CIRCUIT DESCRIPTION

METER CIRCUIT

This circuit has two functions. One permits almost direct feeding of signals with strengths from 10dBμ to 100dBμ to the Signal meter. The other permits selection of AM components in the FM signal, thus showing the multipath element and displaying it as a Signal-minus-Multipath deflection. This system permits the owner to find the best balance of strong and "clean" signals by switching between the two functions of this meter while experimenting with different antenna locations.

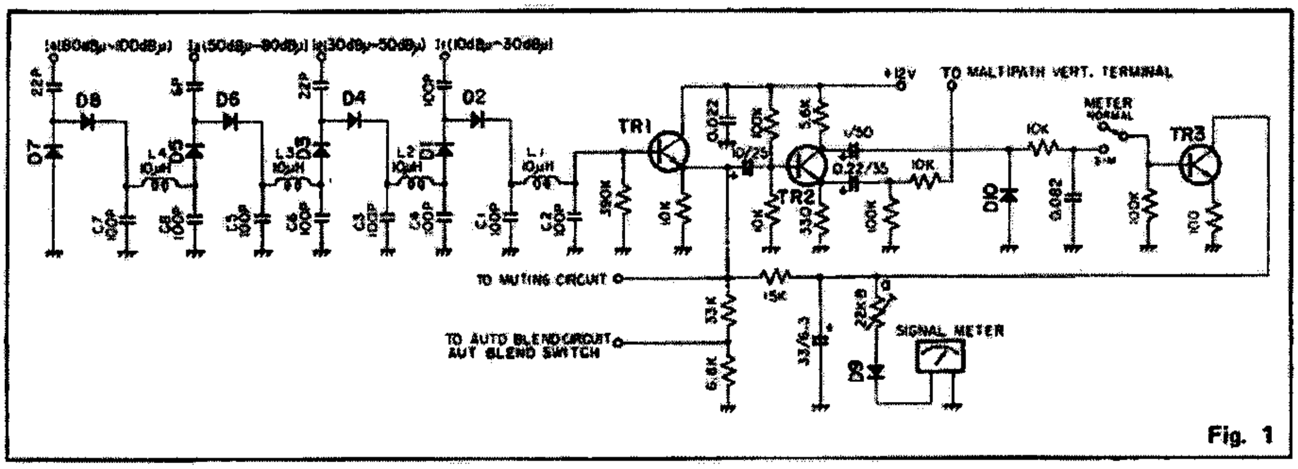

Fig. 1

Operation

1. Signal Display

IF stage signals are detected at terminals $I_1 \sim I_4$, and each is rectified to double voltage through the actions of two diodes, then sent to Tr1. The signal strength detection circuits are divided into a series of four. For example, when a 10dBμ signal is received, the IF stage amplifier connected to the I_1 terminal generates a signal operating diodes D1 and D2 for the output. That means that the D1, D2, C1, C2, L1 circuit is not operating at this time. When a stronger signal is received, input from I_1 rises above 10dBμ to saturation point (app. 30dBμ), at which time input is transferred to I_2 to cover the 30dBμ-50dBμ range. The I_3 terminal is for signals between 50dBμ and 80dBμ, while I_4 covers the range from 80dBμ and 100dBμ. This assures excellent, linear meter response. These circuits – L1L2L3L4 (C1-C8) are connected with DC current, not AC.

2. Multipath Display

The Signal meter display signal is amplified at Tr1 to operate the meter. At the same time, the AC element in the signal which shows multipath strength is amplified and rectified to a half wave by D10. In this way positive potential is obtained. At this time, if the meter switch is set to S-M, positive potential is fed to Tr3 (in parallel with the signal meter), lowering the impedance of Tr3 and reducing the Signal meter amplification accordingly.

AUTO BLEND CIRCUIT

A weak stereo signal is accompanied by noticeably more noise than a monophonic signal of the same strength. The phase of such noise is opposed in the right and left channels, so it is possible to cancel it, at least in part, through mixing the channels, without losing frequency response. The mixing is done automatically by this circuit, in two stages: for signals below 60dBμ and below 40dBμ. Naturally, the stronger the blend effect, the less stereo separation is available. (Separation 40dBμ 1KHz = 8dB, 60dBμ 1KHz = 14dB)

