis circuits 28. Transmitter pre-emphasis is a standard technique used to improve the signal-to-noise ratio of RF transmission schemes. Typically, the noise voltage output of an FM detector, resulting from phase noise modulation, increases directly in proportion to the frequency, or at 6 dB per octave. By introducing a filter after an FM detector to attenuate at 6 dB per octave, the noise spectrum can be leveled off, thus improving the signal-to-noise ratio. Typically, a standard time constant of 50 microseconds (3.18 KHz) is used. Pre-emphasis circuit 28 compensates for the de-emphasis introduced by the filter after the FM detector. Pre-emphasis circuit 28 applies pre-emphasis to the signal from circuit 26 which matches the de-emphasis which occurs in receiver 12. Of course, other de-emphasis time constants, such as 25 and 75 microseconds, may be used for different applications.

Audio input circuitry 14 also includes an over-modulation detection circuit 30 and an overload indicator 32. The output signals from filter and level adjust circuits 24 are provided to circuit 30. When the audio signal at channel 20 or channel 22 exceeds a predetermined level, circuit 30 drives overload indicator 32 such that the user of transmitter 10 recognizes that an overload condition exists. As discussed below, overload indicator 32 may include an LED. Circuit 30 allows adjustment of transmitter 10 such that an optimal signal may be transmitted by

transmitter 10 without overloading. By eliminating overload, the system will provide optimum performance and fidelity.

Multiplexing circuitry 16 includes a time division
5 multiplexor circuit 34, a buffer circuit 36, a composite
filter circuit 38, a 200 KHz oscillator circuit 40, a
programmable frequency divider circuit 42, a sine wave
shaping circuit 44, a phase shifting circuit 46, and a pilot
frequency level adjusting circuit 48. Oscillator circuit 40
10 provides a stable 200 KHz reference which is a square wave.
This square wave is provided to programmable frequency
divider circuit 42. Frequency divider circuit 42 outputs a
50 KHz square wave to time division multiplier 34, and a 25
KHz square wave to sine wave shaping circuit 44. Sine wave
15 shaper 44 operates as a double integrator of the 25 KHz
square wave to provide a 25 KHz sine wave to phase shifting
circuit 46. Phase shifting circuit 46 provides phase shifts
to the 25 KHz sine wave for the purpose of compensating for
any phase shifts introduced by sine wave shaping circuit 44.
20 The 25 KHz phase adjusted sine wave is applied to pilot
frequency level adjusting circuit 48, which adjusts the
amplitude of the 25 KHz sine wave to produce a 25 KHz sine
wave which operates as a pilot tone. The pilot tone is
applied to buffer 36.

25 The output signals of pre-emphasis circuits 28 are
applied to time division multiplexor circuit 34. Circuit 34
is clocked by the 50 KHz square wave produced by divider
circuit 42. Based upon the 50 KHz square wave, multiplexor
circuit 34 produces an output signal which is a time divided
30 multiplexed signal including alternate samples of both of
the outputs from pre-emphasis circuits 28 (left and right
channel audio information) sampled at the 50 KHz data rate.
Multiplexor 34 provides time division multiplexing to allow
the audio information from the right and left channels to be

transmitted simultaneously on a common carrier. The output signal of multiplexor 34 is a monophonic signal that occupies the base band of 0 to 20 KHz and a double side band suppressed carrier, or difference signal, which is modulated
5 in the 30-70 KHz range about a carrier at 50 KHz.

The output of multiplexing circuit 34 is applied to buffer 36. Buffer 36 sums the multiplexed signal and the pilot tone. Additionally, buffer 36 may amplify the sum of the multiplex signal and the pilot tone. Buffer 36 includes
10 low pass filtering to remove any high frequency harmonics generated during the multiplexing operation of multiplexor circuit 34. The output of buffer 36 is a composite signal including the multiplex signal and a pilot tone, and is applied to composite filter 38. Composite filter 38 is a
15 low pass filter which converts the 50 KHz square wave to a sine wave. By removing the third and fifth harmonics of the 50 KHz square wave to convert it to a 50 KHz sine wave, the required transmission band width of the system is reduced.

Radio frequency (RF) circuitry 18 includes a deviation
20 adjust circuit 50, a varactor modulating circuit 52, an oscillator circuit 54, an oscillator buffering circuit 56, an RF amplifying circuit 58, an output filtering circuit 60, and an antenna 62. Circuits 52, 54, 56, 58 and 60 are shielded from the other circuits of the transmitter by a grounded
25 metallic shield 64 made of tin or other suitable shielding material.

The filtered composite signal from composite filter circuit 38 is applied to deviation adjust circuit 50. Deviation adjust circuit 50 limits the maximum amplitude of
30 the composite signal. The output signal of adjust circuit 50 is applied to varactor modulating circuit 52 and oscillator circuit 54. Circuit 52 modulates the frequency of oscillator circuit 54. The frequency of oscillator

circuit 54 is determined by a coaxial ceramic resonator operating as a 1/4 wave resonant line. The output of oscillator circuit 54 is applied to oscillator buffering circuit 56. Circuit 56 provides very high reverse isolation and prevents external impedance fluctuations at antenna 62 from being reflected back and phase modulating oscillator circuit 54.

The output signal of oscillator buffering circuit 56 is applied to RF amplifying circuit 58. RF amplifying circuit 58 amplifies the output signal of circuit 56 to provide the required output power to antenna 62. The output signal of circuit 58 is applied to output filtering circuit 60. Output filtering circuit 60 is a low pass filter used to match the high output impedance of amplifying circuit 58 to the low impedance of antenna 62. Filtering circuit 60 is also used to attenuate the upper harmonics of the output signal of amplifying circuit 58. Output filtering circuit 60 is configured to be impedance matched to antenna 62. The output electric signal of filtering circuit 60 is applied to antenna 62. Antenna 62 is a 1/4 wave resonant monopole antenna tuned to the desired output frequency. Antenna 62 may be permanently attached to transmitter 10. Antenna 62 radiates the modulated EM waves produced by transmitter 10 such that they may be applied to antenna 66 of receiver 12.

Referring to FIGURE 2, receiver 12, shown in block diagram form, includes antenna matching and intermediate frequency (IF) circuitry 68, local oscillator circuitry 70, frequency demodulation circuitry 72, and demultiplexing and audio output circuitry 74. The circuitry for receiver 12 is illustrated in FIGURES 6, 7, 8 and 9, and described in further detail below.

Antenna matching and intermediate frequency circuitry 68 includes antenna 66, antenna matching circuit 76, radio

frequency (RF) amplifying circuit 78, band pass filter circuit 80, mixing circuit 82, intermediate frequency (IF) filtering circuit 84, IF amplifying circuit 86, IF filtering circuit 88, and buffering circuit 90. Antenna 66 is a 1/4
5 wave resonant monopole antenna which is removably attached to receiver 14. By way of modification, antennas 62 and 66 may be a 1/4 wave monopole omnidirectional antenna, a three-element Yagi directional antenna, a dipole loop antenna, or a 5/8 wave monopole antenna. Of course, transmission range,
10 multipath rejection, and product packaging will all influence the configuration of an antenna used for a given application.

Antenna 66 is tuned to receive electromagnetic waves radiated by antenna 62. In response to the reception of
15 electromagnetic waves, antenna 66 applies an electric signal to antenna matching circuit 76. Antenna matching circuit 76 matches the impedance of antenna 66 to the impedance of radio frequency amplifying circuit 78. The output signal of circuit 76 is amplified by amplifying circuit 78 which
20 provides high gain, high reverse isolation, low noise and low input capacitance. Amplifier circuit 78 provides a high level signal for driving mixing circuit 82. The amplified output signal from circuit 78 is filtered by band pass filter circuit 80 prior to application to mixing circuit 82.
25 Band pass filter circuit 80 filters the output of circuit 78 to select the specific signals to which receiver 12 is tuned.

The filtered and amplified signal from band pass filter circuit 80 is applied to mixing circuit 82. Additionally,
30 the output signal (local signal) of local oscillator circuitry 70 is applied to circuit 82. Circuit 82 mixes the output signal from circuitry 70 and filter circuit 80. The output signal from circuit 82 is the difference between the signals from circuits 80 and 112. The signal from circuits

80 includes a carrier signal component (e.g., 902-928 MHz) which is offset from (typically greater than) the output signal of circuitry by an offset frequency. This frequency is preferably held at 10.7 MHz which is a typical IF
5 frequency. This mixing process is commonly referred to as a hetrodyne process.

The IF output signal from mixing circuit 82 is applied to IF filtering circuit 84. Circuit 84 is a selective filter which filters the IF output signal to produce a
10 filtered output signal which may be centered about an IF frequency, e.g., 10.7 MHz. The filtered output signal of circuit 84 is applied to IF amplifying circuit 86. Circuit 86 provides isolation between IF filters 84 and 88, and amplifies the filtered output signal from circuit 84 to
15 compensate for internal losses of IF filters 84 and 88. This amplification may be in the range of 10 db. The amplified output signal of circuit 86 is applied to IF filtering circuit 88. Circuit 88 is a selective filter which further filters the amplified output signal from
20 circuit 86. The signal from circuit 88 is centered about the IF frequency. The filtered output signal of circuit 88 is applied to frequency demodulation circuitry 72.

Frequency demodulation circuitry 72 includes an IF amplifying circuit 90, an IF filtering circuit 92, a
25 limiting amplifier and quadrature detecting circuit 94, a center tune indicator circuit 95, an automatic frequency control (AFC) buffering circuit 96, an AFC tuning circuit 98, and a fine tuning circuit 100. The filtered output signal from IF filtering circuit 88 is applied to IF
30 amplifying circuit 90. IF amplifying circuit 90 provides the proper impedance match between IF filter 88 and IF filter 92. Additionally, IF amplifying circuit 90 provides phase shift correction for phase shifting which may occur in IF filtering circuit 92. The output signal of circuit 90 is

applied to IF filtering circuit 92. Circuit 92 filters the output signal of circuit 90 to provide a high degree of selectivity which results in improved adjacent channel rejection. Circuit 92 also improves the frequency modulation quieting curve as well as the signal-to-noise ratio by reducing the bandwidth of the IF signal.

The filtered output signal of IF filtering circuit 92 is applied to limiting amplifier and quadrature detecting circuit 94. Circuit 94 demodulates the output signal from circuit 92 to produce a composite, demodulated output signal (audio output), a received signal strength indicating signal, and an automatic frequency control (AFC) signal. The composite demodulated output signal and received signal strength indicating signal are applied to demultiplexing and audio output circuitry 74. The AFC signal is applied to indicator circuit 95 and automatic frequency control (AFC) buffering circuit 96.

Circuit 95 indicates when the receiver is properly tuned and provides feedback for the adjustment of fine tuning circuit 100. Circuit 96 amplifies the AFC signal from circuit 94 and provides isolation between AFC tuning circuit 98 and circuit 94. The output signal of circuit 96 is applied to circuit 98. Circuit 98 automatically tunes the frequency of the receiver to the frequency of the transmitter in dependence upon the output signal of circuit 96 and fine tuning circuit 100. Circuit 100 provides a manual input for purposes of fine tuning the receiver frequency to the transmitter frequency. AFC tuning circuit 98 provides an AFC voltage signal to local oscillator circuitry 70.

Local oscillator circuitry 70 includes a local oscillator circuit 102, a band pass filter circuit 104, a buffering circuit 106, a band pass filter circuit 108, and a

buffering circuit 110. The AFC voltage signal from AFC tuning circuit 96 is applied to circuit 102. Circuit 102 produces a local oscillator signal having a local frequency determined by a coaxial ceramic resonator similar to that in circuit 54. The local oscillator frequency is controlled by the AFC voltage signal.

The local oscillator signal is applied to band pass filter circuit 104. Circuit 104 filters the local oscillator signal, and applies the signal to buffering circuit 106. Circuit 104 provides band pass filtering centered on the local oscillator frequency to remove harmonics and provide isolation. Buffering circuit 106 isolates circuit 106 from band pass filter circuit 108 and also amplifies the local oscillator signal to account for losses in circuit 104. By way of example, circuit 106 may provide 10 db of amplification. The output signal of circuit 106 is applied to band pass filter circuit 108. Band pass filter circuit 108 provides band pass filtering centered on the local oscillator frequency to remove harmonics and provide isolation. The output of circuit 108 is applied to buffering circuit 110. Circuit 110 provides low impedance suitable for driving buffering circuit 112. Buffering circuit 112 provides a low impedance signal to mixing circuit 82 which produces a mixed output signal, as described above.

The demodulated output signal and strength indicating signal produced by circuit 94 are applied to demultiplexing and audio output circuitry 74. Demultiplexing and audio output circuitry 74 includes a buffering circuit 114, and a stereo decoding circuit 116 which has a right channel output and a left channel output. Circuitry 74 also includes de-emphasis circuits 118, pilot filtering circuits 120, and output buffering circuits 122. One of circuits 118, 120 and 122 is associated with the right channel output, whereas the

other of circuits 118, 120 and 122 is associated with the left channel output. The composite output signal from circuit 94 is provided to buffering circuit 114. Buffering circuit 114 amplifies the composite output signal and provides the correct signal level to stereo decoding circuit 116.

The amplified composite signal and strength indicating signal from circuit 95 are applied to circuit 116. Circuit 116 provides a time division demultiplexing scheme for demultiplexing the amplified composite signal. Based upon the strength indicating signal, circuit 116 provides blending of a right channel signal (right audio signal) at the right channel output and a left channel signal (left audio signal) at the left channel output for the purpose of providing noise cancellation under weak signal conditions to improve the signal-to-noise ratio. The right and left channel signals are applied to their respective de-emphasis circuits 118. De-emphasis circuits 118 provide 50 microsecond de-emphasis to compensate for the pre-emphasis applied by transmitter 10. Circuits 118 apply the de-emphasized signals to the respective pilot filtering circuits 120. Circuits 120 filter out the pilot signal from the de-emphasized signals. The filtered signals from circuits 120 are provided to the respective output buffering circuits 122. Output buffering circuits 122 amplify the filtered signals and provide a low impedance output. Output buffering circuits 122 may be coupled to conventional stereo jacks appropriate for a particular application.

The signals produced by output buffers 122 are of the type which are satisfactory for driving audio power amplifiers 124, which in turn drive audio speakers 126. Receiver 12, power amplifiers 124 and speakers 126 may all be housed in separate enclosures, but preferably, receiver 12, two audio power amplifiers 124, and one audio speaker

126 would be housed in one enclosure. Where receiver 12, two amplifiers 124 and one speaker 126 are housed in one enclosure, a wire would be provided from receiver 12 to the second speaker 126, which may be housed in separate enclosures.

5 To provide for proper electromagnetic shielding within receiver 12, a shield 128 houses circuitry 68 and circuitry 70. By way of example only, this shield may be fabricated from tin or any other appropriate shielding material. Additionally, circuitry 68 and 70 may be shielded
10 separately.

Referring to FIGURES 3-5, FIGURES 3-5 illustrate the circuit diagrams for transmitter 10, and FIGURES 6-9 illustrate the circuit diagrams for receiver 12. At the end of the detailed descriptions of transmitter 10 and receiver
15 12 are Tables A and B. Table A is a listing of the circuit components for transmitter 10, and Table B is a listing of the components for receiver 12. By way of example only, the components of transmitter 10 and receiver 12 may be surface mount components mounted on their respective circuit boards.

20 Referring to FIGURE 3, FIGURE 3 is the circuit diagram for a transmitter power supply 130 and audio input circuitry 14. Power supply 130 includes a 120 volt AC plug 132 coupled to an 18 volt transformer 134 via a fuse 136. The secondary winding of transformer 134 is coupled to a full
25 wave rectifier 138 which provides an 18 volt rectified signal to the input of a 12 volt voltage regulator 140. The input of regulator 140 is coupled to ground via parallel capacitors 142 and 144, and a resistor 146 in series with an
30 LED 148. Capacitors 142 and 144 filter the 18 volt signal applied to regulator 140 to provide a range of filtering for the 60 Hz AC power voltage and higher frequency noise, and LED 148 provides an indication that power is being supplied to regulator 140. Regulator 140 provides a 12 volt filtered

output to 12 volt supply voltage terminal 150. Terminal 150 is coupled to ground via capacitor 152 to filter noise developed by regulator 140 from the 12 volt output.

5 Right audio input 20 and left audio input 22 are applied to filter and level adjust circuits 24. The inputs are applied to a resistor 156 coupled to ground and a resistor 158 coupled to ground via a capacitor 160 and a potentiometer 162. The combination of resistor 156, resistor 158 and capacitor 160 provides a 20 KHz low pass
10 filter for the signals applied at audio inputs 20 and 22. Potentiometer 162 allows the output signals from circuits 24 to be level adjusted to accommodate different output levels of various audio sources.

The signals at the taps of potentiometers 162 are
15 applied to buffering and gain circuits 26. Each signal is applied to a capacitor 164 which is coupled to the non-inverting input of an op amp 166, which is coupled to a reference voltage (which by way of example, may be 6 volts via resistor 168. This reference voltage is also coupled to
20 the inverting input of op amp 166 by a resistor 172 and the non-inverting input of op amp 176. Resistor 174 provides the feedback circuit to the inverting input of op amp 166. The signals from the outputs of op amps 166 are applied to pre-emphasis circuits 28. Each signal is applied to the
25 inverting input of an op amp 176 via a series arrangement of a resistor 178 and a capacitor 180 in parallel with a resistor 182. The combination of capacitor 180 and resistor 182 provide the 50 microsecond time constant for pre-emphasis circuit 28, and resistor 178 provides a 20 KHz
30 shelf to restrict pre-emphasis to frequencies below 20 KHz.

A resistor 184 provides feedback for op amps 176. The output of op amp 176 for the right audio signal is applied to conductor 186, and the output of op amp 176 for the left

audio signal is applied to conductor 188. Op amps 166 and 176 are part of a quad package which is coupled to ground and coupled to supply voltage terminal 150 as a source of 12 volt electrical power. The non-inverting inputs of op amps
5 176 are coupled to ground via capacitors 170, and also coupled to a reference voltage via a resistor 190. This reference voltage is coupled to ground with a parallel arrangement of a capacitor 192 and a resistor 194. Capacitor 192 and resistor 194 are coupled to voltage
10 terminal 150 by a resistor 196. Resistors 194 and 196 operate as a voltage divider to provide 6 volts at their connection, where capacitor 192 further filters this voltage. The terminal between capacitor 192 and resistor 194 is coupled to terminal 150 by a resistor 198.

15 The output signals of op amps 176 are applied to over-modulation detection circuit 30 via conductors 186 and 188. Conductor 188 is coupled to the non-inverting input of op amp 202 and the inverting input of op amp 206 by resistor 198. Potentiometer 200 couples this junction to the
20 reference voltage point between resistors 194 and 196. Conductor 196 is coupled to this same junction by resistor 204. The inverting input of op amp 202 is coupled to the half supply point between resistors 190 by a resistor 208 and also connected to supply 150 by resistor 201. The non-
25 inverting input of op amp 206 is coupled to ground by resistor 210 and the reference voltage between resistors 194 and 196 by a resistor 212. The outputs of the op amps are coupled to ground via diodes 214 and 216, respectively, and a capacitor 218. Potentiometer 200 provides an adjustable
30 reference voltage which is applied to op amps 202 and 206 as discussed above.

