PATENT SPECIFICATION

(11) 1 561 544

(21) Application No. 46208/76 (22) Filed 5 Nov. 1976
(31) Convention Application No. 632060
(32) Filed 14 Nov. 1975 in
(33) United States of America (US)
(44) Complete Specification published 20 Feb. 1980
(51) INT CL³ H03J 7/06 H03L 7/18
(52) Index at acceptance
H3Q 200 4G 6R1 CCF
H3A C10 L2D1 L2D2 L3X P XM

(19)

1 561 544

(54) TUNING APPARATUS FOR RADIO FREQUENCY ESPECIALLY TELEVISION RECEIVERS

(71) We, RCA CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is directed to tuning apparatus for radio frequency, especially television receivers and is particularly directed to such apparatus including a frequency synthesizer.

In the United States, television over the air broadcast carrier frequencies for VHF (very high frequency) and UHF (ultra high frequency) channels are allocated by the Federal Communications Commission (FCC). During over the air broadcast transmission, these frequencies are required to be maintained to a high degree of accuracy.

Recently, frequency synthesizers including a phase locked loop (PLL) have been suggested to accurately generate local oscillator signals at predetermined frequencies corresponding to the various channels which a viewer may select. For example, a tuning apparatus utilizing a phase locked loop is described in the Digital Integrated Circuits Application Note ICAN-6716 entitled "Low-Power Digital Frequency Synthesizer Utilizing COS/MOS IC's" by R. E. Funk appearing in the 1972 RCA Solid State Databook on COS/MOS Digital Integrated Circuits (SSD-203) published by the RCA Corporation.

Other types of systems are also known for tuning a television receiver to standard frequencies. In one type, described in U.S. Patent 3,818,363 entitled "Automatic Tuning Apparatus Having Dual Frequency Sweep" by Sakamoto, issued June 18, 1974, the system includes two oscillators which are swept alternately and in a stepwise manner from a preliminary frequency over the range of over the air broadcast channel local oscillator frequencies. By counting the number of times that sweeping and stopping of the oscillators occurs, it is possible to determine when a preliminary local oscillator control voltage close to but slightly less than the control voltage which is proper for tuning to a particular channel has been reached. Thereafter, an auxiliary sweep circuit increases the control voltage to the proper tuning voltage.

Tuning apparatus of the frequency synthesizer type for standard frequency broadcast carriers is thus known. However, not all television signals are transmitted on standard over-the-air broadcast carriers. In some television distribution systems, such as in apartment house and motel installations, television signals are coupled to the receivers through cables. In these and other systems employing cable (or even microwave links), the modulated broadcast carrier may be demodulated and then remodulated on to a different carrier (herein termed a nonstandard carrier) arbitrarily near the standard broadcast carrier before coupling to a receiver. It is therefore desirable to provide apparatus for tuning receivers to such nonstandard carriers.

To this end, according to one aspect of the present invention, apparatus for tuning a receiver to a radio frequency carrier associated with a tuning position and having either a standard frequency or a nonstandard frequency located arbitrarily near the standard frequency is constituted as set forth in Claim 1 hereafter. Other aspects of the invention as applied more specifically to the tuning of television signals are also set forth in the claims.

In the accompanying drawings:

Figure 1 shows, in block diagram form, a channel tuning apparatus constructed in accordance with the present invention employed in a television receiver;

Figure 2 shows a logic diagram of implementations of a portion of the tuning apparatus shown in Figure 1;

Figure 3 shows, partially in schematic form and partially in logic diagram form, implementations of other portions of the tuning apparatus shown in Figure 1;

Figures 4 and 5 show graphical representations of voltage versus frequency characteristics associated with portions of the tuning apparatus shown in Figure 1; and

Figure 6 shows a table useful in understanding the operation of the tuning apparatus shown in Figure 1.

In Figure 1 the general arrangement of a television receiver is shown which employs a channel tuning apparatus constructed in accordance with the present invention. Radio frequencies (RF) are received by an antenna 12 and are amplified by a radio frequency amplifier 14. The amplified RF signals are coupled to a mixer 16 where they are combined with a local oscillator signal of the appropriate frequency, derived in accordance with a selected channel as will be subsequently described, to form an intermediate frequency (IF) signal. The IF signals are amplified by an IF amplifier 18 and thereafter are coupled to a video detector 20. Video detector 20 extracts video signals comprising, for example, chrominance, luminance and synchronizing signal components, from the amplified IF signals. The video signals are coupled to a video processing unit 22 including, for example, channels for processing the chrominance, luminance and synchronizing signal components of the video signal to form an image on a kinescope 24.

The general arrangement thus far described may employ the components utilized in a color television receiver of the CTC-68 type shown, for example, in RCA Color Television Service Data, FILE 1974 C-5, published by the RCA Corporation, Indianapolis, Indiana.

In the illustrated apparatus, channel selection information is entered by a viewer through a channel selection keyboard 26. Keyboard 26 comprises, for example, a calculator type keyboard by which VHF or UHF channels may be selected in decimal format. Keyboard 26 may include, for example, a matrix circuit for converting the decimal information to binary coded decimal (BCD) format. The binary coded signals representing channel information are coupled to a channel number register 28 via a multiple conductor path 30.

Register 28 converts the binary channel selection information into other binary signals representing a number "N" corresponding to the presently selected channel. For this purpose, register 28 may, for example, include a read only memory (ROM) in which the "N" number information is stored for later retrieval in response to entry of the binary signals from keyboard 26.

The binary signals representing the number N are coupled via a multiple conductor path 32 to a programmable frequency divider 34 which is arranged to divide the frequency of incoming signals by the number N. Divider 34 is arranged in a phase-locked loop (PLL) configuration along with a voltage controlled local oscillator 50, a prescaler frequency divider 52, a crystal reference oscillator 40, a programmable divide by "R" circuit 38, a phase detector 36 and a low pass filter amplifier 46. The phase-locked loop arrangement in combination with the channel selection apparatus forms a frequency synthesizer of the type described in the above-mentioned RCA Application Note and is suitable for tuning a television receiver to standard frequency carriers.

