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COMPLETE SPECIFICATION

Improvements relating to Demodulating Circuits for Colour Television Receivers

We, TELEFUNKEN PATENTVERWERTUNGSGESELLSCHAFT MIT BESCHRANKTER HAFTUNG, a company organised under the laws of Germany of Elisabethenstr. 3., Ulm/Donau, Germany, 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 relates to demodulating circuits for colour television receivers and especially to such receivers for signals modulated in accordance with a modified N.T.S.C. system known as PAL in which the phase of the colour sub-carrier alternates between two values in consecutive line periods of the video signal.

In the N.T.S.C. type of colour television signal a chrominance signal is produced by the addition of the resultant of suppressed carrier amplitude modulation of two quadrature components of a sub-carrier wave by two colour difference signals. The phase of the chrominance signal represents the hue of the respective picture element. However, for various reasons, including the various reactive components in the transmission path of the chrominance signal, phase errors may be introduced which can cause considerable and undesirable errors in the hue of the reproduced picture. So as to reduce the effect of these phase errors it has been proposed to change the phase of one of the quadrature oscillations of the sub-carrier by 180° for alternate line periods of the video signal so that the hue errors appear in opposite directions in the reproduced picture. As a result of the integrating action of the eye the viewer sees substantially the correct hue with a slight

reduction in the saturation of the colour if there are phase errors. Because of the interlaced scanning system universally used for commercial television broadcasts consecutive lines of the video signal transmitted during consecutive line periods are not immediately adjacent to one another in the reproduced picture but are separated by a line of the other field. As a result of this, if the phase errors are large then a coarse line structure is apparent on the picture, this structure being formed of two adjacent lines having one phase error followed by two other lines having the opposite phase error.

It is an object of the present invention to provide an improved demodulating circuit for a colour television receiver by which the above disadvantage can be largely overcome.

According to the present invention there is provided a demodulating circuit, for a colour television receiver, for demodulating a chrominance signal formed by quadrature amplitude modulation of a carrier wave by two colour dependent signals, one of the modulation axes being changed by 180° for alternate line periods of the video signal, the circuit including a supersonic delay line arranged to delay the chrominance signal for one line period and means for producing by combination of delayed and undelayed signals or signals derived therefrom two different combinations each representing colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods.

According to one form of the invention there is provided a demodulating circuit, for a colour television receiver, for demodulating a chrominance signal formed by quadrature amplitude modulation of a carrier wave by

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two colour dependent signals, one of the modulation axes being changed by 180° for alternate line periods of the video signal, the circuit including means for providing simultaneously the chrominance signals received during two consecutive line periods, means for adding said two simultaneous chrominance signals with such relative phase and amplitude as to produce a first combined signal of which the amplitude modulation represents substantially only one of said colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods, and means for subtracting one of said simultaneous chrominance signals from the other with such relative phase and amplitude as to produce a second combined signal of which the amplitude modulation represents the other of said colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods, and means for demodulating the two combined signals so produced.

In order that the invention may be clearly understood and readily carried into effect it will now be described with reference to the accompanying drawings of which:—

Figure 1 is a vector diagram illustrating the operation of the present invention,

Figure 2 is a block diagram of a demodulating circuit for a colour television receiver according to one example of the present invention,

Figure 3 is a block diagram of a second example of a demodulating circuit according to the present invention,

Figures 4, 5, 6, 7 and 8 are vector diagrams to be used in the explanation of the operation of a circuit arrangements and as illustrated in Figures 2 and 3,

Figure 9 is another diagram to be used in the explanation of Figure 3,

Figure 10 is a circuit diagram showing in greater detail part of the circuit shown in Figure 3,

Figure 11 is a block diagram of the components of Figure 10,

Figure 12 is an alternative arrangement to that shown in Figure 10,

Figure 13 is a circuit arrangement showing in greater detail the phase adjusting circuit 7 of Figure 3,

Figure 14 is a vector diagram to be used in the explanation of Figure 13,

Figure 15 is another circuit arrangement for the phase adjusting circuit 7,

Figure 16 is another vector diagram,

Figure 17 is another circuit arrangement for the phase adjusting device 7,

Figure 18 is a further alternative arrangement for the phase adjusting device of 7 and,

Figure 19 is a vector diagram to be used

in the explanation of the arrangement in Figure 18.

