

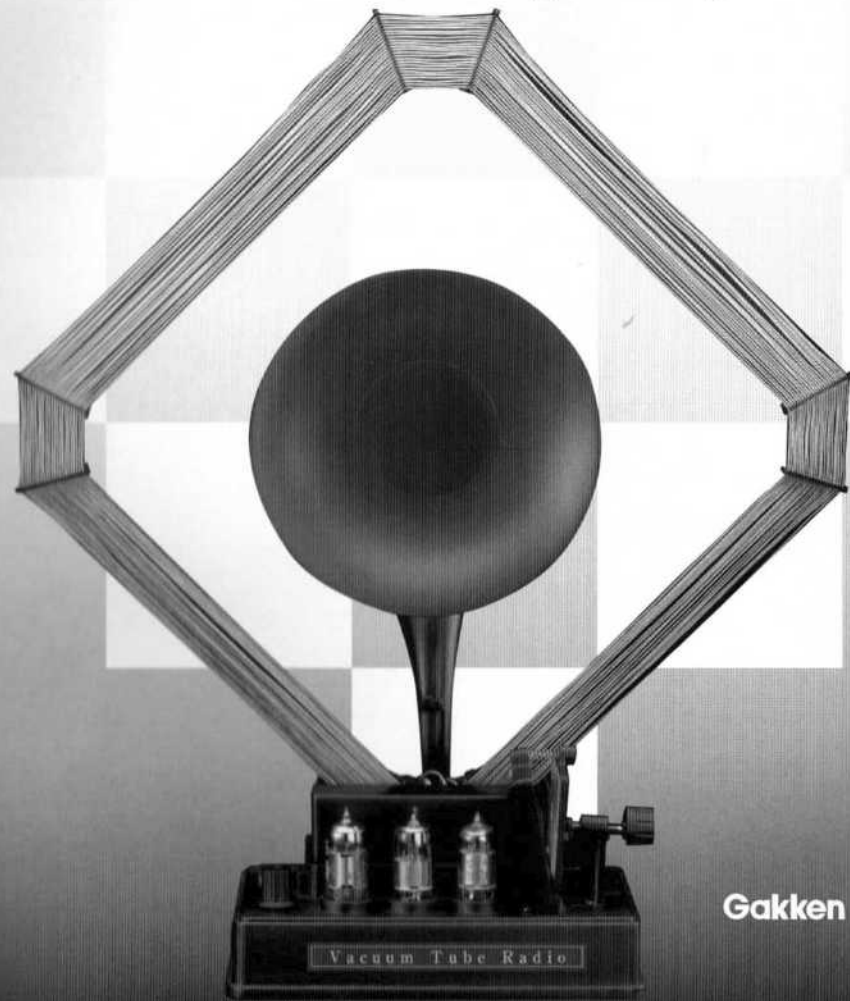
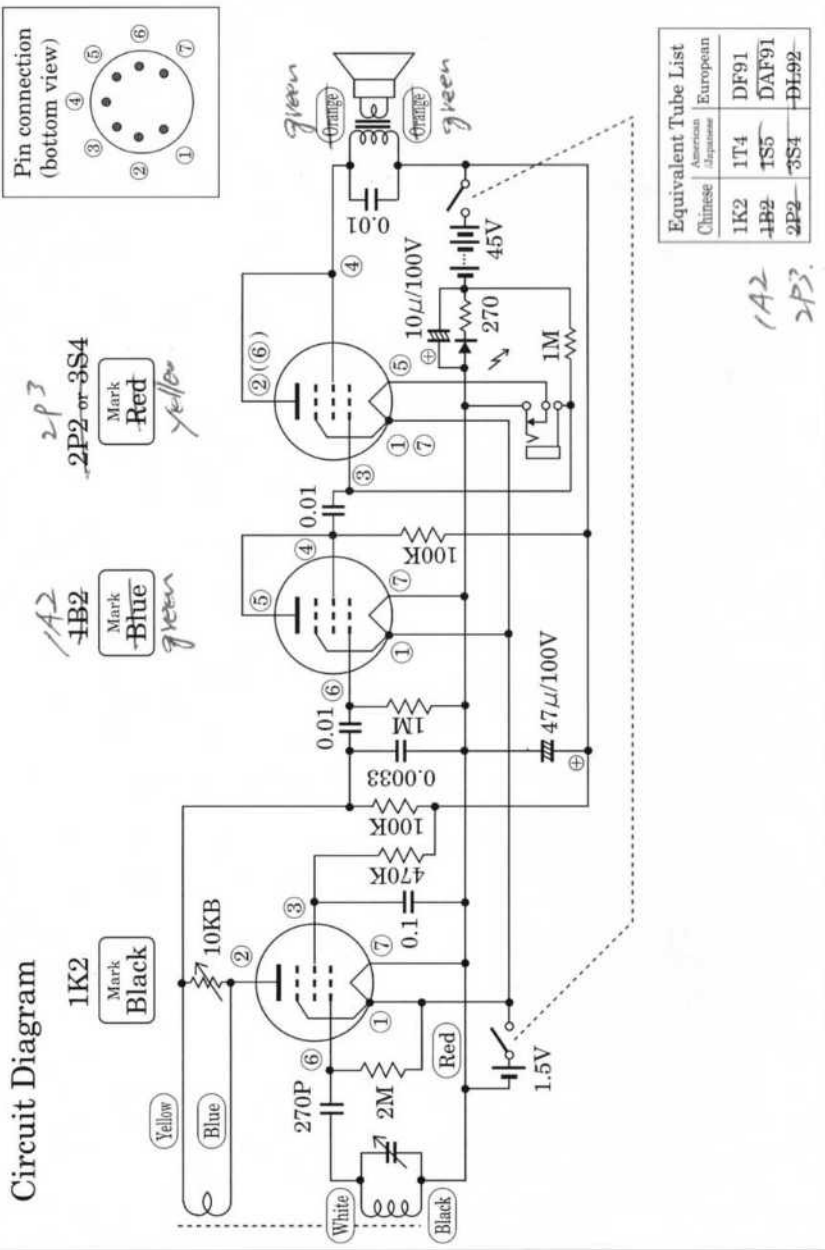
大人の科学 Otona no Kagaku  
The Sophisticated Science Kit for Adults

# Vacuum Tube Radio Kit

Ver. 2

Instructions for Assembling and Operation

Circuit Diagram



Gakken

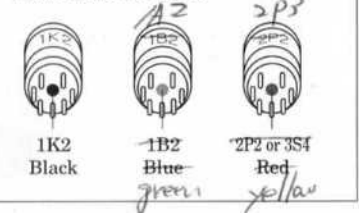
## Some notes before start assembling the radio kit.

### 1. Vacuum tubes used in this radio kit.

A. All vacuum tubes used in this radio kit are made in China. There may be dirty or print scratched tubes because they are manufactured more than thirty years ago. But they are electronically tested when making the kit. We do not accept replacing tubes because they are simply scratched and dirty. If the tube is not electronically functional, of course, we will replace it.

#### Identification of tube type

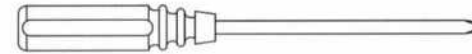
In case if tube names are not visible, identify tubes by color code painted in the bottom of tubes.



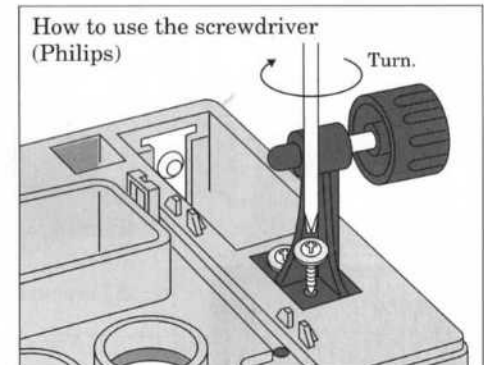
B. There are three different kind of tubes used in this kit. If you cannot read type of it, please refer to painted color code as shown in the figure.

C. Please handle tubes with extra care because it is made out of glass.

### 2. Screw driver.



A service screwdriver is used to tighten screws when assembling the kit. Self-tapping screws are used for fixing kit parts firmly. Please do not over tighten screws because it will damage plastic body.



### 3. Other parts to be purchased by your own expenses.

Five pieces of 006P, 9V dry cell batteries

One LR14 1.5V Alkaline battery

Scotch tape

Felt pen, oil base, black

Ruler,

Long nose pliers

\* Use of rechargeable battery such as nickel cadmium and Oxyride is not recommended. It may damage vacuum tubes.  
\* Please note that some illustrations of components shown in this manual are different from actual ones.

**Caution** \* Please read the following instructions carefully before start assembling the radio kit.

- \* Carefully handle vacuum tubes. It is glass made and you may cut your fingers if it breaks.
- \* Carefully handle thin and sharp metal parts. Improper use may cause injury.
- \* Tube top tip and litz wire ends are sharp. Please carefully handle it.
- \* There are some small parts used. Do not mistakenly swallow them. It may cause suffocation.
- \* This radios set may transmit radio signal to disturb nearby electronic equipment when tuning radio station. Please read tuning procedure described in page 19 carefully not producing excessive obstacle beat signal.

- \* The set use five 006P, 9V dry cell batteries and one LR14, 1.5V Alkaline battery. Wrong setting of batteries may cause troubles such as heat, leakage and explosion of battery cells.
- \* Do not use Oxyride battery for substituting LR14 Alkaline battery. It may burn filament of vacuum tubes.
- \* Do not use rechargeable battery for substituting LR14 Alkaline batteries. It may cause low voltage.
- \* Please make it sure that the polarity of battery is correctly set.
- \* If liquid from leaked battery gets in your eye, rinse the eye well and immediately consult with eye doctor. When liquid stick to skin or clothes, wash it up with plenty of water immediately.
- \* Remove batteries from the set if the set is not used for a long time.
- \* Please read carefully this manual before assembling the kit.
- \* Please follow instructions shown in this manual for safe assembling. Please do not use damaged parts.
- \* Keep this radio kit away from reach of small children.

