Service Information

Model: Nakamichi ST-7/ST-7E (AM/FM Stereo Tuner)
Serial No.: from –

Subject: Principle of Operation

Nakamichi

No. OOD-SI-3094 (1/12)
Date 15 April 1986

Contents

1. Power Supply Circuit

When the Power switch is turned ON, the AC power is applied to the primary side of power transformer T1. The secondary side of power transformer T1 consists of a 15 V AC winding, 30 V AC winding, and 3.3 V AC x 2 winding.

(1) Output from 15 V AC Winding

The output from the 15 V AC winding follows two paths. One goes to the line mute circuit via D401 and D402. The other is full-wave rectified by diode bridge DB401, smoothed by C401, and sent into the +15 V 3-terminal regulator IC401 to provide a stabilized +15 V DC output. This +15 V DC output provides the +5 V DC output which is obtained through a voltage stabilizer circuit composed of Q405, ZD402, etc. The +5 V DC is supplied to the digital ICs, synthesizer IC (IC310) and FL (fluorescent) display control circuit.

(2) Output from 30 V AC Winding

The output from the 30 V AC winding is full-wave rectified by diode bridge DB402, smoothed by C403, and sent into the voltage stabilizer circuit consisting of Q401, ZD401, etc. The voltage stabilizer circuit produces a stabilized output of +15 V DC which is used as the bias voltage of the charge pump circuit.

(3) Outputs from 3.3 V AC x 2 Winding

The outputs from the 3.3 V AC x 2 winding are rectified by D403 and D404, and smoothed by C408 and C407. The result is a nonstabilized power supply of approx. –4 V DC. The –4 V DC serves as the bias voltage of the line mute circuit. The outputs from the 3.3 V AC x 2 winding are also applied across pins 1 and 25 of the FL display tube so that they serve as the filament power supply.

2. Line Mute Circuit and Power Off Signal Circuit

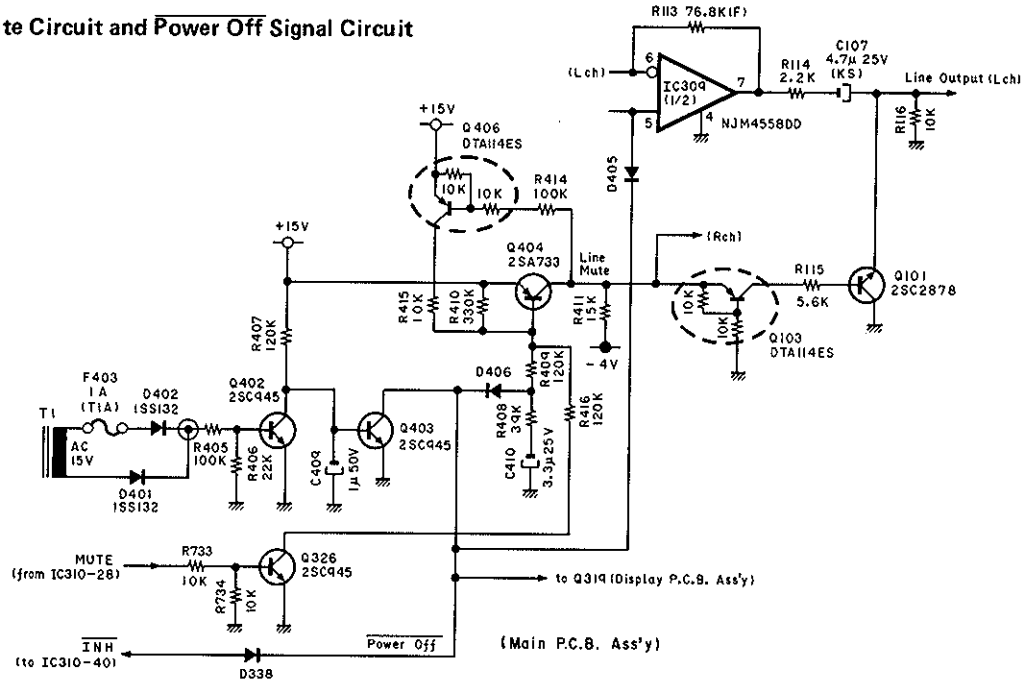

Fig. 1 Line Mute Circuit/Power Off Signal Circuit

The line outputs are muted when the power is turned ON or OFF or when synthesizer IC310-28 (Mute) becomes H. When the power is turned OFF, the $\overline{\text{Power Off}}$ signal instantly becomes L, muting the line outputs and also extinguishing the FL display tube. At the same time, a L signal is sent to synthesizer IC310-40($\overline{\text{INH}}$) to cause IC310 to execute the power-off sequence.

(1) Power ON

When the Power switch is set to ON, the output of the 15 V AC winding is full-wave rectified by D401 and D402 and, without smoothing, applied to the base of Q402. Accordingly, Q402 is ON and C409 is discharged. Thus, Q403 cannot turn ON but it stays OFF after the power is turned ON.

On the other hand, when the power is turned ON, a differentiated base current flows into Q404 through C410. As a result, Q404 turns ON in the form of a pulse over a certain period of time, which turns ON Q103, Q203, Q101 and Q201, muting the line outputs for this period. (Since Q406 is ON at the power ON time, R415 (10 kΩ) is parallel-connected with R410 (330 kΩ). For this reason, Q404 has adequate base current when the power is turned ON. As Q404 becomes ON, Q406 becomes OFF.)

(2) Power OFF

When the Power switch is set to OFF, the output of 15 V AC winding instantly ceases, setting Q402 to OFF. After C409 is charged, Q403 turns ON and the $\overline{\text{Power Off}}$ signal becomes L. This turns Q404 ON and mutes the line outputs. At the same time, the non-inverting inputs of the buffer amp. IC309 in the last stage is grounded through D405, disabling the outputs.

