Automatic-Tuning Principles and Circuit Description

(Refer to Figs. 10, 14 & 15)

I OUTLINE

The radio signal picked up by the ferrite core antenna is converted to a 455 kc/s IF signal by the converter. This IF signal is detected by Diode D_2 and becomes an audio signal that can be heard from the speaker after being amplified in the audio stage. This procedure is the same system as found in the usual super-heterodyne radio receiver.

In addition, the R-1030 includes an automatic-tuning circuit and mechanism. For automatic-tuning, the IF signal is taken out after the last IF Amp. stage and is used as a trigger signal to drive the tuning mechanism.

Figure 15 shows the tuning mechanism, consisting of the Relay, Drive Gears, Spring Motor and Tuning Capacitor. The function of the tuning mechanism and its relation to the trigger signal for automatic-tuning is as described below:

(a) Fully wind the Key clockwise. Turn on the volume control knob to power the radio.
Pressing the Automatic-Tuning button (either left or right) will energize the Relay and begin the automatic-tuning cycle.
After the Automatic-Tuning button (either left or right) is released, the Relay will remain energized, "shorting out" the audio stage of the radio and no sound will come from the speaker.

(b) Further, when the Relay is energized, the Lever connected to the Relay moves in the direction of the arrow (Fig. 15), in opposition to the force of the spring tension, and releases the Impeller.
The Impeller consists of four small blades which are held in position by the Lever plus two additional large blades that control the rotation speed of the Impeller by air resistance.

(c) The Impeller, through a series of gears, allows the Spring Motor to turn the Tuning Capacitor. The rotating speed of the Impeller enables the Tuning Capacitor to turn at a constant rate, providing for pinpoint station selection without error.

(d) The Tuning Capacitor continues to turn until it is tuned to a broadcasting signal. The incoming radio signal is converted to an IF signal, and this signal then passes through the Ceramic Filter and is applied to the trigger stage.

(e) The output of the Ceramic Filter is a very narrow band 455 kc/s signal, regardless of the strength of the incoming signal. The signal that has been amplified and detected in the trigger stage is then amplified by the DC Amp. and causes the Relay to open instantaneously.

(f) The Lever, which is no longer held by the Relay, returns to the Impeller (by spring tension) and causes the Impeller to stop rotating. At the same time, the Relay contacts open, removing the "short" across the audio stage.

(g) The Tuning Capacitor stops turning and the tuning and the tuning cycle has been completed.

II AUTOMATIC-TUNING CIRCUITS

When the Auto-Tuning button is pressed, Switch S_5 energizes the Relay by the connecting 2 & 6 contacts of S_5. As long as the Automatic-Tuning button is pressed, the audio stage and the automatic-tuning circuits will not function with the operation of relay, and the Tuning Capacitor will continue to turn, passing over all stations. Therefore, the user is advised, when tuning to a specific broadcasting station, to keep pressing the Automatic-Tuning button and release only when the dial approaches the desired station.

A. RELAY CIRCUIT

Relay Contacts S_5

Relay contacts S_5 are connected to the emitter of the Relay Control transistor (TR_{10}) through R_{30} and open or connect the emitter to the positive side of the battery, as shown in the schematic diagram.

Relay Contacts S_4

Relay contacts S_4 are connected in the emitter circuit of 1st IF Amp. (TR_2) circuit and open or shunt the Sensitivity switch (S_3) as follows:

(a) Relay Operation When Tuned to a broadcasting Signal

When the radio is tuned to a specific radio broadcasting signal, Relay contacts S_5 are open.

Relay Contacts S_5

Relay contacts S_5 open the emitter of the Relay Control transistor (TR_{10}) and disconnect the positive bias line from the Trigger Amp. (TR_8). The Trigger Amp. is not in use during the time the radio is tuned to a broadcasting signal.

Relay Contacts S_4

Relay contacts S_4 short the Sensitivity Switch (S_3) to the positive bias line in order for the radio receiver to obtain maximum gain, and the short across the audio stage is removed so that sound may be heard from the speaker.

(b) Relay Operation While Seeking a Broadcasting Signal

By pressing Automatic-Tuning button S_5, the Relay is energized and the Tuning Capacitor turns.

Relay Contacts S_5

Relay contacts S_5 connect the emitter of the Relay Control Transistor (TR_{10}) to positive bias line so that collector current flows through the Relay winding, causing Relay contacts (2-6 of S_5) to remain closed even after the Auto-Tuning button is released.

