ELEMENTS OF RADIO SERVICING

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PREFACE

The field of radio servicing has reached adulthood. Receiver circuits have become so complex that the day of the tinkering repairman is over. Definite and intricate areas of information are a necessity, but perhaps even more important is an approach to servicing. It is the dual purpose of this book to furnish both the information and the approach required for successful radio servicing, especially for the beginner.

It is assumed that the reader has acquired an elementary background of radio theory prior to delving into service work. Nevertheless, elementary theory is presented in this book wherever it serves to make more clear a particular procedure.

Design theory has been eliminated, since it is felt that such theory does not fall within the province of the serviceman. It is axiomatic that the serviceman must never redesign a receiver brought in for repair, unless so advised by the receiver manufacturer.

A book of this size could not possibly cover all the variations in radio receivers, so the authors have confined their survey to the most widely used practices of the past ten years. It is felt that on this basis the serviceman will be able to comprehend other variations.

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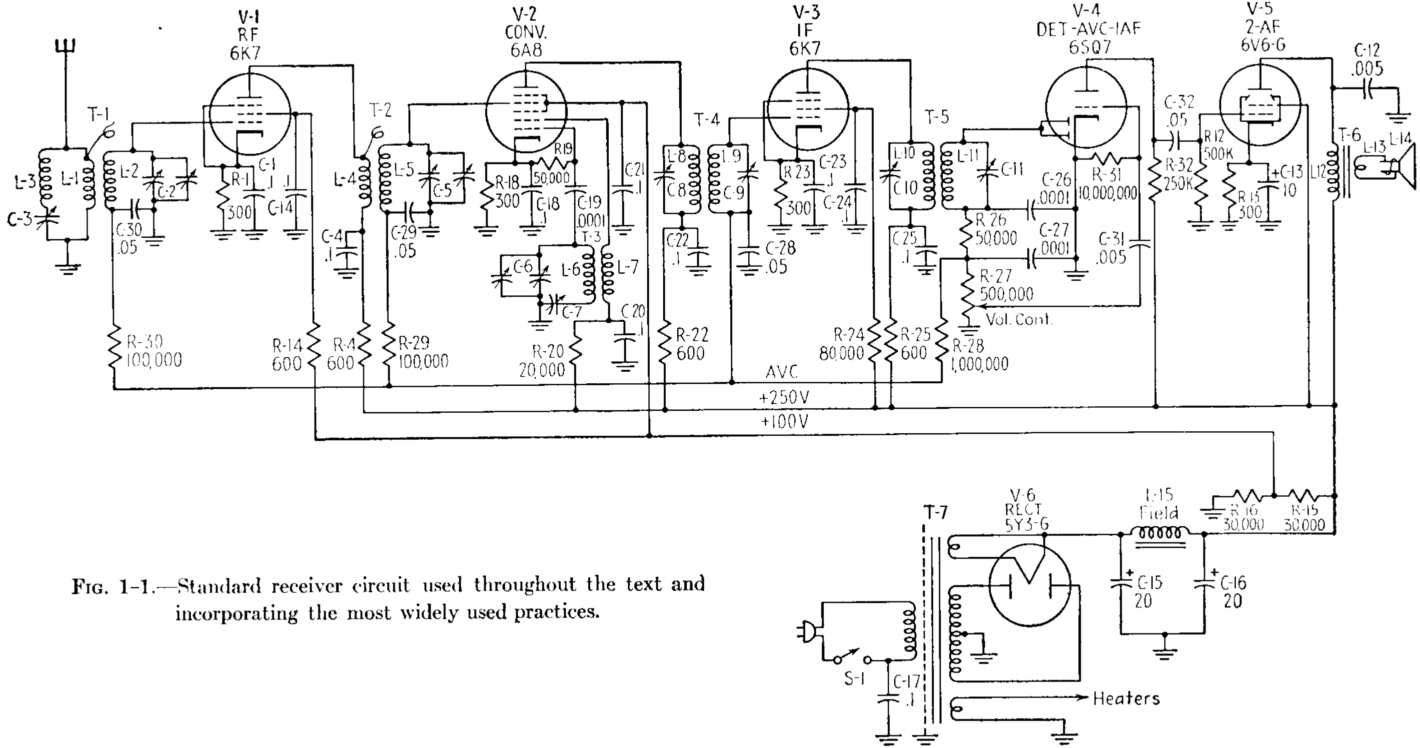


Fig. 1-1.—Standard receiver circuit used throughout the text and incorporating the most widely used practices.