Capacitor 218 is also coupled to overload indicator 32. More specifically, the voltage across capacitor 218 is applied to a resistor 220 which is coupled to the base of a

transistor 222, and also coupled to a resistor 224 which is coupled to ground. Capacitor 218 operates as an integrator of the signals from op amps 202 and 206, since these signals are of such a frequency that LED 226 would appear as always ON without capacitor 218 present. The emitter of transistor 222 is coupled to ground, and the collector is coupled to the cathode of LED 226. The anode of LED 226 is coupled to voltage terminal 150 by resistor 228. Accordingly, the over-modulation detection circuit 30 and overload indicator 32 cooperate to light LED 226 when the signals from op amps 176 are above a predefined voltage.

Circuits 30 and 32 are configured such that LED 226 is lit up when the signals from op amps 176 exceed a predetermined unacceptable voltage. Potentiometer 200 allows the signal output levels from op amps 176 to be adjusted such that the voltage level output of the signals is lowered to a point where LED 226 is turned off. Alternatively, potentiometer 200 may be adjusted to maximize the voltage of the output signals of op amps 176 by adjusting the signal levels such that LED 226 is at the threshold of turning on.

Referring to FIGURE 4, FIGURE 4 is a circuit diagram for multiplexing circuitry 16. Conductors 186 and 188 are coupled to multiplexing circuitry 16. A resistor 230 couples conductor 186 to one input pin of a multiplexor 232, and resistor 234 couples conductor 188 to the other input pin of multiplexor 232 of time division multiplexor circuit 34. 200 KHz oscillator 40 includes a capacitor 236 coupled to voltage terminal 150 and ground. Capacitor 236 is also coupled to inverter 238. Inverter 248 is coupled to the input of inverter 238 and is coupled to a circuit including a ceramic resonator 240. The terminals of ceramic resonator 240 are coupled to ground by capacitors 242 and 244, respectively. One of the terminals of resonator 240 is also

coupled to the output of inverter 248 by resistor 246, and the other terminal of resonator 240 is coupled to the input terminal of inverter 248. Inverter 248 with feedback resistor 250 has its output coupled to the input of inverter 238. The output of inverter 238 has a frequency of 200 KHz, and is applied to programmable frequency divider circuit 42.

The 200 KHz output signal of inverter 238 is applied to the clock input of programmable frequency divider 252. The voltage terminal of divider 252 is coupled to ground by capacitor 254 and also coupled to supply terminal 150. Divider 252 is grounded in a conventional manner. The output of divider 252 provides an output square wave having a frequency equal to the clock frequency divided by M, where M is 2^n , where n may range between 1 and 12. In particular, to obtain a particular frequency square wave from divider 252, the appropriate terminal on divider 252 is chosen. For the current application, the terminal providing a 50 KHz square wave is coupled to the clock input of multiplexor 232, and the 25 KHz output is coupled to sine wave shaping circuit 44.

The 25 KHz square wave is applied to a capacitor 256 which is coupled to ground by resistor 258 and capacitor 260. The terminal between capacitor 260 and resistor 258 is coupled to the inverting input of an op amp 262 by a resistor 264. For feedback, the output of op amp 262 is coupled to the inverting input by a resistor 266 coupled in parallel with a series arrangement of capacitors 268 and 270. The junction between capacitors 268 and 270 is coupled to ground by resistor 272. The non-inverting input of op amp 262 is coupled to a reference voltage (which, by way of example, may be 6 volts) by a resistor 274. From this point, capacitor 276 is coupled to ground in parallel with a resistor 278, resistor 277 provides positive voltage by coupling this point to terminal 150. The arrangement of

shaping circuit 44 produces a 25 KHz sine wave at the output of operational amplifier 262.

The 25 KHz sine wave is applied to a potentiometer 280 of pilot frequency level adjusting circuit 48.

5 Potentiometer 280 is coupled to ground by capacitor 282. The terminal between potentiometer 280 and capacitor 282 is coupled to a resistor 284, which is coupled to a potentiometer 286. Potentiometer 286 is coupled to the non-inverting input of op amp 262 by resistor 274. The
10 combination of potentiometer 280 and capacitor 282 provide a phase delay to compensate for the phase advance introduced by circuit 44.

The center tab of potentiometer 286 is coupled to the inverting input of op amp 288 by a resistor 290, providing a
15 means of adjusting the pilot level into op amp 288. The non-inverting input of op amp 288 is coupled to the reference voltage mentioned above along with the bottom of potentiometer 286. The output of multiplexor 232 is coupled to the inverting input of op amp 288 by a resistor 292. A
20 resistor 294 and capacitor 296 are coupled in parallel between the output of op amp 288 and its inverting input. Op amp 288 provides isolation between adjusting circuit 48 and filter circuit 38 and amplification with a gain of approximately 4. Capacitor 296 provides filtering for the
25 output signal at op amp 288. Op amps 202, 206, 262 and 288 are housed in a quad op amp package which is coupled to ground and is provided power via a connection to voltage terminal 150.

The output of op amp 288 is coupled to composite filter
30 circuit 38. The composite signal applied to circuit 38 is applied to output conductor 298 by a series connection of a potentiometer 300, resistor 302, inductor 304, inductor 306, inductor 308, and capacitor 310. The terminal between

inductors 304 and 306 are coupled to ground by capacitor 312, and the terminal between inductors 306 and 308 is coupled to ground by capacitor 314. The arrangement of circuit 38 provides for a filtered composite signal at conductor 298. Circuit 38 removes harmonics from the composite signal to produce a signal with a more sinusoidal shape.

Referring to FIGURE 5, FIGURE 5 illustrates the circuit diagram for radio frequency (RF) circuitry 18. Conductor 298 from multiplexing circuitry 16 is coupled to ground via a resistor 311 coupled in series with a potentiometer 315 of deviation adjust circuit 50. The center tab of potentiometer 315 is coupled to modulating circuit 52 with a capacitor 316 and an inductor 318. The terminal between inductor 318 and resistor 334 is coupled to ground with capacitors 320 and 322. The adjustment of potentiometer 315 limits the maximum amplitude of the composite signal. Capacitor 316 is a DC blocking capacitor, where inductor 318 and capacitors 320 and 322 form a low pass filter which minimizes RF radiation at this location in circuit 50.

Resistor 324 is coupled to the output of a voltage regulator 326. Voltage regulator 326 is a 5 volt regulator having its input coupled to ground via capacitor 328 and also coupled to voltage terminal 150 by an inductor 330. Capacitor 328 and inductor 330 provide further filtering for the input voltage to regulator 326. Regulator 326 is coupled to circuit ground in a conventional manner. The terminal between capacitor 322 and resistor 324 is coupled to the cathode of a varactor 332 (device with variable capacitance based upon voltage) by a resistor 334. The anode of varactor 332 is coupled to ground. The voltage applied at the cathode of varactor 332 varies the capacitance of varactor 332 in such a way to modulate the frequency of the signal produced by oscillating circuit 54.

Capacitor 322 and resistor 324 form a low pass filter for the signal applied to varactor 332 to reduce noise.

The terminal between varactor 332 and resistor 334 is coupled to a coaxial ceramic resonator 336 by a capacitor 338. Resonator 336 is also grounded. The terminal between capacitor 338 and resonator 336 is coupled to ground via a capacitor 340 and a variable capacitor 342. The terminal between resonator 336 and capacitor 340 is coupled to the collector of transistor 346 by a capacitor 344. Variable capacitor 342 is used to adjust the oscillator frequency.

Resonator 336 provides a very stable, low-noise resonating component which operates at the fundamental frequency of circuit 54 without the requirement of frequency multiplication. Additionally, resonator 336 is substantially immune from microphonic effects such as speaker vibration or mechanical shock. Resonator 336 allows oscillating circuit 54 to operate in such a way that transmitter 10 may transmit signals to receiver 12, where high signal-to-noise ratios are obtained at receiver 12.

The collector of transistor 346 is also coupled to the output of voltage regulator 326 by a resistor 348 coupled in series with an inductor 350. The output of voltage regulator 326 is coupled to ground by a capacitor 352 to provide further filtering for the voltage output by regulator 326. It is important that the voltage applied by regulator 326 to circuits 52 and 54 is adequately filtered to prevent disturbances in the frequency produced by oscillating circuit 54. The terminal of resistor 348 coupled to the output of regulator 326 is also coupled to ground by a capacitor 354 for further filtering. The terminal between resistor 348 and capacitor 354 is coupled to the base of transistor 346 by a resistor 356 coupled in series with a resistor 358. The terminal between resistor

356 and 358 is coupled to ground by a capacitor 360 in parallel with a resistor 362. The base of transistor 346 is also coupled to ground by a capacitor 364 in parallel with a capacitor 366. The emitter of transistor 346 is coupled to
5 its collector by a capacitor 368. The emitter of transistor 346 is also coupled to ground by an inductor 370 in series with a capacitor 372 parallel with a resistor 374. The emitter of transistor 346 is also coupled to ground by a capacitor 376. Generally, transistor 346 is configured as
10 described to form a common base Colpitts oscillator.

The above described arrangement of varactor 332, resonator 336, transistor 346 and other associated components allows for a broad and linear modulation of the resonator 336 frequency. For example, at a resonator 336
15 frequency of 910 MHz, this frequency may be deviated by \pm 120 KHz while maintaining a linearity with the voltage across varactor 332 within .1%.

The emitter of transistor 346 is coupled by a capacitor 378 to one gate of a dual gate transistor 380 of oscillator buffering circuit 56. The terminal between capacitor 378
20 and the first gate of transistor 380 is coupled to ground by inductor 382. The second gate (2) of transistor 380 is coupled to ground by a capacitor 384 coupled in parallel with a resistor 386. The second gate of transistor 380 is
25 also coupled to the output of regulator 326 by a resistor 388. The source (S) of transistor 380 is coupled to ground by a capacitor 390 in parallel with a resistor 392. The drain of transistor 380 is coupled to the output of
regulator 326 by an inductor 394 in series with a resistor
30 396. The terminal between inductor 394 and 396 is coupled to ground by a capacitor 398. A capacitor 400 also couples the drain (D) of transistor 380 to the base of transistor 402 of RF amplifying circuit 58. Dual gate transistor 380 operates as a low noise amplifier and provides isolation

between oscillator circuit 54 and amplifying circuit 58 to avoid adverse effects upon the frequency generated by circuit 54. Capacitor 378 and inductor 382 provide impedance matching between transistors 346 and 380, and
5 inductor 394 and capacitor 400 provide impedance matching between transistors 380 and 402.

The base of transistor 402 is coupled to ground by a resistor 404 and coupled to the output of regulator 326 by resistor 406. The emitter of transistor 402 is coupled to
10 ground by capacitor 408 in parallel with a resistor 410. The collector of transistor 402 is coupled to voltage terminal 150 by inductor 330, an inductor 412, and an inductor 414. The terminal between inductors 330 and 412 is coupled to ground by capacitor 416, and the terminal between
15 inductors 412 and 414 is coupled to ground by a capacitor 418. Inductors 330 and 412 provide isolation for the voltage applied to the collector of transistor 402. Inductor 414 and capacitor 420 provide impedance matching between transistor 402 output filtering circuit 60.

20 The collector of transistor 402 is coupled to a capacitor 420 of output filtering circuit 60. Capacitor 420 is coupled to antenna 62 by an inductor 422 in series with an inductor 424. The terminal between capacitor 420 and inductor 422 is coupled to ground by capacitor 426, the
25 terminal between inductors 422 and 424 is coupled to ground by capacitor 428, and the terminal between inductor 424 and antenna 62 is coupled to ground by a variable capacitor 430. Circuit 60 is a double-pi low pass filter which removes undesired harmonics from the output signal of transistor
30 402.

In the preferred embodiment of transmitter 10 described in detail above, the base frequency of oscillating circuit 54 may be tuned to a frequency between 902 and 928 MHz,

where the base frequency is determined by coaxial ceramic resonator 336, and modulated based upon the voltage applied at varactor 332. This high frequency signal is applied to antenna 62 after the appropriate buffering, amplification and filtering by circuits 56, 58 and 60. By way of
5 modification, the base frequency of oscillating circuit 54 may be tuned to frequencies outside of the 902-928 MHz frequency range, depending upon the application and particular governmental regulations.

10 Referring to FIGURE 6, FIGURE 6 is the circuit diagram for antenna matching and intermediate frequency (IF) circuitry 68. The electromagnetic waves from antenna 62 which are received by antenna 66 produce a signal in antenna matching circuits 76. Antenna 66 is coupled to ground by a
15 variable capacitor 432. The terminal between antenna 66 and capacitor 432 is coupled to one gate (1) of dual gate transistor 434 by a capacitor 436. The terminal between gate 1 of transistor 434 and capacitor 436 is coupled to ground by inductor 438. Capacitor 436 and inductor 438
20 impedance match antenna 66 to transistor 434.

Transistor 434 is the main component of radio frequency (RF) amplifying circuit 78. The second gate (2) of transistor 34 is coupled to ground by a capacitor 440 arranged in parallel with a resistor 442. The second gate
25 of transistor 434 is also coupled to a 12 volt DC source 448 which may be of a conventional source having a configuration such as the power supply for transmitter 10. A series arrangement of a resistor 450, an inductor 452, and an inductor 454 connect gate 2 of transistor 434 to DC source
30 448. The terminal between gate 2 and resistor 450 is coupled to ground by capacitor 456, and the terminal between resistor 450 and inductor 452 is coupled to ground by capacitor 458. Inductor 452, inductor 454, capacitor 456 and capacitor 458 serve to further filter the DC voltage

supplied by source 448 to transistor 434 to avoid introducing unwanted noise into circuit 78. The source (S) of transistor 434 is coupled to ground by a capacitor 460 arranged in parallel with resistor 462.

5 The drain (D) of transistor 434 is coupled to band pass filter circuit 80. In particular, the drain is coupled to a capacitor 464 where the terminal between capacitor 464 and the drain is coupled to ground by a capacitor 466, and this terminal is also coupled to DC source 448 by a series
10 arrangement of an inductor 468, a resistor 470 and inductor 454. The terminal between inductor 468 and resistor 470 is coupled to ground by a capacitor 472, and the terminal between resistor 470 and inductor 454 is coupled to ground by capacitor 474. Capacitors 472 and 474, and inductor 468
15 provide filtering for the DC voltage applied by source 448 to circuit 80. The side of capacitor 464 opposite the drain of transistor 434 is coupled to ground by inductor 476. The arrangement of capacitor 464, capacitor 466, and inductor 476 provides a band pass filter for the signal produced by
20 the drain of transistor 434.

 The terminal between capacitor 464 and inductor 476 is coupled to one gate (1) of a dual gate transistor 478, which is the main component of mixing circuit 82. The second gate (2) of transistor 478 is coupled to the drain of dual gate
25 transistor 480 which is the main component of buffering circuit 112. Gate 2 of transistor 478 is coupled to the drain of transistor 480 by capacitor 482, and gate 2 of transistor 478 is also coupled to ground by an inductor 484. The source of transistor 478 is coupled to ground by a
30 parallel arrangement of a capacitor 486, a capacitor 488 and a resistor 490. The difference of the signal from band pass filter circuit 80 and buffering circuit 112 are produced at the drain of transistor 478 which is coupled to intermediate frequency (IF) filtering circuit 84. IF filtering circuit

84 provides a band pass filter, centered upon the IF frequency, for the difference of the signals..

The drain of transistor 478 is coupled to DC source 448 by a resistor 492 arranged in series with a resistor 494 and inductor 454. The terminal between inductor 454 and resistor 494 is coupled to ground by a capacitor 496 which provides filtering for the voltage applied by source 448 to circuit 84. The terminal between resistor 492 and resistor 494 is coupled to ground by a capacitor 498 and capacitor 500 arranged in parallel, which provide filtering. The drain of transistor 478, in addition to being coupled to resistor 492, is coupled to the anode of a diode 502, the cathode of a diode 504, and the primary winding of a transformer 506. Resistor 492, diode 502, diode 504 and the primary winding of transformer 506 are arranged in parallel along with a capacitor 508. This arrangement provides filtering and isolation for the signal from the drain of transistor 478. Diodes 502 and 504 provide amplitude limitation to prevent overload. For example, an overload condition may occur when transmitter 10 is close to receiver 12. Transformer 506 provides a component of the band pass IF filtering in circuit 84.

The secondary winding of transformer 506 is coupled between ground and IF amplifying circuit 86. The secondary winding is coupled to the gate of a transistor 510, where the gate is also coupled to ground by a resistor 512. The source of transistor 510 is coupled to ground by a capacitor 514 arranged in parallel with a resistor 516. The drain of transistor 510 is coupled to the primary winding of a transformer 518 in IF filtering circuit 88. The primary winding is also coupled to DC source 448, a capacitor 520 and resistor 522 are arranged in parallel across the primary winding. To provide further filtering for the DC voltage applied to circuit 88, capacitors 524 and 526 connect the

output of inductor 454 to ground. The secondary winding of transformer 518 is coupled between ground and frequency control circuit 72.

Referring again to mixing circuit 82, a buffering
5 circuit 112 provides a signal to circuit 82. Circuit 112 is coupled to local oscillator circuit 70 by a resistor 528 which is coupled to one gate (1) of transistor 480. To provide filtering and impedance matching, an inductor 530 is coupled between ground and gate 1. The second gate (2) of
10 transistor 480 is coupled to ground by a capacitor 532 arranged in parallel with a resistor 534. Gate 2 is also coupled to DC source 448 by a resistor 536 coupled to inductor 454. The drain of transistor 480 is also coupled to source 448 by an inductor 538, a resistor 540 and
15 inductor 454. The terminal between inductor 538 and resistor 540 is coupled to ground by a capacitor 542. As discussed above, the drain of transistor 480 is also coupled to gate 2 of transistor 478 by capacitor 482. The source of transistor 480 is coupled to ground by a capacitor 544
20 arranged in parallel with a resistor 546. Capacitor 542 and inductor 438 provide filtering and isolation of the voltage applied by source 448 to the drain of transistor 480. This arrangement for gate 2 provides a DC bias to gate 2.

Referring to FIGURE 7, FIGURE 7 is a circuit diagram
25 for frequency demodulation circuitry 72. The signal from the secondary winding of transformer 518 (IF output 519) of antenna matching and IF circuitry 68 is applied to the gate of a transistor 544, which is the main component of IF amplifying circuit 90. The gate of transistor 544 is
30 coupled to ground by a resistor 546 and also coupled to the drain of transistor 544 by a capacitor 548. The drain of transistor 544 is also coupled to DC source 448 by a resistor 550. The source of transistor 544 is coupled to ground by a resistor 552. The drain of transistor 544 is

coupled to IF filtering circuit 92. Resistor 550 provides impedance matching between circuits 90 and 92. Capacitor 548 corrects the phase shift introduced by circuit 92.

