

**LESSON  
37 R**

**A POPULAR  
SUPERHETERODYNE RECEIVER**



**RADIO-TELEVISION TRAINING SCHOOL, INC.**

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## A POPULAR SUPERHETERODYNE RECEIVER

Numerous superheterodyne receivers have been developed and placed on the market; but if all of these are analyzed and their circuits studied in detail, it will be seen that they are all essentially alike. Each one contains the six basic parts: A tuner for selecting the desired signals, an oscillator for generating the local heterodyne frequency, a first detector in which the incoming and locally generated oscillations are superimposed and converted into a lower or intermediate frequency, an intermediate or long wave amplifier, a second detector in which the oscillations are reduced to an audio frequency, an audio frequency amplifier for increasing the signal strength, and lastly a power output stage that will operate the loud speaker effectively.



Some superheterodyne receivers are designed for loop operation, while others are intended for operation from an outside antenna. Both systems have their advantages. A loop operated set is generally more free from interference and static disturbances; but a set operated from an antenna has a little greater pick-up ability, although it is frequently also more noisy in operation. Some superheterodynes, it will be seen, employ one or two stages of tuned radio frequency amplification ahead of the first detector. This is done in order to increase the sensitivity and selectivity of the receiver. However, this also complicates the operation of the circuit somewhat, and calls for the use of additional stabilizing methods.

The chief respects in which the various superheterodynes differ and the points on which the various manufacturers claim advantages for their product, are the design and construction of the intermediate frequency transformers. Different frequencies have been chosen for the frequency at which these intermediate transformers are peaked. Also, some transformers have an iron core while others are built with an air core. It is hardly possible to say that one or the other is the better, for both have their relative advantages. An iron core transformer generally has a broader amplification curve than an air core unit has, but at the same time it is capable of giving greater amplification. A practice that has worked out very satisfactorily and that is used in most receivers, is a combination of the two. Two or three iron core transformers are used to secure the amplification, and together with these are used one or two sharply tuned air core transformers, more commonly known as filter transformers or merely filters. These filters are tuned with a fixed condenser built right into the transformer case, and permit only a definite band of frequencies to pass through. But the most important feature of any transformer arrangement and the factor upon which the success of the entire intermediate amplifier depends, is the accuracy with which a given group of transformers are peaked. Unless they are all built and selected so that they function at exactly the same frequency, the amplifier will operate at a very low efficiency, and the set in which the transformers are used will be broad tuning and lack all sensitivity. In other words, the very purpose of the superheterodyne will have been defeated.

From this previous discussion one can see that a superheterodyne receiver can be built without an RF section. It is true that it is claimed that an RF section will increase the sensitivity of the receiver, but for the fact that the RF frequency is changed in the first detector to the IF frequency,

manufacturers claim that it does not matter if we have an RF section or not. The duty of the first detector is only to mix the incoming frequency with the local oscillator frequency to produce the IF frequency; therefore, if the radio frequency signal is sent into the first detector, it does not receive as great an amplification as it enters the receiver, but will not have as great a distortion because of the fact that it is not amplified before going into the first detector. The first detector merely changes the frequency of the RF carrier wave without changing the form of the audio in the slightest. Some of the more popular tubes found in superheterodynes today are the following stage by stage.

<u>Power Supply</u>	<u>R.F.</u>	<u>First Detector</u>	<u>I.F.</u>	<u>Second Detector</u>	<u>First Audio</u>	<u>Output Stage</u>	
5Z4	6K7	6A8	6K7	6H6	6C5	6F6	
5W4	12SK7	12A8	12SK7	6Q7	6F5	6K6	
25Z5	6D6	6L7	6D6	12SQ7	6J5	6L6	Loud Speaker
25Z6	78	6A7	78	6R7	12J5	2A5	
35Z5	54	12SA7	58	6J7	76	41	
80	24	2A7	24	6C6	56	42	
		1A6		55	37	43	
				75	27	45	
				85		38	
						50L6	
						35L6	

At this point the student will take notice that the tubes that are used in the R.F. and I.F. stages are identical. In other words the I.F. section is really composed of radio frequency tubes plus the intermediate transformer. These tubes are interchangeable in either the R.F. or I.F. section.