At the same time, the positive bias voltage from the battery is supplied to the Trigger Amplifier stage (TR_8).

Relay Contacts S_4

Relay contents S_4 shunt across the emitter bias resistor (R_{12}) of the 1st IF Amp., (TR_2) is opened and the IF gain is reduced because of the emitter bias change corresponding to the position (DX-L) of the Sensitivity Switch (S_3).

Sliding the Radar-Matic Sensitivity Switch to "L" causes the Tuning Capacitor to stop only on the strong signals, and moving the Sensitivity Switch to "DX" allows the Auto-Tuning to select all stations within normal reception range.

At the same time, the shunt across the emitter bias resistor (R_{12}) is opened, Relay Contacts S_4 connect the detector output of the detector diode (D_1) directly to the positive bias line, effectively preventing the audio from reaching the speaker during the time the Auto-Tuning circuit is seeking a station.

B. TRIGGER AMPLIFIER CIRCUIT

In the Trigger Amplifier (TR_8) circuit, the IF signal that has been taken from the IF Amp. stage is fed to the Ceramic Filter (T_4) which has high selectivity characteristics, and then amplified as a very sharp, narrow band trigger signal. This controls the Relay (through the Relay Control Transistor TR_{10}) after passing through the Trigger Detector (D_2) and the DC Amplifier (TR_9).

When trigger signal is applied to DC Amplifier (TR_9) the collector current of DC Amplifiers increases.

C. TRIGGER DETECTION AND RELAY CONTROL CIRCUIT

While seeking a broadcasting signal, the Relay operation continues to allow the Tuning Capacitor to be driven by the mechanism of the Spring Motor.

When the broadcasting signal is received by the radio, the 455 kc/s IF signal is fed through the Ceramic Filter (T_4) Trigger Amp. (TR_8), Trigger Detector (D_2) and then amplified by the DC Amp. (TR_9) causing the Relay Control Transistor (TR_{10}) to de-energize the Relay instantaneously. The Lever will then return to its normal position preventing the Impeller from turning, which stops further rotation of the Gears and Spring Motor.

In this manner, the radio receiver is automatically tuned to a broadcasting signal.

During the time the radio is receiving a broadcasting signal, the emitter of the Relay Control Transistor (TR_{10}) is open and no current flows to its collector. Also, the trigger signal is not amplified in the Trigger Amp. (TR_8) stage because of the open of the Relay Control Transistor which prevents the bias voltage from being supplied to the trigger stage.