The $\overline{\text{Power Off}}$ = L signal is also applied to the base of Q319 on the Display P.C.B. Ass'y. So Q319 turns ON and Q320 turns OFF, extinguishing the FL display tube without flickering.

Furthermore, the $\overline{\text{Power Off}}$ = L signal is also applied to synthesizer IC310-40 ($\overline{\text{INH}}$). Consequently, when $\overline{\text{INH}}$ = L, IC310 enters the data storing status to store the data. The data (broadcasting station frequencies, etc.) stored in IC310 is held for about a week due to backup by C381 (47,000 μF).

(3) Mute of inter-station noise

To remove the inter-station noise, synthesizer IC310-28 (MUTE) outputs H. This turns ON Q326 and then Q404, thus muting the line outputs. The line outputs are also muted when the FM Mute switch is ON, because IC310-28 (MUTE) becomes H.

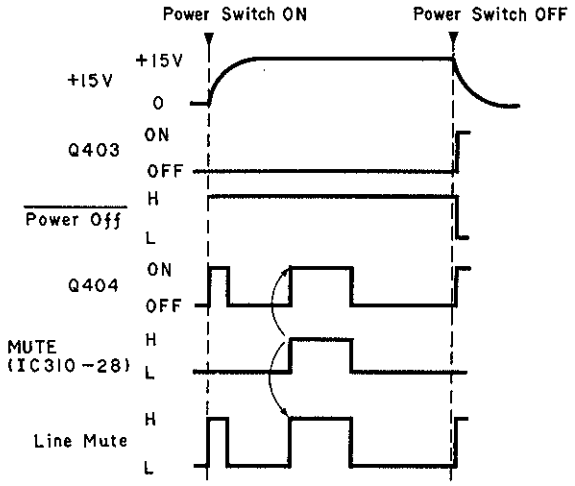

Fig. 2 Line Muting Timing Chart

3. Synthesizer IC and Peripheral Circuits

(1) I/O signals and functions of synthesizer IC310 (TC9147BP)

Table 1

Pin No.	Symbol	Description	In/Out	Function
1	GND	GND terminal	–	
2 3	XT $\overline{XT}$	Crystal oscillator terminals	–	Crystal for 7.2 MHz reference frequency is connected.
4	FM	FM band select	In	Provides FM/MW/(LW) band selection by resetting currently effective band. Active H.
5	MW	MW band select	In	
6	LW	LW band select (Unused)	In	
7	MANUAL	Manual tuning mode select	In	Selects manual or auto tuning mode. While Manual Tuning knob (incremental rotary encoder) is rotating, manual tuning mode is selected. When Seek button (UP or DOWN) is pressed, auto tuning mode is selected. Active H.
8	AUTO	Auto seek tuning mode select	In	
9 10	UP DOWN	Up Seek button input Down Seek button input	In	Selects a station by increasing (UP) or decreasing (DOWN) the frequency. Active H.
11	STO	Memory store command	In/Out	Sets preset memory in write state. Active H.
12 | 19	M1 | M8	Preset Station button inputs	In	M1 to M8 are used in conjunction with MC1 and MC2 to read and write 16 stations to preset Memory. Active H.
20	MC1	Memory control input (non-shift)	In	
21	MC2	Memory control input (shift)		
22	OSC2	Oscillator terminal for AM	–	Capacitor and resistor that determine scan speed in AM seek are connected.
23	OSC1	Oscillator terminal for FM	–	Capacitor and resistor that determine scan speed in FM seek are connected.
24	50 kHz	50 kHz step select (FM)	Out	Causes 50 kHz step display for FM band in the European area. Becomes H level when 50 kHz display is ON.
25	CK2	Clock output	Out	Transmits serial data and timing clocks to the received-frequency display driver.
26	CK1	Clock output		
27	DATA	Received-frequency serial data output		
28	MUTE	Muting output	Out	Becomes H when muting. Active H.

Pin No.	Symbol	Description	In/Out	Function
29	AREA 0	Area select	In	Selects area of U.S.A. and Canada, Europe or Japan.
30	AREA 1			
31	STOP3	AM-IF signal input	In	Unused.
32	STOP2	Auto-search stop signal input	In	With H level given to STOP1 input, stops auto seek upon input of H level to STOP2. Active H.
33	STOP1	Scan speed slow input	In	Unused. Connected to pin 32.
34	DO-2	Phase comparator outputs	Out	Sent from tri-state buffers. Pin 35 is unused.
35	DO-1			
36	TEST	Test terminal	In	Unused. Grounded.
37	FM IN	FM program counter input	In	Output of prescaler TD6104 isconnected.
38	PSC	Prescaler control output	Out	Controls switching between 1/30 and 1/32 dividing of prescaler TD6104. (1/30 for Japan only)
39	AM IN	AM program counter input	In	Receives AM local oscillator signal.
40	$\overline{\text{INH}}$	Inhibit input	In	Causes normal operation at H level, and inhibit mode at L level. Active L.
41	$\overline{\text{INT}}$	Initialization input	In	Causes normal operation at H level, and initialization of internal status at L level. Active L.
42	VDD	Power supply terminal	–	Connected to +5 V. Backup is available for above approx. 2 V.

(2) FM Prescaler

IC311 (TD6104) is a 5-bit digital counter. The frequency from the FM local oscillator circuit is input to IC311, which performs 1/32 division to produce a 25 kHz reference frequency. The reference frequency is input to FM program counter input, pin 37 of synthesizer IC301 (TC9147BP).

The functions of IC311 are described in Table 2.