The majority of the remainder of the block diagram shown in Figure 1 is directed to apparatus for automatically tuning the receiver to nonstandard frequency carriers such as may be encountered, for example, in CATV and MATV systems. More detailed logic and block diagram for such apparatus are shown in Figures 2 and 3. However, a detailed description of the implementations shown in Figures 2 and 3 will not be given because such implementations will readily be understood by one skilled in the art from the following description of the tuning apparatus of the receiver of Figure 1. For this purpose, portions of the implementations shown in Figures 2 and 3 and their interconnections have been identified by the same reference designation by which they are identified in Figure 1. Also, for the purpose of relating the implementations of Figures 2 and 3 to Figure 1, in the following description of Figure 1, reference is made to logic "0" and "1" signals related to control signals associated with the tuning apparatus. These logic "0" and "1" signals correspond respectively to voltages near ground and approximately +12 vdc in the logic circuits of Figures 2 and 3, which may, for example, be formed of COS/MOS integrated circuits utilizing such voltages.

The tuning apparatus of the television receiver of Figure 1 operates in two modes. In a first or nonscanning mode, that is, for the reception of a standard frequency carrier allocated to a selected channel, programmable ÷N divider 34 and programmable ÷R divider 38 are set respectively to predetermined values.

In the nonscanning mode of operation utilized for tuning the receiver to standard frequency carriers, a scan mode enable switch 54, operable by the viewer, is placed in its open position (as shown) so that a

$\overline{\text{SCAN ENABLE}}$ control signal (a logic "1" representing the absence or complement of a SCAN ENABLE control signal) is coupled to a switch logic unit 56 via a conductor 58 and to a count preset logic unit 62 via a conductor 60 to a disable apparatus associated with receiving nonstandard carriers in the manner to be explained below.

In response to the $\overline{\text{SCAN ENABLE}}$ control signal, switch logic unit 56 generates a STOP SCAN #1 control signal (a logic "0") which is coupled to a clock enable unit 68 via a conductor 90 to prevent clock pulses from a ÷A divider 66 from reaching the clock input (at conductor 114) of an up/down counter 42. As a result, counter 42 will not change the ÷R number of divider 38 as it does in the scanning mode to be subsequently discussed.

In either mode of operation, a viewer selects a channel by depressing or otherwise activating appropriate keys on channel selection keyboard 26. Channel number register 28 receives binary signals representing the channel selection information from keyboard 26 and extracts from its memory binary signals representing the number N corresponding to the channel selected. The binary information representing the number N is entered in programmable divide by N divider 34 so that it will divide the frequency of incoming signals by the number N.

In addition to extracting from its memory binary signals representing the number N whenever a new channel is selected, whether in the nonscanning or scanning mode, channel number register 28 also provides the START PULSE control signal (a logic "1") which is coupled to a switch logic unit 56 via a conductor 78, to reset flip-flops 5612 and 5614 (shown in Figure 3) whose function will subsequently be described. In response to the START PULSE control signal, switch logic unit 56 generates a control signal (a logic "0" on conductor 88) to cause a synthesizer/AFT switch 48 to couple the output (conductor 122) of low pass filter and amplifier unit 46 to the control terminal of VCO 50 via a conductor 128 to form the phase locked loop configuration described above.

The START PULSE control signal is also coupled to count preset logic 62 to reset it prior to entry of new information from channel number register 28.

Channel number register 28, in addition to deriving the appropriate number N for programmable divider 34 and generating the START PULSE control signal, provides three band switching control signals (logic "1's"): a UHF control signal when a channel in the UHF range (e.g., channels 14—83) has been selected; a LOV control signal when a channel in the low VHF range, (e.g., channels 2—6) has been selected; and an HIV control signal when a channel in the high VHF range (e.g., channels 7—13) has been selected. The band switching control signals in conjunction with the $\overline{\text{SCAN ENABLE}}$ control signal are coupled to count preset logic 62 to cause it to select the appropriate number R.

These band switch control signals are also coupled in a suitable known manner (not shown) to voltage controlled tuning elements, such as varactor diodes, in VCO 50 and ÷K prescaler 52 to control the frequency of the input signal of ÷N 34 in accordance with the frequency band of the selected channel.

The values of N and R for tuning the receiver to standard frequency carriers are shown in the columns labelled "N SCAN & NONSCAN" and "R NONSCAN" in the table of Figure 6. The values in the table correspond to an implementation wherein the frequency of crystal oscillator 40 is 5 MHz and prescaler 52 divides the frequency of the output signal of voltage controlled oscillator (VCO) 50 by 256. It will be noted that the values of N are equal to the frequencies, in MHz, of the local oscillator output signals of VCO 50 required, when mixed with the respective received standard frequency carriers, to produce frequency difference IF signals having a picture carrier at 45.75 MHz (the standard IF picture carrier in most U.S. receivers).

Initially, when a channel has been selected by the viewer and programmable ÷N divider 34 and programmable ÷R divider 38 have been set, VCO 50 oscillates at an arbitrary frequency (e.g. at some midrange point in the selected band). The frequency of operation of VCO 50 is modified in response to the DC control signal output of low pass filter and amplifier unit 46 until the error output signal provided by phase detector 36 manifests that there is no phase or frequency difference between the output signals of programmable ÷N divider 34 and programmable ÷R divider 38. At this time, the phase locked loop corresponding to VCO 50, ÷K prescaler 52, programmable ÷N divider 34, phase detector 36, programmable ÷R divider 38, crystal oscillator 40 and low pass filter and amplifier unit 46 will provide a local oscillator signal at the output of VCO 50 having a frequency, f_{LO}, related to the frequency, f_{XOSC}, of the output signal of crystal oscillator 40 by the following expression:

$$f_{LO} = \frac{NK}{R} f_{XOSC} \qquad (1)$$

It should be noted that the output signal of low pass filter and amplifier unit 46 should have an amplitude range sufficient to vary the local oscillator signal over a frequency range, for a particular band, in excess of adjacent channel spacing and desirably large enough to allow tuning the receiver to all the channels in the particular band. Thus, for example, in the low VHF range, low pass filter and amplifier unit 46 may provide a control voltage in a range between first and second voltages sufficient to tune the receiver to either channel 2, 3, 4, 5, or 6.