Referring to Figure 1, the vector 1 represents one of the quadrature components of the sub-carrier, amplitude modulated by a colour dependent signal which may be a colour signal or colour difference signal, so that the carrier is substantially suppressed, and the vector 2 represents the other quadrature component of a sub-carrier similarly modulated by a colour dependent signal. In the examples of demodulating circuits which will be described, the signals which are caused to modulate the two quadrature components of the sub-carrier, at the transmitter, correspond to the I and Q signals of the N.T.S.C. waveform. The vector 3 represents the reference phase for the colour sub-carrier short bursts of oscillation of this phase, the so called colour bursts, being included periodically in the transmitted waveform. During one set of alternate lines the signals corresponding to the vectors 1 and 2 are combined to produce a signal which for one element is represented by the vector T_1 and during the other set of alternate lines the vectors 2 and -1 are combined to produce the signal which for the corresponding element is represented by the vector T_2 . Suppose that there is a phase error of β in the transmission path so that instead of the signal corresponding to the vector T_1 being applied to the demodulation circuits a signal corresponding to the vector $T_{1\beta}$ is applied. Similarly a phase error of β will result in the formation of a signal corresponding to the vector $T_{2\beta}$ instead of one corresponding to the vector T_2 . Now if the demodulation of one set of alternate lines is effected in relation to the vectors 1 and 2 and the demodulation of the other set is effected in relation to the vector -1 and 2, it can be shown that the vector $T_{2\beta}$ is effectively transposed to the position indicated by the vector $T'_{2\beta}$. The eye of the viewer can automatically form the average of the colours represented by the vectors $T_{1\beta}$ and $T'_{2\beta}$ so that subject to a slight variation in saturation the correct colour is observed. So as to effect the change of axis to which the demodulation of the vectors 1 and -1 is related it is only necessary to change through 180° the phase of the reference carrier applied to the signal demodulator for the vectors 1 and -1 . The changeover may also be effected in other ways. However in accordance with the invention, the averaging of vectors $T_{1\beta}$ and $T'_{2\beta}$ is effected electrically.

Referring now to Figure 2, the received chrominance signal appears at the terminal 25 from which it is applied directly to the demodulating circuit 26 and also after passage through the delay line 5 to the demodulating circuit 27. Associated with the demodulating circuits 26 and 27 are respective local oscillators 28 and 29 synchronised by the colour

burst of the received signal. The demodulating circuits 26 and 27 each include two individual homodyne demodulators for demodulation the I and Q components of the applied chrominance signal. The delay line 5 is shown as having a delay of 64μ secs, which is the line period in a 625 line television system; of course for other systems the delay would be different since it is equal to one line period. The delay line 5 is an adjustable supersonic line with a very low temperature co-efficient so that the delay of the line 5 may be accurately adjusted to the line period. If sufficiently high accuracy is obtained it will be possible to use the same local oscillation for both the demodulators 26 and 27. In Figure 2 the means for changing over the axis of demodulation of the I demodulator for alternate lines in the circuits 26 and 27 is not shown. In Figures 4 and 5, T_1 is a vector representing the chrominance signal in one line and T_2 is a vector representing the chrominance signal in the next line of the video signal having a transposed modulation axis, and the vectors I_1, I_2 and Q_1, Q_2 represent the quadrature components of the sub-carrier after modulation by the I and Q colour signals respectively. On the line 30 from the I demodulator of circuit 26 will appear the sequence of signals I_1, I_2, I_1, I_2 , etc., on the line 31 on the Q demodulator in the circuit 26 will appear the sequence Q_1, Q_2, Q_1, Q_2 , etc. Because of the delay line 5, on the line 32, from the I demodulator in the circuit 27 there will be the sequence I_2, I_1, I_2, I_1 , etc., and on the line 33 from the Q demodulator in the circuit 27 there will be the sequence Q_2, Q_1, Q_2, Q_1 , etc. Lines 30 and 32 are connected to the adder 34 so that from adder 34 is obtained the mean value

$$\text{between } I_1 \text{ and } I_2, \quad \frac{I_1 + I_2}{2}.$$

The lines 31 and 33 are connected to the adder 35 from which is obtained the mean value of Q_1 and Q_2 , $\frac{Q_1 + Q_2}{2}$. The output signals

$$\text{of the adders 34 and 35 are applied to the}$$

matrixing circuits 36 from which the three colour signals R-Y, G-Y and B-Y, are derived.