CHAPTER 1

INTRODUCTION

Functional Servicing.—Thinking, especially in the solving of problems, involves the application of random bits of information to a particular situation. Two distinct elements are involved in this procedure. The first is that sufficient information to draw from is available. The second is that the information necessary for the solution is applied to the particular problem. The first element is a static one; the information may be compiled in a book for continuous reference. The second element is a dynamic one and cannot be assumed to develop from the first element unless specific exercise is provided.

Too many servicing manuals and books are organized on the premise that servicing skills can be developed if only enough bits of information are presented. In this respect, they fail to develop functional skills. The learner finds his path a slow and uncertain one.

The purpose of this book is to apply the psychology of learning to radio servicing. Basic information is presented at all times. In addition, the information is so organized that it develops whole dynamic procedures for application to specific radio troubles.

Scope of the Book.—It would be impossible to present in any small book procedures for servicing all types of radio receivers, as well as all the variations of each type. For this reason, the scope is restricted to the most widely used receiver—the superheterodyne.

All the individual variations could not be given. Therefore, a standard circuit, based on the most widely used practices, is presented as the basis for study. This circuit is shown in Fig. 1–1. In all probability, there is no receiver that incorporates all the features indicated; but for study purposes, such a standard circuit will be found invaluable. Throughout this book, the standard circuit is broken down and analyzed by stages, in accordance with the plan described in the following section.

All modern practices could not possibly be indicated in one schematic diagram. Therefore, a section on widely used variations in design is included in each chapter of stage analysis. It is felt that enough information will be obtained from the standard circuit and the variations sections to understand and service any other variation.

Finally, the latter part of the book is concerned with important topics that could not be handled in connection with the standard circuit. These topics are the AC/DC power supply, the auto power supply, the service bench, etc. Each of them is important enough to merit a separate chapter.

Organization of Dynamic Material.—In order to make the material of this book dynamically functional, information is presented in the sequence that it would be used practically in servicing a superheterodyne receiver. Instead of proceeding from stage to stage in the order that a radio signal would pass from the antenna to the speaker, the stages are presented in the order that a serviceman would investigate a defective receiver. Standard radio-servicing procedures are given for each stage. In addition, simple practical tests performed by servicemen on the bench are presented. These tests are based on years of practical servicing experience.

Each stage is analyzed in a similar manner. The outline of analysis is presented below:

1. Quick check for normal functioning of the stage.
2. Typical or basic circuit schematic.
3. Function of the stage.
4. Function and common value for each component part.
5. Normal test data for the stage.
6. Common troubles encountered in the stage.
   a. How they are found.
   b. Special problems involved in replacement of components.
7. Variations from the typical stage that are frequently used; special trouble-shooting procedures in these variations.
8. Summary of tests including outline of procedure to be followed in tracing various symptoms to their cause.

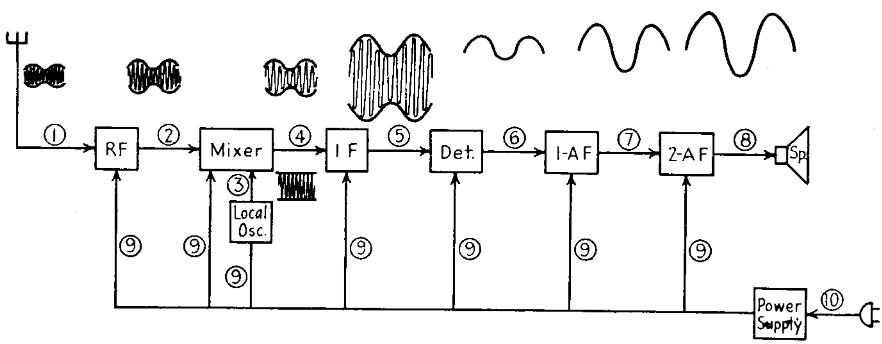
The organization of the information, as outlined above, is the method by which the material information will become quickly functional. A little practice in its use will assure a quick practical approach to radio servicing problems.

It should be understood that this book is not intended to be an encyclopedia of radio servicing. Once the method of attack is mastered, reference to service notes distributed by radio-receiver manufacturers will be more useful than before. Where an unusual circuit is encountered, such notes will prove to be of great value.