\* Plastics used in this kit.

Body / speaker horn / antenna frame / screwdriver handle: ABS

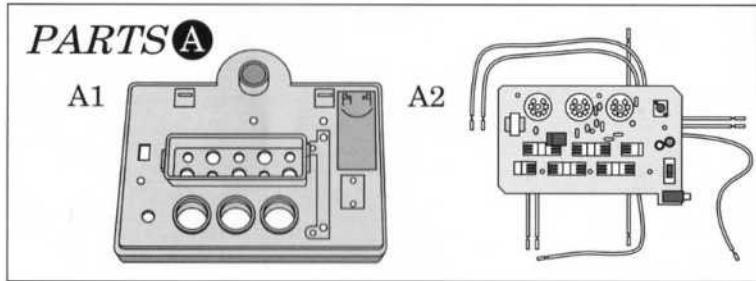
\* Lead wire insulator: vinyl chloride resin.

\* When disposing the kit, please follow the recycling rules set in your living area.

# Parts List Vacuum Tube

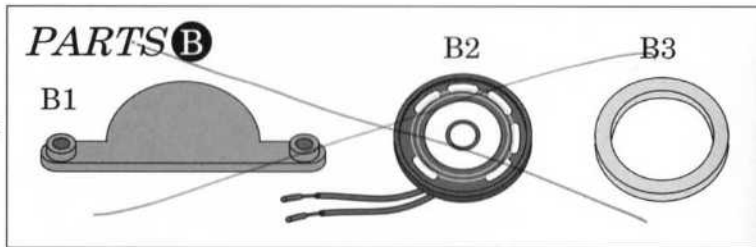
## PARTS A

A1/ main case  
A2/ printed circuit board, PCB



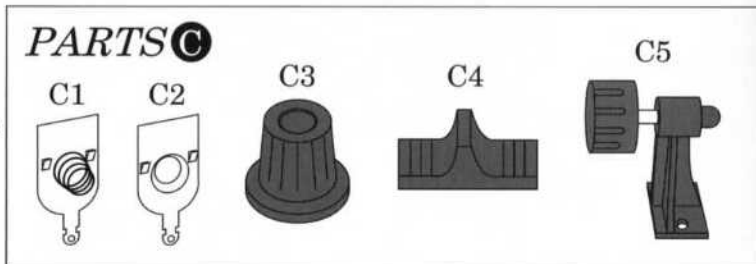
## PARTS B

B1/ speaker support  
B2/ a speaker unit  
B3/ speaker unit packing



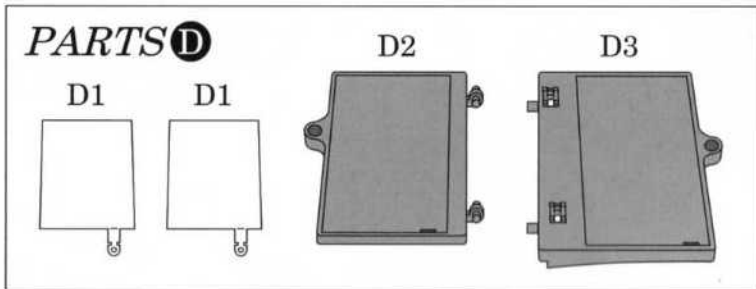
## PARTS C

C1/ battery terminal (-)  
C2/ battery terminal (+)  
C3/ knob for re-generative volume control  
C4/ power switch knob  
C5/ tuning knob



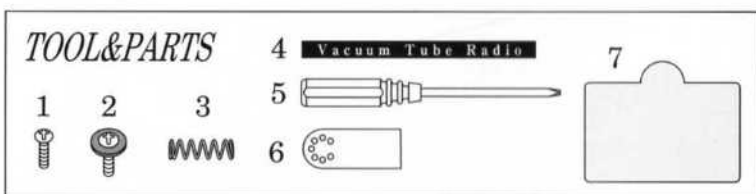
## PARTS D

D1/ aluminum sheet  
D2/ tuning capacitor case  
D3/ tuning capacitor base



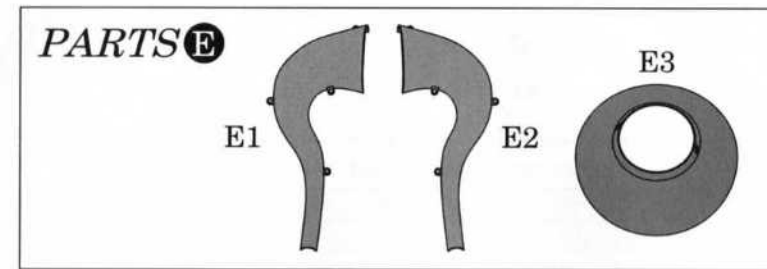
## TOOL&PARTS

1/ self-tapping screw  
2/ brim head self-tapping screw  
3/ spring  
4/ emblem seal  
5/ screw driver, Philips  
6/ vacuum tube pin alignment tool  
7/ hard board bottom cover



# Radio Kit

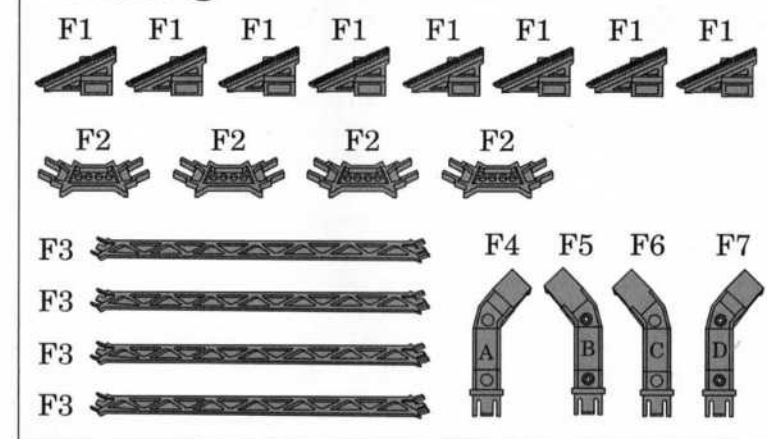
## PARTS E



## PARTS E

E1/ speaker cone, left  
E2/ speaker cone, right  
E3/ speaker funnel

## PARTS F



## PARTS F

F1/ guide for antenna wire (8 pieces)  
F2/ frame joints (4 pieces)  
F3/ frame pole (4 pieces)  
F4/ frame holder A  
F5/ frame holder B  
F6/ frame holder C  
F7/ frame holder D

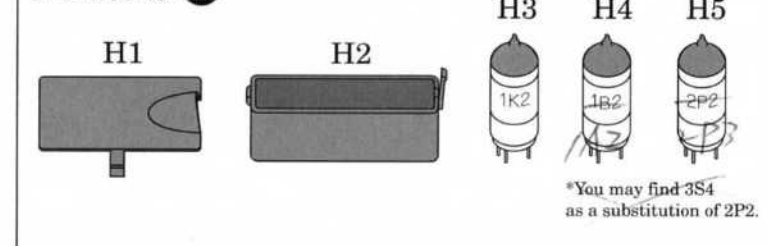
## PARTS G



## PARTS G

G1/ litz wire for antenna, long  
G2/ litz wire for re-generative circuit, short  
G3/ crystal earphone  
G4/ Mic unit

## PARTS H



## PARTS H

H1/ battery case cover  
H2/ battery case cover  
H3/ vacuum tube (1K2, marked black)  
H4/ vacuum tube (1B2, marked blue/green)  
H5/ vacuum tube (2P2 or 3S4, marked red)

\*You may find 3S4 as a substitution of 2P2.

Figure 4  
Installation of C3, knob for re-generative volume control and C4, on/off switch lever.

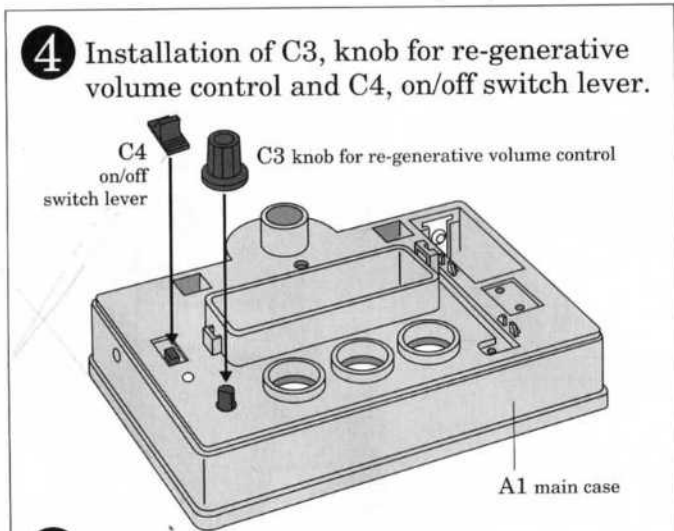


Figure 5  
Installation of C5, tuning knob using two brim head self-tapping screws.