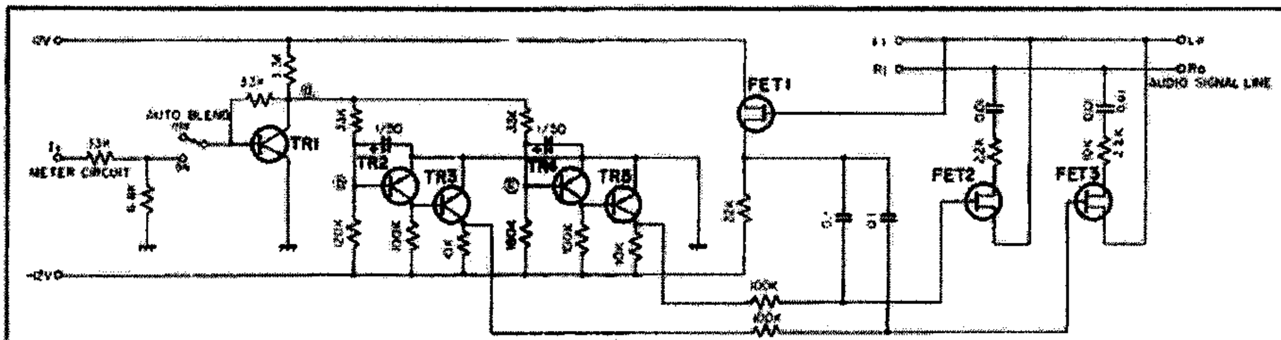

Fig. 2

Operation

1. With the Auto Blend Switch Off

Since the Tr1 bias is positive, Tr1 switches on and E potential at point ⓐ is zero. Potentials at points ⓑ and ⓒ are below −0.5V, so Tr2 and Tr4 are on, Tr3 and Tr5 off. In addition −12V is fed to the gates of FET1 FET2, so there is no blend effect.

2. With the Auto Blend Switch On

a. If the strength of the received signal is less than 40dBμ, potential present at input terminal I_1 is low, so that the output impedance from Tr1 is high, raising the potentials at points ⓑ and ⓒ to more than −0.5V. This switches Tr2 and Tr4 off, and Tr3 and Tr5 on, and potential almost the value of E is fed to FET2 and FET3 gates. In addition, the left channel audio signal is fed from FET1 to the FET2 and FET3 gates for a steady blend effect in both stages.

b. When the strength of the received signal is below 60dBμ but over 40dBμ, Tr1 impedance lowers and potential at point ⓐ is enough to cause the potential at points ⓑ and ⓒ to drop, below −0.5V, so that the blend effect is available, but only via FET3.

c. When the strength of the received signal is over 60dBμ Tr1 is almost switched on, which is the same condition as that described in (1) above. This cancels the blend effect.

AUTO TOUCH AFC OFF CIRCUIT & STATION/AFC INDICATOR CIRCUIT

These circuits turn the AFC off when a station is being tuned, and also indicate when tuning is in the reception area of a station, showing that the AFC is off at the same time. This gives rise to the following merits:

1. If the AFC is constantly operating in the tuner then, assuming that AFC-caused frequency drift is 1/n, the apparent selection zone is increased n times. In such a case, if there is a powerful station nearby on the dial, the tuning is apt to be pulled off, even during station selection, which will make it impossible to tune the nearby station. To avoid this problem the AFC goes off automatically when the tuning knob is touched.

2. More recent tuners tend to do away with the AFC function altogether, depending upon advanced circuit technology to suppress drift. In these tuners, circuits are designed to resist the affect of temperature fluctuations, so that drift can be forgotten as a serious problem.

In such a tuner, the addition of AFC will of course provide extra protection against drift — and this is the superior feature of the Yamaha system.