5 The 12 volt DC source will now be described in more detail. Source 448 is connected to circuit 90, which is connected to a 15 volt DC supply 554 coupled to the input of a conventionally grounded voltage regulator 556. The input of voltage regulator 556 is coupled to ground by a capacitor 558 in parallel with a capacitor 560. Capacitors 558 and
10 560 provide high and low frequency filtering at the input of regulator 556. Source 448 is provided at the output of regulator 556, where the output is coupled to ground by a capacitor 562 which provides a degree of filtering for the output voltage of regulator 556.

15 IF filtering circuit 92 includes a ceramic filter 564 which is conventionally grounded. A capacitor 566 couples the drain of transistor 554 to ceramic filter 564. Filter 564 is coupled to limiting amplifier and quadrature detecting circuit 94. In particular, filter 564 is coupled
20 to intermediate frequency detector 568. Circuit 92 provides highly selective band pass filtering about the IF frequency.

The filtered signal from filter 564 is coupled directly to pin 1 of detector 568 and coupled to pin 3 of detector 568 by resistor 570. Pin 3 is coupled to pin 2 of detector
25 568 by a capacitor 572 and coupled to pins 4 and 14 (ground) by capacitor 574. Pin 2 is coupled to ground by capacitor 576. Pin 15 of detector 568 is coupled to ground by a capacitor 578 arranged in parallel with a potentiometer 580. Potentiometer 580 allows adjustment of the mute threshold.
30 Pin 11 of detector 568 is coupled to DC source 448 by an inductor 582 for filtering. To provide additional filtering of the voltage from source 448, a capacitor 584 is coupled at the terminal between detector 568 and inductor 582.

Still further filtering of the voltage at source 448 is provided by a capacitor 563 coupled between source 448 and ground at circuit 94. Pin 12 of detector 568 is coupled to ground by capacitor 586 arranged in parallel with a resistor 588. Pin 12 is also coupled to pin 5 by a single pole, double throw switch 590 arranged in series with a resistor 592. The terminal between resistor 592 and pin 5 is coupled to ground by a capacitor 594. With switch 590 in the ON mode, muting is provided, and with switch 590 in the OFF mode, muting is defeated. Pin 16 of detector 568 is coupled to ground by a capacitor 596 arranged in parallel with a capacitor 598 and resistor 600.

Pin 6 of detector 568 outputs the composite audio signal and is coupled to ground by capacitor 602 which provides a certain level of filtering. Pin 13 outputs a signal strength signal and is coupled to ground by a capacitor 604 in parallel with the series arrangement of resistor 606 and capacitor 608, where the signal strength signal is produced at the terminal between resistor 606 and capacitor 608. Conductors 610 and 612 provide the composite audio signal and signal strength signal, respectively, to audio output circuitry 74, which will be described in detail below.

The production of the automatic frequency control (AFC) signal will now be discussed. Pins 8 and 9 of detector 568 are coupled to a quadrature detection coil 614. Pin 8 is also coupled to ground by a capacitor 616, and pin 9 is coupled to pin 10 of detector 568 by a resistor 618. A resistor 620 is coupled across the secondary winding of the second transformer in quadrature detect coil 614 to linearize the response of detector 568. Pin 10 of detector 568 is coupled to ground by capacitor 622 arranged in parallel with capacitor 624. Pin 10 is also coupled to pin 7 by resistor 626 and directly coupled to the connection

between the secondary winding and primary windings of the transformers in quadrature detect coil 614. Quadrature detect coil arrangement 614 as arranged with detector 568 provides FM demodulation.

5 Pin 10 is also coupled to a terminal of AFC switch 628 of AFC tuning circuit 98 by a conductor 630. Pin 7 of detector 568 is coupled to AFC buffering circuit 96, and also coupled to ground by a capacitor 632 arranged in parallel with a capacitor 634. Capacitors 622, 624 and 634
10 provide high and low frequency filtering. Pin 7 is coupled to the inverting input of an op amp 636 by a resistor 638. The non-inverting input of op amp 636 is coupled to the center tap of a potentiometer 640 of fine tuning circuit 100. The bottom of potentiometer 640 is coupled to ground
15 and the top to DC source 448 by a resistor 642. The terminal between potentiometer 640 and resistor 642 is coupled to ground by a capacitor 644 to filter the voltage applied to op amp 636. The output of op amp 636 is coupled to the inverting input by a capacitor 646 arranged in
20 parallel with a resistor 643 to provide the appropriate feedback and filtering for op amp 636.

The output of op amp 636 is provided to switch 628 of AFC tuning circuit 98 by a conductor 650. Switch 628 is a single pole, double throw switch which allows the connection
25 of a conductor 652 to either the output of op amp 636 or pin 7 of detector 568. With this circuit, either a reference DC voltage from pin 7 or an AFC signal can be provided to conductor 652 as desired. Conductor 652 is coupled to a resistor 654 which is coupled to local oscillator circuitry
30 70.

Pins 10 and 7 are also coupled to center tune indicator 95. In particular, pin 10 is coupled to the inverting input of an op amp 656 and the non-inverting input of an op amp

658 by a resistor 660. The inverting input of op amp 658 and the non-inverting input of op amp 656 is coupled to the non-inverting input of op amp 656 and the inverting input of op amp 658 by a resistor 662. Pin 7 is coupled to the
5 inverting input of op amp 656 and the non-inverting input of op amp 658 by resistor 664. A resistor 666 is coupled between the output of op amp 656 and the inverting input for feedback. A resistor 668 is coupled between the output and inverting input of op amp 658 for feedback. The outputs of
10 op amps 656 and 658 are coupled by a resistor 670 to the anode of an LED 672 and the cathode of an LED 674, where the cathode of LED 672 and anode of LED 674 are coupled to the output of op amp 658. The output of op amp 656 is coupled to the base of a transistor 676 by a resistor 678, and the
15 output of op amp 658 is coupled to the base of a transistor 680 by a resistor 682. Op amps 656 and 658 are part of a dual op amp package which is appropriately grounded and coupled to DC source 448.

The collector of transistor 676 is coupled to DC source
20 448 and also coupled to ground by capacitor 684 to provide filtering for the voltage supplied by source 448. The emitter of transistor 676 is coupled to the collector of transistor 680, and the emitter of transistor 680 is coupled to ground by a series arrangement of resistor 686 and LED
25 688, where the cathode of LED 688 is coupled to ground. Center tune indicator 95 operates such that when the circuit is properly center tuned via potentiometer 640, LED 688 is lit. When the receiver is not properly center tuned, either LED 672 or 674 is lit, depending upon whether it is tuned
30 low or high.

Referring to FIGURE 8, FIGURE 8 illustrates the circuit diagram for local oscillator circuitry 70. Resistor 654 of frequency control circuitry 72 is coupled to conductor portion 690 of circuit 70. The AFC signal from circuit 72

is applied to conductor portion 690, and conductor portion 690 is coupled to ground by capacitor 692 arranged in parallel with capacitor 694. Conductor 690 is also coupled to the cathode of varactor 696 by an inductor 698. The
5 combination of resistor 654, capacitor 692, capacitor 694 and inductor 698 provides high and low frequency filtering for the AFC signal. The anode of varactor 696 is coupled to ground, where the cathode of varactor 696 is also coupled to ground by a series arrangement of a capacitor 700, a
10 capacitor 702, and a variable capacitor 704.

The terminal between capacitors 700 and 702 is coupled to a coaxial ceramic resonator 706 which is also coupled to ground. The capacitance of varactor 696 is controlled by the AFC input signal and corrects the frequency of resonator
15 706, which controls the frequency of the signal produced by local oscillator circuit 102. Resonator 706 is coupled to the collector of a transistor 708 by capacitor 710, where the collector and emitter of transistor 708 are coupled by capacitor 712. The emitter of transistor 708 is coupled to
20 ground by a capacitor 714 and also coupled to ground by a resistor 716 coupled to an inductor 718, which is coupled to ground in parallel with a capacitor 720. The collector of transistor 708 is coupled to DC source 448 by an inductor 722, a resistor 724, a voltage regulator 726 and an inductor
25 728. Capacitors 730 and 732 couples the input of voltage regulator 726 to ground to provide filtering for the voltage from source 448, and capacitor 734 couples the output of voltage regulator 726 to ground to further filter the
30 voltage output of regulator 726. In addition to capacitor 734, circuit 102 includes a capacitor 736 coupled between the output of regulator 726 and ground to provide still further filtering for the voltage applied to circuit 102.

The base of transistor 708 is coupled to ground by a capacitor 738 and a capacitor 740, and also coupled to the

output of regulator 726 by a resistor 742 coupled in series with a resistor 744. The terminal between resistors 742 and 744 is coupled to ground by a capacitor 746, and resistor 741.

5 The emitter of transistor 708 is coupled to band pass filter circuit 104. In particular, the emitter of transistor 708 is coupled to a capacitor 748, where capacitor 748 is coupled to ground by an inductor 750 on its side opposite to transistor 708. The signal from the
10 emitter of transistor 708 is filtered by the combination of capacitor 748 and inductor 750 which act as a band pass filter, passing the oscillating frequency of circuit 102. Resonator 706 provides advantages and improvements in performance similar to those provided by resonator 336, but
15 in the context of a receiver. Transistor 708 is configured similar to transistor 346 to form a common base Colpitts oscillator.

 The terminal between capacitor 748 and inductor 750 is coupled to one gate (1) of a dual gate transistor 752, which
20 is the main component of buffering circuit 106. Transistor 752 provides high reverse isolation between band pass filter circuit 108 and band pass filter 104. The second gate (2) of transistor 752 is coupled to ground by a capacitor 754 in parallel with a resistor 756. Gate 2 of transistor 752 is
25 also coupled to the output of voltage regulator 726 by a resistor 758. The source of transistor 752 is coupled to ground by a capacitor 760 in parallel with a resistor 762.

 The drain of transistor 752 is coupled, and provides the signal at the drain, to band pass filter circuit 108.
30 In particular, the drain is coupled to the output of voltage regulator 726 by an inductor 764 arranged in series with a resistor 766. The terminal between inductor 764 and resistor 766 is coupled to ground by a capacitor 768, and

the terminal between resistor 766 and the output of regulator 726 is coupled to ground by a capacitor 770. The arrangement of the inductor 764, resistor 766, capacitor 768 and capacitor 770 provide a band pass filter for the signal at the drain of transistor 752, where the signal is filtered to pass the oscillating frequency of circuit 102.

The drain of transistor 752 is also coupled to the base of a transistor 772 by a capacitor 775. Transistor 772 provides the buffering in buffering circuit 110. The collector of transistor 772 is coupled to the output of regulator 726, and also coupled to the base of transistor 772 by a resistor 774. A capacitor 776 couples the collector of transistor 772 to ground to provide filtering. The emitter of transistor 772 is coupled to ground by a resistor 778, and coupled to a conductor portion 780 by a capacitor 782. As discussed above briefly, conductor 780 is coupled to resistor 528 of antenna matching and intermediate frequency circuit 68 to provide the signal at the emitter of transistor 772 to circuit 68. This signal is applied to circuit 68 and used in the hetrodyning process carried out by circuit 68.

Referring to FIGURE 9, FIGURE 9 is the circuit diagram for demultiplexing and audio output circuitry 74. As discussed above, conductors 610 and 612 of frequency control circuitry 72 are coupled to demultiplexing and audio output circuitry 74 to provide the composite audio signal and signal strength signal to circuitry 74. In particular, conductor 610 is coupled to a resistor 784 in buffering circuit 114, and conductor 612 is coupled to potentiometer 786 in stereo decoding circuit 116. Resistor 784 is also coupled to the non-inverting input of op amp 788. The non-inverting input of op amp 788 is also coupled to ground by resistor 799. Op amp 636 (FIGURE 7) and op amp 788 are part of a dual op amp package where the package is appropriately

grounded and coupled to DC source 448. The output of op amp 788 is coupled to the inverting input to provide unity gain such that op amp 788 provides buffering without gain.

To provide filtering for the voltage applied to the demultiplexer 796, the power terminal of the package is
5 coupled to DC source 448 by a resistor 790. Capacitor 792, which is in parallel with a capacitor 794, couples this terminal to ground. The output of op amp 788 is applied to the input of demultiplexer 796 by the series arrangement of
10 a capacitor 798 and a resistor 800. The output of op amp 788 is also coupled to pin 2 of demultiplexer 796 by a series arrangement of a potentiometer 802, capacitor 804 and a resistor 806. A capacitor 808 is provided at the terminal
15 between potentiometer 802 and capacitor 804 to provide further filtering of this signal.

Pin 2 of demodulator 796 is coupled to pin 13 by a capacitor 810 and a potentiometer 812. Pin 13 is coupled to ground by a capacitor 814. The purpose of connecting pin 2 to pin 13 in this manner is to cancel the pilot signal. Pin
20 16 is coupled to ground by a ceramic resonator 816 to form a 600 KHz signal to clock demultiplexor 796. Pin 8 of demultiplexor 796 is coupled to the center tab of potentiometer 786 by a single pole, double throw switch 818 to enable the stereo blending function. Pin 10 of
25 demodulator 796 is coupled to source 448 by a resistor 822 coupled in series with an LED 824, where the anode of LED 824 is coupled to source 448 such that LED 824 is illuminated when a stereo signal is produced by 796. Pins
30 15 and 14 are coupled by a capacitor 826 coupled in parallel with a series arrangement of a resistor 828 and capacitor 830. Pin 9 of demodulator 796 is coupled to ground, and pin 4 of demodulator 796 is coupled to ground by a capacitor 832. Pins 5 and 6 of demodulator 796 provide left and right signals, respectively, to de-emphasis circuit 118.

Pin 5 is coupled to ground by a resistor 834, and coupled to ground by a capacitor 836 in series with a double pole, double throw switch 838. Pin 6 is coupled to ground by a resistor 840 and a capacitor 842 in series with switch 838. De-emphasis is applied, depending upon the position of switch 838. More specifically, pins 5 and 6, the left and right channels, respectively, are coupled to ground by capacitors 836 and 842, respectively, when the switch is switched to the de-emphasis mode, i.e., coupling capacitors 836 and 842 to ground.

The left channel (pin 5) and right channel (pin 6) are coupled by capacitors 844 and resistors 846 to pilot filters 848. Pilot filters 848 are the main components of pilot filtering circuits 120 and filter the left and right channels signals from demultiplexor 796 to pass only the frequencies between 20 Hz and 20 KHz. The outputs of filters 848 are applied to the inverting inputs of operational amplifiers 852 via series arrangements of a capacitor 854 and resistor 856. The non-inverting inputs of op amps 852 are coupled to DC supply 448 by resistors 858 coupled in series with resistor 860 to provide filtering for the voltage at DC source 448, the terminal between resistors 858 and 860 is coupled to ground by a capacitor 862 arranged in parallel with a resistor 864. The inverting inputs of op amps 852 are coupled to their outputs by a feedback resistor 866. The outputs of op amps 852 are applied to conventional jacks 868 by a capacitor 870, where the terminal between capacitor 870 and jacks 868 are coupled to ground by a resistor 872.

Op amps 852 are part of a dual op amp package which is appropriately grounded and coupled to DC source 448 for power. The power terminal of the dual op amp package is filtered by capacitors 874 and 876. Jacks 868 may be coupled to respective conventional audio power amplifiers

124 which amplify the stereo output signals such that they may drive respective audio speakers 126.

TABLE A

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
132	120V AC INPUT		
134	POWER TRANSFORMER		T1
136	FUSE		F1
138	1 AMP BRIDGE RECT	1N4001	D3
140	POS 12 VOLT REG	7812	U2
142	20% 35V	2200 uF	C17
144	Z5U 25V	.1uF	C18
146	.25W 5% CARBON FILM	1K5	R27
148	LIGHT EMITTING DIODE GREEN		LD2
150	+12 VOLTS DC		
152	Z5U 25V	.1uF	C31
154			
156	.25W 5% CARBON FILM	100K	R33 + R40
158	.25W 5% CARBON FILM	4K7	R12 + R39
160	5% 50V	.001uF	C25 + C43
162	SUBMIN PC MOUNT POT	50K	VR1
164	20% 25V	.10uF	C42 + C24
166	QUAD OP AMP		U6B + U6C
168	.25W 5% CARBON FILM	100K	R34 + R41
170	20% 25V	47UF	C41 + C45
172	.25W 5% CARBON FILM	3K3	R35 + R42
174	.25W 5% CARBON FILM	10K	R13 + R38
176	QUAD OP AMP		U6A + U6D
178	.25W 5% CARBON FILM	1K	R55 + R56
180	5% 50V	.0047uF	C26 + C44

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
182	.25W 5% CARBON FILM	10K	R14 + R39
184	.25W 5% CARBON FILM	10K	R36 + R43
186	RIGHT AUDIO		
188	LEFT AUDIO		
5 190	.25W 5% CARBON FILM	10K	R44 + R47
192	20% 25V	10uF	C23
194	.25W 5% CARBON FILM	10K	R16
196	.25W 5% CARBON FILM	10K	R15
198	.25W 5% CARBON FILM	47K	R46
10 200	SUBMIN PC MOUNT POT	10K	VR2
201	.25W 5% CARBON FILM	100K	R25
202	QUAD OP AMP	TL074	U7C
204	.25W 5% CARBON FILM	47K	R45
206	DUAL OP AMP	TL074	U7B
15 208	.25W 5% CARBON FILM	1K	R19
210	.25W 5% CARBON FILM	100K	R24
212	.25W 5% CARBON FILM	1K	R21
214	SIGNAL DIODE	1N914	D1
216	SIGNAL DIODE	1N914	D2
20 218	20% 25V	2.2uF	C30
220	.25W 5% CARBON FILM	10K	R20
222	NPN TRANSISTOR	2N3904	Q4
224	.25W 5% CARBON FILM	2K2	R22
226	LIGHT EMITTING DIODE RED		LD1
25 228	.25W 5% CARBON FILM	1K	R23
230	.25W 5% CARBON FILM	10K	R32
232	4 CH MUX DEMULTIPLEXER	CD4052	U5
234	.25W 5% CARBON FILM	10K	R31
236	Z5U 25V	.01uF	C32

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
238	HEX INVERT BUFFER	CD4069	U3A
240	CERAMIC RESONATOR	200KHZ	CF1
242	NPO 50V	330pF	C28
244	NPO 50V	470pF	C27
5 246	.25W 5% CARBON FILM	4K7	R57
248	HEX INVERT BUFFER	CD4069	U3F
250	.25W 5% CARBON FILM	1M	R17
252	12-BIT RIPPLE CTR/D	CD4040	U4
254	Z5U 25V	.01uF	C33
10 256	5% 50V	.015uF	C48
258	.25W 5% CARBON FILM	15K	R48
260	5% 50v	.001uF	C49
262	QUAD OP AMP	TL074	U7A
264	.25W 5% CARBON FILM	15K	R26
15 266	.25W 5% CARBON FILM	100K	R49
268	5% 50V	.001uF	C51
270	5% 50V	.001uF	C50
272	.25W 5% CARBON FILM	2K2	R50
274	.25W 5% CARBON FILM	100K	R54
20 276	Z5U 25V	.01uF	C53
277	.25W 5% CARBON FILM	10K	R60
278	.25W 5% CARBON FILM	10K	R61
280	SUBMIN PC MOUNT POT	2K5	VR6
282	5% 50V	.0015uF	C52
25 284	.25W 5% CARBON FILM	10K	R51
286	SUBMIN PC MOUNT POT	1K	VR5
288	QUAD OP AMP	TL074	U7D
290	.25W 5% CARBON FILM	4K7	R53
292	.25W 5% CARBON FILM	10K	R52