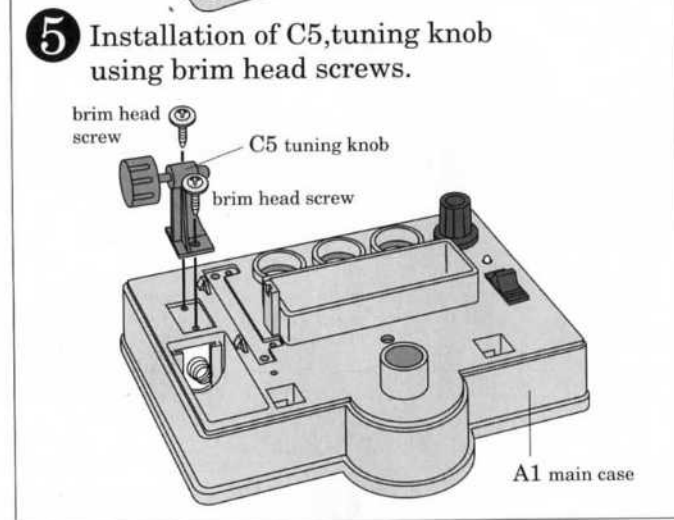


Figure 6  
Carefully peel off papers stick to aluminum sheets. Install them onto D2 tuning capacitor case and D3 base.

Remove plastic protection sheet on D2 by using Scotch tape as shown in Figure 6. (DO NOT remove plastic sheets from D3 base.)

How to remove plastic protection sheets

Use Scotch tape.



In case if D3 protection sheet come off or broken, use Scotch tape to make insulation. Please make center part of aluminum sheet open as shown in the Figure 7.

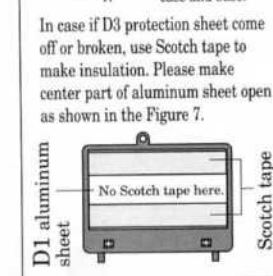
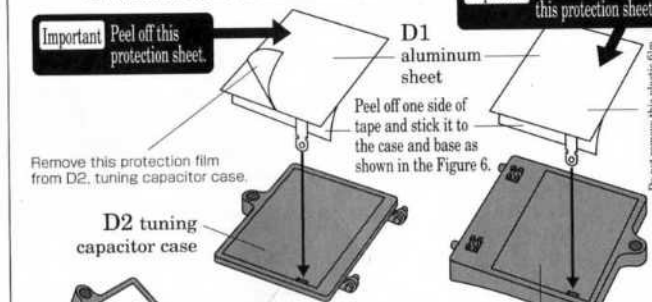


Figure 7  
Assemble D2 tuning capacitor case and D3 tuning capacitor base after attaching D1 aluminum sheets as shown in Figure 7.

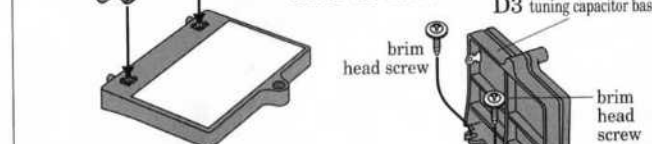
Figure 8  
Install assembled tuning capacitor onto the main case using two brim head screws shown in Figure 8.

Figure 9  
Turn C5 tuning knob counter-clockwise to make opening large. Install a spring when it is widely open as shown in Figure 9.

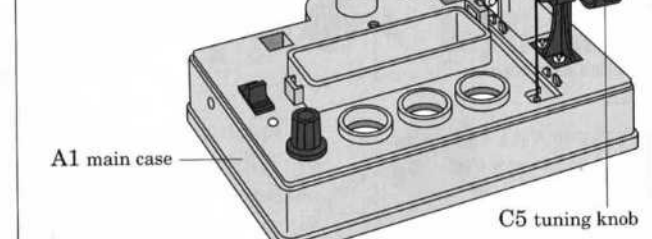
6 Assembling of D2 tuning capacitor case and D3 tuning capacitor base. Installation of two aluminum sheets.



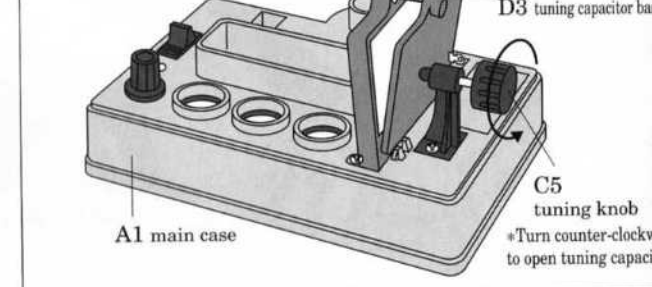
7 Set tuning capacitors face to face.



8 Install assembled tuning capacitor onto the A1 main case.

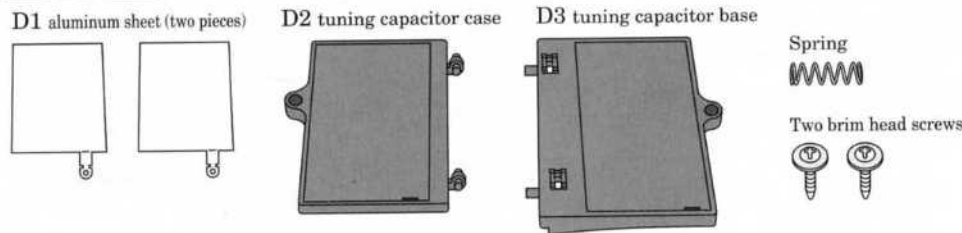


9 Installation of spring to tuning capacitor.



## 4 Construction of a Tuning Capacitor

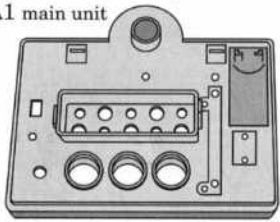
### Parts to be used PARTS D



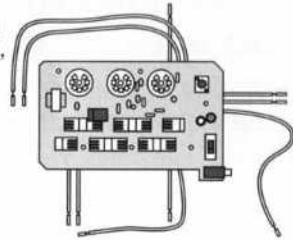
# 1 Installation of Printed Circuit Board, PCB

## Parts to be used PARTS A

A1 main unit



A2 printed circuit board, PCB



Self-tapping screws  
(7 pieces. You may find some extra screws in the package.)

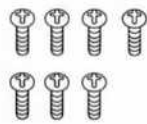
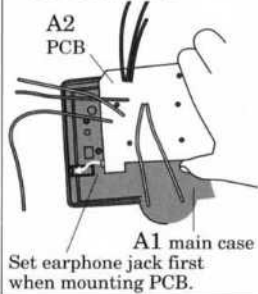


Figure 1

Make A1 main unit upside down. Install PCB to the main case as shown in the Figure 1. Please note that earphone jack must be inserted first to its assigned hole.

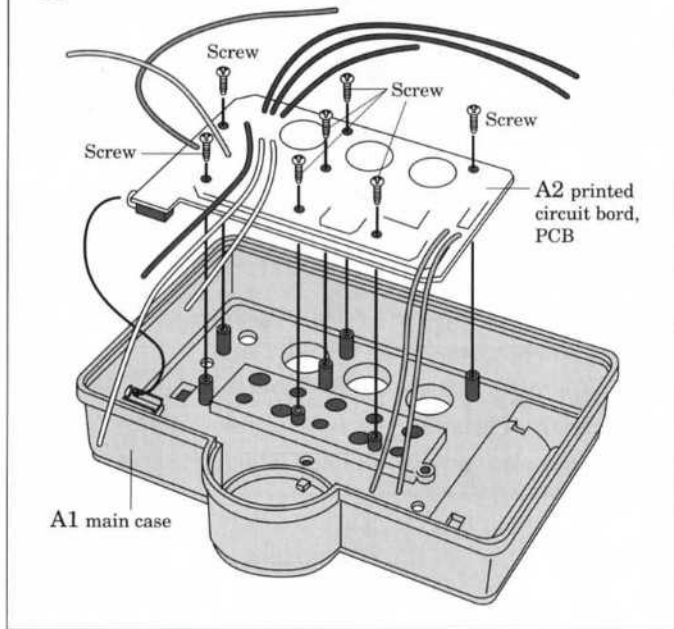
How to mount A2 PCB to A1 main case



Set earphone jack first when mounting PCB.

**Important** Tighten screws sufficiently so that A2 PCB is not floating in the main case.

## 1 Install A2 PCB to A1 main case.



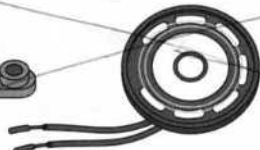
# 2 Speaker Unit Installation

## Parts to be used PARTS B

B1 speaker support



B2 speaker unit



B3 speaker unit packing



Screw (two pieces)

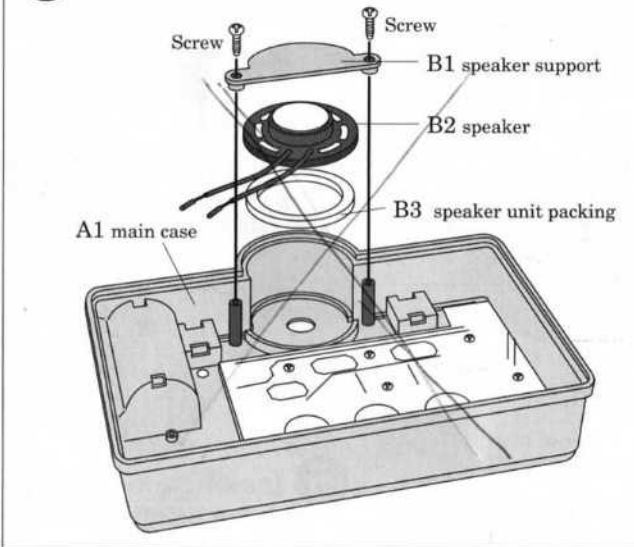


6

Figure 2

Set B3 speaker unit packing into A1, speaker hole, and install a speaker unit, B2. Use B1 a speaker support to fix a speaker to main case.