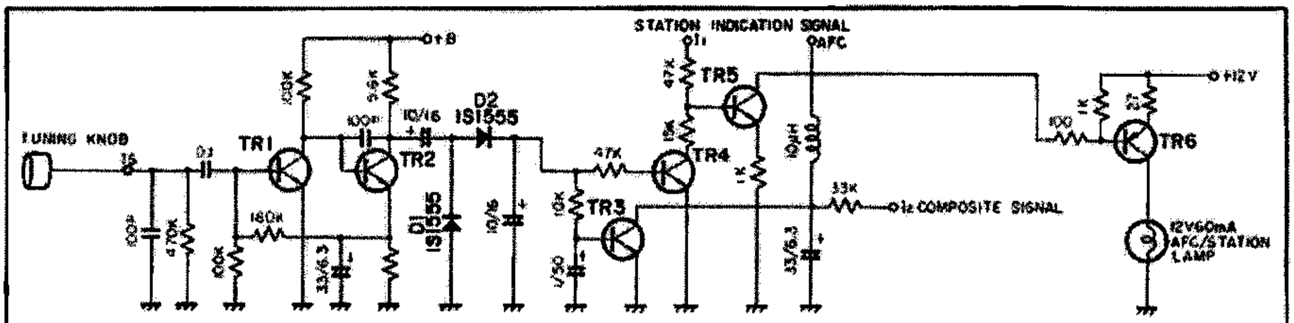

Fig. 3

Operation

1. Touching the tuning knob with your finger passes the electric potential in the human body to the TS terminal, and it is amplified by Tr1 and Tr2, then rectified by D1 and D2 diodes for (+) potential.
2. This potential is added to the base of Tr3, switching it on and grounding the AFC terminal (i.e., canceling the AFC effect).
3. At the same time, this potential is fed to the base of Tr4, so that that transistor comes on and grounds Tr5 with 15kΩ.
4. When the station display signal is fed to the I1 terminal, Tr5 comes on and switches Tr6 on. This lights the AFC/Station lamp. At this time, if operation (3) above is added, Tr5 output voltage drops and Tr6 output impedance rises, so that the AFC/Station lamp dims to show that the AFC is off.

TRANSIENT NOISE CANCELATION CIRCUIT

This circuit serves to cancel the noise and distortion caused by turning the Power switch on and off.

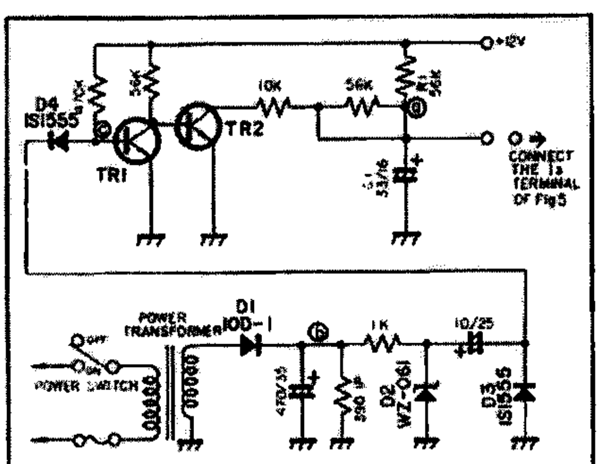

Fig. 4

Operation

1. When the Power switch is turned on

When the power is switched on, potential at point ⓐ is equal to E, and rises to +12V according to a time constant decided by C1R1. When this +12V is added to the base of Tr1 this transistor switches on and shuts Tr2 off, so that the difference in voltage obtained by C1R1 appears as it is at terminal 0. This switches Tr7 (previous diagram) on, and the same condition continues until the voltage at point ⓐ reaches +11.5V, thus cancelling unwanted signals at the time power is switched on.

2. When the Power switch is turned off

When the power is switched off voltage at point ⓑ changes from 12V to E potential. This change is rectified to couple voltage by D3D4, and negative load potential is obtained at point ⓒ. This switches Tr1 off and Tr2 comes on, so that E potential is present at the collector of Tr2 and the negative potential change is available at terminal 0, providing a muting effect at the instant the power is switched off.

D2 removes the ripple in the negative voltage at point ⓑ which means it cancels the operation of this circuit, which works via ripples when the power switch is turned on.

MUTING CIRCUIT

This circuit eliminates weak signals and inter-station noise during tuning, or in case of station drift. This circuit also functions to cut transient noises, a function which will be explained in another section.

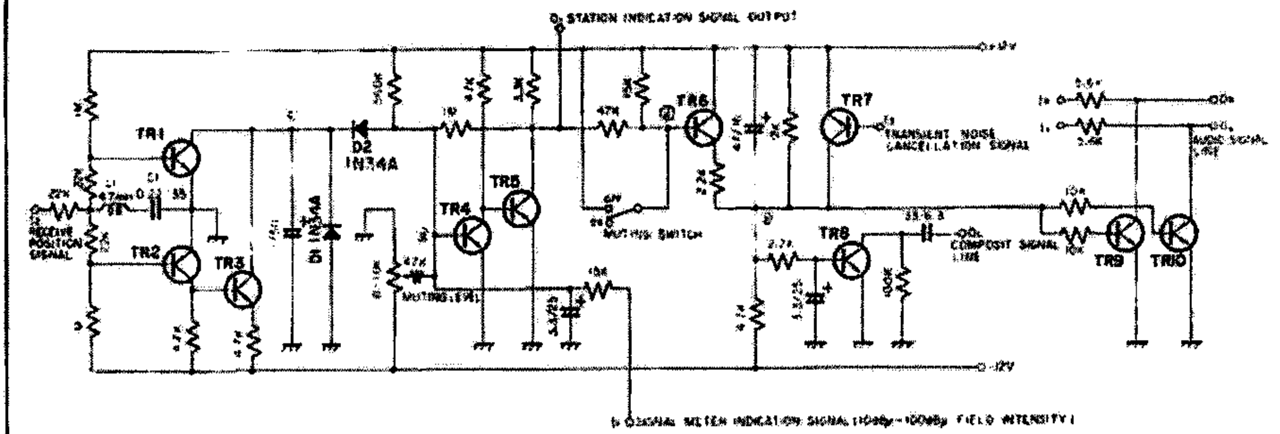

Fig. 5

Operation

1. Muting operation due to a signal from terminal I_1.

a. DC voltage $e1$, which shows the strength of the received signal between 10dBμ and 100dBμ is fed to the I_1 terminal and passes to the base of Tr4, which has had its bias adjusted by VR1.