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
294	.25W 5% CARBON FILM	20K	R18
296	1206 SMT CAP NPO 50V	22pF	C40
298	MODULATION OUTPUT		
300	SUBMIN PC MOUNT POT	1K	VR4
5 302	.25W 5% CARBON FILM	1K	R58
304	RF CHOKE	820uH	L14
306	RF CHOKE	2.5mH	L13
308	RF CHOKE	820uH	L12
310	20% 25V	10uF	C39
10 311	.25W 5% CARBON FILM	1K	R59
312	5% 50V	.0022uF	C47
314	5% 50V	.0022uF	C46
315	SUBMIN PC MOUNT POT	1K	VR3
316	20% 25V	10uF	C29
15 318	SURF MOUNT COIL	100nH	L2
320	1206 SMT CAP NPO 50V	22pF	C8
322	NPO 50V	470pF	C38
324	1206 SMT RESISTOR	1K8	R7
326	POS 5 VOLT REG		U1
20 328	1206 SMT CAP Z5U 50V	.1uF	C10
330	SURF MOUNT COIL	100nH	L11
332	VARACTOR DIODE		VD1
334	1206 SMT RESISTOR	10K	R29
336	COAXIAL CERAMIC RESONATOR		L5
25 338	1206 SMT CAP NPO 50V	0.5pF	C2
340	1206 SMT CAP NPO 50V	1pF	C15
342	CERAMIC TRIM CAP	1-10PF	VC1
344	1206 SMT CAP NPO 50V	0.5pF	C5
346	NPN TRANSISTOR	NE85633	Q1

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #	
348	1206 SMT RESISTOR	100	R5	
350	SURF MOUNT COIL	68nH	L3	
352	1206 SMT CAP Z5U 50V	.1uF	C9	
354	1206 SMT CAP Z5U 50V	22pF	C12	
5	356	1206 SMT RESISTOR	1K	R4
358	1206 SMT RESISTOR	4K7	R1	
360	Z5U 25V	.01uF	C4	
362	1206 SMT RESISTOR	1K5	R3	
364	1206 SMT CAP Z5U 50V	.1uF	C3	
10	366	1206 SMT CAP Z5U 50V	22pF	C1
368	1206 SMT CAP NPO 50V	1pF	C16	
370	SURF MOUNT COIL	100nH	L1	
372	1206 SMT CAP NPO 50V	22pF	C37	
374	1206 SMT RESISTOR	220	R2	
15	376	1206 SMT CAP NPO 50V	3.3pF	C19
378	1206 SMT CAP NPO 50V	0.5pF	C14	
380	DUAL GATE MOSFET	NE25139	Q2	
382	SURF MOUNT COIL	12nH	L6	
384	1206 SMT CAP NPO 50V	22pF	C6	
20	386	1206 SMT RESISTOR	18K	R8
388	1206 SMT RESISTOR	10K	R10	
390	1206 SMT CAP NPO 50V	22pF	C7	
392	1206 SMT RESISTOR	150	R9	
394	SURF MOUNT COIL	15nH	L4	
25	396	1206 SMT RESISTOR	100	R30
398	1206 SMT CAP NPO 50V	22pF	C11	
400	1206 SMT CAP NPO 50V	1pF	C13	
402	NPN TRANSISTOR	NE85633	Q3	
404	1206 SMT RESISTOR	680	R28	

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
406	1206 SMT RESISTOR	33K	R11
408	1206 SMT CAP NPO 50V	22pF	C36
410	1206 SMT RESISTOR	150	R6
412	FERRITE BEAD		L7
5 414	SURF MOUNT COIL	12nH	L10
416	1206 SMT CAP NPO 50V	22pF	C34
418	1206 SMT CAP NPO 50V	22pF	C22
420	1206 SMT CAP NPO 50V	1pF	C35
422	SURF MOUNT COIL	4.7nH	L8
10 424	SURF MOUNT COIL	4.7nH	L9
426	1206 SMT CAP NPO 50V	3.3pF	C20
428	1206 SMT CAP NPO 50V	4.7pF	C21
430	CERAMIC TRIM CAP	3-10PF	VC2

TABLE B

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
15 432	CERAMIC TRIM CAP	3-10PF	VC2
434	NPN TRANSISTOR	NE25139	Q4
436	1206 SMT CAP NPO 50V	1pF	C66
20 438	SURF MOUNT COIL	10NH	L12
440	1206 SMT CAP NPO 50V	22pF	C25
442	1206 SMT RESISTOR	8K2	R12
444			
446			
25 448	12V DC INPUT		
450	1206 SMT RESISTOR	82K	R13
452	FERRITE BEAD		L6

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #	
454	FERRITE BEAD		L16	
456	1206 SMT CAP NPO 50V	22pF	C67	
458	1206 SMT CAP NPO 50V	22pF	C72	
460	1206 SMT CAP NPO 50V	22pF	C21	
5	462	1206 SMT RESISTOR	100	R14
464	1206 SMT CAP NPO 50V	0.5pF	C18	
466	1206 SMT CAP NPO 50V	1pF	C73	
468	SURF MOUNT COIL	10NH	L7	
470	1206 SMT RESISTOR	220	R15	
10	472	1206 SMT CAP NPO 50V	22pF	C19
474	1206 SMT CAP NPO 50V	22pF	C20	
476	SURF MOUNT COIL	22NH	L13	
478	DUAL GATE MOSFET	NE25139	Q9	
480	DUAL GATE MOSFET	3SK177	Q5	
15	482	1206 SMT CAP NPO 50V	2.2pF	C22
484	SURF MOUNT COIL	22NH	L14	
486	1206 SMT CAP Z5U 50V	0.2uF	C70	
488	1206 SMT CAP NPO 50V	22pF	C69	
490	1206 SMT RESISTOR	330	R48	
20	492	1206 SMT RESISTOR	10K	R54
494	1206 SMT RESISTOR	.02uF	R49	
496	1206 SMT CAP Z5U 50V	.0022uF	C46	
498	1206 SMT CAP Z5U 50V	.02uF	C71	
500	1206 SMT CAP NPO 50V	22pF	C83	
25	502	SIGNAL DIODE	1N914	D1
504	SIGNAL DIODE	1N914	D2	
506	POWER TRANSFORMER		T1	
508	1206 SMT CAP NPO 50V	47pF	C23	
510	N CH FET SOT 23	MMBFJ310	Q6	

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
512	1206 SMT RESISTOR	330	R29
514	1206 SMT CAP Z5U 50V	.02uF	C45
516	1206 SMT RESISTOR	180	R30
518	RF TRANSFORMER		T3
519	IF OUTPUT		
520	5% 50V	47pF	C47
522	1206 SMT RESISTOR	10K	R53
524	1206 SMT CAP Z5U 50V	.02uF	C24
526	1206 SMT CAP NPO 50V	22pF	C29
528	1206 SMT RESISTOR	100	R55
530	SURF MOUNT COIL	10nH	L11
532	1206 SMT CAP NPO 50V	22pF	C28
534	1206 SMT RESISTOR	10K	R16
536	1206 SMT RESISTOR	47K	R17
538	SURF MOUNT COIL	10nH	L8
540	1206 SMT RESISTOR	220	R18
542	1206 SMT RESISTOR	22pF	C30
544	1206 SMT RESISTOR	22pF	C26
546	.25W 5% CARBON FILM	390	R73
548	1206 SMT CAP NPO 50V	10pF	C94
550	.25W 5% CARBON FILM	330	R56
552	.25W 5% CARBON FILM	100	R72
554	15V DC INPUT		
556	POS 12 VOLT REGULATOR	7812	U3
558	Z5U 25V	.1uF	C48
560	20% 35V	1000uF	C49
562	Z5U 25V	.1uF	C50
563	Z5U 25V	.047	C95
564	CERAMIC FILTER		CF2

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
566	Z5U 25V	.01uF	C93
568	IF QUADRATURE DEJECTOR	LA1235	U2
570	.25W 5% CARBON FILM	330	R20
572	Z5U 25V	.047uF	C31
574	Z5U 25V	.047uF	C33
576	Z5U 25V	.047uF	C34
578	Z5U 25V	.047uF	C76
580	SUBMIN PC MOUNT POT	100K	VR1
582	RF CHOKE	2.2nH	L9
584	Z5U 25V	.047	C38
586	20% 25V	1uF	C44
588	.25W 5% CARBON FILM	68K	R26
590	MUTE SWITCH S1		S1
592	.25W 5% CARBON FILM	10K	R25
594	20% 25V	2.2uF	C42
596	20% 25V	1uF	C40
598	Z5U 25V	.047uF	C35
600	.25W 5% CARBON FILM	56K	R24
602	NPO 50V	22pF	C36
604	Z5U 25V	.02uF	C39
606	.25W 5% CARBON FILM	4K7	R59
608	20% 25V	1uF	C85
610	COMPOSITE AUDIO OUTPUT		
612	SIGNAL STRENGTH OUTPUT		
614	QUADRATURE DETECTOR COIL	235S01	T2
616	NPO 50V	4.7pF	C82
618	.25W 5% CARBON FILM	2K2	R22
620	.25W 5% CARBON FILM	2K2	R23
622	Z5U 25V	.047uF	C37

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
624	20% 25V	220uF	C43
626	1206 SMT RESISTOR	7K5	R28
628	AFC SWITCH		S3
630			
5 632	20% 25V	220uF	C41
634	Z5U 25V	.047uF	C75
636	DUAL OP AMP	LM1458	U4B
638	.25W 5% CARBON FILM	10K	R27
640	SUBMIN PC MOUNT POT	10K	VR4
10 642	.25W 5% CARBON FILM	100K	R51
644	20% 25V	47uF	C81
646	Z5U 25V	.02uF	C96
648	.25W 5% CARBON FILM	220K	R21
650			
15 652			
654	.25W 5% CARBON FILM	1K	R50
656	DUAL OP AMP	LM1458	U5A
658	DUAL OP AMP	LM1458	U5B
660	.25W 5% CARBON FILM	10K	R38
20 662	.25W 5% CARBON FILM	10K	R39
664	.25W 5% CARBON FILM	470K	R40
666	.25W 5% CARBON FILM	220K	R46
668	.25W 5% CARBON FILM	220K	R47
670	.25W 5% CARBON FILM	1K	R37
25 672	LIGHT EMITTING DIODE GREEN		LD2
674	LIGHT EMITTING DIODE GREEN		LD3
676	NPN TRANSISTOR	2N3904	Q7
678	.25W 5% CARBON FILM	47K	R41

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
680	NPN TRANSISTOR	2N3904	Q8
682	.25W 5% CARBON FILM	47K	R42
684	Z5U 25V	.047uF	C61
686	.25W 5% CARBON FILM	1K	R43
5 688	LIGHT EMITTING DIODE GREEN		LD4
690	AFC INPUT		
692	1206 SMT CAP NPO 50V	22pF	C8
694	TANTALUM CAP 25V	10uF	C74
696	VARACTOR DIODE	BB811	VD1
10 698	SURF MOUNT COIL	100nH	L2
700	1206 SMT CAP NPO 50V	0.5pF	C2
702	1206 SMT CAP NPO 50V	1pF	C79
704	CERAMIC TRIM CAP	3-10PF	VC1
706	COAXIAL CERAMIC RESONATOR		L5
15 708	NPN TRANSISTOR	NE85633	Q1
710	1206 SMT CAP NPO 50V	0.5pF	C5
712	1206 SMT CAP NPO 50V	1pF	C16
714	1206 SMT CAP NPO 50V	3.3pF	C60
716	1206 SMT RESISTOR	220	R2
20 718	SURF MOUNT COIL	100nH	L1
720	1206 SMT CAP NPO 50V	22pF	C78
722	SURF MOUNT COIL	68nH	L3
724	1206 SMT RESISTOR	100	R5
726	POS 5 VOLT REG	7805	U1
25 728	FERRITE BEAD		L15
730	1206 SMT CAP Z5U 50V	.1uF	C10
732	NPO 50V	.001uF	C27
734	1206 SMT CAP Z5U 50V	.1uF	C9

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #	
736	1206 SMT CAP NPO 50V	22pF	C12	
738	1206 SMT CAP NPO 50V	22pF	C1	
740	1206 SMT CAP Z5U 50V	.1uF	C3	
741	.25W 5% CARBON FILM	1K5	R3	
5	742	1206 SMT RESISTOR	4K7	R1
744	1206 SMT RESISTOR	1K	R4	
746	Z5U 25V	.01uF	C4	
748	1206 SMT CAP NPO 50V	0.5pF	C14	
750	SURF MOUNT COIL	12nH	L10	
10	752	DUAL GATE MOSFET	NE25139	Q2
754	1206 SMT CAP NPO 50V	22pF	C6	
756	1206 SMT RESISTOR	18K	R6	
758	1206 SMT RESISTOR	10K	R9	
760	1206 SMT CAP NPO 50V	22pF	C7	
15	762	1206 SMT RESISTOR	150	R7
764	SURF MOUNT COIL	15nH	L4	
766	1206 SMT RESISTOR	100	R8	
768	1206 SMT CAP NPO 50V	22pF	C80	
770	1206 SMT CAP NPO 50V	22pF	C11	
20	772	NPN TRANSISTOR	NE85633	Q3
774	1206 SMT RESISTOR	100K	R10	
775	1206 SMT CAP NPO 50V	2pF	C13	
776	1206 SMT CAP NPO 50V	22pF	C15	
778	1206 SMT RESISTOR	270	R11	
25	780	LO OUTPUT		
782	20% 35V	2pF	C17	
784	.25W 5% CARBON FILM	10K	R57	
786	SUBMIN PC MOUNT POT	10K	VR5	
788	DUAL OP AMP	LM1458	U4A	

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
790	.25W 5% CARBON FILM	47K	R52
792	5% 50V	100uF	C51
794	Z5U 25V	.1uF	C58
796	MULTIPLEX DECODER	LA3430	U6
5 798	5% 50V	.047uF	C65
799	.25W 5% CARBON FILM	47K	R58
800	.25W 5% CARBON FILM	2K2	R45
802	SUBMIN PC MOUNT POT	1K	VR3
804	20% 25V	10uF	C63
10 806	.25W 5% CARBON FILM	20K	R44
808	5% 50V	.0033uF	C64
810	5% 50V	.0033uF	C84
812	SUBMIN PC MOUNT POT	100K	VR2
814	5% 50V	.022uF	C62
15 816	CERAMIC RESONATOR	CSB600J	CF1
818	BLEND SWITCH		S2
820	20% 25V	1uF	C53
822	.25W 5% CARBON FILM	1K	R35
824	LIGHT EMITTING DIODE RED		LD1
20 826	5% 50V	.22uF	C59
828	.25W 5% CARBON FILM	4K7	R34
830	20% 25V	1uF	C57
832	5% 50V	.01uF	C77
834	.25W 5% CARBON FILM	3K3	R33
25 836	5% 50V	.015uF	C55
838	DE-EMPHASIS SWITCH		S4
840	.25W 5% CARBON FILM	3K3	R32
842	5% 50V	.015uF	C52
844	20% 25V	10uF	C56

DRAWING REF. #	DESCRIPTION	PART # OR VALUE	REF. #
846	.25W 5% CARBON FILM	10K	R31 + R36
848	21MHZ LPF	PFB-2	L18 + L19
852	QUAD OP AMP	LM1458	U7A + U7B
854	20% 25V	10uF	C88 + C89
5 856	.25W 5% CARBON FILM	5K6	R62 + R63
858	.25W 5% CARBON FILM	100K	R66 + R67
860	.25W 5% CARBON FILM	10K	R68
862	20% 25V	10uF	C90
864	.25W 5% CARBON FILM	10K	R69
10 866	.25W 5% CARBON FILM	62K	R65 & R64
868	AUDIO OUTPUTS		J1 + J2
870	20% 25V	10uF	C86 + C87
872	.25W 5% CARBON FILM	10K	R60 & R61
874	Z5U 25V	.1uF	C92
15 876	20% 25V	10uF	C91

In a second embodiment of transmitter 10 and receiver 12, transmitter 10 and receiver 12 are modified to eliminate the multiplexing and demultiplexing features of these devices. More specifically, multiplexing and demultiplexing are not required where the transmitter 10 and receiver 12 are used to transmit composite digital signals. A composite digital signal may be produced by a device such as a CD ROM player which provides the multiplexing feature. This digital signal may be provided to a device which includes demultiplexing to convert the composite digital signal to left and right channel digital signals.

Transmitter 10 would be modified by eliminating the left audio input 22 and associated circuits 24, 26 and 28,

and time division multiplexor 34. Programmable divider 32 could be eliminated, oscillator 40 would be eliminated. Receiver 12 would be modified by eliminating stereo decoder 116 and the provision of signal strength level signal from limiting amplifier and quadrature detecting circuit 94. 5 Additionally, circuits 118, and pilot filter 120 and output buffer 122 for one channel would be eliminated.

Of course, further modifications to transmitter 10 and receiver 12 could be made to improve the transmission of 10 digital signals from transmitter 10 to receiver 12 as deemed necessary for the particular application.

It will be understood that the above description is of the preferred exemplary embodiment of the invention, and that the invention is not limited to the specific form 15 shown. For example, as previously discussed, the above-described transmitter and receiver may be modified for use in transmitting digital signals which are audio signals or digital data signals for other systems such as computer systems. Furthermore, it is contemplated that portions of 20 the circuitry may eventually be replaced with microprocessor based signal conditioning circuits having the appropriate analog-to-digital and digital-to-analog conversions when such circuits are developed to operate at the frequencies required to implement the transmitter and receiver 25 arrangement of the present invention. Various other substitutions, modifications, changes and omissions may be made in the design and arrangement of the elements without departing from the spirit of the invention as expressed in the appended claims.

CLAIMS

1. A system for transmitting at least two transmitted signals carried by electromagnetic waves, the system comprising:
a transmitter including;
5. means for multiplexing the transmitted signals to produce a multiplexed signal,
means, including a first ceramic resonator, for producing a carrier signal having a carrier frequency determined by the first ceramic resonator,
10. means for modulating the carrier frequency based upon the multiplexed signal to produce a first electric signal, and
means for radiating electromagnetic waves in response to the first electric signal; and a receiver including;
15. means for converting the electromagnetic waves to a second electric signal,
a second ceramic resonator,
20. means for mixing a local signal, having a local frequency, with the second electric signal to lower the frequency of the carrier signal from the second electric signal to produce a third signal, where the local frequency is offset from the carrier frequency and is determined by the second ceramic resonator,
25. means for demodulating the third signal to produce a fourth signal, and
means for demultiplexing the fourth signal to produce fifth and sixth signals representative of the transmitted signals.
- 30.
2. The system of Claim 1, wherein the transmitted signals are digital signals.
3. The system of Claim 1, wherein the transmitted signals are analog signals.
- 35.