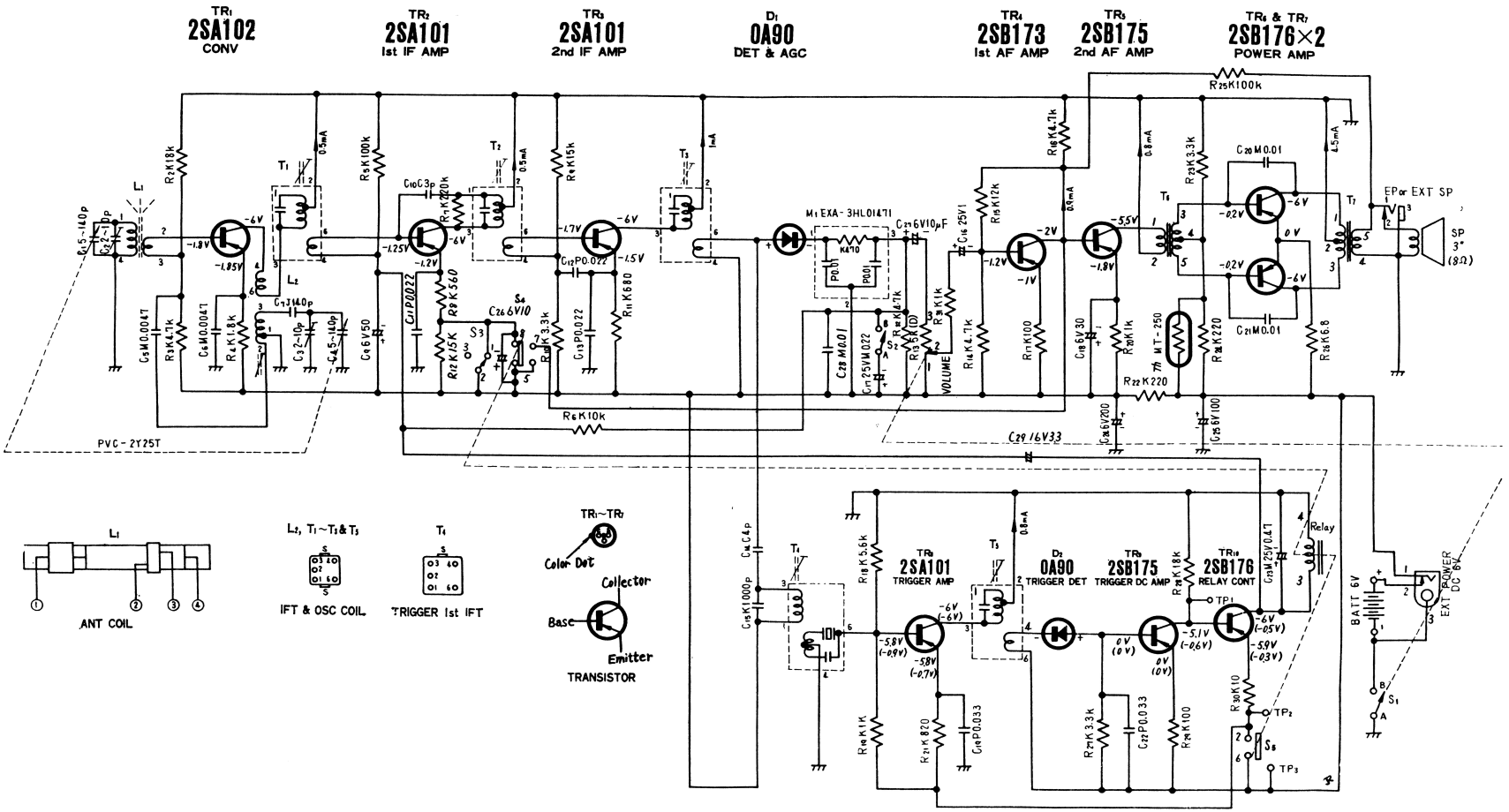
Very little collector current flows in the DC Amp. (TR_9) during the time a broadcasting signal is being received. Therefore, the Relay will not operate while the radio is tuned to a signal, nor will de-tuning occur because of noise pick-up.

(a) By pressing the Automatic-Tuning button the Relay is energized which, in turn, causes the Tuning Capacitor to be moved away from the tuned position.
Even though the base and emitter of the Trigger Amp. (TR_8) are now connected to positive bias line, there will be negligible current flow in the DC Amp. (TR_9) because there is no trigger signal when the Tuning Capacitor is in the de-tuned position.
Without the trigger signal, deep forward base bias voltage is supplied to the Relay Control Transistor (TR_{10}), causing a large flow through TR_{10} and the Relay which then keeps the Relay contacts S_5 closed, allowing the Tuning Capacitor to continue tuning.

(b) As soon as the Tuning Capacitor picks up a broadcasting signal, the resultant 455 kc/s IF is fed into the Trigger Amp. (TR_8) through the Ceramic Filter (T_4) and detected by diode (D_2) which causes a current flow in the DC Amp. (TR_9).

(c) The collector current that flows in the DC Amp. (TR_9) causes a voltage drop across the resistors (R_{28}) changing the base bias voltage of the Relay Control Transistor (TR_{10}) to almost zero. The Relay is then de-energized because of the drop in current through (TR_{10}) and the Relay windings.

(d) The Tuning Capacitor comes to a complete stop and the automatic-tuning cycle is completed.



Notes:

1. S_1: Power source switch in "OFF" position.
2. S_2: Tone switch in "HIGH" position.
3. S_3: Radar-Matic sensitivity switch in "DX" position.
4. $S_{4,5}$: Relay contacts in "Receiving" position.
5. Relay operations may stop when the battery voltage drops 3.5 volts or less.
6. DC Voltage measurements are taken with circuit tester 10KΩ/Volt from positive terminal of battery.
   TR8~TR10..... ☐ When Seeking Signal.
7. Capital letters (J,K,M,P,C,D) in the circuit diagram show allowable tolerances of resistors and capacitors as follows:
   J=±5% K=±10% M=±20% P=+100% − 0%
   C=±0.25PF D=±0.5PF
8. PF=pico farad=mmf
   μF=micro farad=mfd
9. Battery current: No Signal.....12mA
   Maximum Output.....95mA
   Seeking signal.....45mA
10. All resistor values in ohms (K=1000Ω).
11. All capacitor values in micro farads (P=mmf).