b. If $e1$, is less than the set bias value, Tr4 switches off, switching Tr5 and Tr6 on. This makes the voltage at point ⓑ sufficient to turn on Tr8, Tr9 and Tr10, grounding the composite signal via Tr8 and the audio signal via Tr9 and Tr10.

c. On the other hand, if $e1$ is greater than the set bias value, the Tr4 switches on, thus switching off Tr5 and Tr6. This means that the voltage at point ⓑ will switch off Tr8, Tr9 and Tr10, thus passing the composite and audio signals.

2. Muting operation due to a signal from terminal I_2.

a. Signal $e2$, which contains a DC component showing the tuning aberration, is fed to the I_2 terminal. This is potential which can be obtained by the discriminator S curve. When the received signal is lower than the correct tuning point, negative voltage is contained in $e2$; when it is higher, positive voltage is present.

b. When the received signal is lower than the correct tuning point, Tr1 is continually off, but Tr2 can be switched on by voltage of below −0.5V, and at this time Tr3 comes on. In this case potential at point ⓒ becomes zero due to diode D1, while point ⓐ is grounded by D2, thus switching on the muting.

c. When the signal is higher than the muting point, Tr2 and Tr3 are continually off. Tr1 comes on when it receives more than −0.5V, creating E potential at point ⓒ. D2 thus grounds point ⓐ switching on the muting.

d. In addition to selecting DC voltage, this circuit works in the same way to block unwanted signals of below 20Hz and over 50kHz through the actions of C1 and L1. This cuts the noises normally heard when the tuning knob is turned quickly and passes one or more stations.

e. When the muting effect is not desired it can be bypassed by raising voltage at point ⓓ to +12V via the Muting switch, thus turning Tr6 off.

PHASE LOCKED LOOP CIRCUIT

This circuit accurately creates a switching signal which divides the stereo components of the FM signal. It is divided into two parts: an oscillator and a section to match the oscillator 19kHz pilot signal to the broadcast pilot signal.

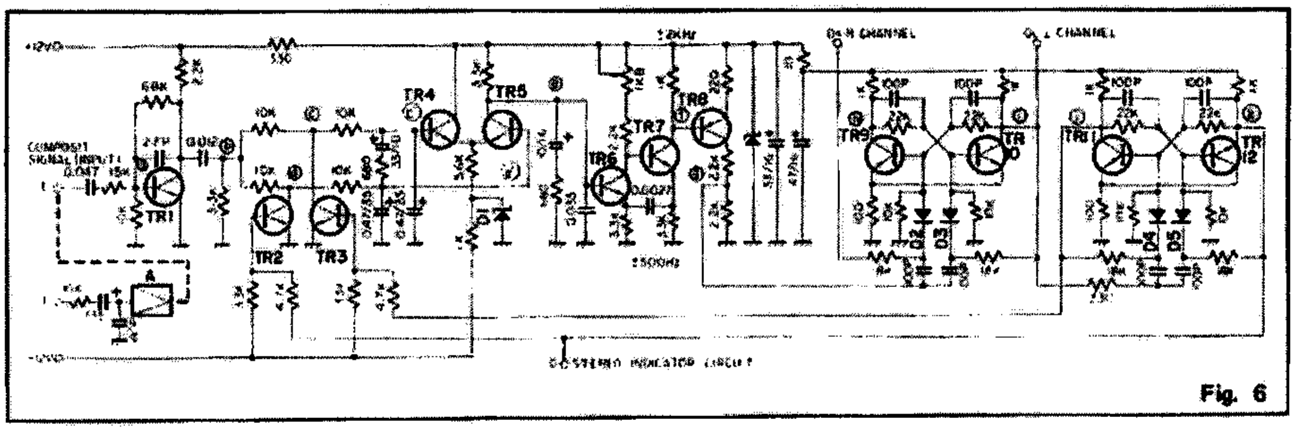

Fig. 6

Operation

1. Oscillator Section

a. A 76kHz sine wave is obtained from the VCO formed by Tr6 and Tr7. It is changed into a square wave at Tr8 and then fed to the doubled multivibrator formed by Tr9 and Tr10. Thus at OR and OL 38kHz square waves of opposite phase are obtained.
   At the same time this 38kHz signal is fed to the doubled multivibrator formed by Tr11 and Tr12, creating 19kHz square waves of opposed phase at points ⓙ and ⓚ. Waveforms and phase relations at each time point are as shown below:

b. As a principle of operation, the oscillation frequency (phase) of the VCO rises (advances) as the Tr6 potential becomes more positive, and drops (retards) as it becomes more negative.