4. The system of Claim 1, further comprising means for correcting the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset
5. frequency.
5. The system of Claim 4, further comprising means for buffering the means for radiating from the means for modulating.
6. The system of Claim 5, further comprising means for buffering the means for converting from the means for mixing.
10. 7. In a system for transmitting at least two transmitted signals carried by electromagnetic waves, a transmitter comprising:
15. means for multiplexing the transmitted signals to produce a multiplexed signal;
- means, including a ceramic resonator for producing a carrier signal having a carrier frequency determined by the ceramic resonator;
20. means for modulating the carrier frequency based upon the multiplexed signal to produce an electrical signal; and
- means for radiating electromagnetic waves in response to the electric signal.
25. 8. The transmitter of Claim 7, wherein the transmitted signals are digital signals.
9. The transmitter of Claim 7, wherein the transmitted signals are analog signals.
10. The transmitter of Claim 7, further comprising means for buffering the means for radiating from the means for modulating.
- 30.

11. In a system for transmitting at least two transmitted signals carried by electromagnetic waves, a receiver comprising:

5. means for converting electromagnetic waves, having a carrier frequency, to a first electric signal including a carrier signal component;
a ceramic resonator;
10. means for mixing a local signal having a local frequency with the first electric signal to lower the frequency of the carrier signal component from the first electric signal to produce a second electric signal, where the local frequency is offset from the carrier frequency and is determined by the ceramic resonator;
15. means for demodulating the second electrical signal to produce a third signal, the multiplexed signal; and
means for demultiplexing the third signal to produce fourth and fifth signals representative of the transmitted signals.
20. 12. The receiver of Claim 11, wherein the transmitted signals are digital signals.
13. The receiver of Claim 11, wherein the transmitted signals are analog signals.
25. 14. The receiver of Claim 11, further comprising means for correcting the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.
30. 15. The receiver of Claim 14, further comprising means for buffering the means for converting from the means for mixing.

16. A system for transmitting first and second channel stereophonic signals carried by electromagnetic waves, the system comprising:
- a transmitter including;
 - 5. a multiplexer disposed to multiplex the signals to produce a composite signal,
 - an oscillator including a first ceramic resonator disposed to produce a carrier frequency determined by the first ceramic resonator,
 - 10. means for modulating the carrier frequency based upon the composite signal to produce a first electric signal, and
 - a first antenna coupled to the means for modulating to radiate electromagnetic waves in response to the first electric signal; and
 - 15. a receiver including;
 - a second antenna arranged to convert the electromagnetic waves to a second electric signal,
 - a local oscillator including a second ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the second ceramic resonator,
 - 20. a mixer coupled to the second antenna and the local oscillator to lower the frequency of the carrier signal from the second electric signal to produce a third signal,
 - 25. a demodulator coupled to the mixer to demodulate the third signal to produce a fourth signal representative of the multiplexed signal,
 - 30. a demultiplexer coupled to the demodulator to demultiplex the fourth signal to produce fifth and sixth signals representative of the first and second channel stereophonic signals, respectively.

5. 17. The system of the Claim 16, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

10. 18. The system of Claim 17, further comprising a first buffering circuit coupled between the first antenna and the means for modulating, wherein the buffering circuit isolates the first antenna from the means for modulating.

15. 19. The system of Claim 18, further comprising a second buffering circuit coupled between the second antenna and the mixer, wherein the second buffering circuit isolates the second antenna from the mixer.

20. 20. In a system for transmitting first and second channel stereophonic signals carried by electromagnetic waves, a transmitter comprising:

20. a multiplexer disposed to multiplex the signals to produce a composite signal;

an oscillator including a ceramic resonator disposed to produced a carrier frequency determined by the ceramic resonator;

25. means for modulating the frequency based upon the composite signal to produce an electric signal; and an antenna coupled to the means for modulating to radiate electromagnetic waves in response to the electric signal.

30. 21. The transmitter of Claim 20, further comprising a first buffering circuit coupled between the first antenna and the means for modulating, wherein the first buffering circuit isolates the first antenna from the means for modulating.

22. In a system for transmitting first and second channel stereophonic signals carried by electromagnetic waves, a receiver comprising:

5. an antenna arranged to convert electromagnetic waves, having a carrier frequency, to a first electric signal including a carrier signal component;

10. a local oscillator including a ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the ceramic resonator;

15. a mixer coupled to the antenna and the local oscillator to lower the frequency of the carrier signal component from the second electric signal to produce a second signal;

a demodulator coupled to the mixer to demodulate the second signal to produce a third signal representative of the composite signal; and

20. a demultiplexer coupled to the demodulator to demultiplex the third signal to produce fourth and fifth signals representative of the first and second channel stereophonic signals, respectively.

25. 23. The receiver of Claim 22, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

30. 24. The receiver of Claim 23, further comprising a first buffering circuit coupled between the second antenna and the mixer.

25. A system for transmitting a digital signal carried by electromagnetic waves, the system comprising:
- a transmitter including:
 - 5. an oscillator including a first ceramic resonator disposed to produce a carrier signal having a carrier frequency determined by a first ceramic resonator,
 - 10. a first varactor coupled to the oscillator to modulate the carrier signal based upon the digital signal to produce a first electric signal,
 - a first antenna coupled to the oscillator to radiate electromagnetic waves in response to the first electric signal, and
 - 15. a buffering circuit coupled between the oscillator and the first antenna to buffer the oscillator from the first antenna; and
 - a receiver including:
 - 20. a second antenna arranged to convert the electromagnetic waves to a second electric signal,
 - a local oscillator including a second ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the second ceramic resonator,
 - 25. a second varactor coupled to the local oscillator to control the local signal,
 - 30. a mixer coupled to the second antenna and the local oscillator to lower the frequency of the carrier signal from the second electric signal to produce a third electric signal, and a demodulator coupled to the mixer to remove the carrier signal from the third electric signal to produce a fourth electric signal.

26. The system of Claim 25, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

5.

27. The system of Claim 26, further comprising a first buffering circuit coupled between the first antenna and the local oscillator.

10.

28. The system of Claim 27, further comprising a first amplifying circuit coupled between the first buffering circuit and the antenna.

29. The system of Claim 27, further comprising a second amplifying circuit coupled between the antenna and the mixer.

15.

30. In a system for transmitting a transmitted signal carried by electromagnetic waves, a transmitter comprising:

an oscillator including a ceramic resonator disposed to produce a carrier signal having a carrier frequency determined by a first ceramic resonator;

20.

a varactor coupled to the oscillator to modulate the carrier signal based upon the composite signal to produce an electric signal;

25.

an antenna coupled to the means for modulating to radiate electromagnetic waves in response to the electric signal; and

a buffering circuit coupled between the oscillator and the antenna to buffer the oscillator from the antenna.

30.

31. The transmitter of Claim 30, further comprising a buffering circuit coupled between the first antenna and the local oscillator.

32. The transmitter of Claim 31, further comprising an amplifying circuit coupled between the first buffering circuit and the antenna.

5. 33. In a system for transmitting a transmitted signal carried by electromagnetic waves, a receiver comprising:

10. an antenna arranged to convert electromagnetic waves, having a carrier frequency, to a first electric signal including a carrier signal component;

a local oscillator including a ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the ceramic resonator;

15. a varactor coupled to the local oscillator to control the local signal;

20. a mixer coupled to the antenna and the local oscillator to lower the frequency of the carrier signal component from the first electric signal to produce a second signal; and

a demodulator coupled to the mixer to remove the carrier signal from the second electrical signal to produce a third signal.

25. 34. The receiver of Claim 33, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

30. 35. The receiver of Claim 34, further comprising an amplifying circuit coupled between the antenna and the mixer.

AMENDED CLAIMS

[received by the International Bureau on 21 January 1993 (21.01.93);
original claims 1,6,7,11,16,19,20,22,25,26,27 amended;
new claims 36-52 added; other claims unchanged (14 pages)]

1. A system for transmitting at least two transmitted signals carried by radio waves having a frequency of at least 900 MHz, the system comprising:

a transmitter including;

 multiplexing means for multiplexing first and second input signals to produce a multiplexed signal,

 first local oscillator means, including a first ceramic resonator, for producing a carrier signal of a predetermined carrier frequency of at least 900 MHz determined by the first ceramic resonator,

 modulation means for frequency modulating the carrier signal based upon the multiplexed signal to produce a first electric signal,

 radiation means for radiating said radio waves in response to the first electric signal,

 first high impedance buffering means for isolating said first local oscillator means from said radiation means; and

a receiver including;

 converting means for converting said radio waves to a second electric signal,

 second local oscillator means including a second ceramic resonator,

 mixing means for mixing a local signal, having a local frequency, with the second electric signal to lower the frequency of the carrier signal from the second electric signal to produce a third electric signal, where the local frequency is offset from the carrier frequency and is determined by the second ceramic resonator,

demodulation means for demodulating the third electric signal to produce a fourth electric signal, and

demultiplexing means for demultiplexing the fourth electric signal to produce fifth and sixth electric signals representative of the first and second input signals.

2. The system of Claim 1, wherein the transmitted signals are digital signals.

3. The system of Claim 1, wherein the transmitted signals are analog signals.

4. The system of Claim 1, further comprising means for correcting the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

5. Cancel.

6. The system of claim 1 further comprising second high impedance buffering means coupled between said second local oscillator means and said converting means for isolating said second local oscillator from said converting means.

7. In a system for transmitting at least two transmitted signals carried by radio waves, a transmitter comprising:

 multiplexing means for multiplexing first and second input signals to produce a multiplexed signal;

 local oscillator means, including a ceramic resonator for producing a carrier signal of a predetermined carrier frequency of at least 900 MHz determined by the ceramic resonator;

 modulation means for frequency modulating the carrier signal based upon the multiplexed signal to produce a first electric signal;

 radiation means for radiating said radio waves in response to the first electric signal;
and

high impedance buffering means for isolating said local oscillator means from said radiation means.

8. The transmitter of Claim 7, wherein the transmitted signals are digital signals.

9. The transmitter of Claim 7, wherein the transmitted signals are analog signals.

10. Cancel.

11. In a system for transmitting at least two transmitted signals carried by radio waves, a receiver comprising:

converting means for converting said radio waves, having a predetermined carrier frequency of at least 900 MHz, to a first electric signal including a carrier signal component;

local oscillator means including a ceramic resonator;

mixing means for mixing a local signal having a local frequency with the first electric signal to lower the frequency of the carrier signal component from the first electric signal to produce a second electric signal, where the local frequency is offset from the carrier frequency and is determined by the ceramic resonator;

demodulation means for demodulating the second electric signal to produce a third electric signal, the multiplexed signal;

demultiplexing means for demultiplexing the third electric signal to produce fourth and fifth electric signals representative of the first and second input signals; and

high impedance buffering means coupled between said local oscillator means and said converting means for isolating said local oscillator means from said converting means.

12. The receiver of Claim 11, wherein the transmitted signals are digital signals.

13. The receiver of Claim 11, wherein the transmitted signals are analog signals.

14. The receiver of Claim 11, further comprising means for correcting the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

15. Cancel.

16. A system for transmitting first and second channel stereophonic signals carried by radio waves having a frequency of at least 900 MHz, the system comprising:

a transmitter including;

a multiplexer disposed to multiplex first and second channel stereophonic signals to produce a composite signal,

a first local oscillator including a first ceramic resonator disposed to produce a carrier signal of a predetermined carrier frequency of at least 900 MHz determined by the first ceramic resonator,

modulation means for frequency modulating the carrier signal based upon the composite signal to produce a first electric signal,

a first antenna coupled to the modulating means to radiate said radio waves in response to the first electric signal,

a first high impedance buffering circuit coupled between the first antenna and said first local oscillator, wherein said first buffering circuit isolates said first local oscillator from the first antenna; and

a receiver including;

a second antenna arranged to convert said radio waves to a second electric signal,

a second local oscillator including a second ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the second ceramic resonator,

a mixer coupled to the second antenna and the second local oscillator to lower the frequency of the carrier signal from the second electric signal to produce a third electric signal,

a demodulator coupled to the mixer to demodulate the third electric signal to produce a fourth signal representative of the multiplexed signal,

a demultiplexer coupled to the demodulator to demultiplex the fourth electric signal to produce fifth and sixth electric signals representative of the first and second channel stereophonic signals, respectively.

17. The system of Claim 16, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

18. Cancel.

19. The system of claim 16, further comprising a second high impedance buffering circuit coupled between said second local oscillator and said mixer, wherein said second high impedance buffering circuit isolates said second local oscillator from said second antenna.

20. In a system for transmitting first and second channel stereophonic signals carried by radio waves, a transmitter comprising:

a multiplexer disposed to multiplex the first and second channel stereophonic signals to produce a composite signal;

a local oscillator including a ceramic resonator disposed to produce a carrier signal of a predetermined frequency of at least 900 MHz determined by the ceramic resonator;

modulation means for frequency modulating the carrier signal based upon the composite signal to produce an electric signal;

an antenna coupled to the modulating means for radiating said radio waves in response to the electric signal; and

a high impedance buffering circuit coupled between the antenna and said local oscillator means, wherein said buffering circuit isolates said local oscillator from the antenna.

21. Cancel.

22. In a system for transmitting first and second channel stereophonic signals carried by radio waves, a receiver comprising:

an antenna arranged to convert radio waves, having a carrier frequency, to a first electric signal including a carrier signal component;

a local oscillator including a ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the ceramic resonator;

a mixer coupled to the antenna and the local oscillator to lower the frequency of the carrier signal component from the second electric signal to produce a second signal;

a demodulator coupled to the mixer to demodulate the second electric signal to produce a third electric signal representative of the composite signal;

a demultiplexer coupled to the demodulator to demultiplex the third electric signal to produce fourth and fifth electric signals representative of the first and second channel stereophonic signals, respectively; and

a high impedance buffering circuit coupled between the local oscillator and the antenna, wherein the buffering circuit isolates the local oscillator from the antenna.

23. The receiver of Claim 22, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

24. Cancel.

25. A system for transmitting a digital signal carried by radio waves, the system comprising:

a transmitter including;

a first local oscillator including a first ceramic resonator disposed to produce a carrier signal of a predetermined carrier frequency of at least 900 MHz determined by a first ceramic resonator,

a first varactor coupled to the oscillator to modulate the carrier signal based upon the digital signal to produce a first electric signal,

a first antenna coupled to the first local oscillator to radiate said radio waves in response to the first electric signal,

a high impedance buffering circuit coupled between the first local oscillator and the first antenna to isolate the local oscillator from the first antenna; and

a receiver including;

a second antenna arranged to convert the radio waves to a second electric signal,

a second local oscillator including a second ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the second ceramic resonator,

a second varactor coupled to the local oscillator to control the local signal,

a mixer coupled to the second antenna and the local oscillator to lower the frequency of the carrier signal from the second electric signal to produce a third electric signal,

a demodulator coupled to the mixer to remove the carrier signal from the third electric signal to produce a fourth electric signal.

26. The system of Claim 25, further comprising an automatic frequency control circuit coupled to the second local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

27. The system of claim 25, further comprising a high impedance buffering circuit coupled between the second local oscillator and the second antenna to isolate the second local oscillator from the second antenna.

28. Cancel.

29. Cancel.

30. A system for transmitting a transmitted signal carried by electromagnetic waves, the transmitter comprising:

an oscillator including a ceramic resonator disposed to produce a carrier signal having a carrier frequency determined by a first ceramic resonator,

a first varactor coupled to the oscillator to modulate the carrier signal based upon the composite signal to produce an electric signal,

an antenna coupled to the means for modulating to radiate electromagnetic waves in response to the electric signal; and

a buffering circuit coupled between the oscillator and the antenna to buffer the oscillator from the antenna.

31. The transmitter of Claim 30, further comprising a buffering circuit coupled between the first antenna and the local oscillator.

32. The transmitter of Claim 31, further comprising an amplifying circuit coupled between the first buffering circuit and the antenna.

33. In a system for transmitting a transmitted signal carried by electromagnetic waves, a receiver comprising:

an antenna arranged to convert electromagnetic waves, having a carrier frequency, to a first electric signal including a carrier signal component;

a local oscillator including a ceramic resonator disposed to produce a local signal having a local frequency offset from the carrier frequency and determined by the ceramic resonator;

a varactor coupled to the local oscillator to control the local signal;

a mixer coupled to the antenna and the local oscillator to lower the frequency of the carrier signal component from the first electric signal to produce a second signal; and

a demodulator coupled to the mixer to remove the carrier signal from the second electrical signal to produce a third signal.

34. The receiver of Claim 33, further comprising an automatic frequency control circuit coupled to the local oscillator and the demodulator to correct the local frequency such that the local frequency is maintained offset from the carrier frequency by a predetermined offset frequency.

35. The receiver of Claim 34, further comprising an amplifying circuit coupled between the antenna and the mixer.

36. The system of Claim 1, wherein said transmitter additionally comprises filtering means coupled to said radiation means.

37. The transmitter of Claim 7, wherein said transmitter additionally comprises filtering means coupled to said radiation means.

38. The system of Claim 16, wherein said transmitter additionally comprises filtering means coupled to said first antenna.

39. The transmitter of Claim 20, wherein said transmitter additionally comprises filtering means coupled to said antenna.

40. The system of Claim 25, wherein said transmitter additionally comprises filtering means coupled to said first antenna.

41. In a system for transmitting a signal, a transmitter comprising:

an oscillator circuit comprising;

a ground,

a varactor including a cathode and an anode,
where the anode is coupled to the ground,

a ceramic resonator coupled to the ground,
a first capacitor coupled between the resonator and the cathode of the varactor,
a second capacitor coupled between the ground and a junction between the first capacitor and the resonator,
a transistor including a base, a collector, and an emitter, where the base is coupled to the ground by a third capacitor,
a fourth capacitor coupled between the junction and the collector,
a voltage source coupled to the collector and base,
a filtering circuit coupled between the emitter the ground, and
a fifth capacitor coupled between the collector and the emitter of the first transistor;
an antenna; and
an isolation circuit which couples the oscillator circuit to the antenna such that the antenna is prevented from modulating the frequency of the oscillator circuit.

42. The transmitter of claim 41, wherein the isolation circuit comprises:

an isolating transistor including a gate and a drain, where the drain is coupled to the antenna;

a sixth capacitor for coupled between the emitter and the gate; and

an inductor coupled between the ground and the gate.

43. The transmitter of claim 41, further comprising a metallic shield arranged to substantially enclose the oscillator circuit.

44. The transmitter of claim 42, where the varactor, the resonator, the capacitors, the transistors and the components of the filtering circuit are surface mount components.

45. In a system for transmitting a signal, a receiver comprising:

an oscillator circuit comprising;

a ground,

a varactor including a cathode and an anode, where the anode is coupled to the ground,

a ceramic resonator coupled to the ground,

a first capacitor coupled between the resonator and the cathode of the varactor,

a second capacitor coupled between the ground and a junction between the first capacitor and the resonator,

a transistor including a base, a collector, and an emitter, where the base is coupled to the ground by a third capacitor,

a fourth capacitor coupled between the junction and the collector,

a voltage source coupled to the collector and base,

a filtering circuit coupled between the emitter the ground, and

a fifth capacitor coupled between the collector and the emitter of the first transistor;

an antenna; and

an isolation circuit which couples the oscillator circuit to the antenna such that the antenna is prevented from modulating the frequency of the oscillator circuit.