The local oscillator output signal of VCO 50 is coupled to mixer 16 where it is combined in the conventional manner with the output signal of RF amplifier 14 to form an IF signal including a picture carrier at a frequency (e.g., 45.75 MHz) equal to the difference between the frequencies of the received carrier and the local oscillator signal. The IF signal is amplified by IF amplifier 18 and video information is extracted from it by video detector 20. The video signals are processed by signal processing unit 22 to form an image on the face of kinescope 24.

When the viewer elects to receive signals from a nonstandard carrier distribution system (e.g., via a CATV or MATV distribution system), the scan mode enable switch 54 is placed in the closed position thereby generating a SCAN ENABLE control signal (a logic "0") to place the tuning apparatus in the second or scanning mode of operation. In the second or scanning mode, during the reception of a nonstandard frequency carrier arbitrarily near (e.g., in the range of ±2 MHz) the frequency of an associated standard frequency carrier, programmable divide by N divider 34 is again set to a fixed value corresponding to the selected channel. However, ÷R divider 38 is initially set to a first division ratio or value less than the division ratio or value corresponding to the associated standard frequency carrier (to which programmable ÷R divider 38 would have been set during the first mode) and then is incremented toward a second ratio greater than that corresponding to the associated standard frequency carrier until tuning is achieved or until the second value is reached as will be explained in detail below.

In the scanning mode (as in the nonscanning mode) of operation, a viewer selects a channel by depressing the appropriate keys on channel selection keyboard 26 and in response, binary information representing the number N is entered in programmable divide by N divider 34. Furthermore, channel number register 28 also generates a START PULSE control signal (a logic "1") which is coupled to switch logic unit 56 to reset flip-flops 5612 and 5614. In response to the START PULSE control signal, switch logic unit 56 generates a control signal (a logic "0" on conductor 88) to cause synthesizer/AFT switch 48 initially to couple the output terminal of low pass filter and amplifier unit 46 to the control terminal of VCO 50. In addition, the START PULSE control signal also resets count preset logic unit 62 prior to entry of new data from channel number register 28. Also as in the nonscanning mode, channel number register 28 provides either a UHF, LOV or HIV control signal depending on which frequency band the selected channel is in.

In accordance with either the HIV or LOV control signals provided by channel number register 28 and the SCAN ENABLE control signal provided by switch 54, count preset logic unit 62 couples binary signals to up/down counter 42 representing the first preselected value below the value to which the number R would be set for the same channel selected during the nonscanning mode. The first preselected values corresponding to the various channels which are entered in up/down counter 42 during the scanning mode are indicated in the "START R" column of the table of Figure 6.

Count preset logic unit 62 also generates the complements, $\overline{\text{HIV}}$ and $\overline{\text{LOV}}$, of the HIV and LOV control signals. These complement signals are coupled to a scan stop logic unit 70 via a multiple conductor path 64 to set it to one of two preselected values (dependent on whether the selected channel is in the high or low VHF ranges) above the value to which the number R would be set in the nonscanning mode. The second preselected value corresponds to the highest value to which the number R could be incremented during the scanning mode. The second preselected values corresponding to the various channels are indicated in the "STOP R" column of the table of Figure 6.

In response to the SCAN ENABLE control signal, switch logic unit 56 generates a $\overline{\text{SCAN STOP \#1}}$ control signal (a logic "1" indicating the absence or compliment of the SCAN STOP #1 control signal) to allow clock signals from divide by A divider 66 to reach the block input of up/down counter 42. In response to these clocking signals, up/down counter 42 increments the number R from the first preselected value toward the second preselected value.

The phase locked loop comprising VCO 50, ÷K prescaler 52, programmable ÷N divider 34, phase detector 36, crystal oscillator 40, programmable ÷R divider 38 and low pass filter and amplifier unit 46 operates as in the nonscanning mode to control the frequency, f_{LO}, of the local oscillator signal according to expression 1. However, as each successive clock pulse of the clock signal output of divide by A circuit 66 reaches up/down counter 42, the number R is successively incremented a predetermined amount as is indicated in the "ΔR" column of the table of Figure 6; the step sizes of R for the various channels when A is selected equal to 2 is 2. As a result, the frequency of the local oscillator signal is decremented (i.e. decreased in stepwise fashion). The starting and stopping frequencies of the local oscillator signals and the frequency step sizes for the various channels are indicated in the "f_{LO} START," "f_{LO} STOP" and "Δf_{LO}" columns of the table of Figure 6 for an implementation wherein A is selected to be 2.

The local oscillator output signal of VCO 50, as in the nonscanning mode, is combined with the output signal of RF amplifier 14 in mixer 16 to provide a modulated IF signal whose carrier frequency is incremented in direct relationship in a range corresponding to the frequency range of the local oscillator signal. The scanning range for each channel is selected wide enough to include the frequency of the local oscillator signal required, when combined with the received nonstandard frequency carrier in mixer 16, to provide a modulated IF signal having a picture carrier at a predetermined frequency, e.g., 45.75 MHz.