CHAPTER 2

SUPERHETERODYNE RECEIVERS

Block Diagram of a Superheterodyne Receiver.—Before the stage analysis of the superheterodyne receiver is presented, it is advisable for the serviceman to have an overview concept of how it works. This picture will be obtained readily from a block diagram. Each block represents a stage that will be shown later in schematic and more detailed form. The accompanying wave forms or pictures of the types of electric currents show how each stage alters the signal entering it. It will be seen later that some of these stages may be omitted or that two stages may be combined into one. The block diagram of the superheterodyne receiver is given in Fig. 2–1.



1. *RF* (550 to 1,600 kc)—modulated at audio frequencies.
2. Tuned and amplified *RF* (550 to 1,600 kc)—modulated at audio frequencies.
3. Unmodulated *RF* (*RF* ① + 455 kc).
4. *IF* (455 kc)—modulated at audio frequencies.
5. Amplified *IF* (455 kc)—modulated at audio frequencies.
6. Audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.
7. Amplified audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.
8. Amplified audio frequencies (50 to 10,000 cycles) for high-fidelity receivers.
9. DC *B*—supply.
10. 110-volt, 60-cycle AC supply or 110-volt DC supply.

Fig. 2–1.—Block diagram of a superheterodyne receiver with associated wave forms.

How the Superheterodyne Receiver Works.—An analysis of the block diagram shown will clarify this matter. Down the antenna come the modulated RF carrier signals of all stations within the receiving area of the set. In the broadcast band, they vary from 550 to 1,600 kc. Before passing through the RF stage, one station is selected by tuning and its signal is passed on. The modulated RF carrier signal is a high-frequency wave modulated or varied by a lower frequency wave known as the "audio modulation." The audio modulations represent the useful component that will eventually drive the speaker.

The RF stage merely amplifies the station to which we are tuned and passes the amplified signal with its audio modulation on to the mixer. The audio modulation retains the same wave form as the signal received at the antenna.

The mixer and local oscillator work together as a team. Often the two stage functions are performed by one tube, which is called a "converter." The local oscillator is a generator of unmodulated RF waves, automatically adjusted to a frequency of about 455 kc above that of the received station RF frequency. When the output of the local oscillator is mixed with the RF station frequency in the mixer stage, the resulting output of the mixer is at a frequency of 455 kc, with the same audio modulations as that of the original signal that came down the antenna.

The 455-kc signal is then fed into the IF stage, which is fixed-tuned to about 455 kc. Here the signal is amplified and fed into the detector. The audio modulations still retain the original wave form.

The detector stage removes the 455-kc RF component from the audio modulation component and passes the latter into the first audio stage. This detector is frequently referred to as the "second" detector, and the mixer or converter is called the "first" detector.

The audio component enters the first audio stage, where its voltage is amplified. It still retains the same wave form as that of the original audio modulation on the station carrier.

The second audio stage amplifies the audio signal even more, developing sufficient power to drive the speaker, which is a power-driven device. The audio signal still retains its same wave form at the input to the speaker. The speaker response is a series of sound waves.

Power for the entire receiver is usually obtained from a 110-volt, 60-cycle AC source or a 110-volt DC source. The power supply will rectify the AC supply, where such power is supplied, and will filter the rectified voltage to obtain a fairly smooth direct current, which now becomes our *B* supply. Where 110-volt DC power is furnished, the power supply will merely filter it to obtain the *B* supply. In portable sets the *B* supply is obtained directly from batteries.

Using the Block Diagram.—It is important that the block diagram shown in Fig. 2–1 be committed to memory before going on. Where test instruments are used, the input and the output waves of each stage will determine how to make proper settings. This is especially important in signal-substitution methods where a signal generator is used.

CHAPTER 3

SERVICING PROCEDURE

Receiver Servicing Systems.—When a radio receiver is brought in for servicing, the demand made of the serviceman is that he put the set back into normal operation. The means is of relatively no importance to the customer. Although this end also becomes the aim of the serviceman, he is confronted with a more immediate goal. What method shall he follow in locating the defect?

The various techniques that he uses can be grouped into a few systems of procedure, which are listed below:

1. Reliance on sight, touch, smell, and past experiences with the same type of receiver.
2. Part-substitution method.
3. Voltage measurements across components.
4. Point-to-point resistance measurements.
5. Electrode-current checking.
6. Signal substitution.
7. Dynamic-signal tracing with a vacuum-tube voltmeter and oscilloscope.

The first system is a self-evident one. Wherever a component appears to be broken or burned, or smells as if it has been overheated, or feels too hot, the assumption might reasonably be made that it is defective and should be replaced. Similar difficulties previously experienced with the same type of receiver might guide the serviceman. Unfortunately, too many defects will not result in extremes of breakdown. Also, the defective component is not disclosed as the cause of the receiver failure or the result of some other defect. Finally, experience as the guide can at most be a helpful rather than an infallible aid.