A suitable form for the delay line 5 is one which uses a special glass as the transit medium, this glass being such that the line produced has a substantially zero temperature co-efficient. Alternatively two lines having temperature co-efficients of opposite sign may be connected in series so that the temperature co-efficients of the lines may compensate for each other. In another arrangement a line having an electrically adjustable delay is used, a thermo couple or a phase comparison circuit being used to derive a control signal for the line.

Another example of the invention is shown in Figure 3 in which by combination of the chrominance signal after suitable phase adjustment the demodulation may be achieved by simple amplitude detectors. The received chrominance signal appears at the terminal 4 and is applied directly by conductor 9 to the adder 8, after a phase change of 180° in the block 14 to the adder 13. It is also applied through the delay line 5, having a delay of one line period, the amplifier 6 and phase adjusting circuit 7 to both adders 8 and 13. The circuit 7 is adjusted so that the chrominance signal for corresponding points of the two lines periods are applied to the adder 8 in the same phase. The line scanning generator 17 of the television receiver produces a square wave 18 of half line frequency which is applied to the phase shift circuit 16. Line frequency pulses from the generator 17 are also applied by the conductor 24 to the local oscillator 15 to admit the colour burst received from the adder 8 via the conductor 23. The colour bursts synchronise the local oscillator. The local oscillation is applied to the adder 8 directly by means of the conductor 22 and to the adder 13 through the phase shifting circuit 16. The circuit 16 is such that it introduces a phase shift of $+90^\circ$ for one line and -90° for the next under the control of the square wave 18. The output signals from the adders 8 and 13, which comprise chrominance signals and local oscillations, appearing on the conductors 10 and 19 are applied to amplitude detectors 11 and 20 where they are demodulated to produce output signals at terminals 12 and 21 respectively.

The operation of Figure 3 will be described with reference to Figures 4 to 9. Figure 4 shows the carrier vector T_1 for one line which consists of the quadrature components $+I_1$ and Q_1 . Figure 5 shows the carrier vector T_2 for the next line in the video signal consisting of the quadrature component $+Q_2$ and $-I_2$. In the adder 8 of Figure 3 the vectors T_1 and T_2 are added in all one period in accordance with the vector diagram shown in Figure 6. It is clear from this diagram that the components $+I_1$ and $-I_2$ cancel one another out, assuming that I_2 is not greatly different from I_1 , and components Q_1 and Q_2 add together. The components Q_1 and Q_2 combine to form an amplitude modulated signal with suppressed carrier so that with the locally generated carrier added with correct phase via the conductor 22 a true amplitude modulated signal is produced on the conductor 10 which is demodulated by the detector 11 to produce a signal representing $Q_1 + Q_2$ at the terminal 12.

In the adder 13 the carrier vector T_1 delayed by one line period is added to the carrier vector T_2 of the following line, T_2 having been subjected to a 180° phase shift

in 14, giving rise to the vector addition diagrams shown in Figures 7 and 8 during alternate line periods, from which it is clear that the components Q_1 and Q_2 now being of opposite sign and assumed to be of the same magnitude cancel out, whereas the component I_1 and I_2 are added. Since the phase changes with every line, it is necessary to change the phase of the local generated oscillation through $+90^\circ$ for one line and -90° for the next to effect amplitude demodulation. After the addition of the reference oscillation with the correct phase in the adder 13, the signal which appears on the conductor 19 may be demodulated by the amplitude detector 20 to produce an output signal at 21 representing $I_1 + I_2$. This arrangement enables demodulation to be achieved without the need for a synchronous demodulator, by which is meant a demodulator utilising a sampling technique dependent on accurate phasing of a local oscillator to avoid cross-talk.