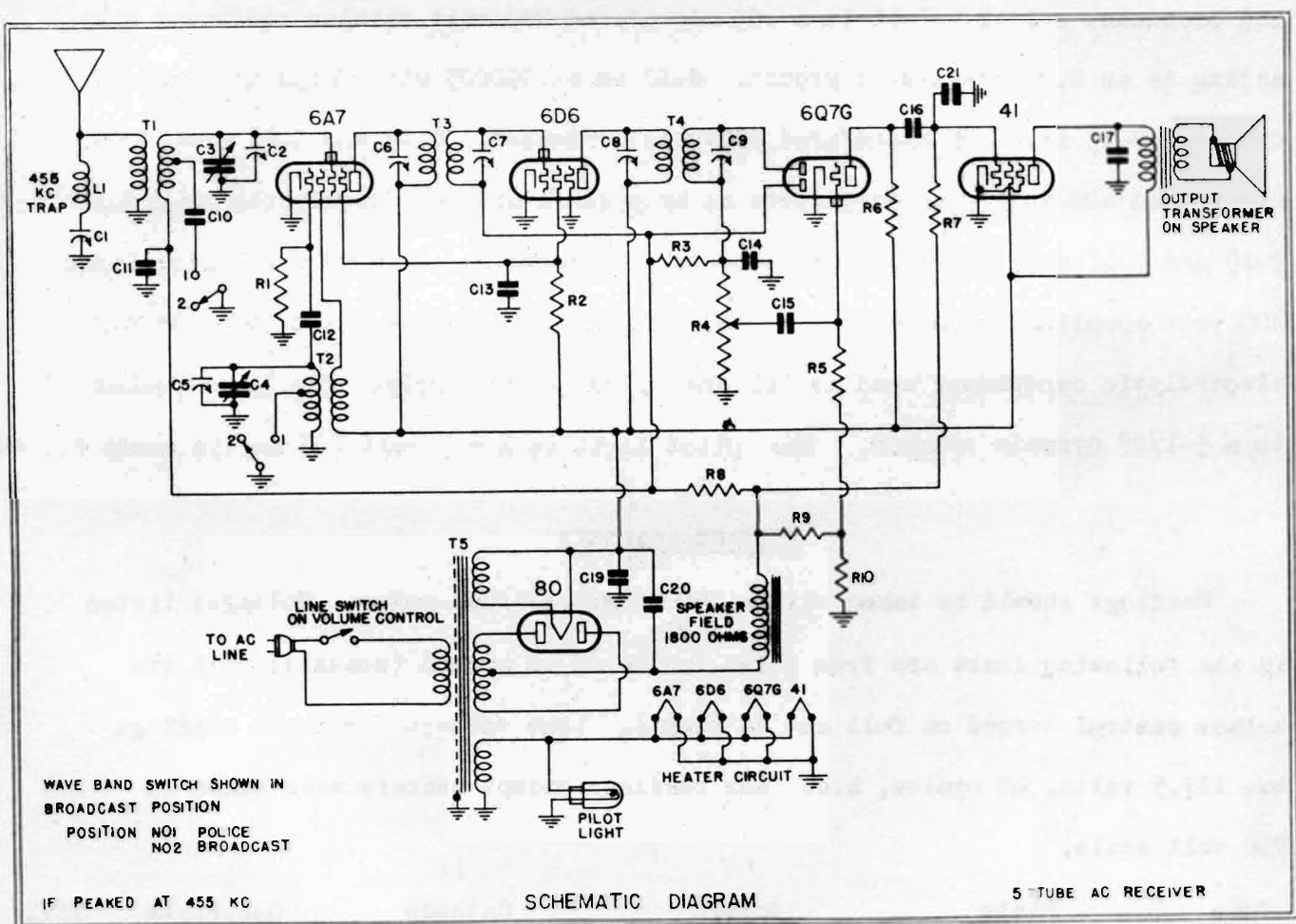
On the following pages is given a brief description of one of the more popular superheterodyne receivers. This receiver is typical of the entire series of superheterodynes that has been developed. All the various principles that have been discussed are here put into practice. Some employ tuned radio frequency amplification, others use a regenerative detector.