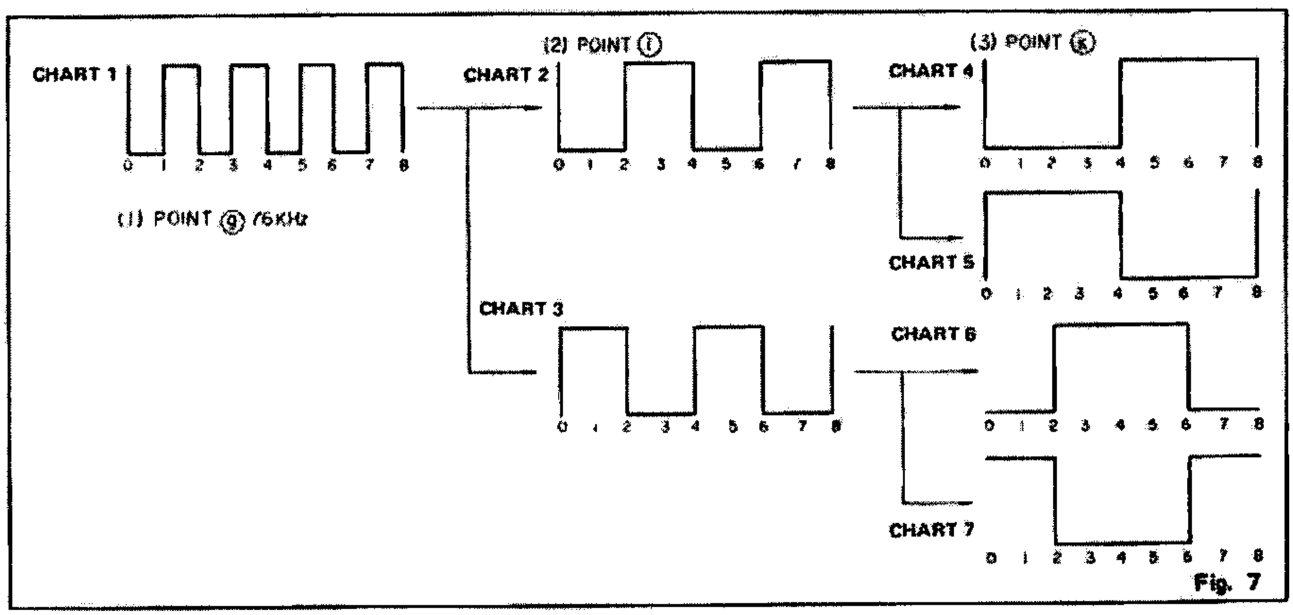

Fig. 7

Notes:

1. Waveforms at point ⓗ are the same square wave as at point ⓘ, but phasing is opposite.
2. The waveform at point ⓙ is the same square wave as that at point ⓚ, but the phase is opposite.

2. Phase Comparison and Detection Section

a. The 19kHz pilot signal, a composite signal necessary for phase comparison and detection, is selected by the band pass filter composed of the circuit from the I' terminal to point ⓐ.

b. This selected 19kHz pilot signal is amplified by Tr1 and fed to points ⓒ and ⓓ, connected to Tr2 and Tr3 respectively. To these transistors the 19kHz square wave from the oscillation section points ⓙ and ⓚ are also fed.

c. In this way the phase comparison and detection circuit is formed, and output Vc' and Vd' can be obtained. Since the 19kHz square wave signals driving Tr2 and Tr3 are in opposite phase, Vc' and Vd' are activated alternately. This phenomenon is then amplified by the differential amplifier formed of Tr4 and Tr5.

d. The phase relations between the pilot signal and the signals at points ⓙ and ⓚ as well as the potential at points ⓒ and ⓓ, are shown below:

The figure to the left shows the point ⓐ input waveform. The one on the right shows that for point ⓑ.