The gain of the amplifier 6 may be controlled so that the amplitude of the delayed chrominance signal is such that its component I or Q is equal in magnitude to the I or Q component of the signal of the following line applied to the adders 8 and 13 via the conductor 9 or the phase shift circuit 14. The regulating voltage for controlling the gain of the amplifier 6 may, for instance, be derived by transmitting only the I component, say, of the chrominance signal for a short period at the beginning or end of the lines and deriving the gain control signal from the adder 8 during this short period because if the I components cancel out the output of the adder 8 will be zero. Alternatively, only the Q components may be transmitted for a short period and the control signal derived from adder 13.

Figure 9 shows the amplitude of the signals appearing on the conductors 10 and 19 during consecutive line periods of the input video signal during an even line field. The outputs of the adders 8 and 13 are shown for lines n , $n+2$ and $n+4$. In the case of the adder 13 provided the carrier is inserted in the appropriate phase demodulation in the detector 20 will produce the modulus of I as required.

The invention further provides a simple circuit arrangement for the adders 8 and 13. The undelayed colour chrominance signal is applied to a push-pull circuit from which in phase and reversed phase signals are derived for application to respective resistance chains. The delayed chrominance signal is supplied in the same phase to the other ends of the resistance chains so that from intermediate positions of the chains combinations of the delayed and undelayed signals may be derived. In an alternative arrangement the delayed and undelayed chrominance signals may be exchanged so that the delayed signal is divided

into two components having an 180° phase difference and the undelayed signal applied in the same phase to both resistance chains.

Referring to Figure 10 the chrominance signal is applied between the terminals 101 and 102. The terminal 102 is connected to ground. The terminal 101 is connected by means of the capacitor 103 to the control grid of a cathode follower amplifier valve 104. The bias for the control grid of 104 is provided by the potentiometer comprising resistors 105 and 106. The output signal of the cathode follower 104 is set up across the cathode load resistance 107 and is applied via the condenser 108 to the primary winding 109 of the transformer 110. The secondary winding 111 of the transformer 110 has a centre tap which is connected to ground, so that from one end of the winding 111 a voltage may be obtained in one phase and from the other end the voltage is 180° out of phase. One end of the winding 111 is connected to a resistance chain comprising three resistors 113, 114 and 115. The other end of the winding 111 is connected to a second resistance chain comprising resistors 116, 117 and 118. That end of the winding 111 connected to the resistors 113 is connected via the delay line 5 and the transformer 121 to one end of a potentiometer 120, the other end of the potentiometer 120 being connected to ground. The wiper of the potentiometer 120 is connected by means of conductor 119 to resistances 115 and 118. Output voltages are derived from tapping 122 on resistor 114 and tapping 123 on resistor 117, which voltages are applied to output points 124 and 125 respectively.

The method of operation of Figure 10 will be explained with respect to Figure 11 which shows in block diagrammatic form the components of Figure 10 so that they may be related easily to the corresponding components of Figure 3. In Figure 11 the adder 126 comprises the resistance chain 113, 114 and 115 of Figure 10 and the adder 127 comprises the resistance chain 116, 117 and 118. The phase shift of 180° represented by the block 128 is provided in Figure 10 by the lower half of the secondary winding 111. Therefore it is clear the adder 126 receives the chrominance signals of one line and the previous line in the same phase whereas the adder 127 receives these signal in opposite phase. The transformer 121 is tuned and is arranged to provide across the potentiometer 120 a voltage which is rather larger than that applied to the resistance chains by the secondary winding 111. The wiper of the potentiometer 120 and tappings 122 and 123 are adjusted so that the amplitude of the delayed sub-carrier is such that optimum cancellation of the unwanted components of the chrominance signal is obtained.

In one example of Figure 10 the resistor

107 is of 50 ohms so as to match the impedance of a particular form of the delay line 5. If desired the transformer 110 may be replaced by a phase splitting amplifier valve having equal anode and cathode load resistances. Alternatively a further cathode follower may be provided between the secondary winding 111 and the delay line 5 so as to provide the required match to the line. Preferably the winding 111 is bifilar wound in a uniform manner so as to ensure that signals applied to the resistance of 113 and 116 are equal. The signals applied at the other ends of the resistance chains to resistances 115 and 118, are equal because they are derived from a common conductor 119. If desired the resistance chains may include reactive components, for example, suitable capacitors may be provided to maintain the voltage division provided by the resistance chain and to compensate for capacitance in the following circuits. If desired the potentiometer 120 may be omitted, the amplitude adjustment being achieved by adjustment of tappings 122 and 123.