Fig. 10 Schematic Diagram

NATIONAL PANASONIC
Service Manual

RADAR-MATIC AUTO-TUNING 10-TRANSISTOR PORTABLE RADIO

MODEL R-1030

SPECIFICATIONS

Frequency Range:	525~1605 kc/s (571~187 m)	
Intermediate Frequency:	455 kc/s	
Transistors:	2SA102	Converter
	2SA101	1st IF Amplifier
	2SA101	2nd IF Amplifier
	2SB173	1st AF Amplifier
	2SB175	2nd AF Amplifier
	2SB176 / 2SB176	Power Amplifier (push-pull)
	2SA101	Trigger Amplifier
	2SB175	Trigger DC Amplifier
	2SB176	Relay Control
Diodes:	O A 9 0	Detector & AGC
	O A 9 0	Trigger Detector
Sensitivity:	70μV/m	for 50mW Output
Power Output:	200mW	Undistorted
	350mW	Maximum
Batteries:	6V (Four "AA" Size Penlight Batteries) (NATIONAL UM-3 or equivalent)	
Speaker:	8cm (3") PM Dynamic Speaker, 8Ω	
Cabinet Dimensions:	206(Wide)×120(High)×49(Deep)mm (8 1/8"×4 23/32"×1 15/16")	
Weight:	930 g. (2 lb. 1 oz.) with batteries	

To Remove Auto-Tuning Mechanism Unit
(Refer to Figs. 3~5)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
2. Cut dial cord.
3. Remove two (2) relay and relay cover mounting screws, Nos. 1~2, as illustrated in Fig. 3.
4. Remove two (2) auto-tuning mechanism unit mounting screws, Nos. 1 & 3, as illustrated in Fig. 4.
5. Unsolder leadwires, Nos. ①~④, to tuning gang, as illustrated in Fig. 5.
6. To reassemble, reverse the above procedures, noting the following:
   (A) When stringing dial cord, refer to dial cord stringing instructions on page 4.
   (B) After mounting relay, adjust Lever Adjusting Screw (Fig. 3 of page 3).

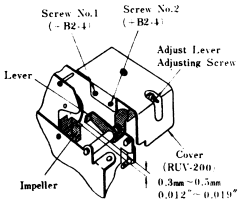


Fig. 3

To Remove Relay (Refer to Figs. 3 & 6)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
2. Remove two (2) relay and relay cover mounting screws, Nos. 1~2, as illustrated in Fig. 3.
3. Unsolder leadwires to relay (Nos. ①~⑦) as illustrated in Fig. 6.
4. To reassemble, reverse the above procedures, noting the following:
   After mounting relay, adjust Lever Adjusting screw (Fig. 3 of page 3).

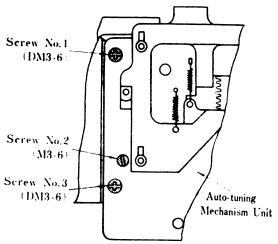


Fig. 4

To Adjust Lever Adjusting Screw

1. Wind the spring with the key (2 or 3 turns clockwise).
2. Turn on the power source switch and operate relay by pressing auto-tuning button.
3. Adjust Lever Screw so that air gap between impeller and lever becomes 0.3 mm~0.5 mm (0.012"~0.019") as illustrated in Fig. 3.
4. Cement Lever Adjusting Screw.

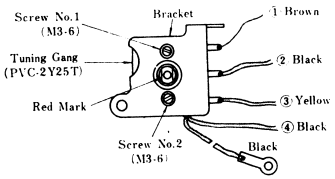


Fig. 5

To Remove Tuning Gang
(Refer to Figs. 4, 5, 7 & 8)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
2. Remove relay from auto-tuning mechanism unit in accordance with Relay Removal Instructions.
3. Remove tuning gear mounting screw, No. 1, as illustrated in Fig. 7.
4. Remove tuning gang bracket mounting screw, No. 2, as illustrated in Fig. 4.
5. Remove tuning gang bracket mounting screw, No. 2, as illustrated in Fig. 7.
6. Unsolder leadwires to tuning gang, (Nos. ①~④) as illustrated in Fig. 5.
7. Remove two (2) tuning gang mounting screws, Nos. 1~2, as illustrated in Fig. 5.
8. To reassemble, reverse the above procedures, noting the following:
   To mount tuning gear for tuning gang:
   (1) Set dial pointer to "10" of the dial scale.
   (2) Set tuning gang shaft so that red mark appears as illustrated in Fig. 5.
   (3) Insert gear to the shaft of tuning gang after setting protuberance of the gear to starting point of the bracket, as illustrated in Fig. 8.