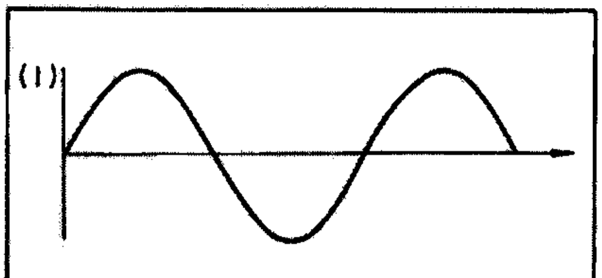

CHART 8

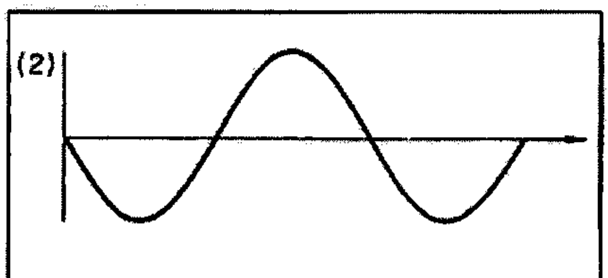

CHART 9

2-1. To detect the waveform in chart 9 above according to chart 4 and chart 5 (previous page),
10-a. Output at (d) when chart 4 is added to Tr2.
10-b. Output at (c) when chart 5 is added to Tr3.
At the same time, these also show the outputs at point ⓒ (in the condition seen in chart 10-ⓐ) when chart 4 is set to Tr3, also show the output at the point ⓓ in chart 10-ⓑ when chart 5 set to Tr2.

2-2. To detect the waveform in chart 9 above using chart 6 and chart 7 shown on the previous page:
11-d. Output at (d) when chart 6 is added to Tr2.
11-d. Output at (o) when chart 7 is added to Tr3.
At the same time, these also show the outputs at point ⓒ (in the condition seen in chart 11-ⓒ) when chart 6 is set to Tr3, also show the output at the point ⓓ in chart 11-ⓓ when chart 7 set to Tr2.

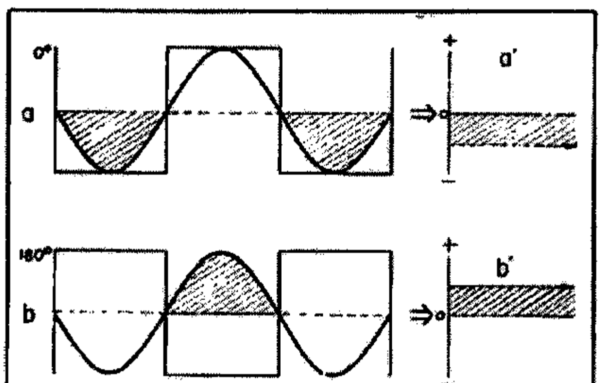

CHART 10

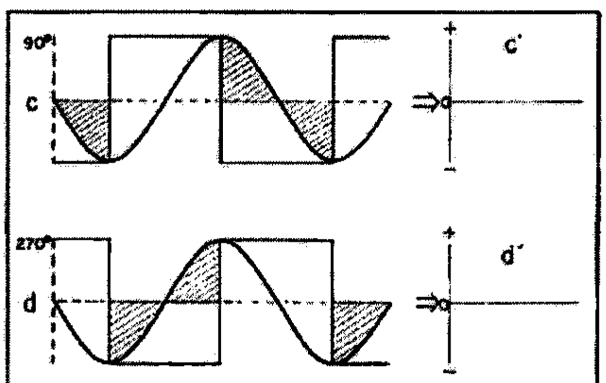

CHART 11

2-3. Potential at points ⓒ' and ⓓ' becomes that shown at a' b' c' and d' in the chart 10 and 11. Phase differences and output relations between pilot signal and detection signal are as shown in the following chart 12.

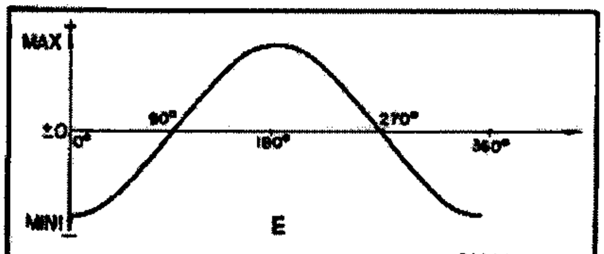

CHART 12

2-4. Since points ⓒ' and ⓓ' are connected to the differential amplifier, its operation creates the following relations. Let the potential at ⓒ' be E ⓒ', at ⓓ', E ⓓ' and at ⓔ, E ⓔ. Then E ⓔ = K(E ⓒ' − E ⓓ'). Furthermore K>O. The output potential at e undergoes the change shown in chart 12, also due to the phase difference between the pilot signal and detection signal j added to Tr3.