Table 2 Functions of IC311 (TD6104)

Pin No.	Description	Function
1	VCC	+5 V power supply terminal.
2	$\overline{OUT}$	Outputs reversing signal of OUT. Unused.
3	OUT	Outputs 1/30 or 1/32 division signal of FIN.
4	GND	Grounding terminal.
5	FIN	Receives FM local oscillator signal.
6	C	Bypass capacitor connecting terminal for internal bias circuit.
7	PSC	Provides a selection of division: 1/32 at 2 V or more 1/30 at 1 V or less (used in Japan only)

(3) Charge pump

The gate of FET Q317 is connected to IC310-34 (output of phase comparator) via R706. The circuit (Fig. 4) in IC310 (TC9147BP) compares the output of the programmable counter to the reference frequency. It outputs pulses as in Fig. 5. The output (IC310-34) is H when the phase of reference frequency R advances; it is L when the phase of the programmable counter S advances. When the phases of the two coincide, the output is in high-impedance state, i.e., open. In other words, the output is H or L when the frequency of the desired broadcasting station is above or under the frequency being received; the output is in high-impedance state when the two frequencies are the same.

The charge pump is a kind of low-pass filter. The collector of Q316 has a DC voltage corresponding to the phase difference. This DC voltage is applied via R702 to the varicap diodes in the FM front-end and AM RF block, thereby controlling the received frequency.

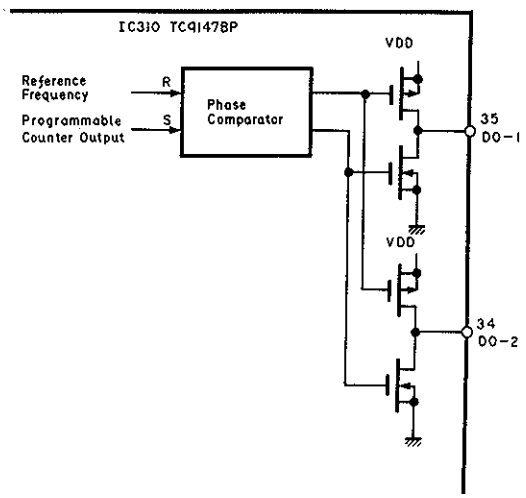

Fig. 4

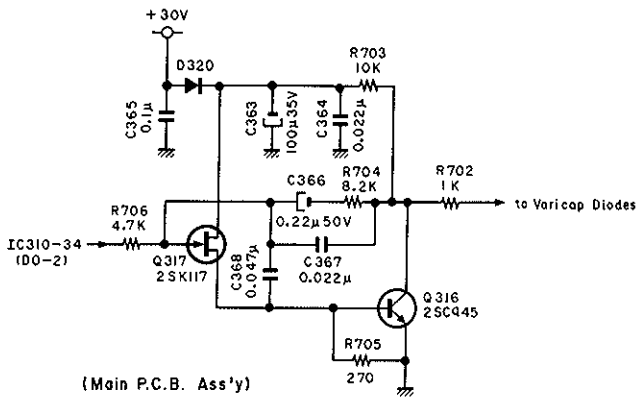

Fig. 3

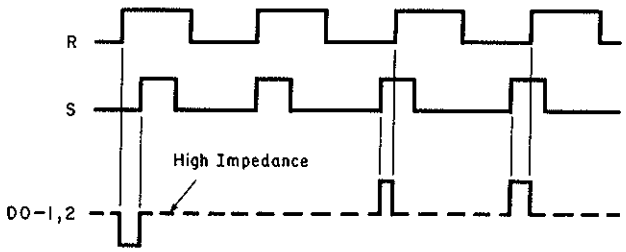

Fig. 5 DO Output Timing Chart

(4) Area assignment

The pins 29 (AREA 0) and 30 (AREA 1) of IC310 (TC-9147BP) are the area assignment inputs. They select the band and scan steps specified in the area of Japan, Europe or U.S.A.

Table 3

29 AREA 0	30 AREA 1	Area	
L	L	Japan	
L	H	Europe	
H	L	Unused	MW 9 kHz separation
H	H	U.S.A. Canada	MW 10 kHz separation

(5) Setting of auto seek speed

The scanning speed in the auto seek mode is determined by the pins 22 (OSC2) and 23 (OSC1) of IC310. These are CR connection pins for FM oscillator (OSC1) and AM oscillator (OSC2). Their oscillation frequencies are set independently from each other. OSC1 also determines the muting output time and the automatic store-state clearing time. The oscillation frequency fosc is given as follows:

$$fosc \fallingdotseq \frac{1}{0.7\ Cx \cdot Rx}$$

As the fosc1 and fosc2 are set to approx. 44 Hz and 20 Hz, respectively, the scanning speed, etc., are determined as in Table 4.

Table 4

Scan Speed (Auto Seek)	FM	fs (FM) = ½·fosc1 ≒ 22 (Step/Sec)
	AM	fs (AM) = ½·fosc2 ≒ 10 (Step/Sec)
Automatic store-state clearing time		TSTO = 224/fosc1 ≒ 5 (Sec)
Muting signal output time	short	TMUTE (S) = 7/fosc1 ≒ 0.16 (Sec)
	long	TMUTE (L) = 15/fosc1 ≒ 0.34 (Sec)

Note: The muting time "long" increases the muting time approximately twice as long as the normal time, as when changing the band or turning the power ON.