46. The receiver of claim 45, wherein the isolation circuit comprises:

an isolating transistor including a gate and a drain, where the drain is coupled to the antenna;

a sixth capacitor for coupled between the emitter and the gate; and

an inductor coupled between the ground and the gate.

47. The receiver of claim 45, further comprising a metallic shield arranged to substantially enclose the oscillator circuit.

48. The receiver of claim 46, where the varactor, the resonator, the capacitors, the transistors and the components of the filtering circuit are surface mount components.

49. A system for transmitting a signal including a transmitter and a receiver which each comprise:

an oscillator circuit comprising;

a ground,

a varactor including a cathode and an anode, where the anode is coupled to the ground,

a ceramic resonator coupled to the ground,

a first capacitor coupled between the resonator and the cathode of the varactor,

a second capacitor coupled between the ground and a junction between the first capacitor and the resonator,

a transistor including a base, a collector, and an emitter, where the base is coupled to the ground by a third capacitor,

a fourth capacitor coupled between the junction and the collector,

a voltage source coupled to the collector and base,

a filtering circuit coupled between the emitter and the ground, and

a fifth capacitor coupled between the collector and the emitter of the first transistor;

an antenna; and

an isolation circuit which couples the oscillator circuit to the antenna such that the antenna is prevented from modulating the frequency of the oscillator circuit.

50. The system of claim 49, wherein the isolation circuits each comprise:

an isolating transistor including a gate and a drain, where the drain is coupled to the antenna;

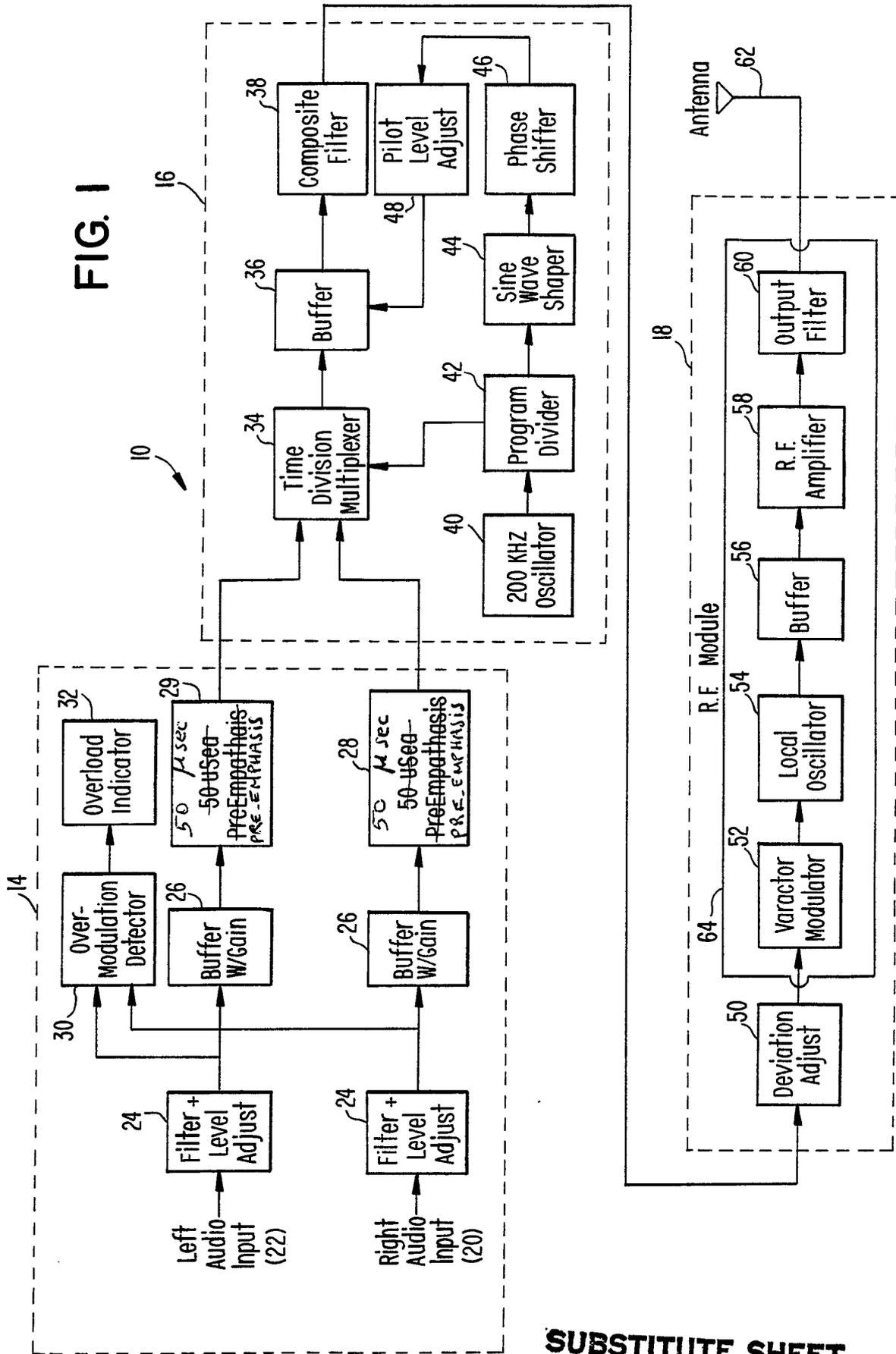
a sixth capacitor for coupled between the emitter and the gate; and

an inductor coupled between the ground and the gate.

51. The system of claim 49, further comprising two metallic shields, where each oscillator circuit is substantially enclosed by one of the metallic shields.

52. The system of claim 50, where the varactor, the resonator, the capacitors, the transistors and the components of the filtering circuit are surface mount components.

FIG. 1



SUBSTITUTE SHEET

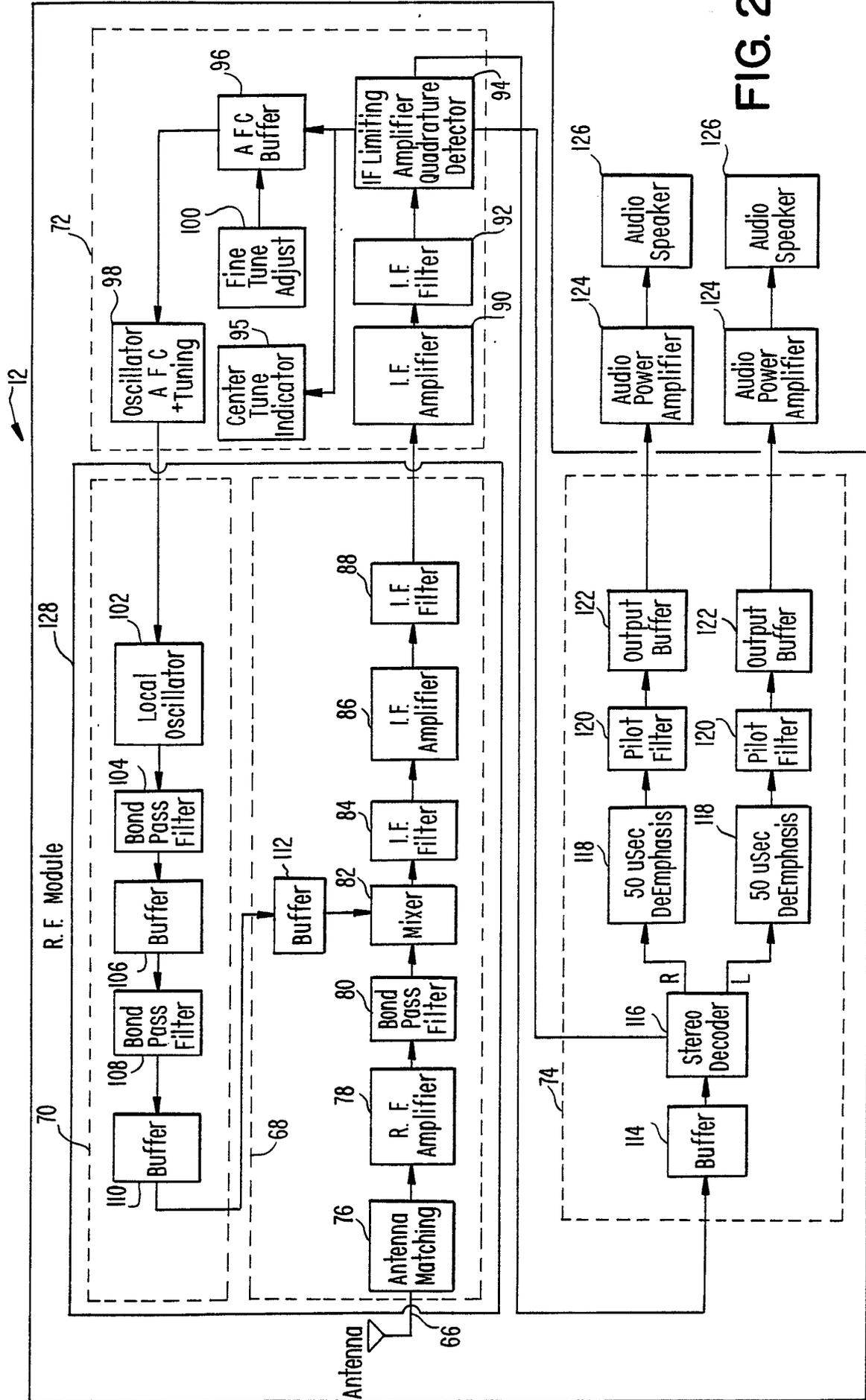


FIG. 2

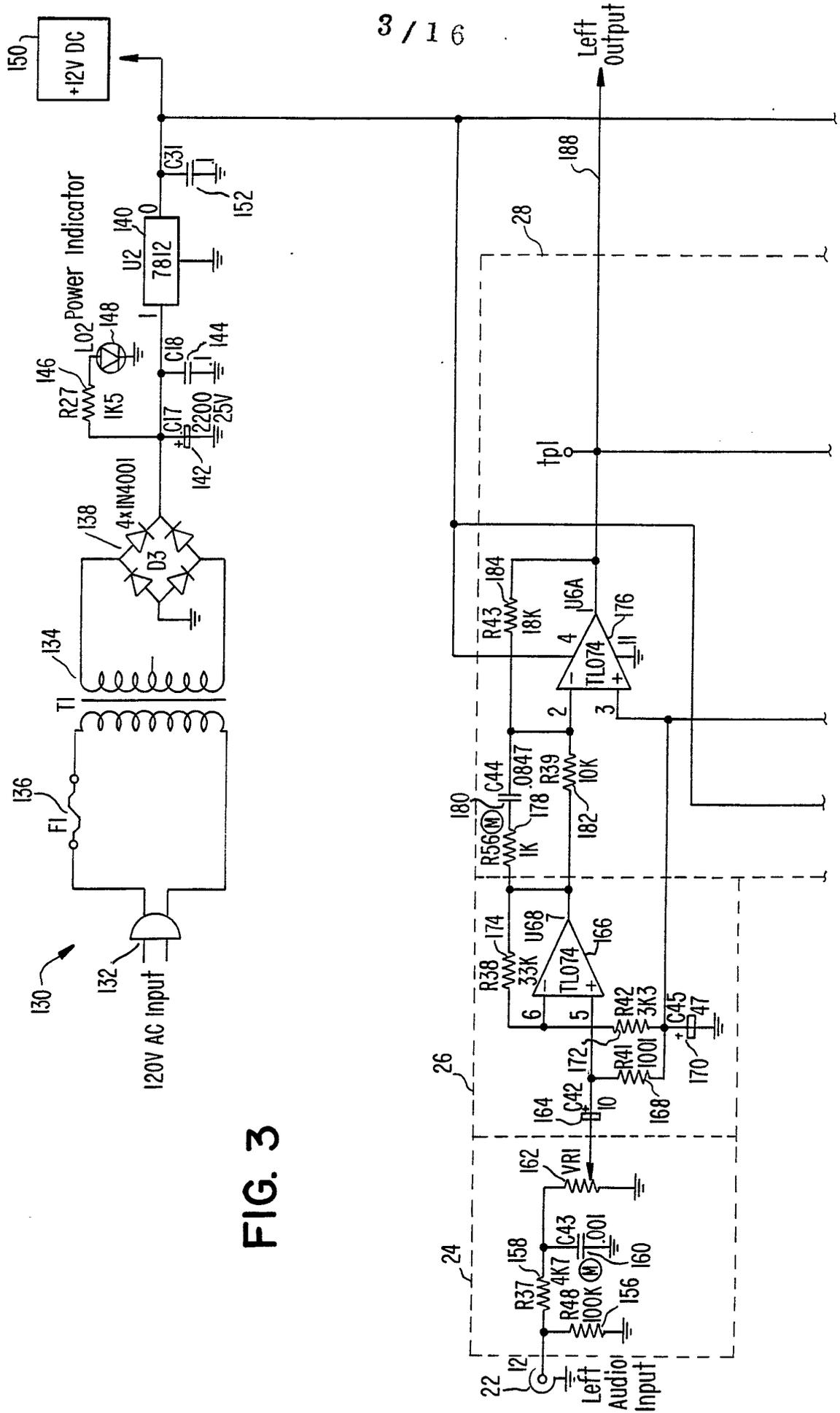


FIG. 3

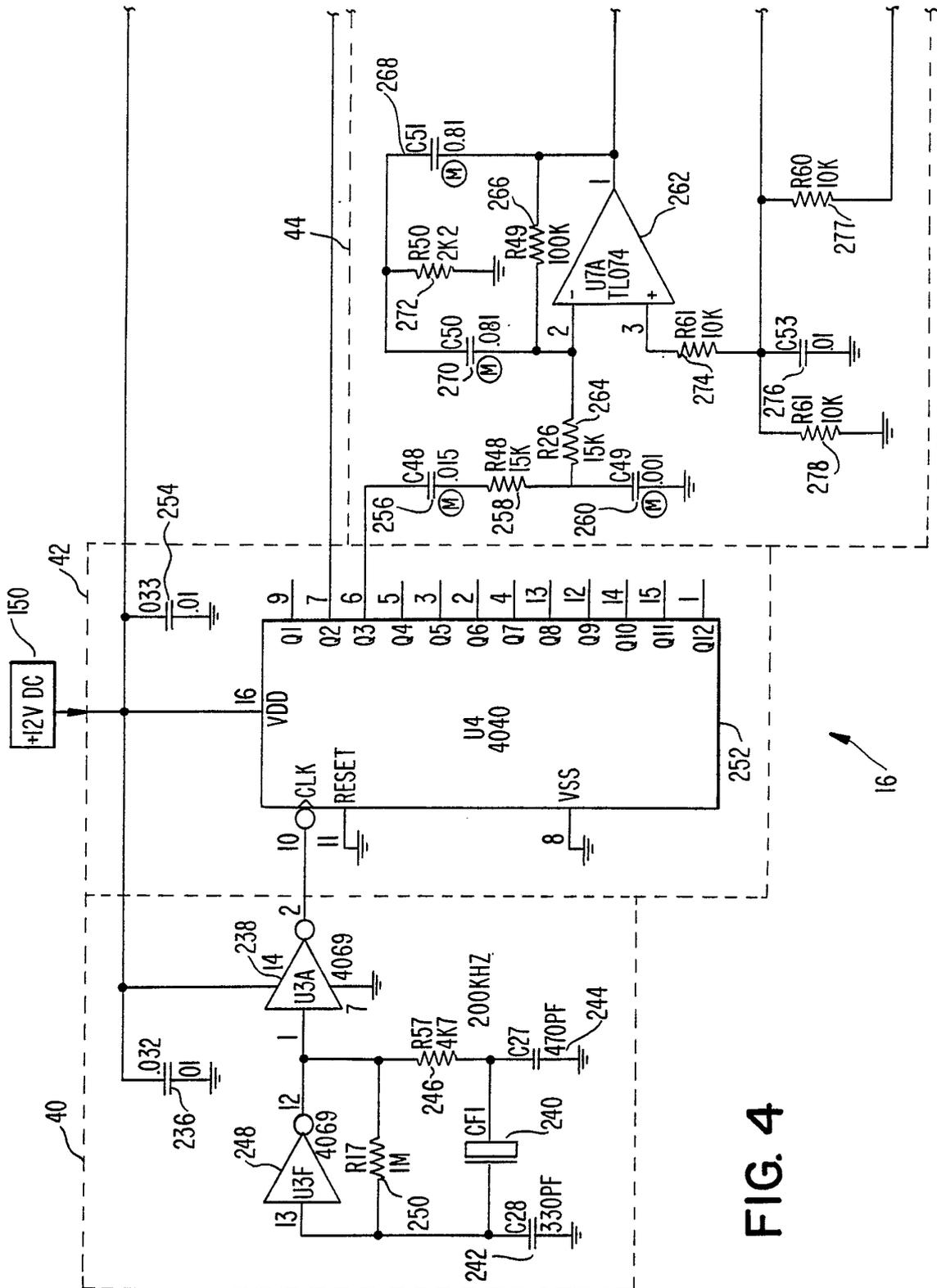


FIG. 4

FIG. 4 CONT.

