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Dougherty

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[54] **APPARATUS AND METHOD FOR INJECTING AN ANCILLARY SIGNAL INTO A LOW ENERGY DENSITY PORTION OF A COLOR TELEVISION FREQUENCY SPECTRUM**

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[52] **U.S. Cl.** **348/486**; 348/1; 348/473

[58] **Field of Search** 348/1, 473, 486, 348/4; H04N 7/081

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,982,813	5/1961	Hathaway	178/5.6
3,838,444	9/1974	Loughlin et al.	178/5.2
3,842,196	10/1974	Loughlin	358/12
3,924,060	12/1975	Bedford	348/486
4,025,851	5/1977	Haselwood et al.	325/31
4,647,974	3/1987	Butler et al.	348/473
5,404,161	4/1995	Douglas et al.	348/1

FOREIGN PATENT DOCUMENTS

WO94/10799	5/1994	WIPO	H04N 7/00

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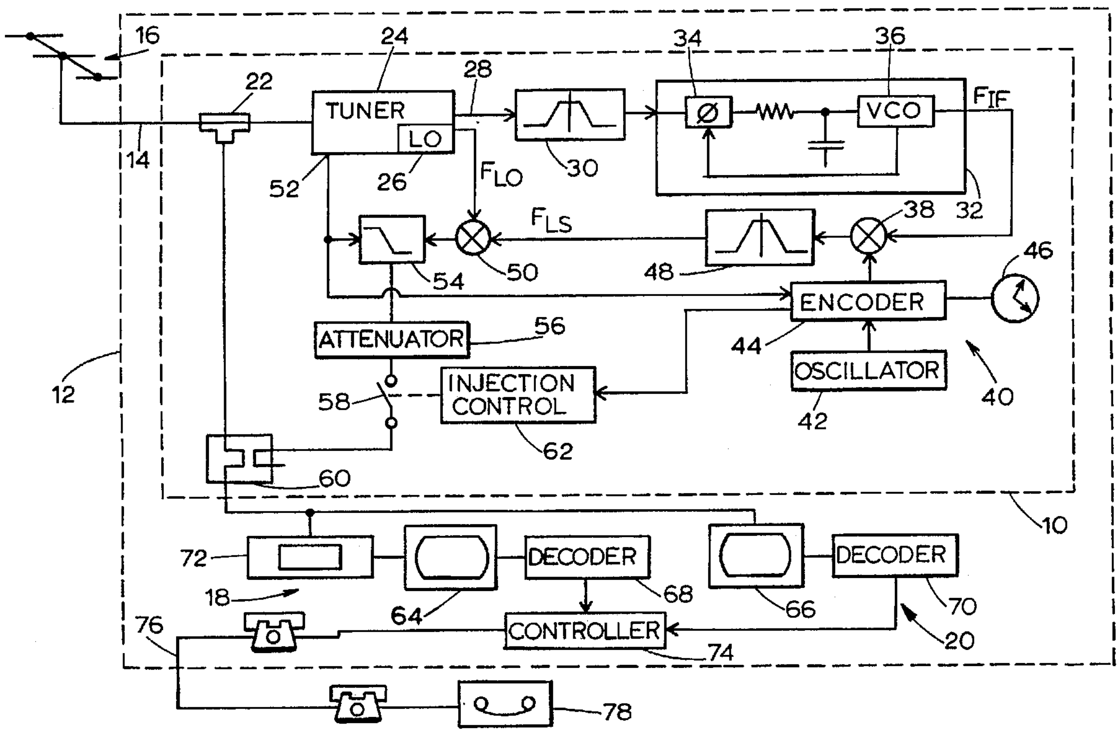
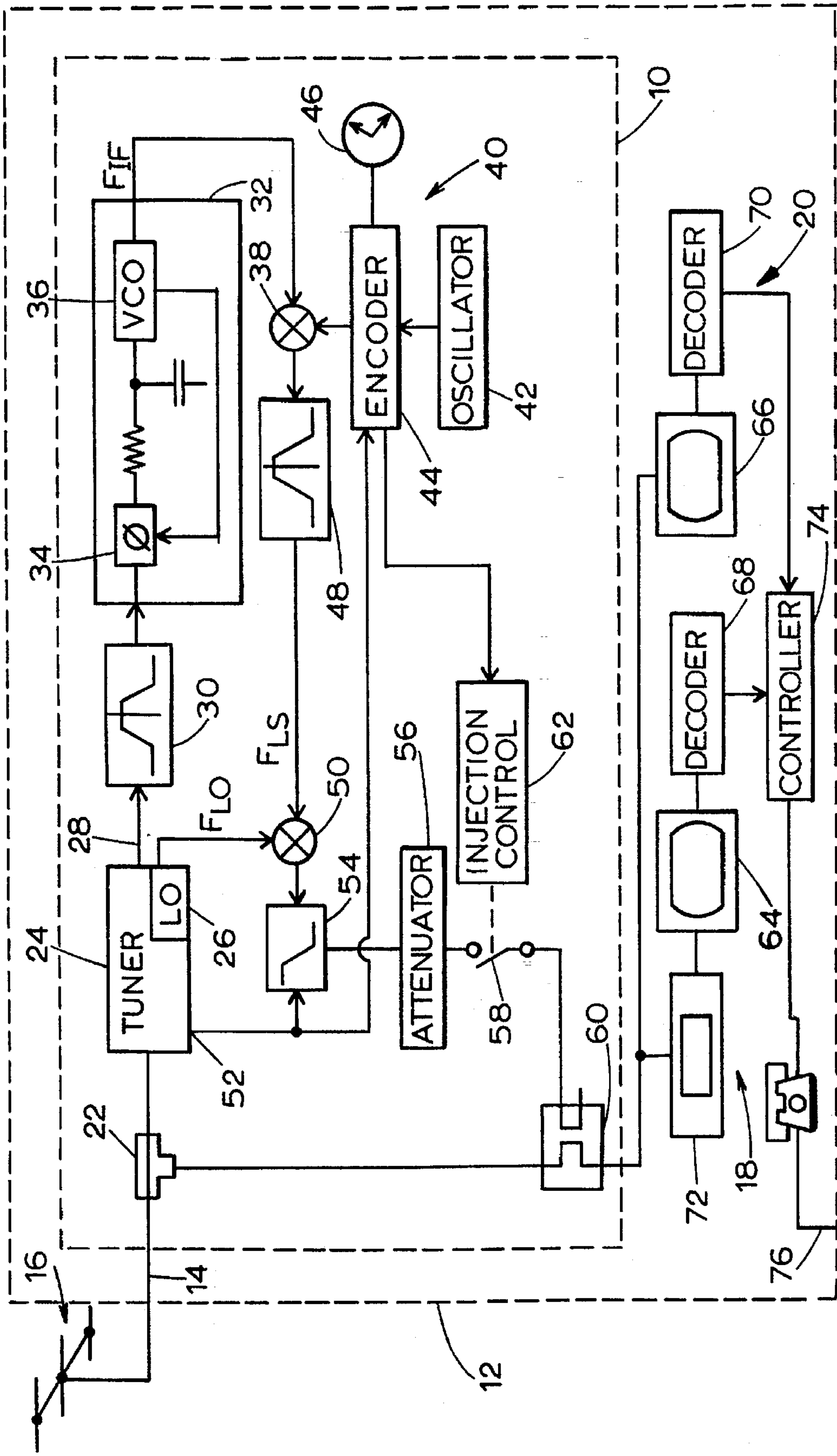
[57] **ABSTRACT**