Figure 12 shows an arrangement alternative to that of Figure 10 and components of Figure 12 having the same functions as those of Figure 10 have the same reference numerals. In Figure 12 the input terminal 101 is connected to the grid of the amplifier valve 130, in the anode of which is provided a filter 131 tuned to the frequency of the sub-carrier used in deriving the chrominance signal. The filter 131 is connected to the control grid of a phase splitting amplifier 132 having equal anode and cathode load resistances. The cathode of the valve 132 is connected by means of conductor 33 to resistances 113 and 116. The anode of the valve 132 is connected via the capacitor 134 to the input of an adjustable delay line 135 which has a tapping 136. The delay line 135 is terminated so as to avoid undesired reflections. The tapping 136 is connected to the control grid of cathode follower amplifier 104, to the cathode of which is connected the delay line 5. The output of the delay line 5 is connected to the primary winding 109 of transformer 110. The ends of the push-pull secondary winding 11 of transformer 110 are connected to the resistance chains. The inductance 137 is connected between the input of the delay line 5 and ground so as to compensate for the relatively high input capacitance of the delay line. Output signals are derived from the points 122 and 123 which are the junctions of resistors 113 and 115 and 116 and 118. The point 122 is connected by means of a capacitor of valve 20pF to the output point 124 and the point 123 is connected by means of a capacitor of valve 20pF to the output point 125. The operation of the arrangement of Figure 12 is similar to that of Figure 10 except that in this

case it is the delayed signal from which signals having a phase difference of 180° are derived. The adjustable delay line 135 is provided to enable adjustment of the phase of the sub-carrier so as to ensure that the total delay provided by the lines 5 and 135 together is accurately equal to one line period. The cathode load resistance 138 of the phase splitting amplifier valve 132 is adjusted so that the amplitudes of the signals applied to the opposite ends of the resistance chains are equal. The arrangement of Figure 12 has a further advantage in that any signal from the cathode of the valve 132 reaching the secondary winding 111 via the resistance chains is self-cancelling so that no signal which might interfere with the operation of the circuit appears in the winding 109.

The phase shifting circuit 7 of Figure 3 is provided for the fine adjustment of the phase of signals passed to the adders 8 and 13. The phase shifting circuit is an all-pass filter and must be capable of shifting the phase of the chrominance signal equally over the whole bandwidth of the signal for up to 90° or possibly more. One example of such a phase shifting circuit is shown in Figure 13 and comprises an all-pass filter 207 having terminating resistors 208 and 209 and is bridged by a potentiometer 210 having a wiper 211. The output of the delay line 5 is connected to the input of the filter and the shifted signal is derived from the wiper 211 and is applied to the adding circuits 126 and 127.

In Figure 14 there is demonstrated the effect of adjustment of the wiper 211 of the potentiometer 210, where A represents the chrominance input to the shifting circuit and jB represents the output of the filter 207 which has now undergone a phase shift of 90° . As the wiper 211 is adjusted from one end of the potentiometer 8 to the other so the output varies as represented by the arrows $F_1, F_2, \dots, F_n$. It will be seen that the amplitude of the output varies slightly with the adjustment of the wiper 211 and, if desired, additional components can be provided to stabilize the output amplitude. From Figure 14 it can be seen that the arrangement of Figure 13 can provide a continuous phase adjustment over a range of 90° .

Another arrangement for the shifting circuit 7 is illustrated in Figure 15 in which two 90° phase shifting all-pass circuits 207 and 207¹ are provided. In this case the potentiometer is connected between the input to the filter 207 and the output of the filter 207¹ the mid point of the potentiometer being connected to the junction of the filters 207 and 207¹. With this arrangement a 180° shift of phase is possible. The operation of the arrangement is similar to that of Figure 13 which is described with reference to Figure 14, for each half of the potentiometer 210 of Figure 15. When the wiper 211 is in the

centre position of the potentiometer 210 the phase shift is 90° and the amplitude of the output signal is substantially equal to that of the input signal.