The Emerson Radio is a remarkable superheterodyne receiver. It was designed and developed by the Emerson Radio and Phonograph Corporation and has earned for itself an enviable reputation.

The Emerson Radio Model BL-210 is a 5-tube 2-band superheterodyne receiver having frequency ranges of 540 to 1580 kilocycles and 1580 to 4200 kilocycles. This radio employs a 6A7 pentagrid oscillator modulator, one 6D6 TF amplifier, one 6Q7G diode detector, audio amplifier, A.V.C., one 41 power output tube, one 80 full wave rectifier tube, and these tubes are run by an A.C. power supply. It will be noticed that this receiver is built for an outside antenna and does not employ an R.F. section.

The general description and analysis of parts are as follows: L-1 is a wave trap which is tuned to 455 kilocycles. The IF coils are also peaked at 455 kilocycles. In other words the wave trap will reject all signals other than 455 kilocycles and will be of great help to the IF coils in the fact that they are also peaked at 455. C-1 of the trimmers which forms part of the assembly of the wave trap which is tuned at 455 kilocycles. T-1 is a 2-band antenna coil and T-2 is a 2-band oscillator coil. We must remember that this particular set is a 2-band receiver; therefore both the antenna and oscillator coil are of the 2-band nature. T-3 is the first IF transformer or intermediate transformer which is tuned to accept frequencies of 455 kilocycles. T-5 is the power transformer from which all voltages for operating the receiver are obtained. R-1 is a 50,000-ohm one-quarter watt carbon resistor which acts as

a leak on the control grid of the oscillator section of the 6A7 pentagrid converter; R-2 is a 40,000-ohm one-quarter watt carbon resistor used as a dropping resistor on the screen of the 6D6; R-3 is a 2-megohm one-quarter watt carbon resistor used in the A.V.C. system. R-4 is a 500,000-ohm volume control with switch also known as a potentiometer. R-5 is a 5-megohm one-quarter watt resistor used on the control grid as a leak on the second detector; R-6 is a 250,000-ohm one-quarter watt carbon resistor used as a plate load resistor on the second detector.



SCHMATIC DIAGRAM FOR MODELS BL-200, BL-210 AND BL-214

R-7 is a 500,000-ohm one-quarter watt carbon resistor used as a grid leak resistor on the 41 power output pentode. R-8 is a 10-ohm one-quarter watt carbon resistor. R-9 is a 290-ohm one-half watt wire wound resistor and R-10 is a 35 one-half watt wire wound resistor which act as the bleeder and bias resistor on the power supply. C-2 are the trimmers of the variable condenser; C-3 and C-4 are the 2-gang variable condenser. A No. 5 is the other trimmer of the variable condenser. C-6 and C-7 are the trimmers on the first IF transformer. C-8 and C-9 are the trimmers of the second IF transformer. C-10 is a .0012 microfarad mica condenser acting as a coupling between short wave and broadcast switch. C-11 is a .05 microfarad 200-volt tubular condenser also acting as an R.F. by-pass to ground. C-12 is a .000025 microfarad mica condenser. C-13 is a .05 microfarad 200-volt condenser. C-14 and C-21 are .0004 microfarad 600-volt mica condensers as by-passers of high frequencies to ground. C-15 and C-17 are .006 microfarad 600-volt condensers. C-16 is a .01 microfarad 400 volt coupling condenser. C-19 and C-20 are dual 5 microfarad 300-volt dry electrolytic condensers used as filters in the power supply. The loud speaker is a 5-1/2" dynamic speaker. The pilot light is a 6.3 volt .25 ampere mazda No. 44.

#### VOLTAGE ANALYSIS

Readings should be taken with a 1000 ohms-per-volt meter. Voltages listed in the following chart are from point indicated to ground (chassis) with the volume control turned on full and no signal. Line voltage for these readings was 117.5 volts, 60 cycles, a.c. All readings except heaters were taken on 250 volt scale.