As the IF carrier is decremented, an automatic fine tuning (AFT) frequency discriminator unit 92 coupled to the output of IF amplifier 18 develops a voltage which is related to the frequency deviation between the frequency of the IF carrier and 45.75 MHz. Figure 4 shows a graphic representation of an S-shaped voltage versus frequency characteristic 412 associated with AFT circuit 92 having typical values of voltage and frequency for the implementation shown in Figures 2 and 3. It is noted that the S-shaped characteristic 412 has an amplitude range between a minimum and a maximum amplitude corresponding to a frequency deviation (±25 kHz) which is a fraction of the frequency spacing between channels (6 MHz). The direction in which the frequency of the modulated IF carrier is scanned is also shown in Figure 4.

The output signal developed at a (+) output terminal of AFT circuit 92 is coupled to a threshold detector 82 via a conductor 104 where it is monitored. Threshold detector 82 generates a THRESHOLD control signal (a logic "1") when the voltage at the (+) output terminal of AFT circuit 92 rises above a predetermined threshold 414. The THRESHOLD control signal is coupled to switch logic unit 56 via a conductor 106 where it sets flip-flop 5612 of switch logic unit 56.

An AFT amplifier 94 amplifies the AFT signal developed at a (−) terminal of AFT circuit 92 and coupled to it via a conductor 124. The gain of AFT amplifier is selected so that the amplified AFT signal has substantially the same amplitude range, between first and second voltages, as does the output signal of low pass filter and amplifier unit 46. That is, the amplitude range of the amplified output signal of AFT amplifier 94 should provide substantially the same voltage for a selected channel, when coupled to VCO 50, as does the output signal of low pass and amplifier unit 46. It is noted that the first and second voltages of the amplified AFT signal correspond to frequency deviations of the intermediate frequency carrier between the deviations associated with the maximum and minimum voltages of the frequency discriminator characteristic associated with AFT circuit 92.

A graphic representation of the voltage versus frequency characteristics 512 of an amplified AFT output signal of AFT amplifier 94 is shown in Figure 5 having typical values of voltage and frequency for the implementations shown in Figures 2 and 3. The direction in which the frequency of the modulated IF carrier is scanned is also shown. Also indicated are the approximate levels of the control voltages supplied to VCO 50 corresponding to the channels in the low VHF frequency range. It will be appreciated that a similar characteristic is associated with the channels in the high VHF range. Also shown in Figure 5 is a partial graphic representation of a step shaped waveform 514 similar to that of the output signal of low pass filter and amplifier 46 which causes the frequency of the modulated IF carrier to be incremented.

A comparator 84 compares the output signal of low pass filter and amplifier unit 46, (waveform 514) coupled to it via a conductor 100, with the output signal of AFT amplifier 94 (waveform 512) coupled to it via a conductor 98, and generates a COMPARISON control signal (a logic "1") when their voltages are equal. The COMPARISON control signal is coupled to switch logic unit 56 via a conductor 102 and sets flip-flop 5614 of switch logic unit 56.

When flip-flop 5612 is set in response to the THRESHOLD control signal and flip-flop 5614 is set in response to the COMPARISON control signal, switch logic unit 56 generates a control signal (a logic "1" on conductor 88) to decouple the output terminal of low pass filter and amplifier unit 46 from the control terminal of VCO 50 and couple the output terminal of AFT amplifier 94 to the control terminal of VCO 50 instead. Thereafter the amplified AFT signal controls the frequency of the local oscillator signal output of VCO 50.

If the frequency of the local oscillator signal drifts, because of temperature changes or component value changes or the like, from the frequency established at the time the control input signal to VCO 50 is switched from the output signal of low pass filter and amplifier unit 46 to the amplified AFT signal, AFT circuit 92 operates in a negative feedback manner to provide an amplified AFT signal to oppose the frequency change due to the drift.

The THRESHOLD control signal indicates that the amplified AFT signal is changing in the right direction to provide AFT control. Threshold 414 in Figure 4 corresponds to threshold 516 in Figure 5. If switch 48 were to couple amplified AFT signals from AFT circuit 92 to VCO 50 before the amplified AFT reached threshold 516, AFT control would not be achieved as the control voltage supplied to VCO 50 would be changing in the wrong direction, i.e., along sloped portion 518 of characteristic 512 rather than along sloped portion 520.

The COMPARISON control signal indicates that the amplified AFT signal is providing a control voltage, which when coupled to VCO 50, causes VCO 50 to generate a local oscillator signal having a frequency sufficiently close to the frequency of the local oscillator signal associated with the selected channel. For example, assuming that channel 4 were the selected channel, then if switch 48 were switched to couple the output terminal of AFT amplifier 94 to the control input terminal of VCO 50 when the voltage of the amplified AFT signal were at level 516 the control voltage that would be applied to VCO 50 would correspond to a channel near channel 2 rather than to the control voltage required for channel 4.

Thus, VCO 50 control is switched from phase locked loop control to AFT control when both the THRESHOLD and COMPARISON control signals are present. In addition, when the THRESHOLD and COMPARISON control signals have been generated, switch logic unit 56 generates a STOP SCAN #1 control signal (a logic "0" on conductor 90) to prevent clock signals from reaching the clock input of up/down counter 42 to prevent the further incrementing of programmable divide by R divider 38 and therefore end the scanning operation.

If no AFT control is achieved before the number R reaches its final value, ("R STOP" of the table of Figure 6), scan stop logic unit 70 generates a SCAN STOP #2 control signal (a logic "0" on conductor 108) to prevent clock signals from reaching the clock input of up/down counter 42 to end the scanning. At this point, the viewer will see a picture of poor quality and may select another channel or initiate a new scanning interval by selecting another channel and then reselecting the originally selected channel.

It is noted that the frequency of the modulated IF carrier is decremented by decrementing the frequency of the local oscillator signal. This is desirable so that the first carrier to be reached will be the desired picture carrier rather than an adjacent channel sound carrier. This avoids or minimizes erroneous tuning.