An ancillary signal is injected into a program signal within the frequency band normally occupied by the program signal alone. The program signal includes a modulated carrier having a carrier frequency and a low energy density portion of the frequency band. The ancillary signal is selectively added at an injection frequency within the lower energy density portion of the frequency band so that the injection frequency is locked to the carrier frequency and to the frequency of a local oscillator.

52 Claims, 1 Drawing Sheet

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APPARATUS AND METHOD FOR INJECTING AN ANCILLARY SIGNAL INTO A LOW ENERGY DENSITY PORTION OF A COLOR TELEVISION FREQUENCY SPECTRUM

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a system and a method for compatibly transmitting and receiving both a program signal and an ancillary signal within the frequency band normally occupied by the program signal alone and, more particularly, to a system and method for compatibly transmitting and receiving both a color television program signal and an ancillary signal so that the ancillary signal is added to a low energy density portion of the color television program signal.

BACKGROUND OF THE INVENTION

It is known to add ancillary signals to radio frequency signals in order either to monitor the broadcasts of programs or to measure audiences of programs. Such programs may include television programs, radio programs, and/or the like, and the broadcast of such programs may include the transmission of these programs over the air, over a cable, via a satellite, and/or the like.

When monitoring the broadcast of programs, a monitoring system typically determines the identity of the programs which were broadcast, the regions in which these programs were broadcast, the times at which these programs were broadcast, and the channels over which these programs were broadcast. One monitoring system, which is commonly used within the United States, is referred to as the "AMOL" system and is taught by Haselwood, et al. in U.S. Pat. No. 4,025,851. This "AMOL" system adds a source identification code to selected horizontal lines on the vertical blanking intervals of the program signal. Monitoring equipment, which is located in selected regions throughout the United States, determines the identity of the programs which are broadcast by detecting the source identification codes of the broadcast programs. The monitoring equipment stores, for later retrieval, these detected source identification codes together with the times at which these source identification codes were detected and the channels on which these source identification codes were detected.

When measuring the audiences of programs, an audience measurement system typically determines which programs were viewed by which members of a statistically sampled panel of dwellings. One type of an audience measurement system uses an ancillary signal to monitor a program receiver, and commonly injects this ancillary signal (which may be a simple tone, or a complex digital code) into a channel that may be carrying a viewed program. The ancillary signal is injected by an apparatus which is located at or near the program receiver being monitored. The detection of such an ancillary signal provides an indication that the program receiver is on and is tuned to the channel carrying the detected ancillary signal. Signal injection systems are taught, inter alia, in PCT/US93/09458 by Mostafa, et al.

Adding an ancillary signal to a program signal must generally be done so as to minimize the probability that the ancillary signal will interfere with any aspect of the basic program signal. Several systems are known which add ancillary signals at selected frequencies within the radio frequency band, or channel, of a program signal. For example, in U.S. Pat. No. 2,982,813, Hathaway teaches a system which frequency interleaves the ancillary and program signals. In U.S. Pat. No. 3,838,444, Loughlin, et al. teach a system which compatibly adds and transmits an ancillary signal in a low energy density portion of a color television frequency spectrum. The low energy density portion of interest is located between the video carrier and the color subcarrier of the NTSC television signal, and is at a frequency which is about 2.4 MHz above the video carrier peak in the radio frequency band of the NTSC television signal. The teachings of Loughlin, et al. in U.S. Pat. No. 3,838,444 are herein incorporated by reference.

Furthermore, in U.S. Pat. No. 3,842,196, Loughlin discloses an improved system which minimizes interference between a primary ancillary signal and the program signal by adding a redundant ancillary signal. The redundant ancillary signal is transmitted with an inverted polarity as compared to the primary ancillary signal so that artifacts which may be caused by the addition of an ancillary signal to the program signal are canceled in the video display.

However, the accuracy with which these systems set the absolute frequency of the ancillary signal which is to be injected into the program signal is limited. For example, a reasonable error (e.g., ±50 KHz) in setting the frequency (e.g., 100 MHz) of the ancillary signal can cause the injected ancillary signal to overlap a harmonic of the horizontal scanning frequency. If the frequency of the ancillary signal, because of an error, overlaps a harmonic of the horizontal scanning frequency, the ancillary signal will interfere with the program signal. This interference is annoyingly apparent to a viewer. Moreover, if the frequency of the ancillary signal is uncertain, a monitoring system or an audience measurement system may have difficulty in picking up and using the ancillary signal for program monitoring and/or audience measurement purposes.

The present invention overcomes one or more of these problems

SUMMARY OF THE INVENTION

Therefore, according to one aspect of the present invention, a method for compatibly transmitting and receiving both a program signal and an ancillary signal within a frequency band normally occupied by the program signal alone, wherein the program signal includes a modulated carrier having a carrier frequency and a low energy density portion of the frequency band, comprises the steps of (i) receiving the program signal, and (ii) selectively adding the ancillary signal at an injection frequency within the lower energy density portion of the frequency band so that the injection frequency is locked to the carrier frequency.