- 5 Figure 16 shows the four vector fields for the sub-carrier signal. With the arrangement of Figure 13 the chrominance signal can be shifted to anywhere within the quadrant I or by means of a 180° phase shift within
10 the quadrants I, III. With the arrangement of Figure 15 a phase shift over two quadrants such as I and II is possible. Four filters each providing a shift of 90° may be connected in series, a potentiometer such as 210 being
15 provided with three quadrant tappings which are connected to the junctions of the filters in the same manner as in Figure 15 so that a phase shift of 360° may be achieved.

- As stated above the all-pass filters 207 and
20 207¹ must be arranged so that they effect a constant phase shift for the sub-carrier frequency and the sidebands of the chrominance signal. The phase shifting circuit 7 does not necessarily have to be connected in series
25 with the delay line 5 but may be connected in any of the other paths to the adders 8 and 13 (or 126 and 127). For example, phase shifts may be included between the block 128 and the adder 126 of Figure 13 and in the
30 conductor 203.

- In Figure 17 the input and output signals of the filter 207 are separately derived from the potentiometers 216 and 217 and applied
35 via the respective transistor amplifiers 218 and 219 to the output point 215. The transistors 218 and 219 have a common collector load 220. In this example the potentiometers 216 and 217 may be so adjusted as to provide a constant amplitude output signal
40 as the phase is adjusted.

- In Figure 18 the arrangement shown is similar to that of Figure 15 except that the output signal is derived by means of a transformer 221, the primary winding of which
45 is connected between the junction of the filters 207 and 207¹ and the wiper 211. In this circuit arrangement a range of 180° of adjustment is possible. The operation of the arrangement of Figure 18 is described with
50 reference to Figure 19 which the input signal of the filter 207 is shown as $+U_2$ and the output signal of the 207¹ as shown is $-U_2$. The voltage at the junction of filters 207 and 207¹ is represented by U_1 . As the wiper 211
55 scans the potentiometer 210 so a variable proportion of the voltage U_2 is added to the voltage U_1 to form the output signal.

- Although the invention has been described with reference to specific embodiments it will be appreciable that it is not in any wise
60 limited to these embodiments and many other arrangements using the invention will be evident to those skilled in the art.

WHAT WE CLAIM IS:—

- 65 1. A demodulating circuit, for a colour tele-

vision receiver, for demodulating a chrominance signal formed by quadrature-amplitude modulation of a carrier wave by two colour dependent signals, one of the modulation axes being changed by 180° for alternate line
70 periods of the video signal, the circuit including a supersonic delay line arranged to delay the chrominance signal for one line period and means for producing by combination of delayed and undelayed signals or signals derived
75 therefrom two different combinations each representing colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods.

2. A demodulating circuit according to Claim 1 in which for the production of said colour dependent signals respective demodulators are provided to which are applied local
85 oscillations of the frequency of said carrier wave and of phases corresponding to the modulation axes at the transmitter.

3. A demodulating circuit according to Claim 1 or 2 comprising two demodulators for the undelayed chrominance signal respectively responsive to said local oscillations to
90 obtain the colour dependent signals two further demodulators for the delayed chrominance signals respectively responsive to said local oscillations to obtain the colour dependent signals, and means for combining similar
95 colour dependent signals from said demodulators to produce said two different combinations.

4. A demodulating circuit according to Claim 1 or 2 in which the delayed and undelayed chrominance signals are combined
100 prior to demodulation in each of two combining means to produce two distinct combined signals the elements of amplitude modulation of each of which represent the average
105 of corresponding elements of two successive line periods of a colour signal and which are then separately demodulated, whereby the need for the use of synchronous demodulators
110 is avoided.