4. FM/AM Mode Switching Circuit

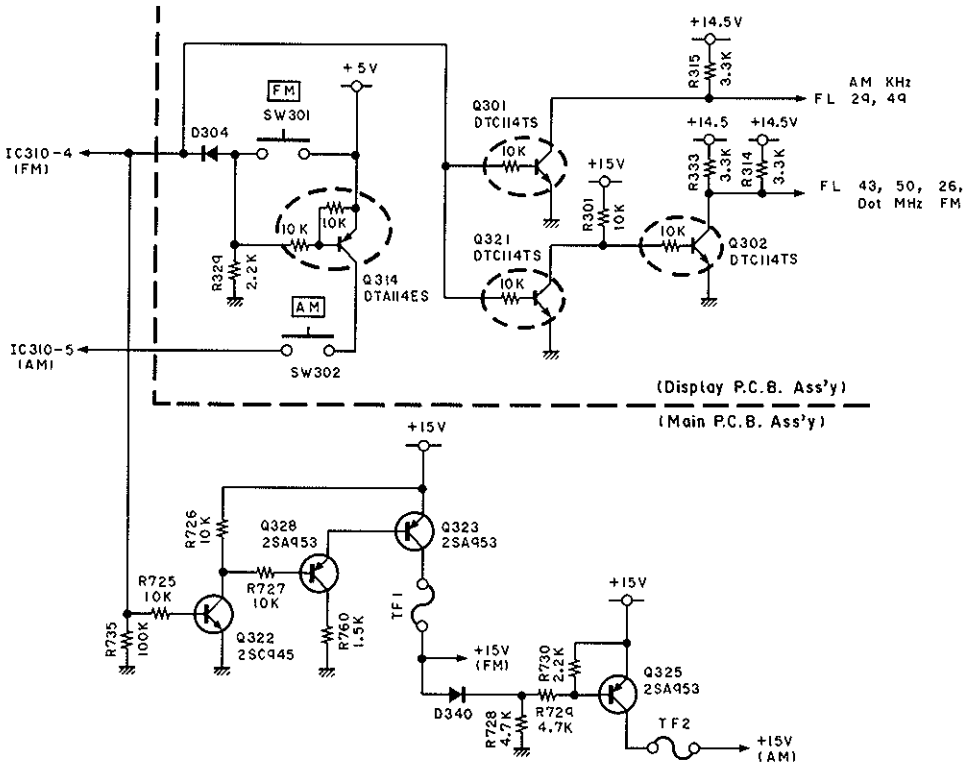

Fig. 6

(1) FM mode

Pressing the FM button (SW301) applies H (approx. 4.5 V) to IC310-4 (FM) via D304; IC310-4 is held in the H state by the mutual-resetting circuit built in it. At this time, Q322, Q328 and Q323 which supply power to the FM tuner circuit turn ON, so the +15 V (FM) is supplied to the FM tuner circuit. On the other hand, the supply to AM tuner circuit is cut off as Q325 turns OFF. Also, Q301 and Q321 turn ON and Q302 turns OFF on the Display P.C.B. Ass'y. Accordingly, the FL display tube's indicators "FM" (26), "dot point" (43) and "MHz" (50) which are pulled up by R314 and R333 light up.

(2) AM mode

When the AM button (SW302) is pressed, IC310-5 (AM) is changed to the H state and is held in this state. At the same time, IC310-4 (FM) changes to the L state, Q322, Q328 and Q323 which have been ON in the FM mode turn OFF, and Q325 turns ON. As a result, the +15 V (AM) is supplied to the AM tuner circuit. Because Q321 turns OFF and Q302 now turns ON, the FL tube's indicators "FM", "dot point" and "MHz" go OFF. Further, as Q301 turns OFF, the FL tube's indicators "AM" (29) and "kHz" (49) that are pulled up by R315 light up.

Table 5

Mode	Q301 AM, kHz	Q302 FM, MHz, Dot	Q323 +15 V (FM)	Q325 +15 V (AM)
FM	ON	OFF	ON	OFF
AM	OFF	ON	OFF	ON

5. Seek Tuning and Manual Tuning

(1) Seek tuning

As the Up Seek button (SW304) is pressed, IC310-9 (UP) and IC310-10 (AUTO) become H via D333 and D334, respectively. The IC310 performs a seek by increasing the frequency. On the other hand, as the Down Seek button (SW303) is pressed, IC310-8 (AUTO) and IC310-10 (DOWN) become H via D335 and D336, respectively. Then the IC310 performs a seek by decreasing the frequency.

When auto seek is made in the FM mode, for example, IC303 (LA1235: FM IF amp.)-12 (Mute) becomes H during the seek. It changes to L upon tuning. Consequently, Q305 turns OFF, and IC310-32 (STOP1) and -33 (STOP2) receive H to stop the auto seek.

In the case of auto seek in the AM mode, the pin 16 (SD) of IC301 on the AM P.C.B. Ass'y outputs a positive DC voltage upon tuning. As a result, Q327 turns ON, and Q304 changes from ON to OFF, so that IC310-32 (STOP1) and -33 (STOP2) receive H to stop the auto seek.