It should be noted, that if a UHF control signal has been generated by channel number register 28, even though scan mode enable switch 54 has been closed to enable tuning the receiver to nonstandard frequency carriers, switch logic unit 56 will, in response to the UHF control signal, generate a SCAN STOP #1 control signal to prevent clock signals from ÷A divider 66 from reaching the clock input of up/down counter 42 via clock enable unit 68. Therefore, the number R is programmable ÷R divider 38 will not be incremented when a UHF channel has been selected whether scan mode enable switch has been depressed or not. This arrangement is provided since most television distribution systems do not reconvert the frequencies of UHF carriers for distribution at other UHF frequencies and therefore the scanning mode of operation is not required when a UHF channel is selected. However, it should be appreciated that the tuning apparatus could be modified to scan for nonstandard frequency UHF carriers.

Although no detailed descriptions of the implementations shown in Figures 2 and 3 have been given for the reasons mentioned before, it is noted that with respect to the logic implementations shown in Figure 2, that the CD4027 integrated circuit included as part of programmable ÷R divider 38 is a flip-flop which divides the frequency of the output signal of the CD4059 integrated circuit counter, also included in divider 38, by 2. As a result, the numbers set in the CD4029 integrated circuit counters forming up/down counter 42 are only one half of the corresponding values of R shown in the table of Figure 6. Furthermore, only the binary signals representing "1", "2", and "4" for forming the most significant digit (MSD), corresponding to the ten's digit position, and the least significant digit (LSD), corresponding to the unit's digit position, of the numbers corresponding to the values of "STOP R" are coupled to scan stop logic unit 70 because the MSD and

LSD of the numbers corresponding to R STOP do not require "8" for their formation. In addition, the binary signals for forming the hundred's digit of the numbers provided by up/down counter 42 are not coupled to scan stop logic unit 70 because the number in the hundred's digit is the same for both the low VHF and high VHF ranges and is not incremented.

While with reference to Figure 1 the frequency incrementing of the modulated IF carrier has been provided by decrementing programmable ÷R divider 38, it should be appreciated that the frequency of the IF carrier may alternatingly be decremented by decrementing the value entered in programmable ÷N divider 34 as is indicated by a multiple conductor path 126 coupled between up/down counter 42 and programmable ÷N divider 34. Furthermore, while the tuning apparatus of Figure 1 has been described as decrementing the frequency of the IF carrier so as to avoid tuning the receiver to the adjacent channel's sound carrier, it will be appreciated that the frequency of the IF carrier may be incremented.

WHAT WE CLAIM IS:—

1. Apparatus for tuning a receiver to a radio frequency carrier associated with a tuning position, said radio frequency carrier having either a standard frequency or a nonstandard frequency arbitrarily near said standard frequency, comprising:

controlled oscillator means for generating a local oscillator signal;

a source of relatively stable frequency signal;

controllable counter means for counting in response to at least one of said local oscillator signal and said stable frequency signal to establish a predetermined proportional frequency relationship between said local oscillator signal and said stable frequency signal;

first control means coupled between said counter means and said controlled oscillator means for controlling the frequency of said local oscillator signal in accordance with said predetermined proportional frequency relationship;

mixer means for combining said radio frequency carrier and said local oscillator signal to generate an intermediate frequency signal having at least one information bearing carrier, the frequency of said information bearing carrier having a standard value;

counter control means coupled to said controllable counter for determining a controllable factor by which the frequencies of said local oscillator signal and said stable frequency signal are proportional, said controllable factor having a nominal value associated with said standard frequency of said radio frequency carrier; and

second control means for offsetting said controllable factor from said nominal value by an amount within a predetermined range corresponding to an acceptable deviation between said nonstandard frequency and said standard frequency and thereafter controlling the frequency of said local oscillator signal to reduce a deviation between the frequency of said information bearing carrier and said standard value.

2. Apparatus as recited in Claim 1 wherein

said first control means generates a first control signal for controlling the frequency of said local oscillator signal;

said second control means includes discriminator means for generating a second control signal representing the frequency deviation between said intermediate frequency signal and said standard value for controlling the frequency of said local oscillator signal, and switching means for initially coupling said first control signal to said controlled oscillator means and thereafter coupling said second control signal to said controlled oscillator means.

3. Apparatus as recited in Claim 2 wherein

said discriminator means has a predetermined frequency control range; and

said switching means couples said second control signal to said controlled oscillator means when the deviation between the frequency of said information bearing carrier and said standard value is within said predetermined frequency control range of said discriminator.

4. Apparatus as recited in Claim 3 wherein

said counter control means is responsive to predetermined conditions of said second control signal to change said controllable factor to reduce the deviation between the frequency of said information bearing carrier and said standard value.

5. Apparatus as recited in Claim 2, 3 or 4 wherein

said controllable counter means includes first and second programmable counters, said first programmable counter being coupled between said controlled oscillator means and said first control means to divide the oscillator frequency by a first controllable factor to generate a frequency divided local oscillator signal, said second programmable counter being coupled between said source of stable frequency signal and said first control means to divide the frequency of said stable frequency signal by a second controllable factor to generate a reference frequency signal;

said counter control means includes

tuning position selection means for controlling said first programmable factor in accordance with a selected channel; and

said first control means includes phase detector means for generating said first control signal in response to the frequency deviation between said frequency divided local oscillator signal and said reference frequency signal.

6. Apparatus as recited in Claim 5 wherein

said first programmable counter is responsive to predetermined conditions of said second control signal.

7. Apparatus as recited in Claim 5 wherein said second programmable counter is responsive to predetermined conditions of said second control signal.

8. Apparatus as recited in any preceding claim wherein

said second control means initially offsets said controllable factor from said nominal value so that the frequency of said information bearing carrier is offset to a value higher than said standard value.