Tube	Plate	Screen	Cathode	Osc. Plate	Fil.
6A7 .....	182	70	0	182	6.3 a.c.
6D6 .....	182	70	0	-	6.3 a.c.
6Q7 .....	87	-	0	-	6.3 a.c.
41 .....	*165	182	0	-	6.3 a.c.

In this set you will notice in the diagram that the filaments or heaters of all the tubes are connected in parallel. You will always find this type of connection in an A.C. receiver.

The color coding of the leads of the I.F. transformer is as follows. The green wire to the grid; black wire the grid return; plate wire, blue and the red wire to B plus.

The color coding of the power transformer is as follows. The primary winding, 2 black leads; the high voltage section, 2 red leads; the high voltage section center tap, the red with yellow tracer lead; the filament lead 6.3-volt section, 2 heavy green leads and the 5-volt section 2 heavy yellow leads.

The general color coding of the wiring of the entire receiver is as follows. Plate connection, the blue wire; B-plus a red wire; screen grid connection, brown wire and grid connection, green wire.

The A.V.C. or automatic volume control wire and cathode connection are the white or the yellow wire; the filament and ground, the black wire.

#### COMMON RADIO TROUBLES STAGE BY STAGE

There are two methods in which to check for troubles in a radio receiver. One is the use of a voltmeter through which you take point to point voltage readings. The other is through the use of an ohmmeter by taking point to point resistances. Some of the common symptoms of radio troubles are as follows:

1. Set inoperative
2. Intermittent fading
3. Oscillation or noise
4. Distortion or hum



The first step in checking a radio is to check the tubes. If you are satisfied that the tubes are in good working order, we now begin to check the radio stage by stage. Start by checking the power supply for the four listed symptoms given previously. We must check each stage thoroughly before proceeding to the next.

### POWER SUPPLY

#### Symptom No. 1

Shorted electrolytic condenser in power supply

Power supply filter choke open

Open voltage divider in power supply

Shorted or open power transformer secondary

#### Symptom No. 2

Shorted or leaky filter condenser

Loose contacts on voltage divider

Defective line switch

Filter choke shorting to ground

#### Symptom No. 3

Open filter condenser

Defective voltage divider

Filter choke leaking to ground

Leaky by-pass condenser from rectifier tube to ground

#### Symptom No. 4

Open or shorted primary by-pass condenser

Center tap on filament winding open

Open or leaky output filter condenser

Grounded pilot light bracket

## RADIO FREQUENCY STAGE

If we are satisfied that the power supply is in good working order, we now proceed to the R.F. section and work back stage by stage to the speaker.

### Symptom No. 1

- Open or shorted R.F. coil
- Band switch contacts dirty
- Shorted tuning or trimmer condenser
- Open plate decoupling resistor

### Symptom No. 2

- Shorting trimmer condenser
- Loose contacting lugs on R.F. coil
- Leaky plate or screen by-pass condenser
- Band switch making poor contact

### Symptom No. 3

- Rotor contacts on tuning condenser dirty
- Open cathode or screen by-pass condenser
- Shorted bias resistor
- Aligned too sharply

### Symptom No. 4

- Shorted filament by-pass condenser
- Antenna too long causing overload
- Shielding making poor contact
- Shorted antenna coupling condenser

## MIXER-OSCILLATOR STAGE KNOWN AS FIRST DETECTOR

The duty of the first detector is to mix the constant wave set up by the oscillator with the incoming radio frequency wave to produce the intermediate frequency. The frequency of the incoming wave is merely changed without changing or distorting the audio signal in the slightest.

### Symptom No. 1

- Oscillator plate resistor open
- First I.F. transformer primary open
- Shorting or open oscillator trimmer condenser
- Open plate choke coil

### Symptom No. 2

- Poor insulation on oscillator trimmer condenser
- Open grid return resistor
- High resistance at lugs of oscillator coil
- Dirty band switch contacts

### Symptom No. 3

- Open grid coil
- Cathode by-pass condenser open or leaky
- Shield on grid leads corroded or open
- Decoupling resistor shorted

### Symptom No. 4

- Oscillator coil misaligned
- Open grid filter condenser
- Shorted or leaky cathode by-pass condenser
- Leaky plate by-pass condenser

THE INTERMEDIATE FREQUENCY STAGE OR I.F.