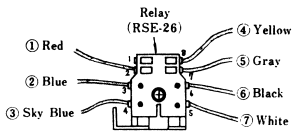


Fig. 6

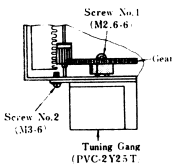


Fig. 7

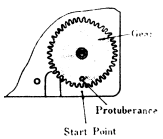


Fig. 8

Automatic-Tuning Principles and Circuit Description

(Refer to Figs. 10, 14 & 15)

I OUTLINE

The radio signal picked up by the ferrite core antenna is converted to a 455 kc/s IF signal by the converter. This IF signal is detected by Diode D_2 and becomes an audio signal that can be heard from the speaker after being amplified in the audio stage. This procedure is the same system as found in the usual super-heterodyne radio receiver.

In addition, the R-1030 includes an automatic-tuning circuit and mechanism. For automatic-tuning, the IF signal is taken out after the last IF Amp. stage and is used as a trigger signal to drive the tuning mechanism.

Figure 15 shows the tuning mechanism, consisting of the Relay, Drive Gears, Spring Motor and Tuning Capacitor. The function of the tuning mechanism and its relation to the trigger signal for automatic-tuning is as described below:

(a) Fully wind the Key clockwise. Turn on the volume control knob to power the radio.
Pressing the Automatic-Tuning button (either left or right) will energize the Relay and begin the automatic-tuning cycle.
After the Automatic-Tuning button (either left or right) is released, the Relay will remain energized, "shorting out" the audio stage of the radio and no sound will come from the speaker.

(b) Further, when the Relay is energized, the Lever connected to the Relay moves in the direction of the arrow (Fig. 15), in opposition to the force of the spring tension, and releases the Impeller.
The Impeller consists of four small blades which are held in position by the Lever plus two additional large blades that control the rotation speed of the Impeller by air resistance.

(c) The Impeller, through a series of gears, allows the Spring Motor to turn the Tuning Capacitor. The rotating speed of the Impeller enables the Tuning Capacitor to turn at a constant rate, providing for pinpoint station selection without error.

(d) The Tuning Capacitor continues to turn until it is tuned to a broadcasting signal. The incoming radio signal is converted to an IF signal, and this signal then passes through the Ceramic Filter and is applied to the trigger stage.

(e) The output of the Ceramic Filter is a very narrow band 455 kc/s signal, regardless of the strength of the incoming signal. The signal that has been amplified and detected in the trigger stage is then amplified by the DC Amp. and causes the Relay to open instantaneously.

(f) The Lever, which is no longer held by the Relay, returns to the Impeller (by spring tension) and causes the Impeller to stop rotating. At the same time, the Relay contacts open, removing the "short" across the audio stage.

(g) The Tuning Capacitor stops turning and the tuning and the tuning cycle has been completed.

II AUTOMATIC-TUNING CIRCUITS

When the Auto-Tuning button is pressed, Switch S_5 energizes the Relay by the connecting 2 & 6 contacts of S_5. As long as the Automatic-Tuning button is pressed, the audio stage and the automatic-tuning circuits will not function with the operation of relay, and the Tuning Capacitor will continue to turn, passing over all stations. Therefore, the user is advised, when tuning to a specific broadcasting station, to keep pressing the Automatic-Tuning button and release only when the dial approaches the desired station.

A. RELAY CIRCUIT

Relay Contacts S_5

Relay contacts S_5 are connected to the emitter of the Relay Control transistor (TR_{10}) through R_{30} and open or connect the emitter to the positive side of the battery, as shown in the schematic diagram.

Relay Contacts S_4

Relay contacts S_4 are connected in the emitter circuit of 1st IF Amp. (TR_2) circuit and open or shunt the Sensitivity switch (S_3) as follows:

(a) Relay Operation When Tuned to a broadcasting Signal

When the radio is tuned to a specific radio broadcasting signal, Relay contacts S_5 are open.

Relay Contacts S_5

Relay contacts S_5 open the emitter of the Relay Control transistor (TR_{10}) and disconnect the positive bias line from the Trigger Amp. (TR_8). The Trigger Amp. is not in use during the time the radio is tuned to a broadcasting signal.

Relay Contacts S_4

Relay contacts S_4 short the Sensitivity Switch (S_3) to the positive bias line in order for the radio receiver to obtain maximum gain, and the short across the audio stage is removed so that sound may be heard from the speaker.