9. A tuning system for receiving composite radio frequency (RF) television signals associated with respective channels, each of said composite RF signals having either a standard frequency carrier or a nonstandard frequency carrier, each of said nonstandard frequency carriers being arbitrarily near a respective one of said standard frequency carriers within a first predetermined range less than the frequency separation between adjacent ones of said channels, comprising:

local oscillator means for generating a local oscillator signal having a frequency controlled in response to a control signal;

mixer means for combining said RF signals and said local oscillator signal to generate an intermediate frequency (IF) signal including at least one information bearing carrier;

a source of a relatively stable frequency signal having a substantially lower frequency than said local oscillator signal;

first programmable divider means for dividing the frequency of said local oscillator signal by a first programmable factor to generate a first frequency-divided signal;

a second programmable divider for dividing the frequency of said stable frequency signal by a second programmable factor to generate a second frequency-divided signal;

phase comparator means for generating said control signal for said local oscillator means in response to at least one of the phase and frequency deviation between said first frequency-divided signal and said second frequency-divided signal;

first control means for controlling said first programmable factor to select one of said channels; and

second control means for controlling the second programmable factor to control the frequency of said information bearing carrier within a second predetermined range determined by said first predetermined range.

10. A tuning system for a tuner of a television receiver capable of receiving composite television signals corresponding to respective channels, each of said composite television signals having either a standard frequency carrier or a nonstandard frequency carrier, said nonstandard frequency carrier being arbitrarily near said standard frequency carrier within a first predetermined range less than the frequency separation between said channels and including automatic fine tuning (AFT) circuit means producing an AFT signal, said system including in combination:

reference oscillator means providing a reference signal at a predetermined frequency;

local oscillator means in the tuner providing a variable output frequency in response to the application of a control signal thereto.

a programmage frequency divider having an input coupled to the output of one of said reference oscillator means and said local oscillator means for producing an output signal having a frequency which is a programmable fraction of the frequency of the signal applied to the input thereto.

means coupled with the output of said programmable frequency divider and the output of said other one of said reference oscillator means and said local oscillator means for developing a control signal and applying such control signal to said local oscillator means for controlling the frequency of operation thereof; and

control means coupled with the output of the AFT circuit means and further coupled with said programmable frequency divider for controlling said frequency divider to change said programmable fraction within a second predetermined range determined by said first predetermined range in response to predetermined signal conditions of the AFT signal.

11. Television receiver tuning apparatus substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

12. Tuning apparatus according to Claim 11 implemented substantially as

hereinbefore described with reference to Figures 2—5 of the accompanying drawings.

13. A television receiver having a tuning system apparatus according to any preceding claim.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1980
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1561544 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

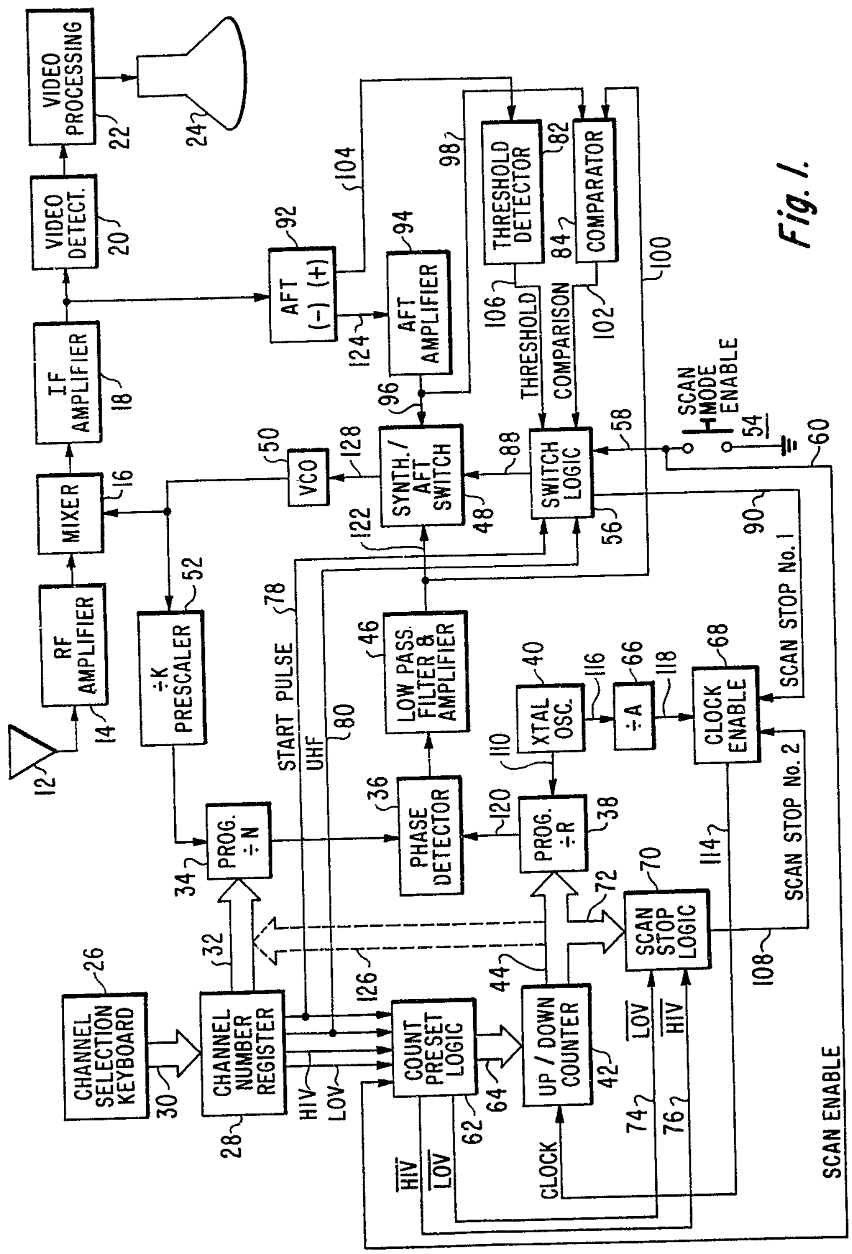

Fig. 1.