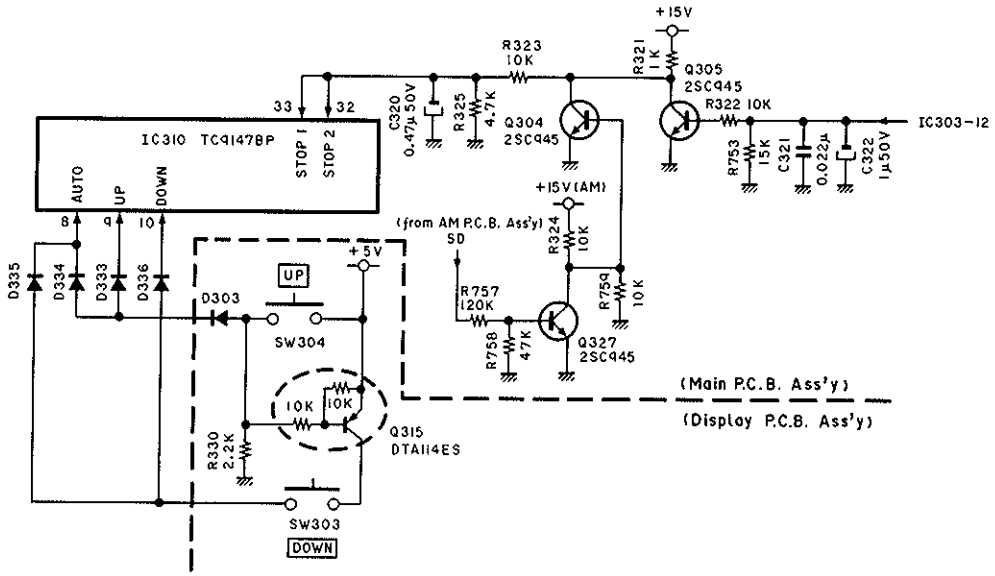

Fig. 7

(2) Manual tuning

As the incremental rotary encoder (Manual Tuning knob) is turned, each of its terminals produces 50 pulses of waveform per rotation as shown in Fig. 9.

Suppose the incremental rotary encoder is turned in the UP (clockwise) direction. The points Ⓐ, Ⓑ and Ⓒ will have pulses generated at the timings shown in Fig. 10.

H pulses are applied to IC310-7 (MANUAL) via D331 and to IC310-9 (UP) via D332, thus increasing the received frequency. On the contrary, turning the incremental rotary encoder in the DOWN (counterclockwise) direction generates H pulses at IC310-7 (MANUAL) and IC310-10 (DOWN), so the received frequency is decreased.

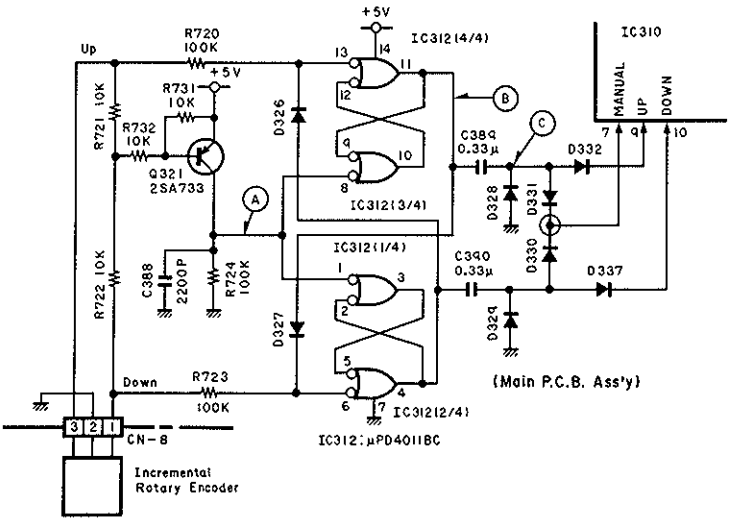

Fig. 8

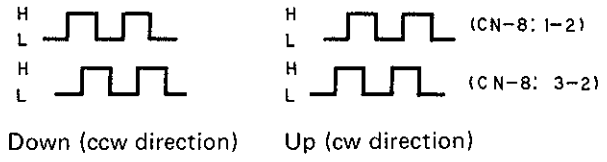

Fig. 9

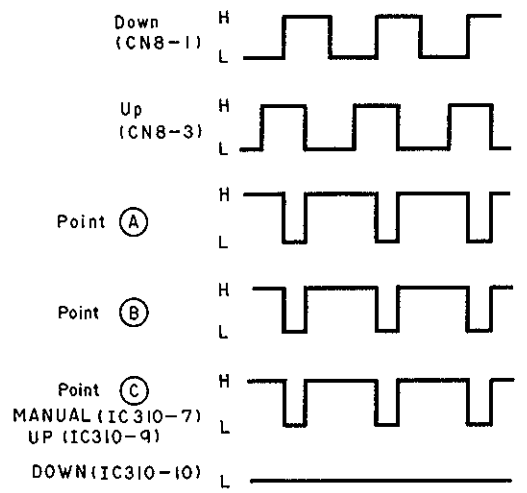

Fig. 10

6. Memory Tuning

(1) Preset station memory (refer to Fig. 11)

The preset station memory can store up to 16 FM and AM stations combined. Pressing the Memory button after tuning to a station causes the Memory indicator to light for about five seconds. If the 1-9 Preset Station button is pressed in the five-second period, the Memory indicator goes OFF and the 1-9 LED goes ON; in the non-shift state, the station being received is stored in preset station memory-1. Pressing the Shift button inverts the shift/non-shift flip-flop which is composed of IC303 (AND Gate) and peripheral circuitry on the Display P.C.B. Ass'y. So the shift signal becomes H, lighting the Shift indicator and sending "shift = H" to IC310-21. If, during lighting of the Shift indicator (i.e., during shift state), the Memory button is pressed and then the 1-9 Preset Station button is pressed, the station being received is now stored in preset station memory-9.

(2) Last-station memory

In addition to the preset station memory discussed in (1) above, the ST-7/ST-7E has last-station memories for FM and AM. If, for example, FM is switched to AM with the AM/FM Band selector, the FM station received just before the switching is stored in the FM last-station memory. When the ST-7/ST-7E is switched back to FM, the station stored in the FM last-station memory is called. This operation is done automatically by synthesizer IC310. The station received just before the power was turned OFF is also stored.