(b) Relay Operation While Seeking a Broadcasting Signal

By pressing Automatic-Tuning button S_5, the Relay is energized and the Tuning Capacitor turns.

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Relay contacts S_5 connect the emitter of the Relay Control Transistor (TR_{10}) to positive bias line so that collector current flows through the Relay winding, causing Relay contacts (2-6 of S_5) to remain closed even after the Auto-Tuning button is released.

At the same time, the positive bias voltage from the battery is supplied to the Trigger Amplifier stage (TR_8).

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Relay contents S_4 shunt across the emitter bias resistor (R_{12}) of the 1st IF Amp., (TR_2) is opened and the IF gain is reduced because of the emitter bias change corresponding to the position (DX-L) of the Sensitivity Switch (S_3).

Sliding the Radar-Matic Sensitivity Switch to "L" causes the Tuning Capacitor to stop only on the strong signals, and moving the Sensitivity Switch to "DX" allows the Auto-Tuning to select all stations within normal reception range.

At the same time, the shunt across the emitter bias resistor (R_{12}) is opened, Relay Contacts S_4 connect the detector output of the detector diode (D_1) directly to the positive bias line, effectively preventing the audio from reaching the speaker during the time the Auto-Tuning circuit is seeking a station.

B. TRIGGER AMPLIFIER CIRCUIT

In the Trigger Amplifier (TR_8) circuit, the IF signal that has been taken from the IF Amp. stage is fed to the Ceramic Filter (T_4) which has high selectivity characteristics, and then amplified as a very sharp, narrow band trigger signal. This controls the Relay (through the Relay Control Transistor TR_{10}) after passing through the Trigger Detector (D_2) and the DC Amplifier (TR_9).

When trigger signal is applied to DC Amplifier (TR_9) the collector current of DC Amplifiers increases.

C. TRIGGER DETECTION AND RELAY CONTROL CIRCUIT

While seeking a broadcasting signal, the Relay operation continues to allow the Tuning Capacitor to be driven by the mechanism of the Spring Motor.

When the broadcasting signal is received by the radio, the 455 kc/s IF signal is fed through the Ceramic Filter (T_4) Trigger Amp. (TR_8), Trigger Detector (D_2) and then amplified by the DC Amp. (TR_9) causing the Relay Control Transistor (TR_{10}) to de-energize the Relay instantaneously. The Lever will then return to its normal position preventing the Impeller from turning, which stops further rotation of the Gears and Spring Motor.

In this manner, the radio receiver is automatically tuned to a broadcasting signal.

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Very little collector current flows in the DC Amp. (TR_9) during the time a broadcasting signal is being received. Therefore, the Relay will not operate while the radio is tuned to a signal, nor will de-tuning occur because of noise pick-up.

(a) By pressing the Automatic-Tuning button the Relay is energized which, in turn, causes the Tuning Capacitor to be moved away from the tuned position.