## 2 Speaker unit installation.



# 3 Setting up of Battery Contactors, On/Off Switch Lever, etc.

## Parts to be used PARTS C

C1

battery contactor (negative)



C2

battery contactor (positive)



C3

knob for re-generative volume control

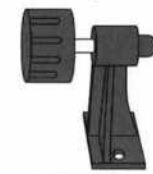


C4

on/off switch lever



C5 tuning knob



Two brim head screws

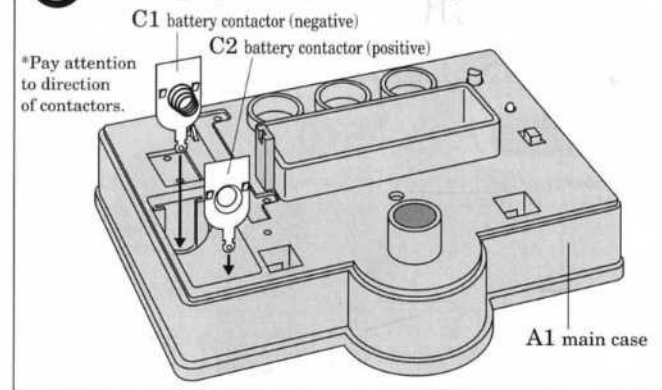


Figure 3

Install battery contactors C1, C2 in battery case as shown in Figure 3. Note polarity and direction of contactors. Use cloth when inserting sharp contactors to battery case.

\*No mistake in selection of positive and negative contactors.

## 3 Setting up of C1, C2 battery contactors.



7

Figure 14  
Assembling of antenna frame joints and poles. Mount properly to make a frame as shown in Figure 14. Mount poles firmly to the joints.

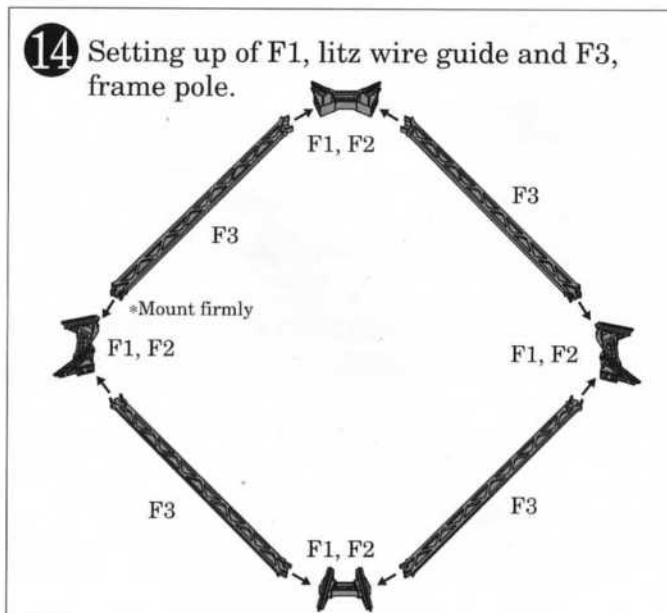
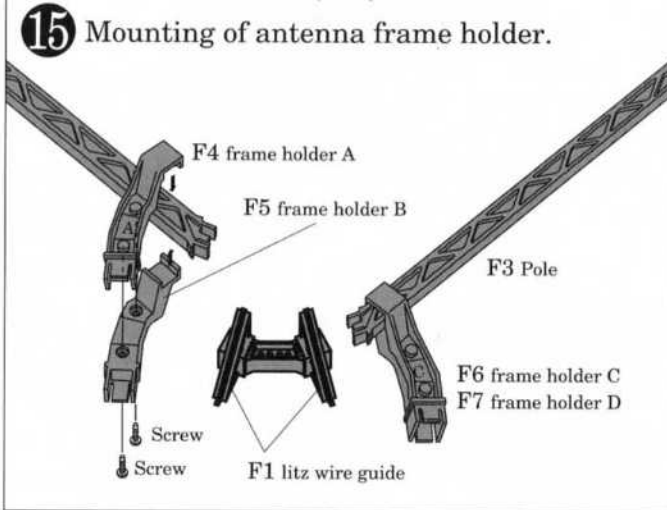


Figure 15  
Mounting of antenna frame holder.



## 7 Antenna and Re-generative Coil Winding

### Parts to be used PARTS G

G1 litz wire for antenna, long



G2 litz wire for re-generative circuit, short



15 Mounting of antenna frame holder.

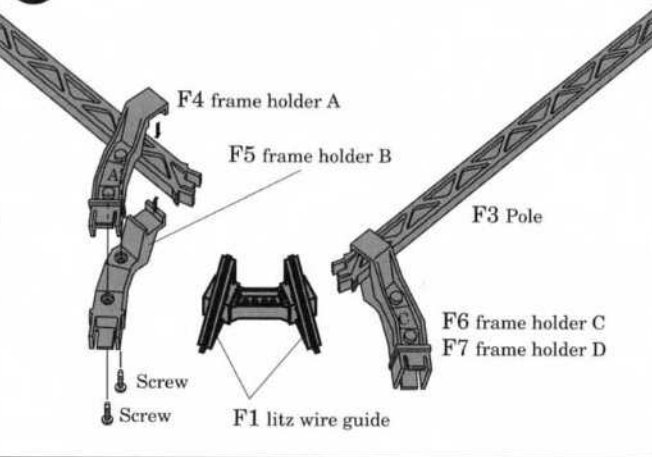


Figure 16  
Set long litz wires go through the most left holes of litz wire guide as shown in Figure 16. Cut lead wire 30cm from making two knots. Use a ruler to make 30cm lead.

Attention: Make it sure that the wire not to become tangled.

Figure 17  
Start winding of litz wire using most outer wire guide as shown in Figure 17. Wind nineteen (19) turns clockwise. Please make it sure that the wire is straight and sufficiently tight.

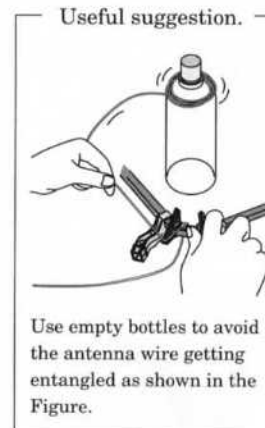
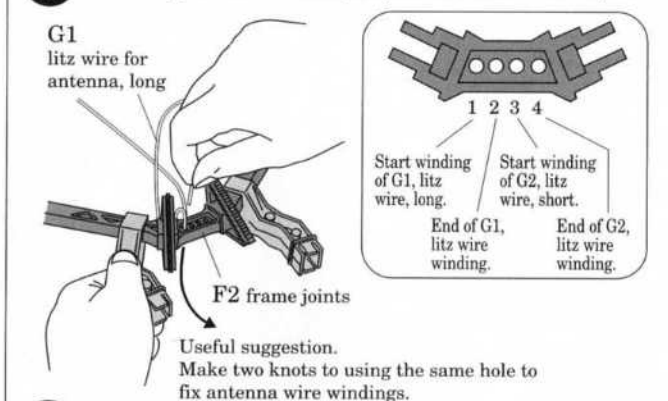
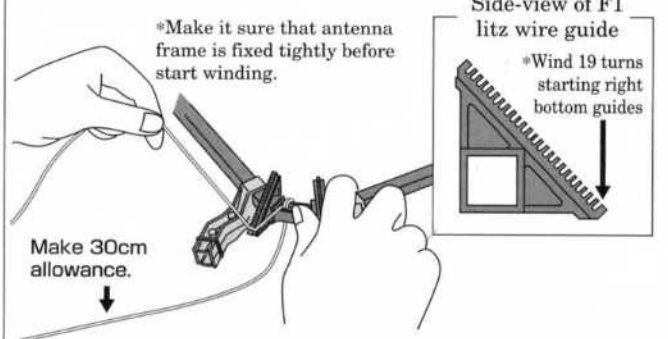


Figure 18  
After winding 19 turns, use hole #2 to terminate wire. Make two knots and make signs to indicate start and end of winding using oil base felt pen as shown in the Figure 18.

16 Winding antenna wire, G1, to antenna frame, F2.



17 Winding of antenna wire, G1, clockwise for 19 turns.



18 End of antenna wire, G1, winding.

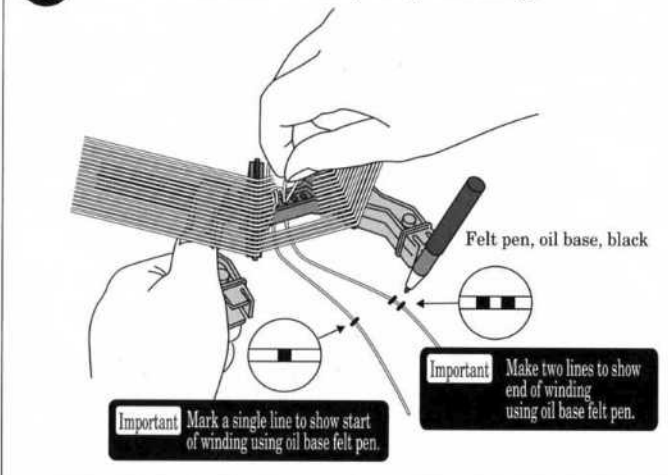
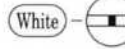
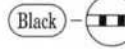
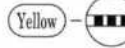
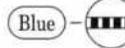


Figure 22

Connect remaining wires to litz wire from antenna.