(3) Hold of memory contents

Once the stations are stored in IC310 in the operation of (1) and (2) above, they will be held for about a week after the power is turned OFF. This is due to the backup by C381 (47,000 μF).

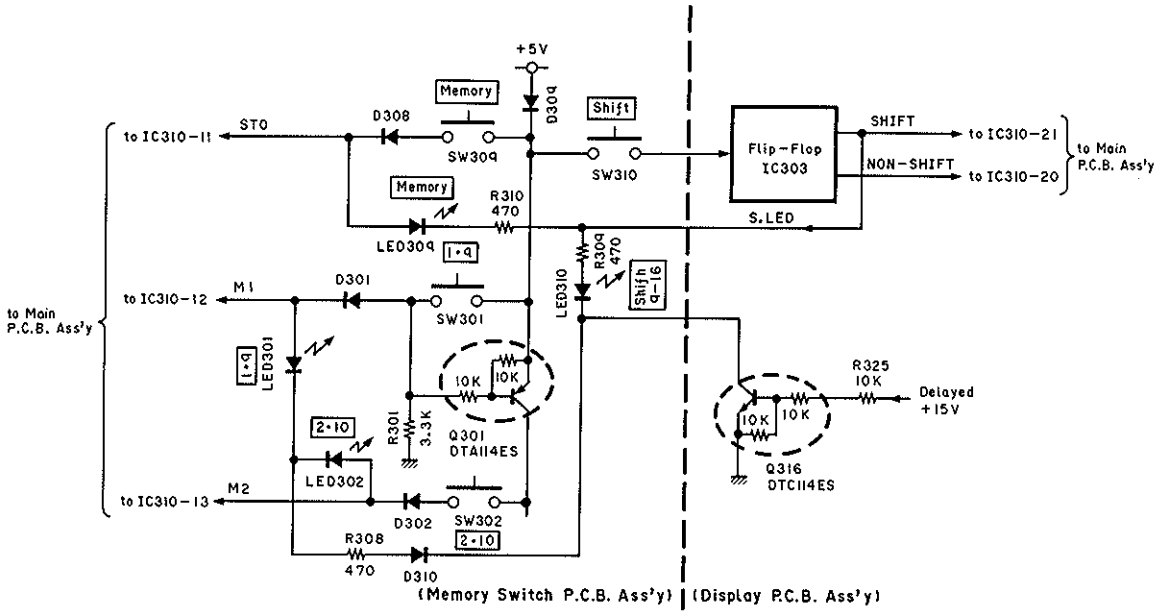

Fig. 11

7. FL Display Control Circuit

The FL display tube consists of the following indicators: FM, AM, MHz, kHz, dot, Lock, Stereo, meter segments, and frequency. The indicators are driven as described below.

(1) FM, AM, MHz, kHz and dot

Refer to Section 4, "FM/AM Mode Switching Circuit".

(2) Lock

When the ST-7/ST-7E is tuned to an FM station, IC303-12 on the Main P.C.B. Ass'y becomes L, so that: Q305 is OFF, D343 cut off, D344 ON, Q319 ON, Q320 OFF, and Q307 on the Display P.C.B. Ass'y is OFF. Consequently, +14.5 V is applied to pin 16 of the FL display tube via R311 (3.3 kΩ), thus illuminating the Lock indicator. When the ST-7/ST-7E is tuned to an AM station, the pin 16 (SD) of IC301 on the AM P.C.B. Ass'y changes to high level, and Q319 turns ON to illuminate the Lock indicator in the same manner as above.

(3) Stereo

When stereo broadcasting is selected by pressing the Mode switch, IC304-12 on the Main P.C.B. Ass'y becomes L, so that: Q303 on the Function Switch P.C.B. Ass'y is ON, Q315 on the Main P.C.B. Ass'y is ON, and Q308 on the Display P.C.B. Ass'y is OFF.

Consequently, +14.5 V is applied to pin 24 of the FL display tube via R309, thus lighting the Stereo indicator.

(4) Signal/Multipath meter (refer to Fig. 12)

When the Meter switch is set to the Signal position, the output of FM or AM signal meter circuit goes through the Meter switch on the Function Switch P.C.B. Ass'y to IC301 (BA656)-8 (VIN) on the Display P.C.B. Ass'y. When the Meter switch is set to the Multipath position, the output of the multipath detection circuit goes through the Meter switch to IC301 (BA656)-8.

The level meter driver IC301 (BA656) on the Display P.C.B. Ass'y sets its five outputs to H depending on the input level. For example, if the outputs of pins 1 and 2 are H, Q313 and Q312 in the next stage turn OFF, which causes lighting of the two lowermost meter segments.