3. Oscillation Section and Phase Comparison Detection Section

The output potential of the phase comparison detection section is added to the base of Tr6 in the VCO, so that by examining 1.b and 2-4 one can see that a locked condition is possible only when the phase difference is either 90° or 270°, and the following conditions hold:

a zone: VCO works for phase retard.
b zone: VCO works for phase advance.
c zone: VCO works for phase advance.
d zone: VCO works for phase retard.

Therefore the only stable, locked condition is 270° phase difference (with a 90° difference, even a tiny retard will cause an automatic shift to 270°).

Therefore, according to the charts in the Oscillator Section discussions, what leads to stability are ⓙ terminal output (chart 7), ⓚ terminal output (chart 6), ⓘ terminal output (chart 3) and ⓗ terminal output (chart 2).

Even if a locked condition arises at 90° phase difference, it will be due to ⓘ terminal output (chart 3) and ⓗ terminal output (chart 2), so that switching will not be affected at all.

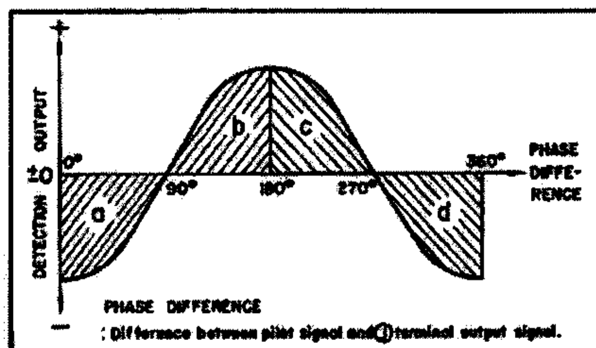

CHART 13

STEREO/MONO DRIVE AND STEREO INDICATOR CIRCUIT

This circuit receives stereo FM signals strong enough for stereo reception. When the PLL circuit is phase locked the demodulator operates and the stereo indicator lamp lights, which is this circuit's function.

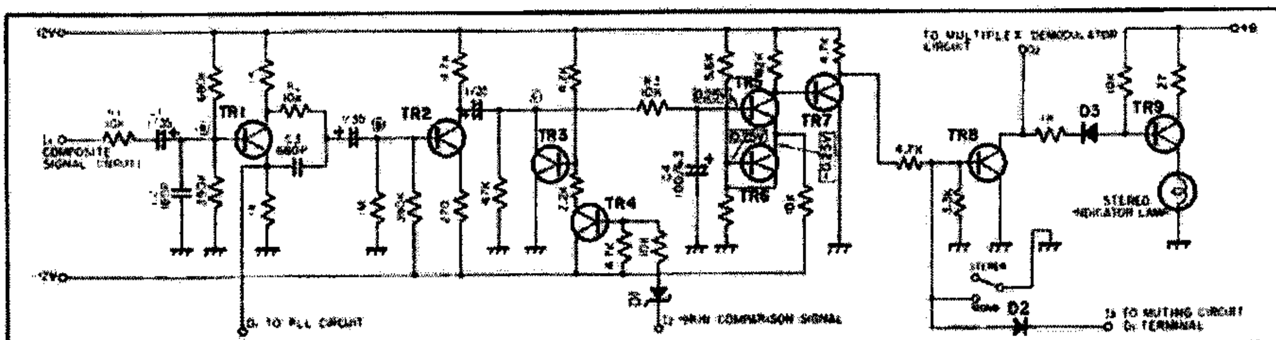

Fig. 7

Operation

1. The composite signal is fed from the I1 terminal and undergoes a high cut due to R1, C1 and C2. It is added to the 19kHz 90° phase shifter composed of Tr1, R2 and C3. In this way the 19kHz pilot signal leads by 90° and is amplified at Tr2 (only during stereo broadcast reception, of course).

2. At the same time, the PLL circuit D terminal output (7) enters via I2 and the phase detector Tr3 is operated by Tr4.

3. Using the phase difference between the pilot signal and signal, Fig. 7 to see the potential at point Ⓒ (i.e., the phase detector output, the following points become clear. See chart 14.
The operation to the detector when the PLL circuit is phase locked is shown by the chart 15. At this time the phase difference is zero, and maximum positive output is obtained.

4. The potential change is integrated by R3 and R4, and when it is more than 0.25V, Tr5 goes on and Tr7 goes off, which switches Tr8 on. In this way the multiplex demodulator begins to operate and at the same time the stereo indicator lamp lights, driven by Tr9.
However, if the station display signal is not received via I3, i.e., if the strength of the received signal is below the muting level, the base of Tr8 will be grounded through D2, keeping it off and keeping the stereo indicator lamp from lighting. The multiplex demodulator will also fail to be activated.