According to another aspect of the present invention, a system compatibly transmits and receives both a program signal and an ancillary signal within a frequency band normally occupied by the program signal alone. The program signal includes a modulated carrier having a carrier frequency and a low energy density portion of the frequency band. The system comprises a receiver and a signal injector. The receiver is arranged to receive the program signal, and the receiver has a local oscillator which produces a local oscillator frequency. The signal injector is arranged to selectively add the ancillary signal at an injection frequency within the lower energy density portion of the frequency band so that the injection frequency is locked to the local oscillator frequency.

According to still another aspect of the present invention, a system compatibly transmits and receives a television program signal and an RF ancillary signal. The television program signal is in a predetermined RF frequency band,

and the television program signal has a modulated video carrier signal and a low energy density portion of the frequency band. The system comprises a tuner, first and second mixers, and a coupler. The tuner is arranged to receive the television program signal and has as outputs a local oscillator signal and a modulated carrier signal. The first mixer is arranged to mix an injection signal at a predetermined baseband injection frequency with a signal representative of the modulated carrier signal to produce an intermediate frequency injection signal. The second mixer is arranged to mix the local oscillator signal with the intermediate frequency injection signal to produce the RF ancillary signal. The coupler is arranged to couple the RF ancillary signal into the received television program signal.

According to yet another aspect of the present invention, a method of injecting an RF ancillary signal into a low energy density portion of a channel normally occupied by a color television program signal, wherein the color television program signal has a modulated video carrier, a chrominance subcarrier, and the low energy density portion, comprises the steps of (i) tuning the color television program signal so as to produce a local oscillator signal and a modulated carrier signal as outputs, (ii) mixing an injection signal at a predetermined injection frequency with a signal representative of the modulated carrier signal to produce an output injection signal, (iii) mixing the local oscillator signal with the output injection signal to produce the RF ancillary signal, and (iv) coupling the RF ancillary signal into the color television program signal.

According to a further aspect of the present invention, a broadcast tuning measurement method in which an RF ancillary channel recognition signal is added to a television program signal received at a predetermined channel frequency within a sampled dwelling unit, wherein the RF ancillary channel recognition signal is subsequently read from the television program signal at a viewing site, comprises the steps of (i) tuning the television program signal so as to produce a local oscillator frequency and a video carrier signal as outputs, (ii) providing an injection signal at a predetermined frequency which is selected to be in a low energy density part of a channel, (iii) combining the video carrier signal with the injection signal to form a carrier/injector signal, (iv) combining the local oscillator frequency with the carrier/injection signal to form the RF ancillary channel recognition signal, and (v) coupling the RF ancillary channel recognition signal into the television program signal.

DESCRIPTION OF THE DRAWING

These and other features and advantages will become apparent from a detailed consideration of the present invention when taken in conjunction with the single FIGURE of the drawing which is a schematic block diagram of a signal injection apparatus of the present invention.

DETAILED DESCRIPTION

A receiving and encoding apparatus **10** is located within a selected dwelling **12** at or near a signal entrance **14** at which television signals from a signal source **16** enter the selected dwelling **12**. The receiving and encoding apparatus **10** encodes all television signals on all channels receivable from the signal source **16**. In the specific embodiment of the present invention shown in FIG. **1**, the source of program signals, i.e. the signal source **16**, is shown as an antenna. However, the signal source **16** may alternatively be a satellite dish, a cable, and/or the like. Moreover, although only one source of program signals, i.e., the signal source **16**, is shown, additional sources may supply program signals to the selected dwelling **12**. If so, either a single receiving and encoding apparatus **10** may encode all television signals on all channels from all sources or, preferably, a receiving and encoding apparatus **10**, which encodes all television signatures on all channels of a corresponding source, may be provided for each source. Other variations are, of course, possible.

If sources of program signals are provided for the selected dwelling **12** in addition to the signal source **16**, and if each such source has its own corresponding receiving and encoding apparatus **10**, each such receiving and encoding apparatus **10** should preferably be located or near the service entrance through which its corresponding program signal source enters the selected dwelling **12**. Because each receiving and encoding apparatus **10** is located at or near the service entrance through which the television signals receivable from a corresponding source of program signals enter the selected dwelling **12**, each receiving and encoding apparatus **10** may be easily arranged to encode only the television signals on the channels receivable from its corresponding source of program signals. Accordingly, if all such sources of program signals are encoded at their respective signal entrances, the source of programs to which a receiver within the selected dwelling **12** is tuned may be more readily identified.