The second system involves the substitution of a part, known to be good, for a similar part that seems to be defective in the receiver. The weakness in this procedure is that it is too time-consuming by itself and may be useless where the trouble involves a number of defective components.

The third system is one in which voltage measurements are taken across various components. When the observed values are compared with normal voltage data, defective components are readily found. There are several weaknesses in this system when used alone. The time required to make all voltage checks in a modern complex receiver makes it extremely inefficient. At the very best, it may be used alone for making routine checks. In addition, many defects will not alter voltage readings to an extent that would indicate where the defects may be found.

The fourth system is similar to the third, except that resistance measurements are taken with an ohmmeter across the various components, rather than voltage measurements with a voltmeter. Used alone, this system has the same weaknesses as the voltage test.

The fifth system is one in which current measurements are made in various portions of the receiver to locate deviations from normal values. It is not often used, because it involves either the opening of circuits to insert ammeters in series, or the use of special adapters.

The sixth system is a popular one. A signal, similar to the one normally encountered in operation, is fed into the input of a stage, and the result at the output is then observed and compared with normal expectations. It is not suitable when used alone, since it primarily locates a defective stage without indicating the defective component.

The last system is one that involves expensive equipment and complex techniques. Commercial instruments are of various types, but most attempt to analyze the stages of the receiver under actual working conditions. Basically, all are combinations of vacuum-tube voltmeters, capable of making measurements without loading the circuits tested, and are excellent for measuring weak signals in the order of microvolts. The signal indicators are of various types: oscilloscopes, electron-ray tubes, loudspeakers, meters, etc. These instruments readily indicate loss of gain of stages, distortion, intermittents, regeneration, oscillation, noise, and other conditions. However, they still require supplementation by the multimeter and the signal generator.

Which Servicing Procedures Shall We Use?—No one of the servicing systems referred to in the above section can be used with speed and efficiency when taken alone. Experience has shown that it is most efficient first to determine the defective stage by means of a signal check and then carefully to analyze that stage for defective components.

This book assumes that the intelligent and combined use of the first four systems listed, plus the signal-substitution system, will give a highly efficient trouble-shooting procedure. Reference to the stage analysis in later sections will give great facility in the proper combined use of the suggested systems.

What instruments should the serviceman have? To follow the suggestions that are recommended, a voltmeter, an ohmmeter, and a signal generator are required. Two of these are combined in one popular instrument called a "multimeter," which combines a voltmeter, ammeter, and ohmmeter in one unit, with a switching device to obtain the desired function as well as the proper range.

Order of Use of Instruments.—The advantages of the recommended procedures will become evident with use. The general rule to be followed in servicing a receiver is, first, to use the signal generator in order to locate the defective stage or interstage components. The voltmeter and ohmmeter are then applied in order to close in for the kill, that is, the determination of the actual defective components.

The latter part of this book breaks down a typical superheterodyne receiver into its stages and gives procedures for testing the normal operation of each one. For each stage, typical test voltage and resistance measurements are listed for comparison with those actually found in the defective receiver. In addition, where possible, practical methods of testing stages are listed.

Finally, the order of presentation of the stages analyzed is, in general, the order in which a serviceman would be expected to subject the defective receiver to analysis. It is felt that in this way he will use this book with a more functional approach to his problem.

The question might arise at this time as to the place of a tube tester in a service shop, since many receiver defects may be due to faulty tubes alone. A word with regard to this matter will explain the lack of emphasis placed on that instrument.

There are two types of tube testers: the mutual-conductance type of tester and the emission tester. In the first, a small designated change of grid voltage is applied to the tube. The resulting change of plate current determines whether to call the tube good or bad. In the emission tester, the current flow or emission that results when the filaments are heated and a fixed voltage is placed on the plate determines whether to call a tube good or bad. Emission decreases with the age of the tube. In addition, both types of testers have circuits for determinating whether there is leakage or a short between the tube elements.

The tube tester is suitable for testing rectifier tubes. However, for other tubes, it does not measure their operation under the same dynamic conditions that they encounter in actual operation. Tubes that test good in it may be poor in actual receiver operation. A far better check for the serviceman is to hook up the signal generator and an output meter to the receiver and observe the output. Then substitute a good tube for the one believed to be bad and compare the two outputs. Of course, where the customer brings only his tubes for testing, the tube tester is the instrument to use, its limitations being understood.