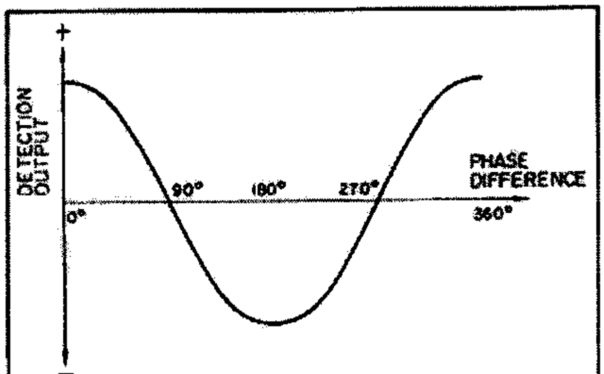

CHART 14

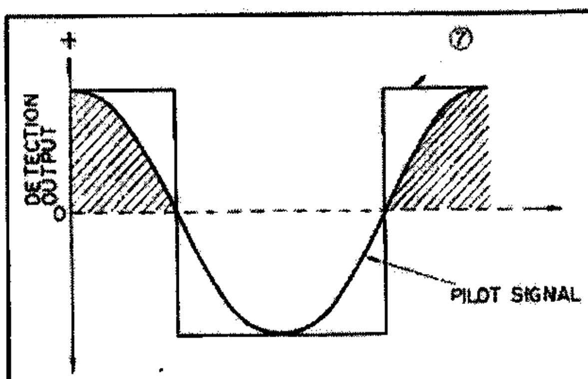

CHART 15

MULTIPLEX DEMODULATOR CIRCUIT

This circuit double tunes the composite signal by a switching method, thus separating out the left and right channel audio signals.

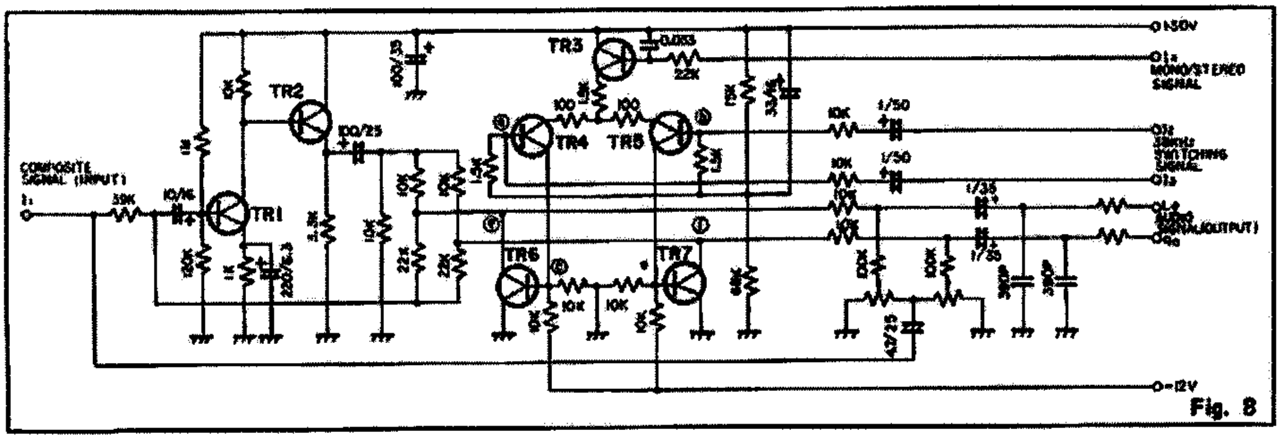

Fig. 8

Operation

The composite signal entering at l_1 is amplified by Tr1 and becomes output due to the low impedance of the Tr2 emitter-follower circuit.

Also, via the l_2 and l_3 terminals a 38kHz square wave is constantly received from the PLL circuit. At terminal l_4 a minus potential is received only when the signal is in stereo.

Therefore, when a stereo signal is received Tr3 comes on. Tr4 and Tr5 repeat seesaw on-off motions at the 38kHz frequency, which drives Tr6 and Tr7. When Tr4 is on, Tr6 comes on (at the same time Tr5 is off, switching Tr7 off). When Tr4 turns off, it switches off Tr6 (at this time Tr5 is on and thus so is Tr7). In this way the grounded-open movement is repeated between points Ⓔ and Ⓕ at the 38kHz rate, permitting the right and left audio signals to be obtained from the composite signal. One part of the audio signal is fed back through terminal l_1 for more perfect separation characteristics. In addition, when a monophonic signal is being received, Tr3 shuts off, and this turns off Tr4, Tr5, Tr6 and Tr7, so that the audio signal obtained at terminals Lo and Ro are monophonic.