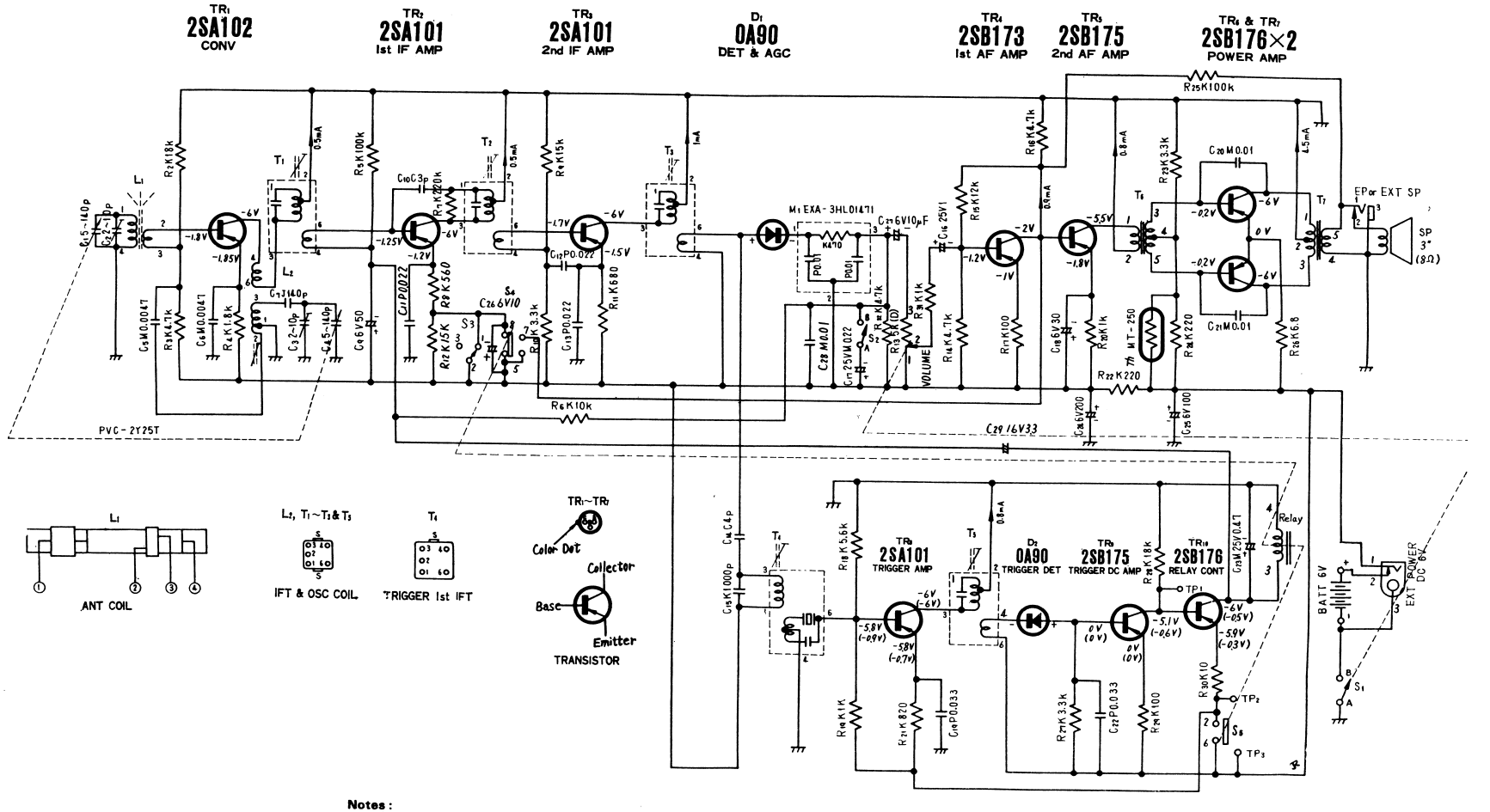
Even though the base and emitter of the Trigger Amp. (TR_8) are now connected to positive bias line, there will be negligible current flow in the DC Amp. (TR_9) because there is no trigger signal when the Tuning Capacitor is in the de-tuned position.

Without the trigger signal, deep forward base bias voltage is supplied to the Relay Control Transistor (TR_{10}), causing a large flow through TR_{10} and the Relay which then keeps the Relay contacts S_5 closed, allowing the Tuning Capacitor to continue tuning.

(b) As soon as the Tuning Capacitor picks up a broadcasting signal, the resultant 455 kc/s IF is fed into the Trigger Amp. (TR_8) through the Ceramic Filter (T_4) and detected by diode (D_2) which causes a current flow in the DC Amp. (TR_9).

(c) The collector current that flows in the DC Amp. (TR_9) causes a voltage drop across the resistors (R_{28}) changing the base bias voltage of the Relay Control Transistor (TR_{10}) to almost zero. The Relay is then de-energized because of the drop in current through (TR_{10}) and the Relay windings.

(d) The Tuning Capacitor comes to a complete stop and the automatic-tuning cycle is completed.



Notes:

1. S1: Power source switch in "OFF" position.
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3. S3: Radar-Matic sensitivity switch in "DX" position.
4. S4, 5: Relay contacts in "Receiving" position.
5. Relay operations may stop when the battery voltage drops 3.5 volts or less.
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   TR8~TR10..... ▭ When Seeking Signal.
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Fig. 10 Schematic Diagram

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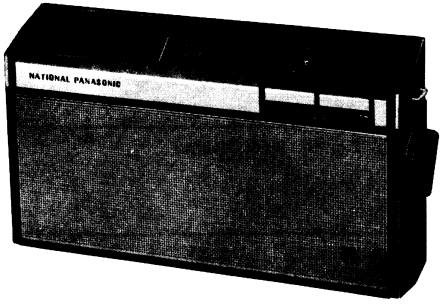
Service Manual