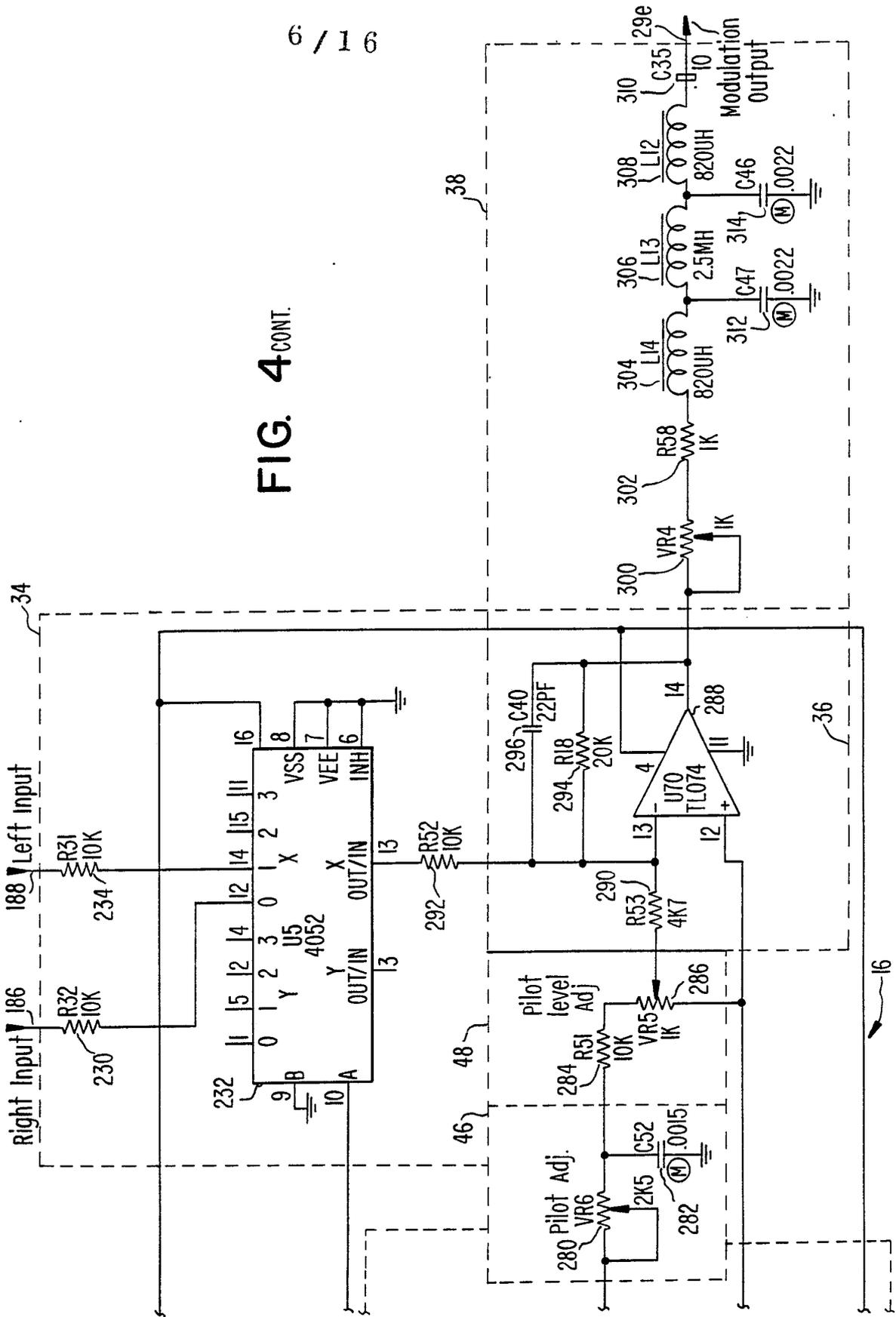
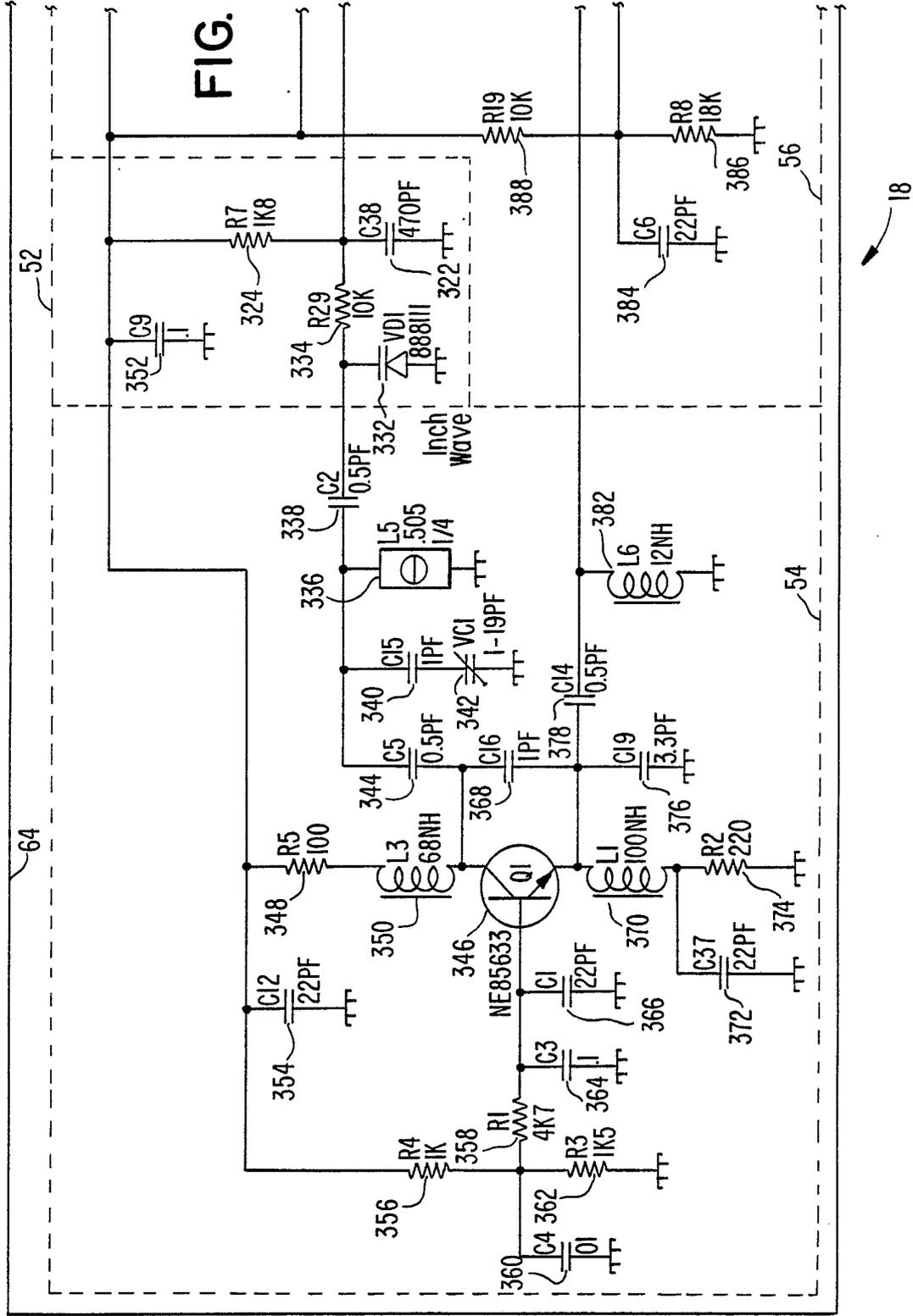


FIG. 5



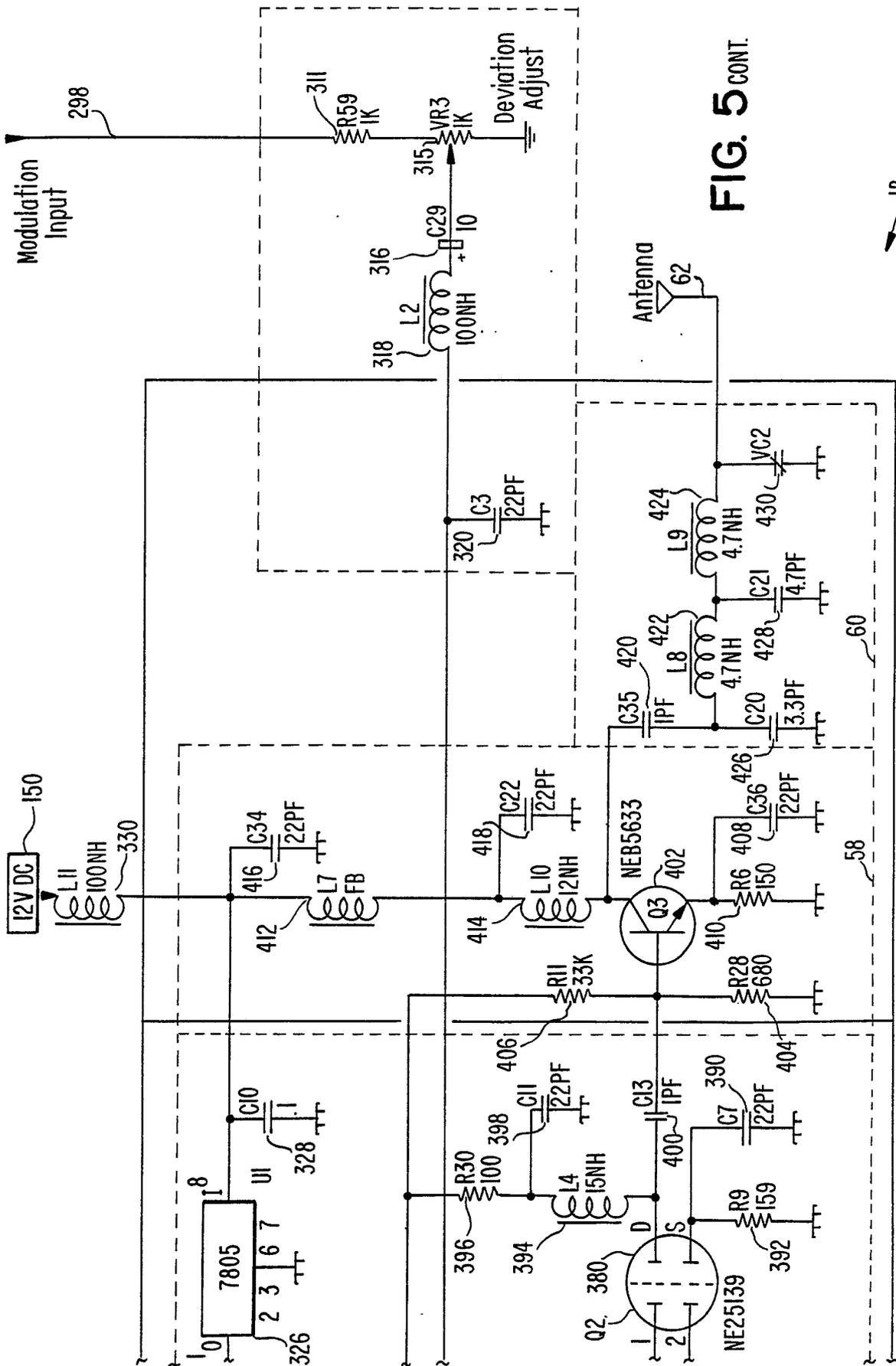
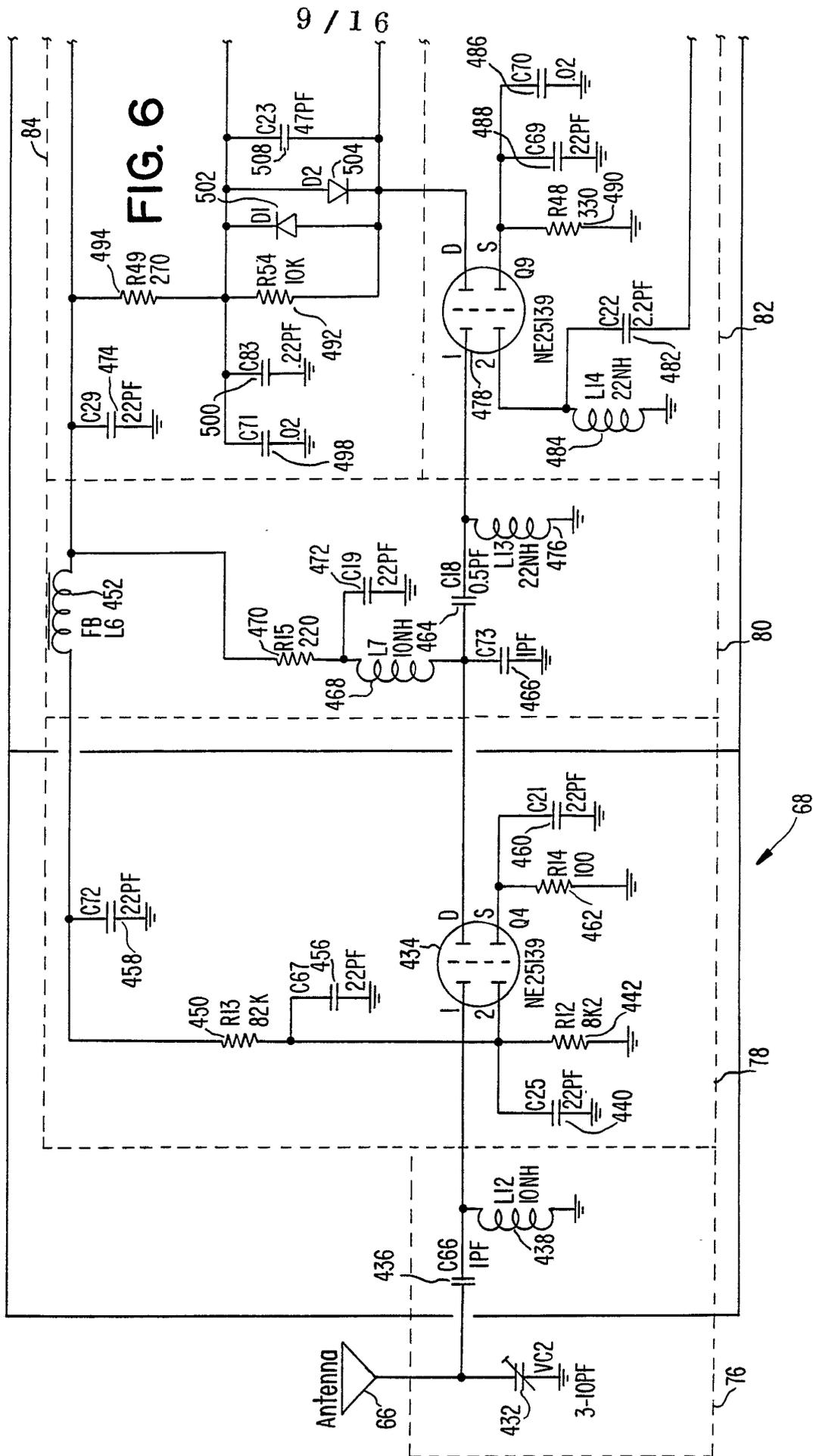


FIG. 5 CONT.

18



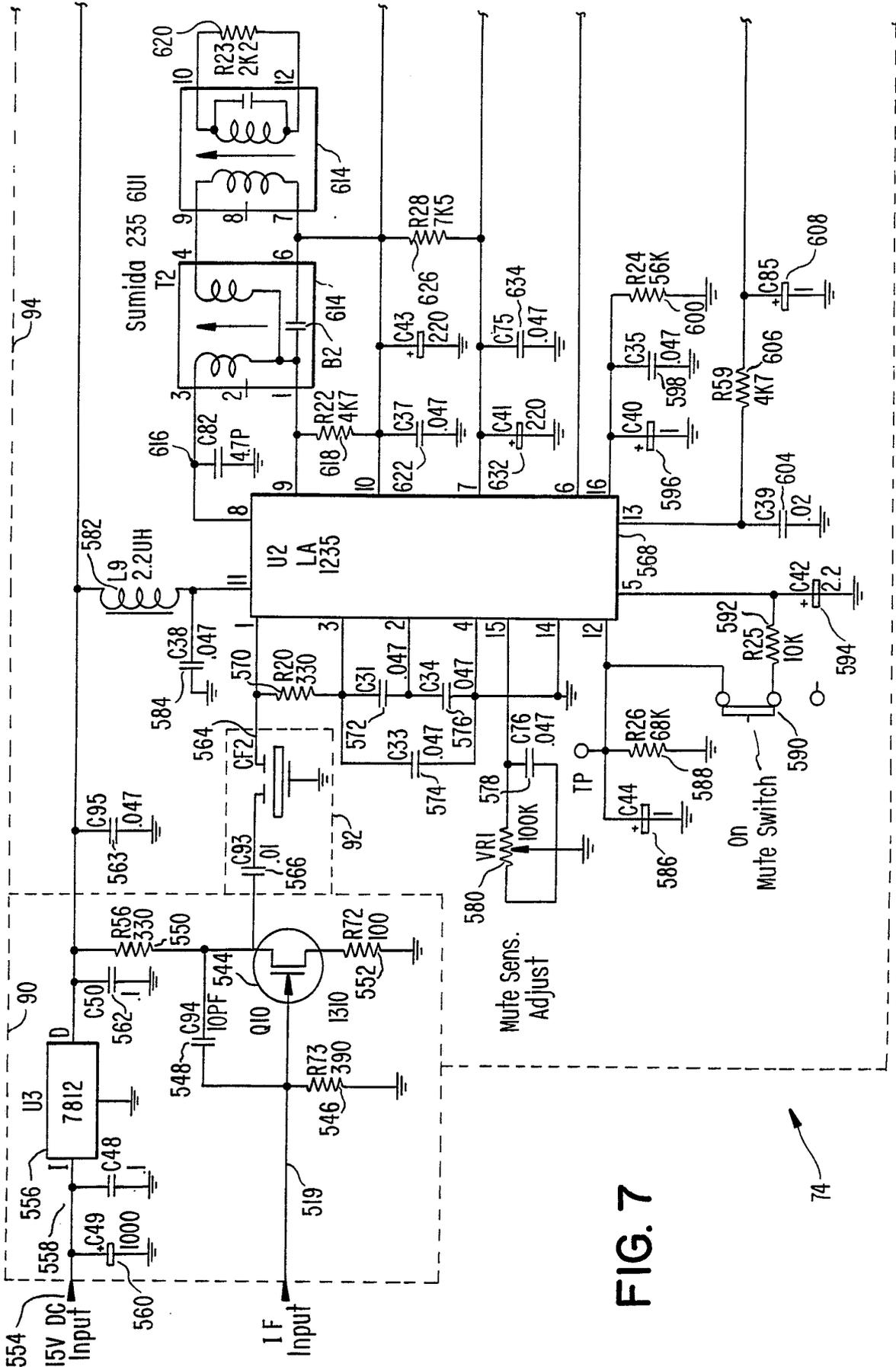


FIG. 7

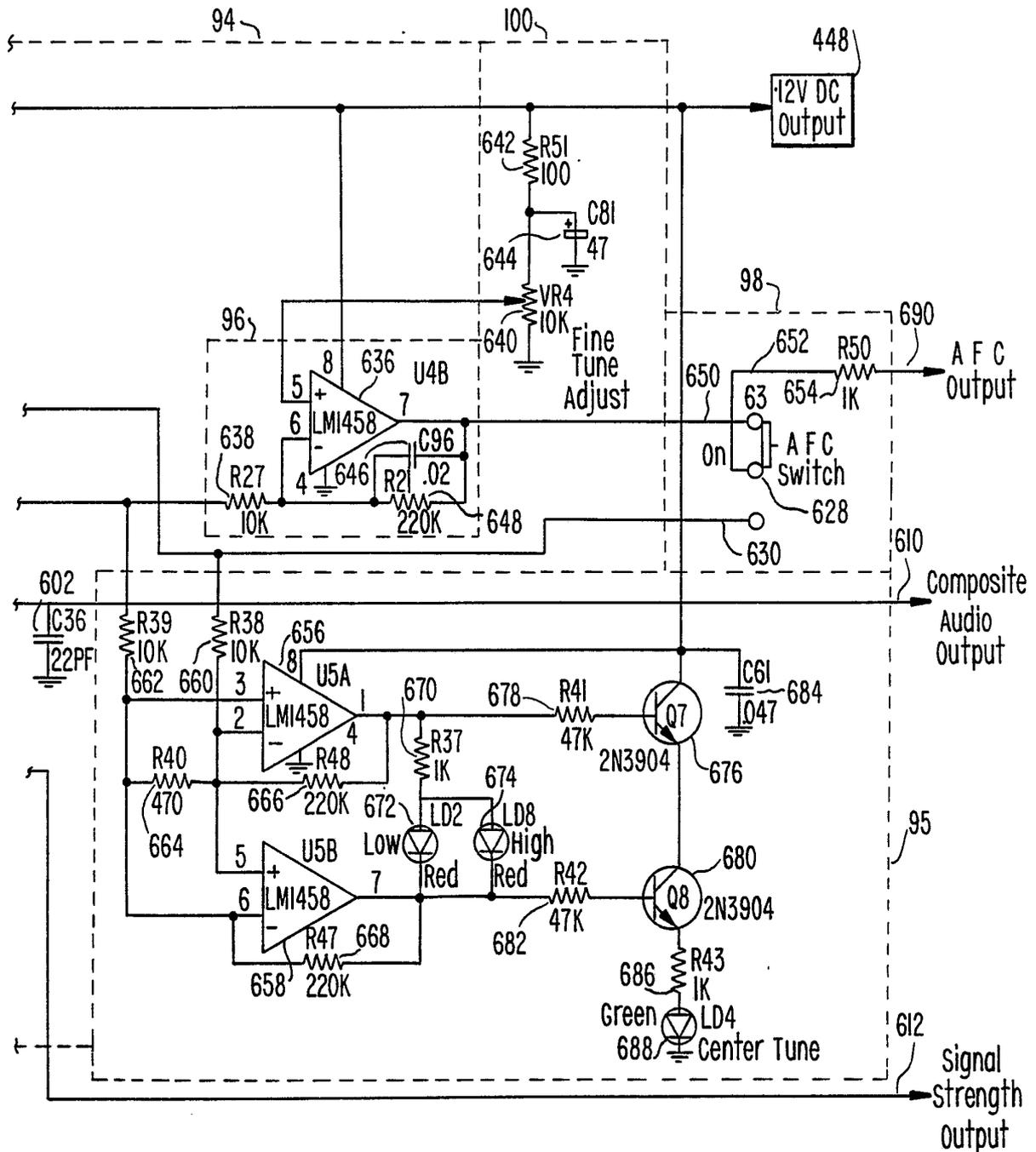


FIG. 7 CONT.