The selected dwelling **12** may contain a first viewing site **18**. Additionally, the selected dwelling **12** may contain a second viewing site **20**. More or fewer viewing sites may be contained within the selected dwelling **12** as is desirable. It will be understood that, although the embodiment of the invention shown in the drawing includes various known elements of the television audience measurement art, the method and apparatus of the present invention are more broadly directed to any system in which the addition of an ancillary signal to a program signal is advantageous.

The receiving and encoding apparatus **10** is connected to the signal source **16** of television program signals by way of a splitter **22**, for example. A tuner **24** is connected to an output of the splitter **22**. The tuner **24** periodically and sequentially tunes to each of the television channel frequencies available from the signal source **16**. The tuner **24** includes a local oscillator **26** and has an output **28**. As is well known in the tuner art, the tuner **24** mixes the frequency of the signal provided by the local oscillator **26** with the television channel frequencies, which are available from the signal source **16** and which are selected by the tuner **24**, in order to down convert the selected television channel frequency to an intermediate frequency. The signal having this intermediate frequency is provided by the tuner **24** on the output **28**.

In the receiving and encoding apparatus **10**, the signal on the output **28** of the tuner **24** is applied to a video carrier bandpass filter **30** which is centered on the intermediate frequency of the video carrier (e.g., which is 45.75 MHz in a conventional NTSC receiver). The video carrier bandpass filter **30** is selected to pass the intermediate frequency of the video carrier, to reject the other intermediate frequencies, and to have a passband which is wide enough to accept the worst case off-frequency error in the intermediate frequency of the video carrier which is expected to be encountered (e.g., a 100 KHz luminance frequency error on a locally-originated cable channel). The video carrier bandpass filter **30** provides the intermediate frequency video carrier to a video carrier reconstruction circuit **32**.

The video carrier reconstruction circuit **32** includes a phase detector **34** and a voltage controlled oscillator **36**. The video carrier reconstruction circuit **32** phase locks the voltage controlled oscillator **36** to the video carrier reference signal from the video carrier bandpass filter **30** in order to generate an unmodulated, reconstructed video carrier signal which has a frequency F_{IF} and which is applied to a first input of a code-adding balanced mixer **38**. Thus, the video carrier reconstruction circuit **32** selects from the output of the video carrier bandpass filter **30** only the frequency of the intermediate frequency video carrier and excludes all other frequencies which may pass through the video carrier bandpass filter **30**. Also, because the unmodulated, reconstructed video carrier signal having the frequency F_{IF} is derived from the frequency of the local oscillator **26** and from the frequency of the modulated video carrier of the television channel selected by the tuner **24**, any shift in the frequency of the local oscillator **26** or in the video carrier frequency selected by the tuner **24** leads to a corresponding shift in the frequency of the unmodulated, reconstructed video carrier signal having the frequency F_{IF} provided by the video carrier reconstruction circuit **32** to the code-adding balanced mixer **38**. Thus, as will be subsequently discussed in greater detail, the apparatus of the present invention locks the frequency at which the ancillary signal is injected to both the received video carrier frequency of the television channel currently selected by the tuner **24** and to the frequency of the signal provided by the local oscillator **26** in order to ensure that the ancillary signal is indeed injected into the desired lower energy density portion of the selected television channel.

An injection signal circuit **40** supplies an injection signal, which has a frequency F_{IJ}, to a second input of the code-adding balanced mixer **38**. The injection signal circuit **40** includes an oscillator **42** and an encoder **44**. The frequency of the oscillator **42** may be, for example, 2.399475 MHz, which is the 305th harmonic of one-half of the horizontal scan rate in an NTSC television signal, and the encoder **44** may be any known encoder capable of modulating the oscillator **42**. (It should be noted here that, when the frequency of about 2.399475 MHz is added to the frequency of a video carrier, the resulting frequency is within the low energy density portion of the color television program signal.) A time-stamped code may be added to the output of the oscillator **42** and, if so, may be derived from a clock **46**. Alternatively, a title code, a channel number code, a source code, or the like, or no code. may be added instead of the time-stamped code. The code-adding balanced mixer **38** mixes the unmodulated, reconstructed video carrier signal having the frequency F_{IF} with the injection signal having the frequency F_{IJ} in order to produce first and second intermediate frequency encoded ancillary output signals having corresponding sum and difference frequencies $F_{IF}+F_{IJ}$ and $F_{IF}-F_{IJ}$.