RADAR-MATIC AUTO-TUNING 10-TRANSISTOR PORTABLE RADIO

MODEL R-1030



SPECIFICATIONS

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	2SB175	2nd AF Amplifier
	2SB176 / 2SB176	Power Amplifier (push-pull)
	2SA101	Trigger Amplifier
	2SB175	Trigger DC Amplifier
	2SB176	Relay Control
Diodes:	O A 9 0	Detector & AGC
	O A 9 0	Trigger Detector
Sensitivity:	70μV/m for 50mW Output	
Power Output:	200mW	Undistorted
	350mW	Maximum
Batteries:	6V (Four "AA" Size Penlight Batteries) (NATIONAL UM-3 or equivalent)	
Speaker:	8cm (3") PM Dynamic Speaker, 8Ω	
Cabinet Dimensions:	206(Wide)×120(High)×49(Deep)mm (8⅛"×4 23/32"×1 15/16")	
Weight:	930 g. (2 lb. 1 oz.) with batteries	

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(Refer to Figs. 3~5)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
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4. Remove two (2) auto-tuning mechanism unit mounting screws, Nos. 1 & 3, as illustrated in Fig. 4.
5. Unsolder leadwires, Nos. ①~④, to tuning gang, as illustrated in Fig. 5.
6. To reassemble, reverse the above procedures, noting the following:
   (A) When stringing dial cord, refer to dial cord stringing instructions on page 4.
   (B) After mounting relay, adjust Lever Adjusting Screw (Fig. 3 of page 3).

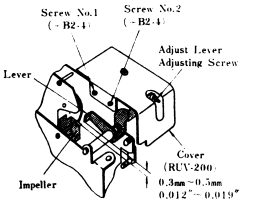

Fig. 3

To Remove Relay (Refer to Figs. 3 & 6)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
2. Remove two (2) relay and relay cover mounting screws, Nos. 1~2, as illustrated in Fig. 3.
3. Unsolder leadwires to relay (Nos. ①~⑦) as illustrated in Fig. 6.
4. To reassemble, reverse the above procedures, noting the following:
   After mounting relay, adjust Lever Adjusting screw (Fig. 3 of page 3).

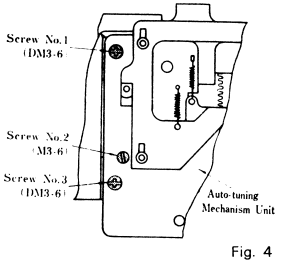

Fig. 4

To Adjust Lever Adjusting Screw

1. Wind the spring with the key (2 or 3 turns clockwise).
2. Turn on the power source switch and operate relay by pressing auto-tuning button.
3. Adjust Lever Screw so that air gap between impeller and lever becomes 0.3 mm~0.5 mm (0.012"~0.019") as illustrated in Fig. 3.
4. Cement Lever Adjusting Screw.

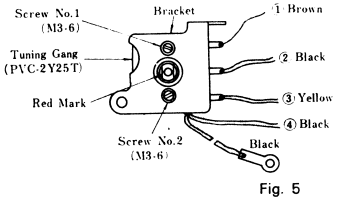

Fig. 5

To Remove Tuning Gang
(Refer to Figs. 4, 5, 7 & 8)

1. Remove chassis from cabinet in accordance with the Chassis Removal Instructions.
2. Remove relay from auto-tuning mechanism unit in accordance with Relay Removal Instructions.
3. Remove tuning gear mounting screw, No. 1, as illustrated in Fig. 7.
4. Remove tuning gang bracket mounting screw, No. 2, as illustrated in Fig. 4.
5. Remove tuning gang bracket mounting screw, No. 2, as illustrated in Fig. 7.
6. Unsolder leadwires to tuning gang, (Nos. ①~④) as illustrated in Fig. 5.
7. Remove two (2) tuning gang mounting screws, Nos. 1~2, as illustrated in Fig. 5.
8. To reassemble, reverse the above procedures, noting the following:
   To mount tuning gear for tuning gang:
   (1) Set dial pointer to "10" of the dial scale.
   (2) Set tuning gang shaft so that red mark appears as illustrated in Fig. 5.
   (3) Insert gear to the shaft of tuning gang after setting protuberance of the gear to starting point of the bracket, as illustrated in Fig. 8.

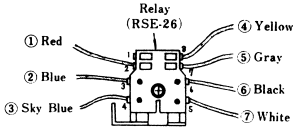

Fig. 6

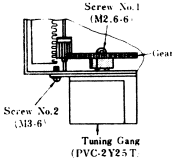

Fig. 7

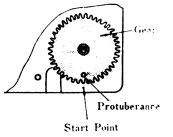

Fig. 8