5. A demodulating circuit, for a colour television receiver, for demodulating a chrominance signal formed by quadrature-amplitude modulation of a carrier wave by two colour
115 dependent signals, one of the modulation axes being changed by 180° for alternate line periods of the video signal, the circuit including means for providing simultaneously the chrominance signals received during two consecutive
120 line periods, means for adding said two simultaneous chrominance signals with such relative phase and amplitude as to produce a first combined signal of which the amplitude modulation represents substantially
125 only one of said colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods, and means for subtracting one
130 of said simultaneous chrominance signals from



centre position of the potentiometer 210 the phase shift is 90° and the amplitude of the output signal is substantially equal to that of the input signal.

5 Figure 16 shows the four vector fields for the sub-carrier signal. With the arrangement of Figure 13 the chrominance signal can be shifted to anywhere within the quadrant I or by means of a 180° phase shift within the quadrants I, III. With the arrangement of Figure 15 a phase shift over two quadrants such as I and II is possible. Four filters each providing a shift of 90° may be connected in series, a potentiometer such as 210 being provided with three quadrant tappings which are connected to the junctions of the filters in the same manner as in Figure 15 so that a phase shift of 360° may be achieved.

As stated above the all-pass filters 207 and 207¹ must be arranged so that they effect a constant phase shift for the sub-carrier frequency and the sidebands of the chrominance signal. The phase shifting circuit 7 does not necessarily have to be connected in series with the delay line 5 but may be connected in any of the other paths to the adders 8 and 13 (or 126 and 127). For example, phase shifts may be included between the block 128 and the adder 126 of Figure 13 and in the conductor 203.

In Figure 17 the input and output signals of the filter 207 are separately derived from the potentiometers 216 and 217 and applied via the respective transistor amplifiers 218 and 219 to the output point 215. The transistors 218 and 219 have a common collector load 220. In this example the potentiometers 216 and 217 may be so adjusted as to provide a constant amplitude output signal as the phase is adjusted.

In Figure 18 the arrangement shown is similar to that of Figure 15 except that the output signal is derived by means of a transformer 221, the primary winding of which is connected between the junction of the filters 207 and 207¹ and the wiper 211. In this circuit arrangement a range of 180° of adjustment is possible. The operation of the arrangement of Figure 18 is described with reference to Figure 19 which the input signal of the filter 207 is shown as $+U_2$ and the output signal of the 207¹ as shown is $-U_2$. The voltage at the junction of filters 207 and 207¹ is represented by U_1 . As the wiper 211 scans the potentiometer 210 so a variable proportion of the voltage U_2 is added to the voltage U_1 to form the output signal.

Although the invention has been described with reference to specific embodiments it will be appreciable that it is not in any wise limited to these embodiments and many other arrangements using the invention will be evident to those skilled in the art.

WHAT WE CLAIM IS:—

65 1. A demodulating circuit, for a colour tele-

vision receiver, for demodulating a chrominance signal formed by quadrature-amplitude modulation of a carrier wave by two colour dependent signals, one of the modulation axes being changed by 180° for alternate line periods of the video signal, the circuit including a supersonic delay line arranged to delay the chrominance signal for one line period and means for producing by combination of delayed and undelayed signals or signals derived therefrom two different combinations each representing colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods.

2. A demodulating circuit according to Claim 1 in which for the production of said colour dependent signals respective demodulators are provided to which are applied local oscillations of the frequency of said carrier wave and of phases corresponding to the modulation axes at the transmitter.

3. A demodulating circuit according to Claim 1 or 2 comprising two demodulators for the undelayed chrominance signal respectively responsive to said local oscillations to obtain the colour dependent signals two further demodulators for the delayed chrominance signals respectively responsive to said local oscillations to obtain the colour dependent signals, and means for combining similar colour dependent signals from said demodulators to produce said two different combinations.

4. A demodulating circuit according to Claim 1 or 2 in which the delayed and undelayed chrominance signals are combined prior to demodulation in each of two combining means to produce two distinct combined signals the elements of amplitude modulation of each of which represent the average of corresponding elements of two successive line periods of a colour signal and which are then separately demodulated, whereby the need for the use of synchronous demodulators is avoided.