The first and second intermediate frequency encoded ancillary output signals having the corresponding sum and difference frequencies $F_{IF}+F_{IJ}$ and $F_{IF}-F_{IJ}$ are applied to a sideband stripping filter **48**. For an example of the frequencies which may be used by the receiving and encoding apparatus **10**, the frequency F_{IF} of the unmodulated, reconstructed video carrier signal produced by the video carrier reconstruction circuit **32** will be 45.75 MHz, if the original input signal is exactly on frequency and if the local oscillator **26** frequency is exactly 45.75 MHz above the input signal frequency. Thus, if the oscillator **42** is set at 2.399475 MHz, the frequency of the first intermediate frequency encoded ancillary output signal of the code-adding balanced mixer **38** is about 48.149475 MHz and the frequency F_{LS} of the second intermediate frequency encoded ancillary output signal of the code-adding balanced mixer **38** is about 43.350525 MHz.

The sideband stripping filter **48** is preferably a bandpass filter centered on the frequency F_{LS} of the second intermediate frequency encoded ancillary output signal of the code-adding balanced mixer **38**. The frequency F_{LS} of the second intermediate frequency encoded ancillary output signal is the lower sideband frequency of the intermediate frequency encoded ancillary output signals produced by the code-adding balanced mixer **38**. Moreover, the sideband stripping filter **48** preferably has a passband width sufficient to pass a worst case off-frequency error which, for example, may be ±100 KHz. The sideband stripping filter **48** necessarily has a narrow enough passband to reject the first intermediate frequency encoded ancillary output signal of the code-adding balanced mixer **38**. The frequency of the first intermediate frequency encoded ancillary output signal is the higher sideband frequency of the intermediate frequency encoded ancillary output signals produced by the code-adding balanced mixer **38**.

The second intermediate frequency encoded ancillary output signal of the code-adding balanced mixer **38**, which is filtered by the sideband stripping filter **48** and which has the frequency F_{LS}, is applied to a first input of a balanced up converting mixer **50**. The signal provided by the local oscillator **26**, which has a frequency F_{LO}, is available as an output from the tuner **24** and is applied to a second input of the balanced up converting mixer **50**. The balanced up converting mixer **50** mixes the second intermediate frequency encoded ancillary output signal, which is filtered by the sideband stripping filter **48** and which has the frequency F_{LS}, and the output signal of the local oscillator **26**, which has the frequency F_{LO}. Accordingly, the balanced up converting mixer **50** produces first and second intermediate frequency tracking signals having corresponding sum and difference frequencies $F_{LS}+F_{LO}$ and $F_{LS}-F_{LO}$.

Continuing the NTSC example discussed above, if the tuner **24** is tuned to VHF channel 3 (i.e., 61.25 MHz) so that the local oscillator **26** produces a frequency F_{LO} of 107 MHz, the first and second intermediate frequency tracking signals have corresponding sum and difference frequencies $F_{LS}+F_{LO}$ and $F_{LS}-F_{LO}$ of about 150.350525 MHz and about 63.649475 MHz. The second intermediate frequency tracking signal having the difference frequency $F_{LS}-F_{LO}$ of about 63.649475 MHz is the desired tracking injection frequency for the selected VHF channel 3. (It should be noted that the difference between the video carrier frequency of 61.25 MHz for channel 3 and the frequency of about 63.649475 MHz is about 2.399475 MHz, which is the frequency of the output of the oscillator **42**.)

The tuner **24** preferably has a channel-select output **52** (e.g., a control voltage which is applied to a varactor). The output of the balanced up converting mixer **50** is preferably filtered by a lowpass tracking filter **54** which is controlled by the channel-select output **52** from the tuner **24** to pass signals at frequencies no more than five to ten MHz greater than the video carrier frequency of the selected television channel. Therefore, the second intermediate frequency tracking signal, which has the difference frequency $F_{LS}-F_{LO}$ (i.e., the ancillary signal) and which is received from the balanced up converting mixer **50**, is passed through the lowpass tracking filter **54**, and then through a controllable attenuation circuit **56** and through a control switch **58** to a directional coupler **60**. The control switch **58** is controlled by an injection controller **62** in order to inject the ancillary signal at controllable times with reference to the television broadcast signal. For example, the ancillary signal may be injected

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