FIG. 8

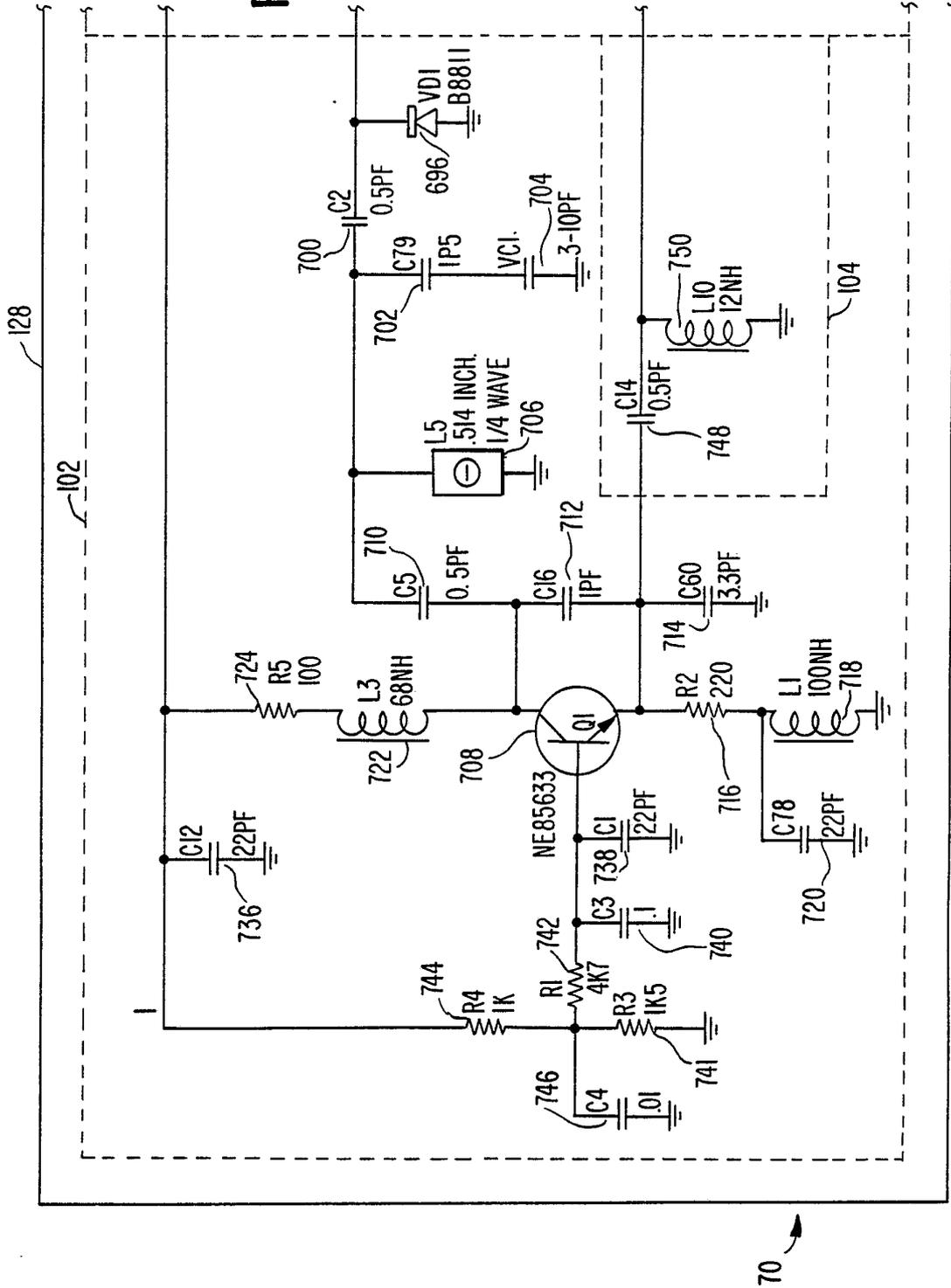


FIG. 8 CONT.

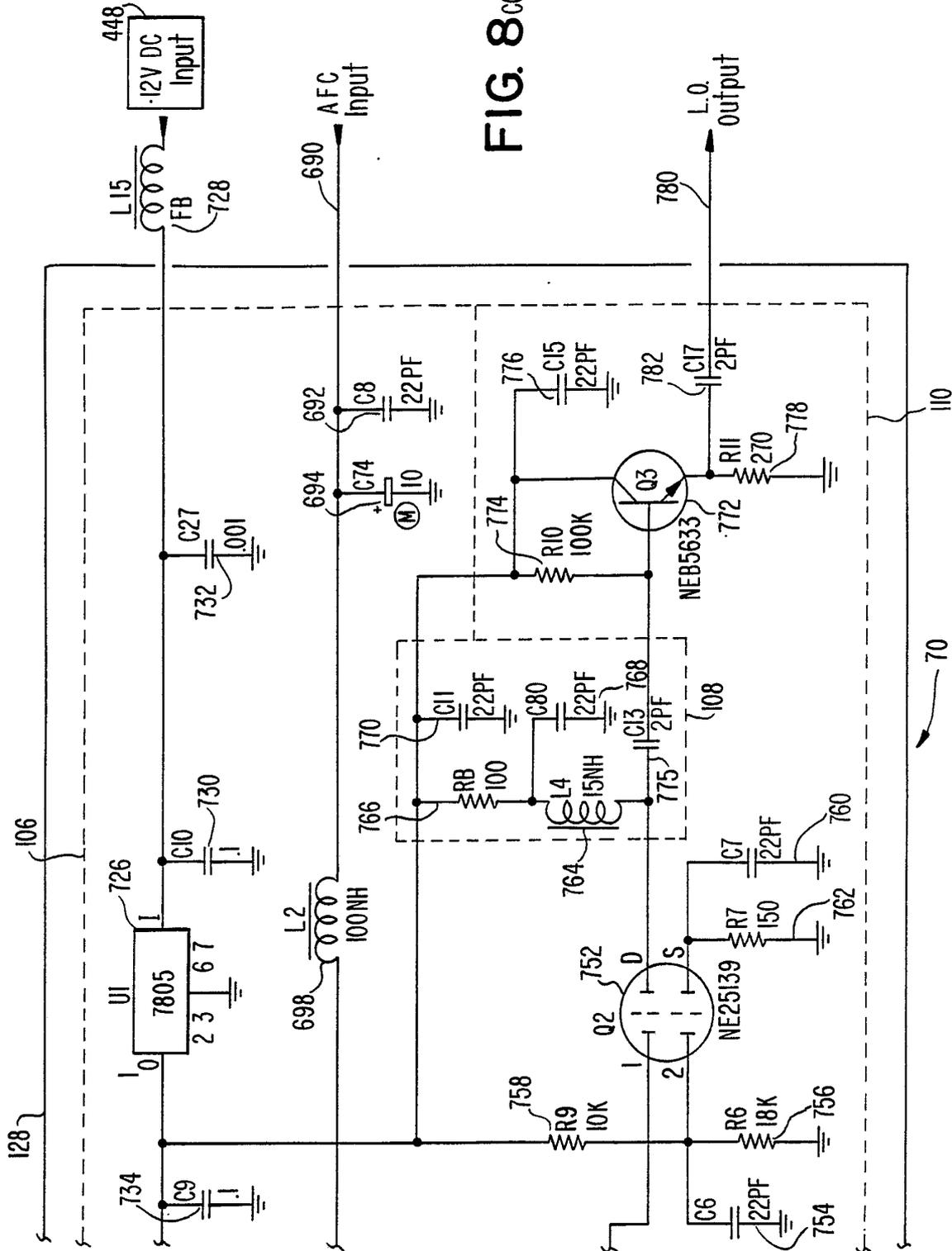


FIG. 9

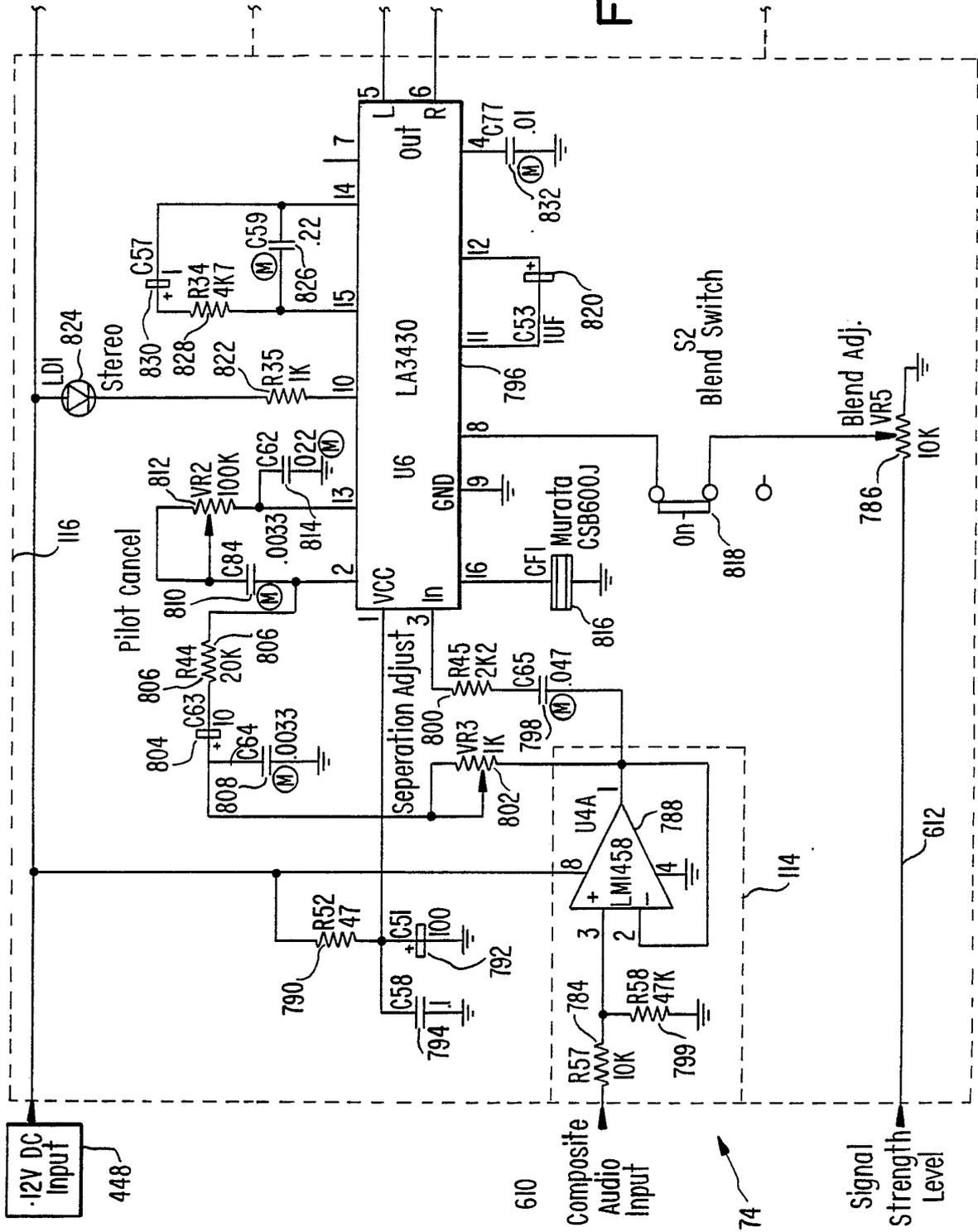
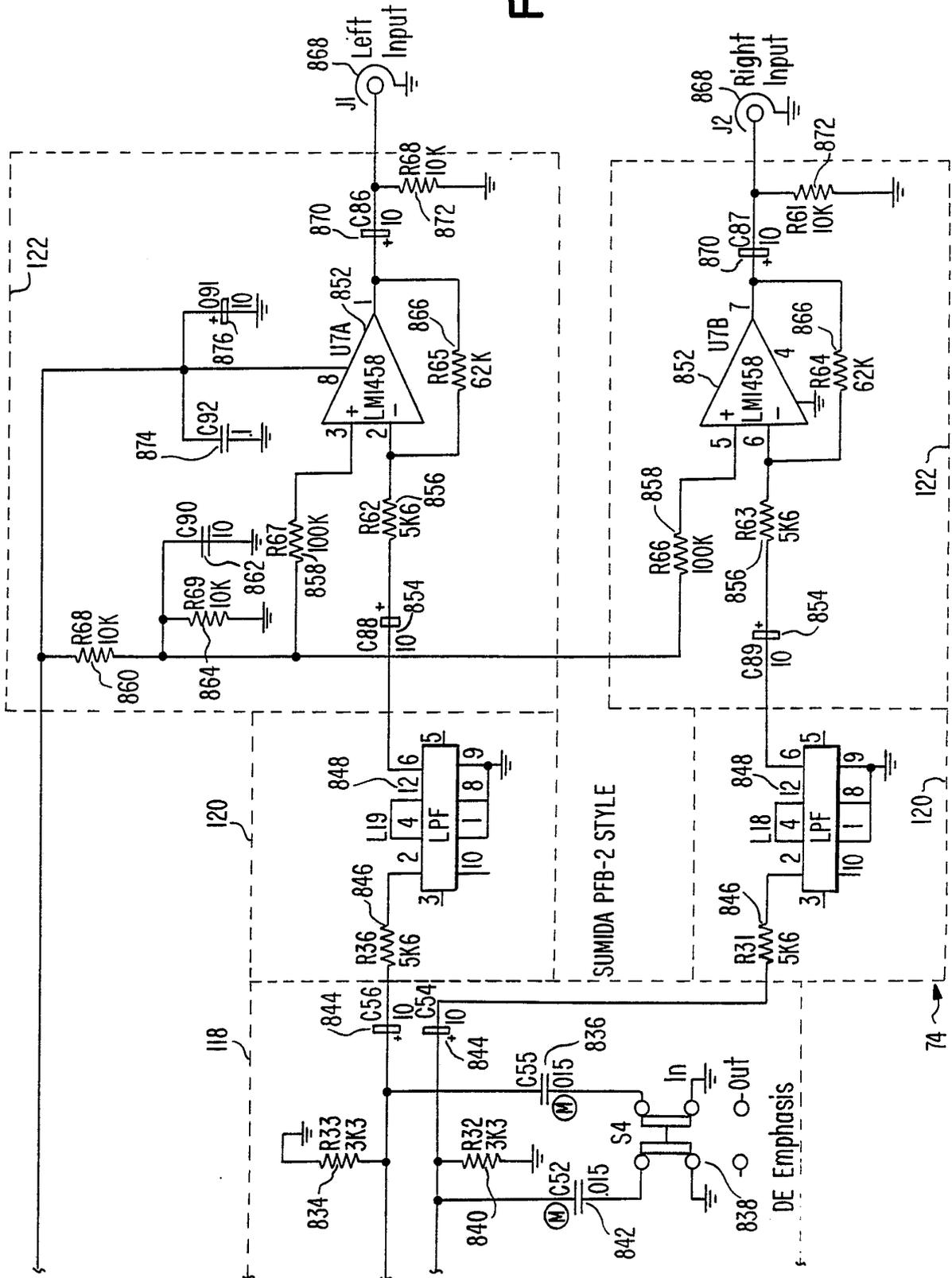


FIG. 9 CONT.



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/06988**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :H04H 5/00

US CL :381/2

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 381/2,14; 370/14,50,120,123

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4704715 (Shibagaki et al) 03 November 1987, Figure 2	1-29
Y	US, A, 4079203 (Dragoo) 14 March 1978, figures 1 and 2	1-29
Y	Siemens App. Notes, 1989, Kuchler, "Coaxial Ceramic Resonators for UHF and Microwaves, Pages 1-5	1-35
Y	US, A, 3256389 (Ehrich) 14 June 1966, see figures 1 and 2	16-29
Y,P	US, A, 5106826 (Alford et al) 21 April 1992, see figures 3-6	30-35
Y,P	US, A, 5077835 (Margairaz et al) 31 December 1991, see figure 1 and abstract	30-35
Y	US, A, 4864636 (Brunius) 05 September 1989, see abstract and figures 1-3	30-35
A,P	US, A, 5046132 (Trefney) 03 September 1991, see figure 1 and abstract	30-35
A	US, A, 4710970 (Wu et al) 01 December 1987 see abstract and figs. 1-4	1-35

 Further documents are listed in the continuation of Box C.
 See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

13 NOVEMBER 1992

Date of mailing of the international search report

28 DEC 1992

Name and mailing address of the ISA/
Commissioner of Patents and Trademarks
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US92/06988

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4922483 (Kobayashi) 01 May 1990, see figures 1 and 2	1-29
A	US, A, 3471646 (Magnuski et al) 07 October 1969, see figures 1 and 2	1-29

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

- I. Claims 1-29, drawn to a multiplexing stereo system classified in Class 381, subclass 2.
- II. Claims 30-32, drawn to a transmitting system, classified in Class 455, subclass 129.
- III. Claims 33-35, drawn to a receiving system, classified in Class 455, subclass 313.

Inventions of groups I, II and III are related as separate and distinct independent inventions. Group I requires multiplexing which is a unique communication system by itself. Groups II and III are directed to general transmission and reception systems which do not require multiplexing and can clearly operate in a non-multiplexing environment. The claims of the different groups do not have in common the same special technical features.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US92/06988

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Extra Sheet.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.