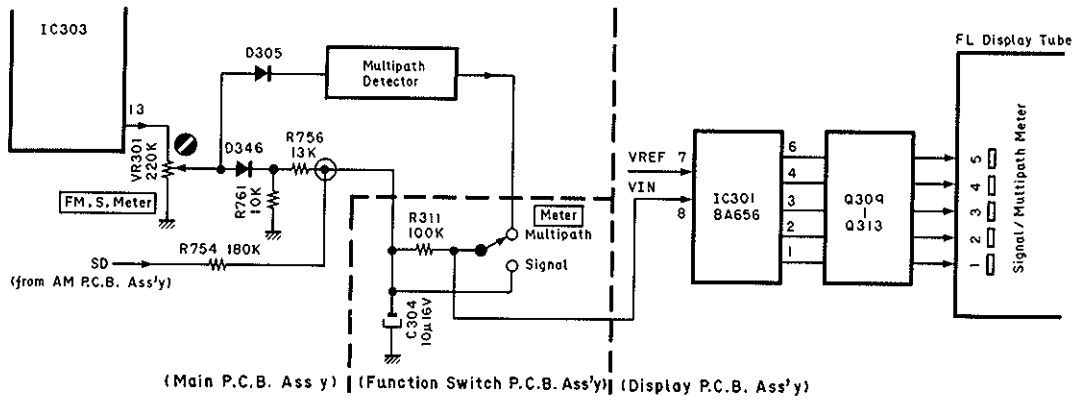

Fig. 12

(5) Frequency

This indicator shows the frequency of the station being received. The received frequency is converted into digital data by synthesizer IC310. The data is then sent in the form of serial data from pin 27 (DATA) of IC310, together with the clocks from pins 25 (CLOCK 2) and 26 (CLOCK 1) of IC310, to IC302 (TD6301A) on the Display P.C.B. Ass'y. IC302 (TD6301A) converts the serial data into BCD (binary-coded decimal) form. This BCD output drives the frequency indicator of the FL display tube.

Of the five digits of frequency indicator, those driven by the BCD output are restricted to the three – the second, third and fourth digits. The uppermost digit is controlled by only pin 5 (1/0) of IC302 because this digit needs only to be 1 or none. The lowermost digit is set to none or 0/5 indication, depending on countries.

In the case of 0/5 indication, the lowermost digit display is not controlled by IC302. Instead, it receives the signal from synthesizer IC310-24 (50 kHz). The numeral segments of the lowermost digit are turned ON and OFF as follows: segment g1 by Q304 and Q305 on the Display P.C.B. Ass'y, segments a1, f1, d1 and c1 by Q321 and Q302, and segments e1 and b1 by Q303. Combinations of the ON/OFF states of these transistors determine the 5 or 0 display (see Fig. 13).

The functions of IC302 (TD6301A) on the Display P.C.B. Ass'y are described in Table 6.

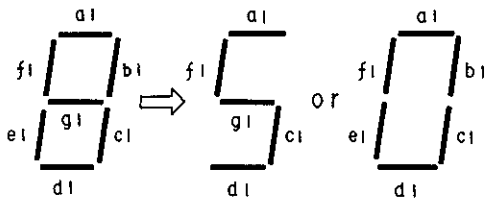

Fig. 13

Table 6 Functions of IC302 (TD6301A)

Pin No.	Description	Function
1	L/D	Receives output-status switching signal. Fixed to GND.
2	Data	Receives serial data on received frequency.
3, 4	CK1, CK2	Receives timing control signal for data on received frequency. The signal is sent from synthesizer IC310 synchronizing with data.
5	1/0	Outputs segment drive signal in units of 100 MHz for FM or 1,000 kHz for AM. Whether in FM or AM, display is 1 or none, so only one pin is used.
6–12	a3–g3	Outputs 7-segment drive signals in units of 10 MHz for FM or 100 kHz for AM.
13, 15–20	a2–g2	Outputs 7-segment drive signals in units of 1 MHz for FM or 10 kHz for AM.
21–27	a1–g1	Outputs 7-segment drive signals in units of 100 kHz for FM or 1 kHz for AM.
14	GND	Connected to GND.
28	VCC	Supplied with +5 V.

8. Schotz Noise Reduction (Schotz NR)

(1) Outline

Schotz NR automatically varies high-frequency channel separation as a function of signal strength and modulation level. Unlike conventional "high-blend" circuits that reduce separation by a fixed amount or simple "adaptive" high-blends that vary separation in accordance with RF level alone, Schotz NR makes full use of the psycho-acoustic "masking" effect. As the station's high-frequency modulation level increases, that is, whenever there is sufficient treble content in the program to mask noise, channel separation increases to provide maximum stereo effect. As signal strength or modulation level decreases, channel separation automatically decreases to reduce noise.

In summary, the Schotz NR system operates as follows:

(a) Schotz NR OFF (high-blend also OFF)
- When the Schotz NR switch is OFF.
- When the broadcasting is monaural.
- When stereo broadcasting is such that adequate S/N is obtained (RF level is 53 dBf or higher).

(b) Schotz NR OFF (high-blend selected)
- When RF signal level is 19 dBf or lower.

(c) Schotz NR ON
- When the high-frequency component of program is short.

(2) Operation of Schotz NR

Fig. 14 is a block diagram of the Schotz NR system. The system consists of IC305, IC306, IC308, Q306 to Q314, Q329, Q330, and their peripheral circuitry on the Main P.C.B. Ass'y.

After stereo de-multiplexing, the left and right signals pass through separate input buffers. These drive a set of high-pass filters that extract the high-frequency energy of the left and right channels separately. Full-wave rectifiers convert the high-frequency energy into DC voltages. These voltages pass through attack and decay filters that determine how quickly the system responds to changes in high-frequency content. The signals now pass through Log Converters, the outputs being DC voltages proportional to the logarithm of the high-frequency energy in each channel, that is, voltages proportional to the treble loudness of the program in each channel. These two signals, designated (A) in Fig. 14, control the cutoff frequencies of two variable high-pass filters that selectively pass more or less of the left-channel audio into the right channel (and right-channel audio into the left channel) depending upon the treble energy in each channel. The actual blending occurs in the output summation buffers.