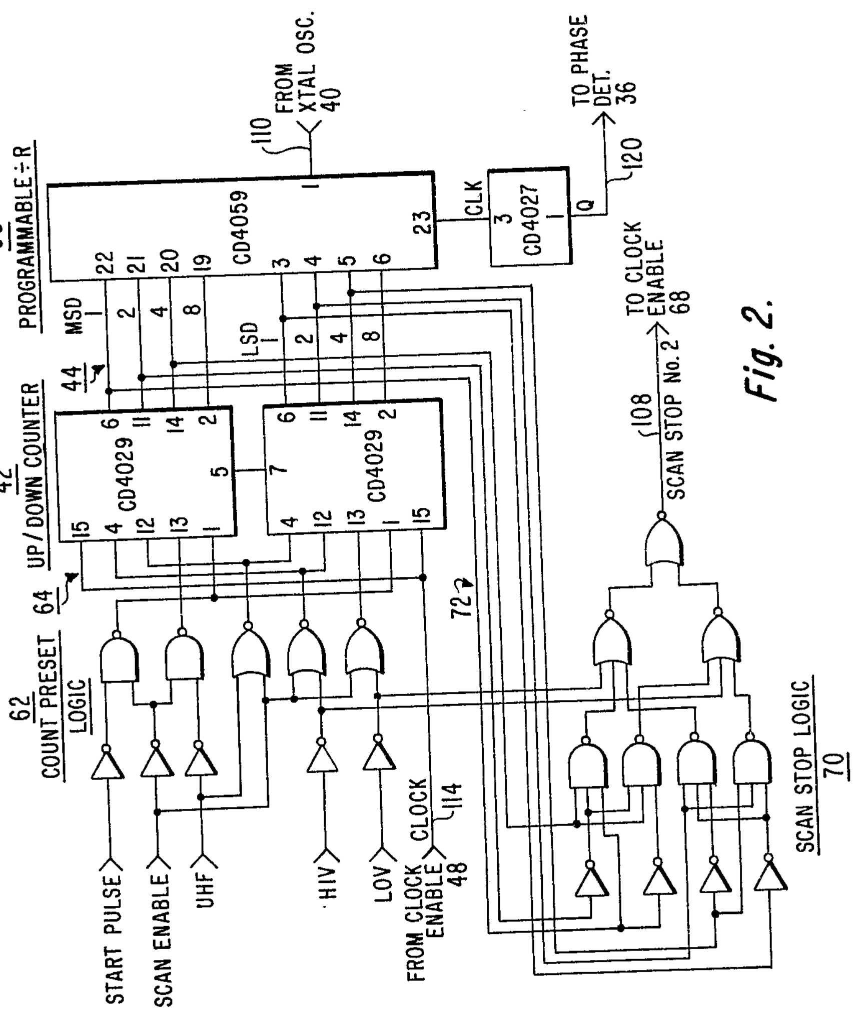
38
PROGRAMMABLE ÷ R
CD4059
110
FROM XTAL OSC. 40
CLK
CD4027
Q
120
TO PHASE DET. 36
42
UP/DOWN COUNTER
CD4029
CD4029
MSD
LSD
44
64
72
62
COUNT PRESET LOGIC
START PULSE
SCAN ENABLE
UHF
HIV
LOV
FROM CLOCK ENABLE 48
CLOCK
114
108
SCAN STOP No. 2
TO CLOCK ENABLE 68
SCAN STOP LOGIC
70

Fig. 2.

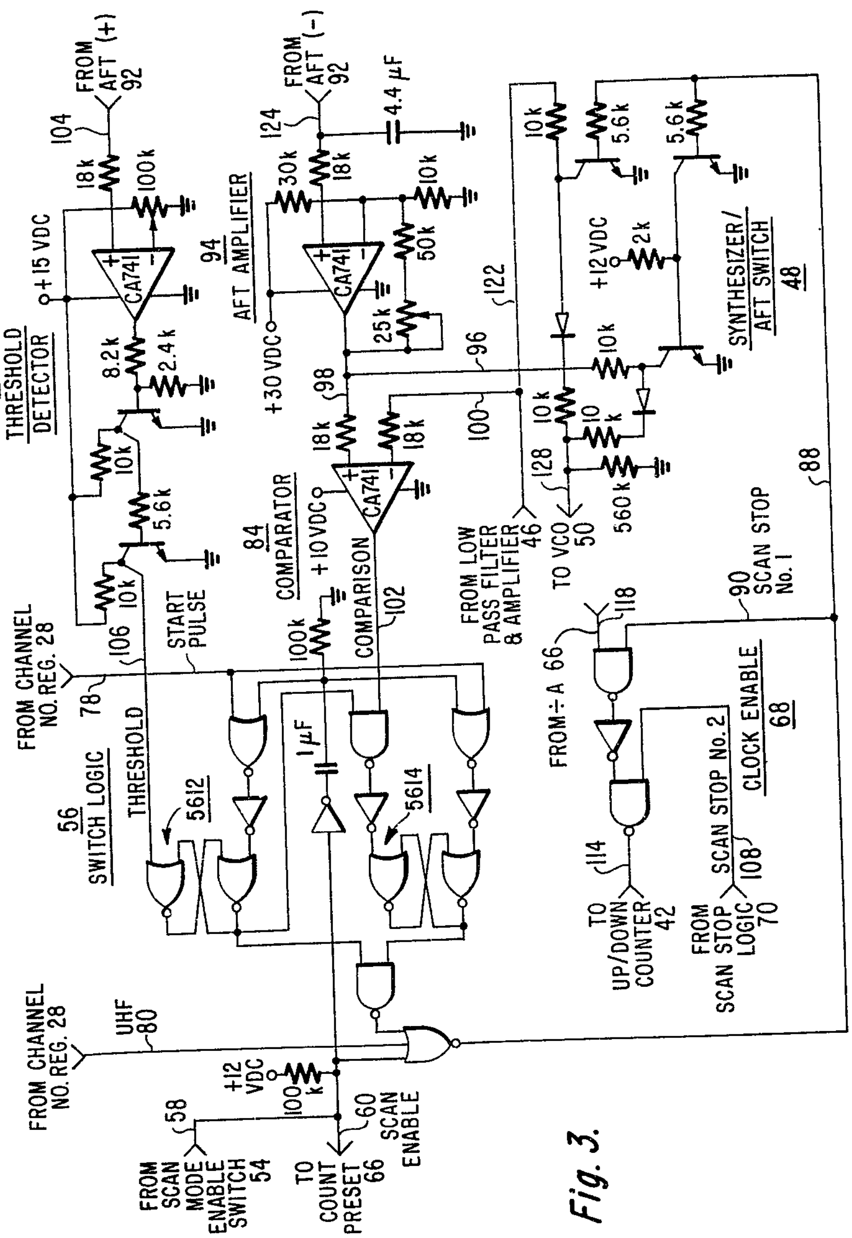
82
THRESHOLD DETECTOR
94
AFT AMPLIFIER
84
COMPARATOR
56
SWITCH LOGIC
SYNTHESIZER/ AFT SWITCH
48
CLOCK ENABLE
68
FROM AFT (+) 92
FROM AFT (-) 92
FROM CHANNEL NO. REG. 28
FROM LOW PASS FILTER & AMPLIFIER 46
TO VCO 50
FROM ÷ A 66
TO UP/DOWN COUNTER 42
FROM SCAN STOP LOGIC 70
FROM SCAN MODE ENABLE SWITCH 54
TO COUNT PRESET 66
SCAN ENABLE
SCAN STOP No. 1
SCAN STOP No. 2
START PULSE
THRESHOLD
COMPARISON
UHF
CA741
+15 VDC
+30 VDC
+10 VDC
+12 VDC
4.4 μF
1 μF