The response that will be given by a radio is dependent upon how well the I.F. coils are peaked. This is the section through which the beat frequency produced in the first detector, is amplified and carried through the receiver.

Symptom No. 1

Open I.F. coil  
Plate decoupling resistor open  
Shorted trimmer condenser  
Primary or secondary by-pass condenser shorted

Symptom No. 2

Open or shorting grid by-pass condenser  
Wire on lug corroded  
Trimmer condenser shorting  
A.V.C. network defective

Symptom No. 3

Shorted cathode bias resistor  
I.F. transformer out of alignment  
Screen by-pass condenser open

Symptom No. 4

Stage out of alignment  
Screen by-pass condenser open  
Shorted cathode bias resistor

## THE SECOND DETECTOR

In this stage we demodulate the beat frequency produced in the first detector and amplified in the I.F. section by by-passing the beat frequency out to ground and leaving only the audio signal. Detection or rectification are one and the same principle.

### Symptom No. 1

- Plate load resistor open or shorted
- Shorted trimmer condenser
- Control grid lead shorting to shield
- Open plate filter choke

### Symptom No. 2

- Defective volume control
- Load resistor by-pass condenser shorting
- R.F. by-pass condenser shorting

### Symptom No. 3

- Open plate or grid by-pass condenser
- Defective plate load resistor
- Defective volume control
- Stage out of alignment

### Symptom No. 4

- Leaky audio coupling resistor
- Leaky plate by-pass condenser
- Plate load resistor too high

## THE AUDIO STAGE

In this stage the audio signal which is received from the second detector is amplified and sent through the next stage of the receiver which would be the power output stage.

### Symptom No. 1

The plate load resistor open  
Open audio coupling condenser  
Shorted plate by-pass condenser  
Open cathode resistor

### Symptom No. 2

Defective audio transformer primary  
Open volume control  
Defective plate load resistor  
Leaky grid or plate coupling condenser

### Symptom No. 3

Shorted cathode by-pass condenser  
Primary or coupling transformer opening  
Open plate by-pass condenser

### Symptom No. 4

Shorted grid or plate coupling condenser  
Cathode by-pass condenser shorted  
Audio transformer open or shorting  
High resistance from primary to secondary of audio transformer

## POWER OUTPUT STAGE

This is the final stage of the radio receiver in which the audio signal is given enough power to operate the loud speaker.

### Symptom No. 1

Primary of output transformer open

Open cathode bias resistor

Secondary of output transformer shorted or open

### Symptom No. 2

Open secondary on input transformer

Shorting audio coupling condenser

Defective primary on output transformer

Open cathode bias resistor

### Symptom No. 3

Open cathode by-pass condenser

Defective cathode resistor

Leaky audio coupling condenser

High resistance from primary to secondary

### Symptom No. 4

Tubes in push-pull out of balance

Screen grid circuit open

Shorted turns on output transformer

Shorted by-pass condenser on cathode

## THE LOUD SPEAKER

It is the duty of the loud speaker to change the electrical audio signal back into a sound wave so that these sounds may be picked up by the human ear and reproduced in the ear almost identically to that which started from the broadcasting station originally. One can readily see that a good loud speaker is very important in the receiving set.

### Symptom No. 1

- Open voice coil
- Secondary of output transformer open
- Voice coil leads open
- Voice coil leads shorting to pole piece

### Symptom No. 2

- Voice coil lugs making poor contact
- Secondary of output transformer opening
- Field coil connection making poor contacts

### Symptom No. 3

- Voice coil winding loose
- Warped cone
- Voice coil rubbing on pole piece
- Unfiltered field supply

### Symptom No. 4

- Field coil open or shorting
- Hum bucking coil shorted or reversed



At this point, it should be remembered that these are not the only difficulties encountered in a radio receiver, but these are the most common troubles. A good percentage of the radio receivers that do not work are due to bad tubes, the coupling or by-pass condensers, coils and resistors. If we thoroughly understand the operation of each of these four parts, we can see how easy it would be to locate troubles in a radio receiver.

- END OF LESSON -

EXAMINATION QUESTIONS ON FOLLOWING PAGES