-  White - Antenna coil (Marked with single line)
-  Black - Antenna coil (Marked with double lines)
-  Yellow - Re-generative coil (Marked with three lines)
-  Blue - Re-generative coil (Marked with four lines)

Insulate connecting joints by Scotch tape.

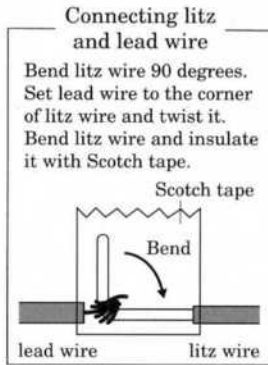
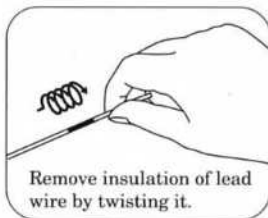
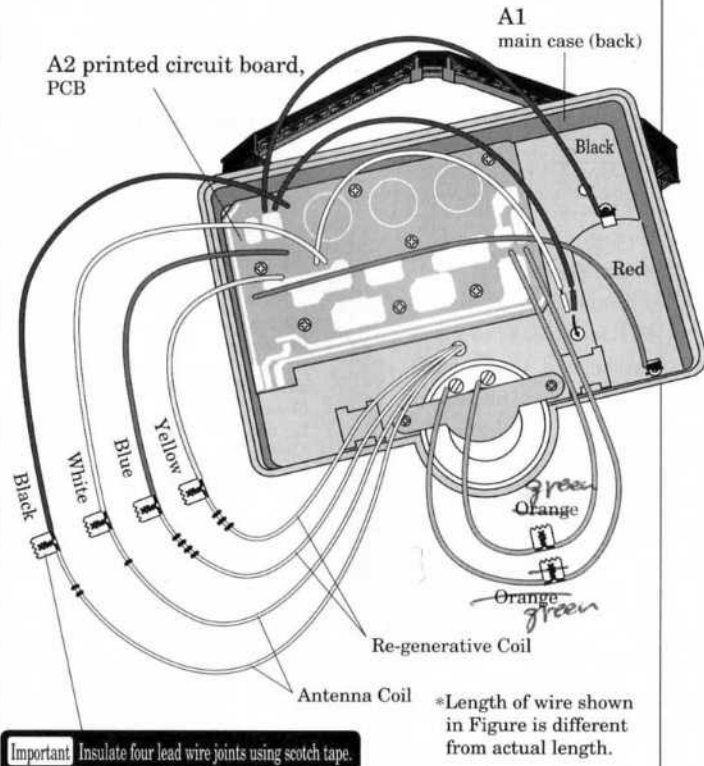


Figure 23

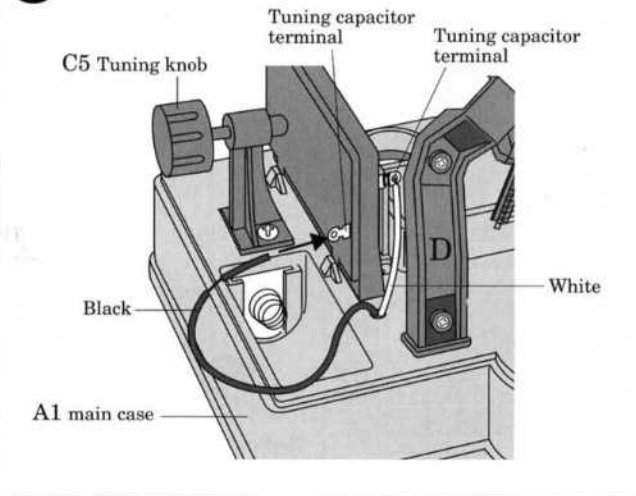
Make main case up and connect lead wires to tuning capacitors. Connect white wire up and black wire down.



22 Connection of antenna and re-generative coil.

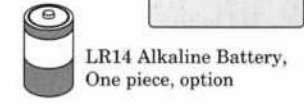
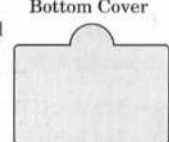
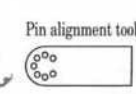
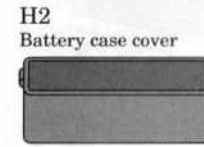
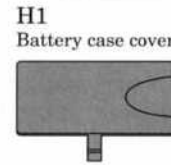


23 Connection of lead wires to tuning capacitor.



# 9 Setting Batteries and Tubes

## Parts to be used PARTS H



\*You may find 3S4 as substitution of 2P2.

006P Photo Batteries, Five pieces, option



Figure 24

Adjust straightness of vacuum tube pins using a pin alignment tool. Align if necessary.

24 Align vacuum tube pins using a pin alignment tool.

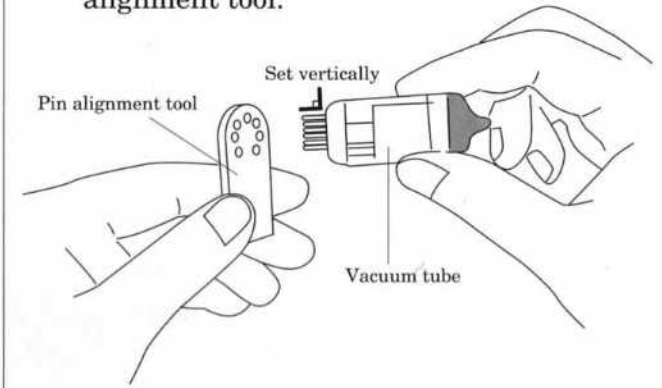
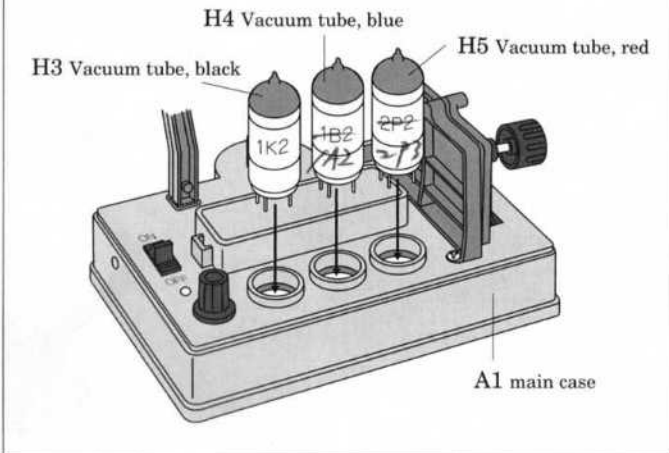
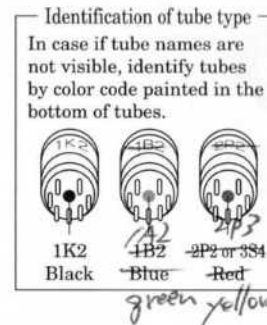


Figure 25

Set Vacuum tube onto A1 main case as shown in Figure 25.

\*Please do not make any mistake setting up the tubes.

25 Vacuum tube installation, H3, H4 and H5.



# 5 Construction of Speaker Horn

## Parts to be used PARTS E

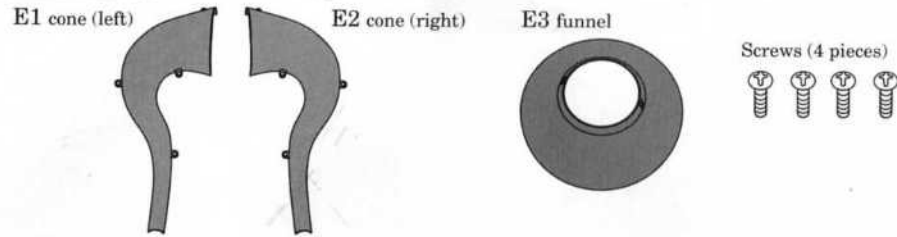
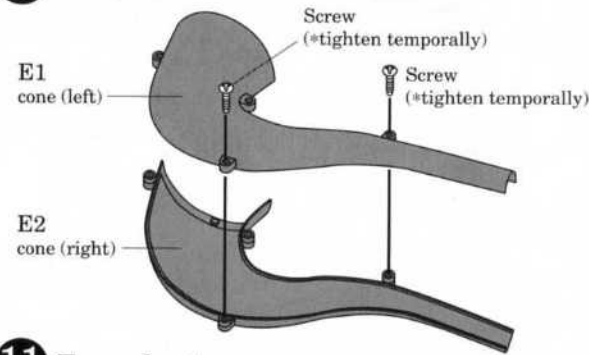


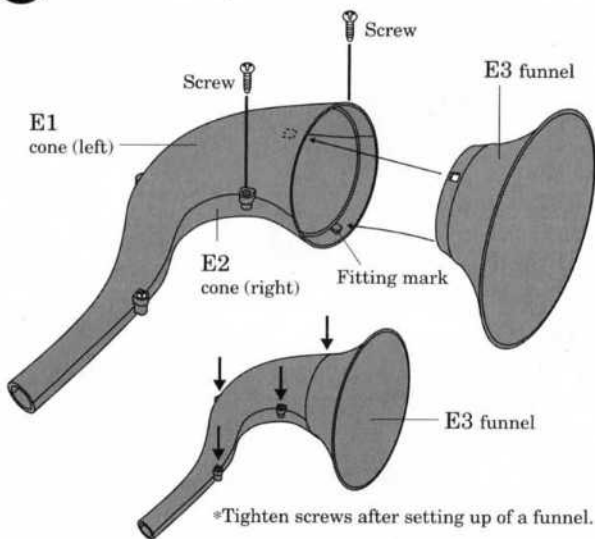
Figure 10 Set E1, E2 cones and screw them temporarily as shown in Figure 10.