Fig. 3.

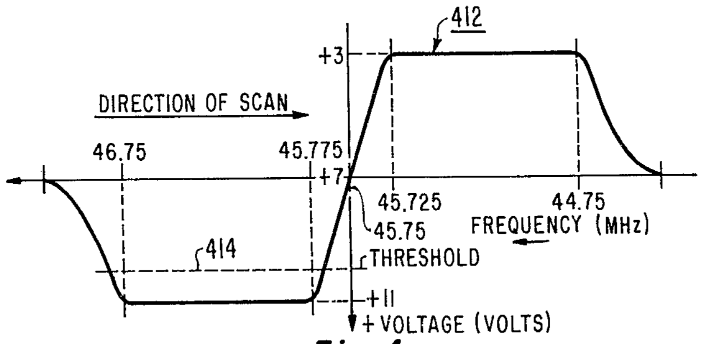
412
+3
DIRECTION OF SCAN
46.75
45.775
+7
45.725
44.75
45.75
FREQUENCY (MHz)
414
THRESHOLD
+11
+ VOLTAGE (VOLTS)

Fig. 4.

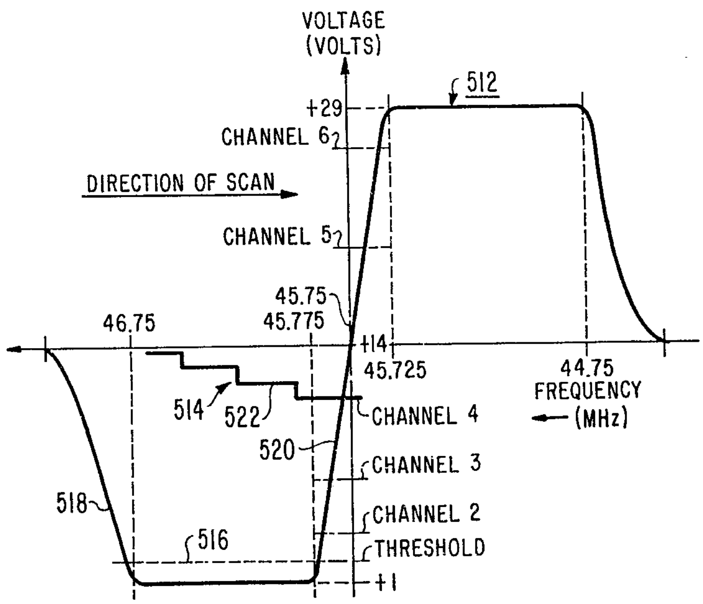
VOLTAGE (VOLTS)
512
+29
CHANNEL 6
DIRECTION OF SCAN
CHANNEL 5
45.75
45.775
46.75
+14
45.725
44.75
FREQUENCY (MHz)
514
522
CHANNEL 4
520
CHANNEL 3
518
CHANNEL 2
516
THRESHOLD
+1

Fig. 5.

Fig. 6.

CHANNEL		N SCAN. & NON-SCAN.	R NON-SCAN.	SCANNING MODE					
				START R	STOP R	ΔR	f_{LO} START (MHz)	f_{LO} STOP (MHz)	Δf_{LO} (kHz)
LOW VHF	2	101	1280	1250	1304	2	103.42	99.14	158
	3	107	"	"	"	"	109.57	105.03	167
	4	113	"	"	"	"	115.71	110.92	176
	5	123	"	"	"	"	125.95	120.74	192
	6	129	"	"	"	"	132.10	126.63	201
HIGH VHF	7	221	"	1266	1292	"	223.44	218.95	345
	8	227	"	"	"	"	229.51	224.89	354
	9	233	"	"	"	"	235.58	230.84	364
	10	239	"	"	"	"	241.64	236.78	373
	11	245	"	"	"	"	247.71	242.72	382
	12	251	"	"	"	"	253.78	248.67	392
	13	257	"	"	"	"	259.84	254.61	401
UHF	14	517	"	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	15	523	"	"	"	"	"	"	"
	16	529	"	"	"	"	"	"	"
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	83	931	"	"	"	"	"	"	"