5. A demodulating circuit, for a colour television receiver, for demodulating a chrominance signal formed by quadrature-amplitude modulation of a carrier wave by two colour dependent signals, one of the modulation axes being changed by 180° for alternate line periods of the video signal, the circuit including means for providing simultaneously the chrominance signals received during two consecutive line periods, means for adding said two simultaneous chrominance signals with such relative phase and amplitude as to produce a first combined signal of which the amplitude modulation represents substantially only one of said colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods, and means for subtracting one of said simultaneous chrominance signals from



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the other with such relative phase and amplitude as to produce a second combined signal of which the amplitude modulation represents the other of said colour dependent signals the elements of which represent the average of corresponding elements of two consecutive line periods, and means for demodulating the two combined signals so produced.

6. A demodulating circuit according to Claim 5 in which said demodulating means comprise amplitude demodulators to which are applied local oscillations of the frequency of said carrier wave and of phase corresponding to the respective modulation axes at the transmitter.

7. A demodulating circuit according to Claim 6 including means for reversing the phase of the local oscillation applied to one of said demodulators after every line period of the video signal to take account of the 180° changes of one of the oscillation axes at the transmitter.

8. A demodulating circuit according to Claim 6 or 7 wherein said local oscillations are added to the chrominance signals in said adding means and said subtracting means.

9. A demodulating circuit according to any of Claims 5 to 8 wherein said subtracting means comprises means for producing a 180° phase shift in one of said simultaneous chrominance signals and means for adding said phase shifted signal and the other of said simultaneous chrominance signals.

10. A demodulating circuit according to Claim 9 wherein both said adding means comprise resistive networks, one of said simultaneous chrominance signals being applied to first ends of said networks in opposite phase by means of a push-pull circuit and the other of said simultaneous chrominance signals being applied to second ends of said networks in the same phase, said first and second combined signals being derived from intermediate points of the respective networks.

11. A demodulating circuit according to Claim 10 wherein a transformer is connected in the path for applying to said networks that one of the two chrominance signals which has undergone relative delay to render it simultaneous with the other chrominance signal, the ratio of said transformer being such that the output thereof has a greater amplitude than that of the chrominance signals applied directly to said networks, and a potentiometer is provided to attenuate the output of said transformer before application to said networks.

12. A demodulating circuit according to any of the Claims 5 to 11 in which said means for providing simultaneously the chrominance signals received during two consecutive line periods includes a supersonic delay line.

13. A demodulating circuit according to any of the preceding Claims 1 to 12 wherein said means for providing the simultaneous chrominance signals comprises delay means for providing a delay of substantially a line period, and a phase adjusting circuit for effecting fine adjustment to said delay.

14. A demodulating circuit according to Claim 13 wherein said phase adjusting circuit comprises an all-pass phase shifting filter and means for adding adjustable proportions of the input and output signals of said all pass filter.

15. A demodulating circuit according to Claim 14 wherein a potentiometer having an adjustable tapping is connected from the output to the input of said all-pass filter and said phase shifted signal is derived from said tapping.

16. A demodulating circuit according to Claim 14 wherein said phase adjusting circuit comprises a plurality of all-pass phase shifting filters connected in series, and a potentiometer having an adjustable tapping connected from the output of the last to the input of the first of said plurality of filters, intermediate points of said potentiometer being connected to the junctions of said phase shifting filters, and said phase shifted signal being derived from said tapping.

17. A demodulating circuit according to Claim 14 wherein said phase adjusting circuit comprises two all-pass phase shifting filters in series, and a potentiometer having an adjustable tapping connected from the output of the second filter to the input of the first filter, said phase shifted signal being derived from between the junction of said two filters and said tapping.

18. A demodulating circuit according to Claim 14 wherein there are provided separate potentiometers both having adjustable tappings for the input and output of said filter means, and means for adding the signals on said tappings to provide said phase shifted signal.

19. A demodulating circuit according to any of Claims 14 to 17 wherein said phase adjusting circuit comprises means for keeping the amplitude of the phase shifted signal substantially constant during phase adjustment.

20. A receiver according to any of Claims 14 to 19 wherein said phase adjusting circuit is connected in series with said delay means.

21. A demodulating circuit substantially as herein described with reference to any one of Figures 2, 3, 9, 12, 13, 15, 17 and 18 of the accompanying drawings.

22. A colour television receiver incorporating a demodulating circuit for the chrominance signal, according to any preceding claim.

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