Figure 11 Set E3 funnel onto temporarily screwed cones as shown in Figure 11. Tighten screws to fix hone properly.

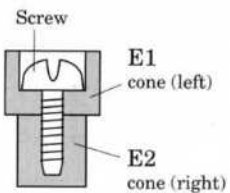
### 10 Construction of cones.



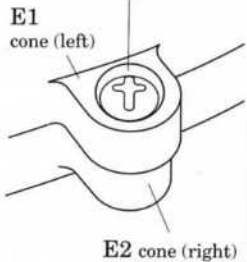
### 11 Funnel set up.



Side view of E1, E2 cones and screws.



Screw holes are designed for self-tapping screws. Tighten screws after setting up of a funnel.



# 6 Loop Antenna Frame Construction

## Parts to be used PARTS F

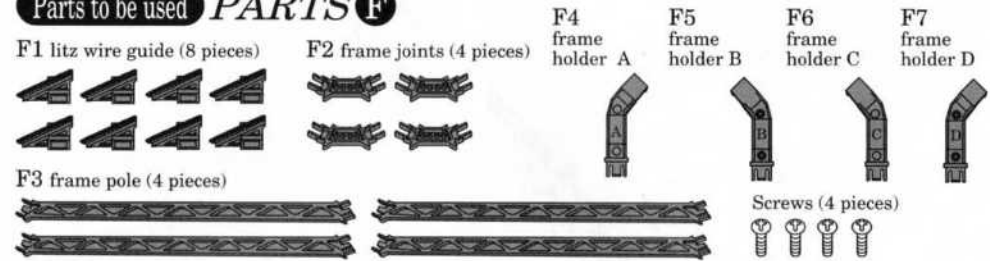


Figure 12 Set loop antenna frame parts temporarily to visualize construction of it as shown in Figure 12.

### 12 Set components temporarily as shown in the figure for parts confirmation.

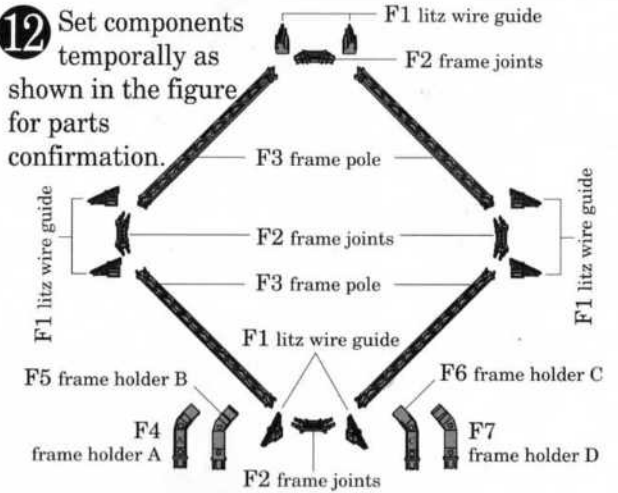
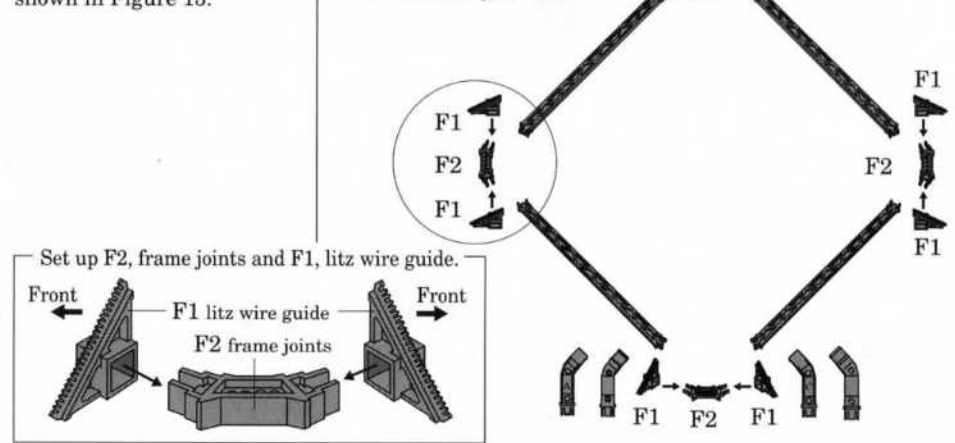


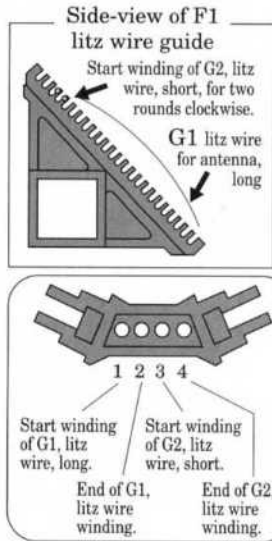
Figure 13 Assemble frames first as shown in Figure 13.

### 13 Assembling of frame joints.

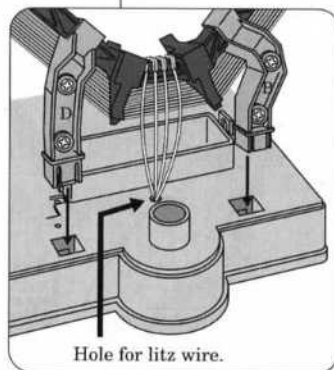




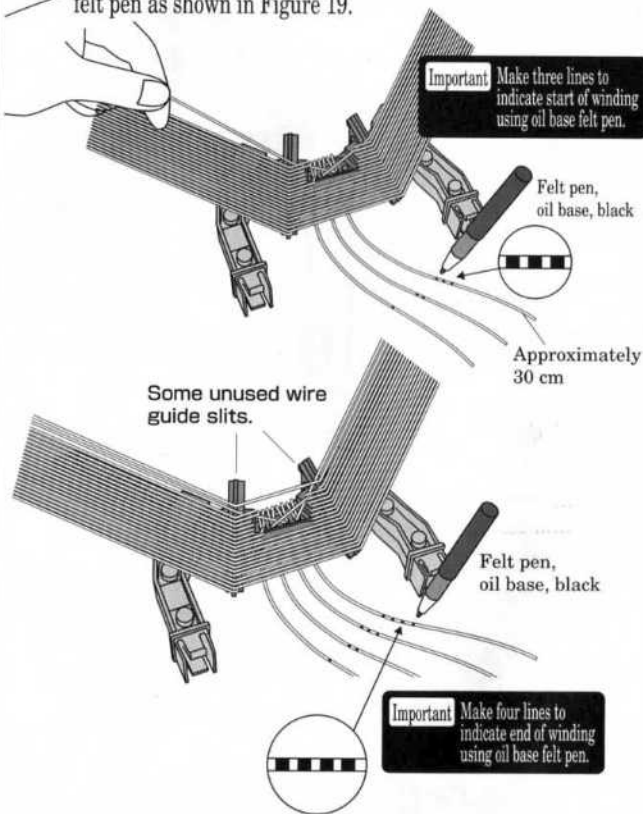
**Figure 19**  
Winding of G2, litz wire for re-generative, short. Use hole #3 and #4 of wire guide to start and end. Mark lines to indicate start and end of winding using oil base felt pen as shown in Figure 19.



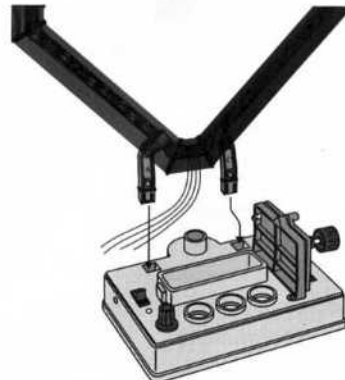
**Figure 20**  
Mount assembled loop antenna frame onto main case. Insert four wires from antenna before mounting frame onto main case.



**19** Winding of G2, litz wire for re-generative circuit, short. Use hole #3 and #4 of wire guide to start and end. Mark lines to indicate start and end of winding using oil base felt pen as shown in Figure 19.



**20** Mounting assembled antenna onto main case.



# 8 Wiring

**Figure 21**  
Connection of lead wires from A2, printed circuit board, PCB.

1. Set black and white wires (for tuning capacitors) go through a hole as shown in Figure 21.
2. Connect orange wires from PCB to orange wires from a speaker unit. Use Scotch tape to insulate connections.
3. Connect red wire to positive (+) of battery terminal, black (-) to negative battery terminal.