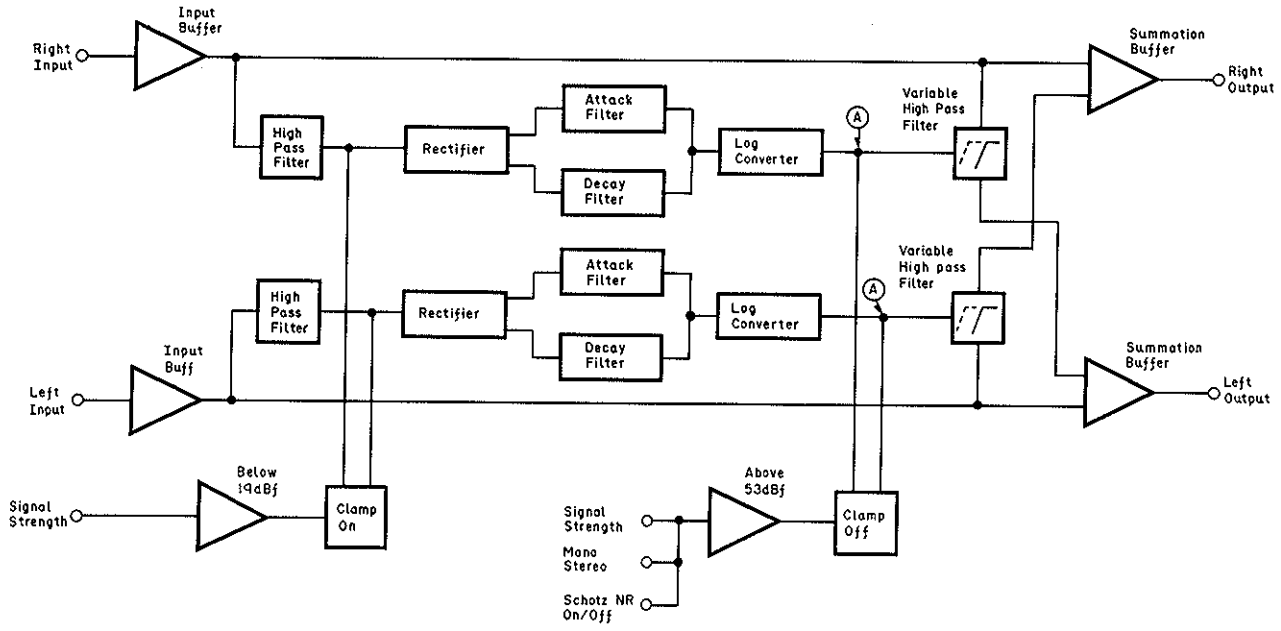

Fig. 14

(3) Conditions for Schotz NR OFF state

The Schotz NR system is OFF in any of the following conditions.

(a) The Schotz NR switch if OFF:
+15 V is applied to the base of emitter follower Q309 through R393 and D310. As a result, Q311 turns ON, and pins 1 and 16 of IC308 (LM13600) are grounded via D317 and D316. On the other hand, Q329 and Q330 turn ON, and pins 1 and 16 of IC308 are shorted to pin 6 via Q330 and Q329, thereby turning OFF the Schotz NR system.

(b) Broadcasting is monaural, that is, the Mode switch is set to the Mono position:
+15 V is applied to the base of Q309 through R398 and D308. As in the case of (a) above, the Schotz NR system is turned OFF.

(c) Signal strength in stereo program is large enough (RF level is 53 dBf or more):
As the output of IC303-13 (FM signal strength) goes through D309 to the base of emitter follower Q309, Q311 turns ON if the signal strength is large enough. In this case, the Schotz NR system is turned OFF in the same manner as (a) above.

(d) Signal strength in stereo program is not large enough (RF level is 19 dBf or lower):
As the output of IC303-13 (FM signal strength) goes through D309 to the base of emitter follower Q309, Q310 changes from ON (normal state) to OFF if the signal strength is not large enough. Consequently, +15 V is applied to pins 1 and 16 of IC308 through D319 and D318. As a result, the Schotz NR system will operate as a high-blend circuit.

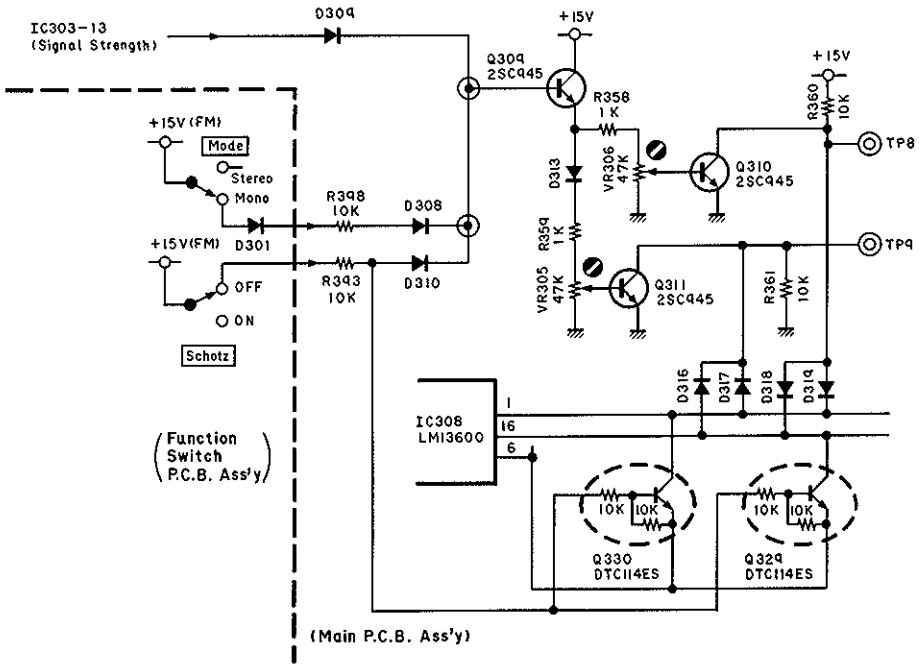

Fig. 15

- Schotz Noise Reduction manufactured under license from L.S. Research, Inc., U.S. and foreign patents pending.