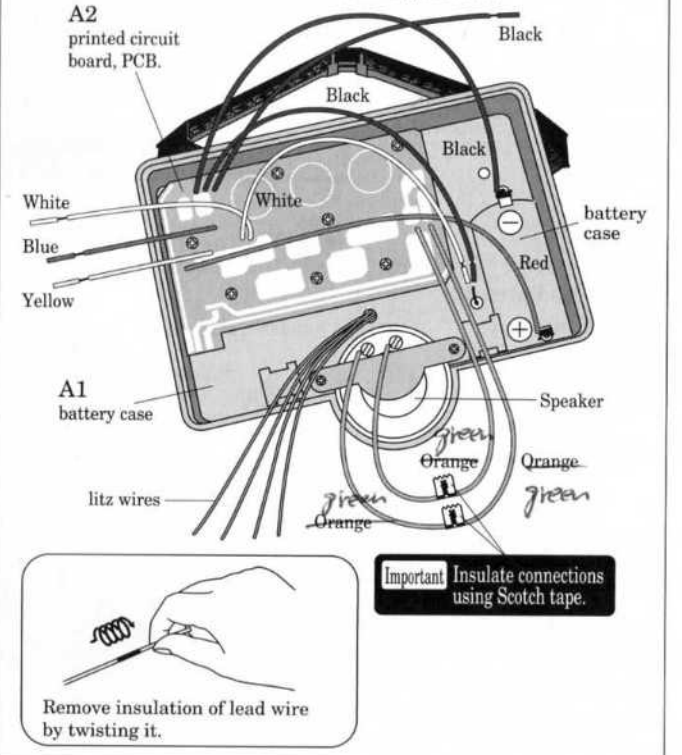
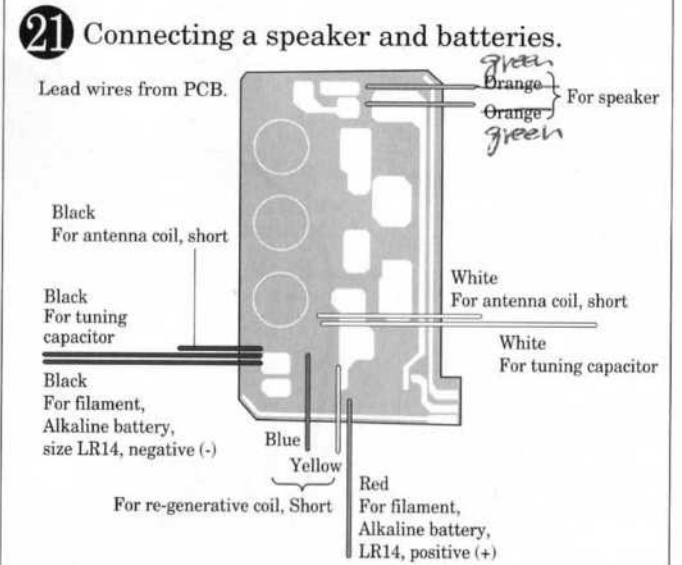
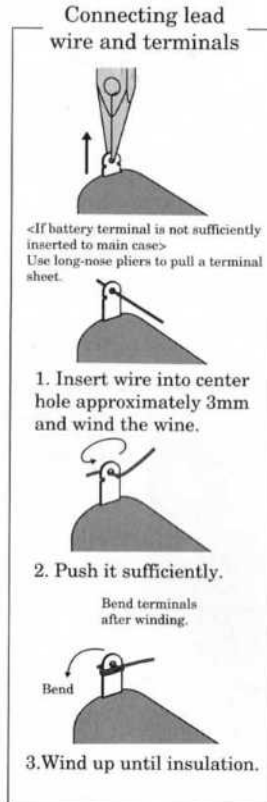
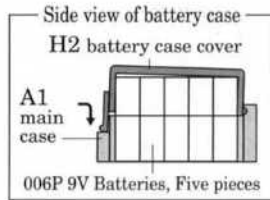


Figure 26

Set five pieces of 006P 9V batteries in battery case. Set battery from tuning capacitor side first.



\*Caution for battery polarity.

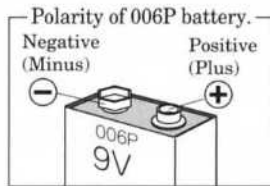


Figure 27

Set LR14 Alkaline battery, optional, to A1 main case and close with H1 battery case cover.

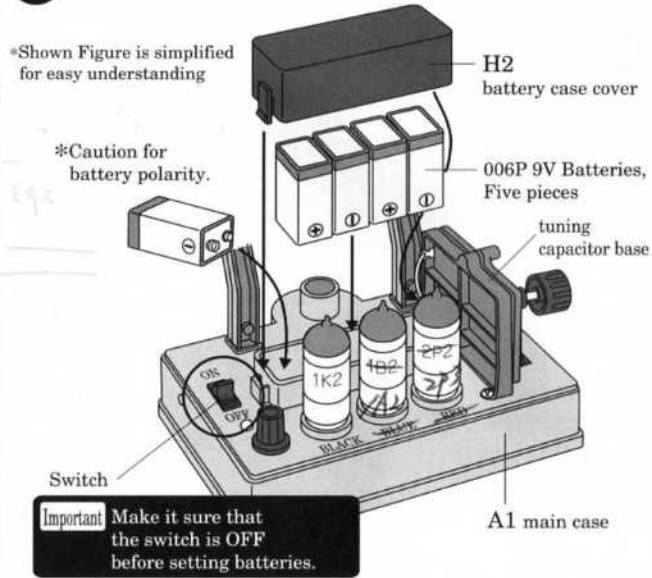
Figure 28

Finally, mount assembled speaker cone to A1 main case. Attach a "Vacuum Tube Radio" seal to front of A1 main case as shown in Figure 28.

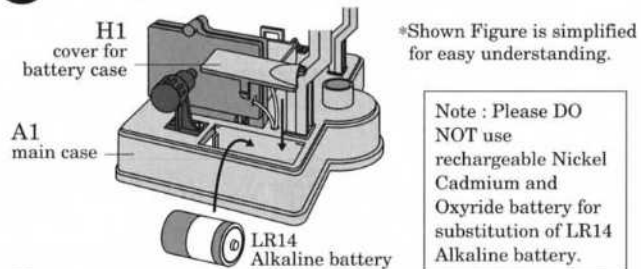
#### Battery Life

Battery will last for approximately twenty days if you use the set one hour every day. Please replace all batteries, 006P and LR14 when you change. Remove batteries if you do not use a radio set for a long time.

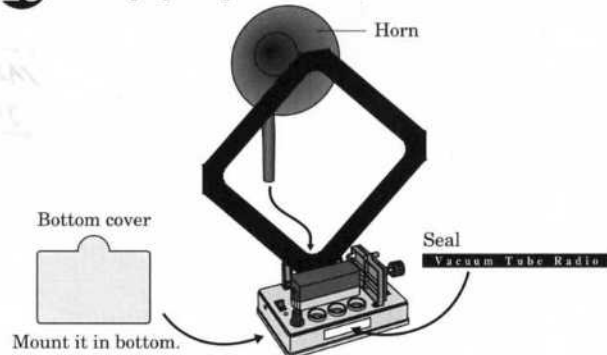
26 Set five pieces of 006P 9V batteries in battery case.



27 Setting LR14 battery, optional, to A1 main case.



28 Setting up of speaker horn, seal and bottom cover.



## 10 Tune Radio Station Signals

### Parts to be used PARTS G

G3 Crystal earphone



Figure 29

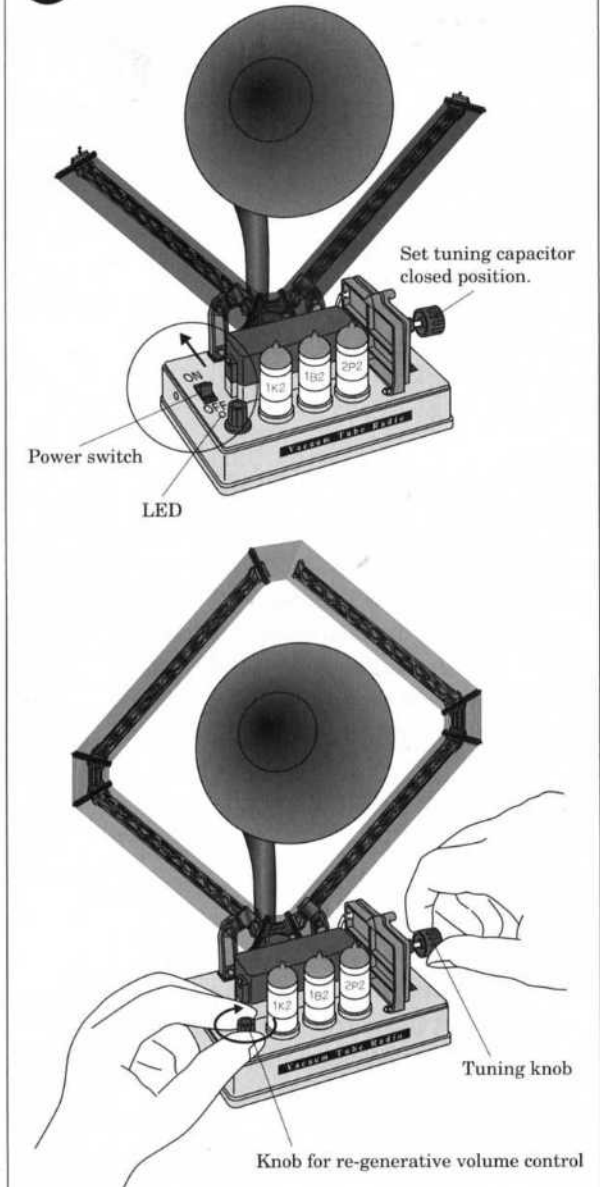
This radio uses an old fashion tuning mechanism. You will get the best result by adjusting tuning capacitor and re-generative volume control at the same time. Tuning procedure is different from radio sets in general.

Here are some hints to get the best results.

Please set the radio set at the best location such as open area. Inside of cemented building and house will not produce the best reception results because radio station signals are shielded.

1. Set batteries properly and switch on. LED will light up.
2. Set tuning capacitor to closed position.
3. Turning knob for re-generative volume control slowly clockwise and open tuning capacitor to get the best become oscillating.
4. Reduce re-generative volume control a little to stop oscillation.

29 How to tune a radio station.



5. Turn tuning knob carefully to change the opening. You'll hear radio broadcast when tune in. The set is designed to receive low frequency, approximately 530kHz, when tuning capacitor is set closed. You'll receive high frequency radio station signals by opening of it.

\*In case if you cannot get radio station signals.

A. Try again by adjusting re-generative volume control.

1. Turn volume control clockwise to make the set oscillating. When the set is oscillating, lower the volume control to stop oscillation.  
2. Adjust tuning knob to get a radio station signal.

B. Change direction of loop antenna.

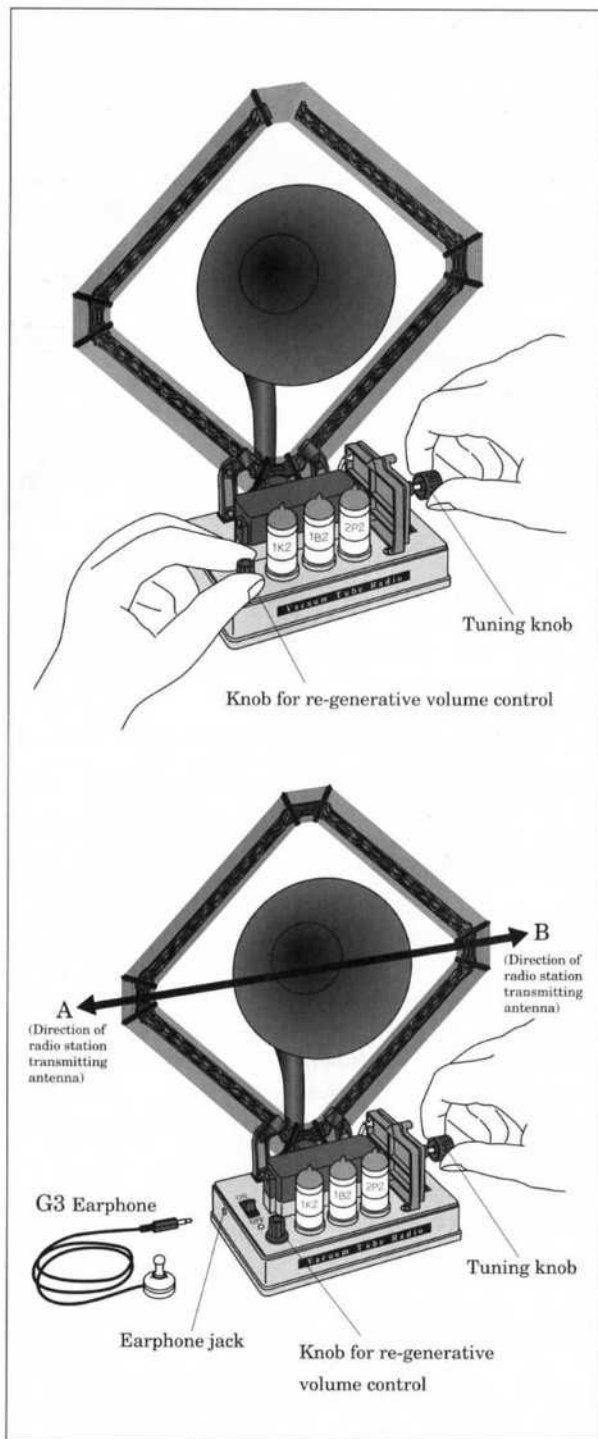
The loop antenna used in this radio kit is very directional. You'll get a good reception by changing the direction. You'll get the best result when transmitting station is located in the direction of A and B shown in the right Figure.

C. Change listening position.

If you are listening in a room in cemented building or electronically shielded house, move radio sets to window side. You can take out the set outdoor because it is battery operated.

\*Use of an earphone set.

You can use G3, earphone substituting a horn speaker. Plug into earphone jack.



## \*Vacuum Tube Radio Set.\*

### 1 About vacuum tubes.

Vacuum tube controls electrical current that flows between filament and plate. This controlled current at plate circuit is wisely used to amplify radio signals. Vacuum tubes are major electronic components before introduction of semiconductors such as transistors.

J.A. Fleming, an English man, invented diode, an origin of vacuum tube, in 1904. Vacuum tubes were used in electronic equipment for many years.

Three different kind of vacuum tubes are used in this radio kit to amplify very weak radio station signal to drive a speaker unit.

### 2 How vacuum tube works?

When a metal plate is heated in vacuum, it emits electrons. This is "Edison Effect" or "Phenomenon of Electron Radiation by Heat."

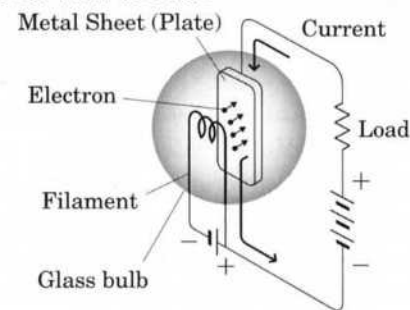
When setting a metal plate close enough to the heated filament of light bulb, and positive voltage is applied on it, electrical current flows between filament and plate. This is a principle of diode.

If AC, Alternating Current, is applied to the plate, it allows flow of current only at positive cycle. This is rectification of diode, converting AC into DC, Direct Current.

If you place a ladder like metal, grid, between plate and filament, and negative voltage is connected, the electrical

current can be controlled by a magnitude of voltage. This is principle of triode. The current flow in the plate circuit is greatly changed by a small voltage change in grid circuit.

Over View of Diode



### 3 Vacuum tubes used in this kit are Chinese made.

This tube radio kit use battery operated vacuum tubes. They are commonly used in portable radio set before introduction of transistors. They are the latest models of vacuum tubes before introduction of transistors.

The Origin of them was developed in Europe and America in 1940's. They are direct heat tubes and become functional immediately after switching on.

There is another kind of vacuum tubes known as In-direct heat tubes. It becomes operational approximately ten to fifteen seconds after switching on.

The tubes used in this radio kit were made in China. They were manufactured in 1950's and 60's. They are new but old stock, called NOS tubes. They are 100%

functional.

Direct heat tubes are used in portable radio sets and communication equipment. The tube code used in China is unique, but most of them are similar to international ones. Please refer to equivalent tube code shown in the end of this manual.

#### 4 Transformation of vacuum tubes.

The early vacuum tubes invented in the beginning of twenty century, are all battery operation tubes. The size of them are much bigger than the current ones. Its outlook are like a balloon and tennis ball. Electricity is not distributed to houses then.

After starting of radio broadcast in various countries in 1920's, people start constructing own radios sets using vacuum tubes and other components. Car batteries, together with dry cell batteries, are used for power supply because automobiles were already popular then.

After distribution of Alternative Current, AC, to houses, AC operated radio sets were invented and become popular.

Many kinds of AC operation vacuum tubes were invented. Most of them are indirect heat types. The shape of them changed from balloon to ST (Standard Tube), GT (Glass Tube) and mT (miniature Tube). It became smaller and smaller. Some other types such as metal and sub-miniature were also available.

The vacuum tubes are commercially made in Japan until 1980's. This is the

same story in US and Europe. Vacuum tubes used in audio amplifier sets are still manufactured Russia, East European Countries and China even now.

Figure: Various vacuum tubes and an early lighting bulb.



#### 5 The circuit used for this radio kit.

There were significant technical achievements in radio circuitry after starting of radio broadcast in 1920's.

The simplest is a crystal radio set with a long wire antenna or large loop antenna bigger than the one used in this radio kit. People use a headphone set to listen in. Reasons for using big antenna is to receive radio station signals loud and clear.

When listening radio broadcast, it is desired that if it can be shared with other people. Then, radio sets with a loud speaker was invented. The vacuum tube played a major part to drive loud speakers.

Function of vacuum tubes in radios set is to amplify weak radio station signal. This radio kit utilizes direct radio wave amplifier with re-generative circuit .

Heterodyne circuit is another circuit often used in old radio sets. It converts high frequency radio signals to low frequency signals, called intermediate frequency for easier amplification.

Figure: Some Early Vacuum Tube Radio Sets



#### 6 Re-generative radio receiver circuit.

A replica of book type tuning capacitor is used in this radio kit. This kind of tuning capacitor is very often seen in early radio sets. A radio station signal is tuned by combined function of loop antenna and a tuning capacitor by changing its opening.

When the tuned radio station signal is applied to the grid circuit of 1K2, the most left hand side vacuum tube, it detects and amplifies a radio station signal in the plate circuit. However, it still contains radio frequency signal.

If this radio frequency signal, a little of it, is returned to antenna circuit, the amplified signal is mixed with a weak radio station signal as if the set received

a strong radio station signal. This kind of circuit is called "re-generative circuit".

Magnitude of feed back signal to antenna can be changed by re-generative volume control. If the amount of it is too much, the circuit oscillates. The set works the highest performance just before start of oscillation.

The detected signal at the first vacuum tube, 1K2 is not strong enough to be heard by human ears. It must be amplified to drive a speaker unit. The second tube, 1B2, amplifies audio signal. Function of the third tube, 2P2 or 3S4, is a power amplifier to drive a speaker unit.

When the set is poorly adjusted and oscillating, it acts similar to a small transmitter. It interferes nearby other electronic equipment.

#### 7 Lighting of vacuum tubes.

When power is applied to the filament of vacuum tubes, it lights up. The tubes used in this radio kit are battery operated direct heat tubes. Filament voltage is only 1.2V DC and current is very small. It will not brightly light up compared to other vacuum tubes used in tube radio and TV sets.

If you place the kit in a dark room, you'll see the filaments dimly lighting. The middle tube, 1B2, is a little brighter.