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from CB to HAM BEGINNER

by
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to Carolyn, David, and Stephen
our wonderful children

Contents

Introduction

In a short time CB radio has grown from virtually nothing to one of the most active types of radio service in the world. The CB bands were created to provide a communication system to supplement the telephone—in situations where the phone is not practical. However, many CB users have discovered that simply operating CB equipment is a lot of fun, regardless of whether or not there is a vital message to transmit. Originally, this type of operation, although practiced, was strictly illegal. Recent relaxation of the rules have allowed "hobby" operation on the CB band. However, there are still restrictions in the availability of channels and the time limitations on transmissions. There is a way to circumvent many of these restrictions and still be able to enjoy the hobby of two-way radio. The CB operator can become a radio amateur, and thus qualify for virtually every kind of operating imaginable.

For example, are you tired of trading short, terse messages for a maximum of five minutes and then pausing for at least a minute of silence? On the ham bands you can talk to the same station all day long if you wish. And if you will avoid using profane language you can talk about anything your heart desires. As proof of this, one of the most popular award certificates in ham radio is that of the "Rag Chewers Club," which is won by staying in solid contact with another ham station for a minimum of one hour.

Have you heard "skip" stations roll in from half-way across the country and wished it were legal to contact them? On the high frequency ham bands "skip" is the usual practice. Talking to foreign stations on the other side of the world is no trick at all. Perhaps you enjoy trading QSL cards with other CBers, even though you never have any chance of talking to them. As a ham, you will frequently trade QSL's with other hams with whom you have hooked up, and the "other" hams may well be in New Zealand or West Germany.

It may be that you enjoy handling messages. If so, there are nets in constant operation which make it their business to handle traffic, frequently from overseas. Ham radio has a message handling system all of its own, called "phone patches." This means using equipment that allows tying your telephone into your transmitter, while the ham at the other end does the same. Thus you can relay a phone conversation between two people, neither of whom have amateur equipment. As many a lonely serviceman overseas has discovered, this is a wonderful way to keep in touch with loved ones at home. The hams who make it possible get the kind of inner glow which comes from doing useful and unselfish things for other people.

Perhaps you are the kind of person who likes to build equipment, starting from scratch and working out the design problems yourself. With CB, you are allowed to make only minor adjustments on your set, but the ham has almost unlimited freedom to design, build, and test his own equipment. Such equipment is often far ahead, technically, of manufactured equipment which the manufacturer can turn out in quantity only after months or even years of tooling and testing.

It may be that you wish you could *see* the guy or gal on the other end of the conversation. Even this is now possible with ham radio; many stations are on the air with slow scan tv, a technique which provides a series of still pictures, one every eight seconds. The pictures are not necessarily from nearby—ham tv from Australia is received very readily in the United States.

In addition, transmitting is no longer strictly earthbound. Years ago, some enterprising amateurs bounced signals off the moon. Later a ham satellite hitchhiked on a launching and went into orbit. There is now a ham repeater station in permanent orbit, which allows relaying of amateur conversations over vast distances.

In short, if you enjoy electronics and would like to get in on all the fun, this book is for you. It is written with the assumption that you have no technical background, except that gained from operating a CB rig. Also, a real effort has been made in the book to enable you to learn enough about electronics to pass the simple Novice license test *without* having to spend hours and hours poring over dull theory. Part of this knowledge can come from making some simple tests with low-cost, readily available equipment and parts—a far better way to learn than simply by reading. In addition, the important things you need to know are often discussed several times, from different points of view, to help you understand them better.

Yes, traveling the road from CB to Ham Beginner does require a bit of effort, but the nice thing about it is that you can have a great deal of fun in the process!

1

Eavesdropping on the Party Line

Chances are good that you started out in CB radio by "listening in" to see what was going on. And there is no better way to take your first step toward ham radio than by tuning to the ham bands and eavesdropping on the conversations which take place there.

However, most things are easier—and also more interesting—when you have some idea of what to expect before you start. This is especially true in operating electronic equipment—a little know-how can make a big difference in results. So let us take a look at exactly what goes on in the ham bands and see how the activity resembles CB work in some ways, but is completely different in others.

BANDS

From CB operation you know a *band* means a *range of frequencies*. Perhaps you also know that there are two CB bands. One has never been too popular because operating in it requires complex and expensive equipment. In addition, it often yields disappointing results because buildings, or other objects, may create weak signal areas, or even wipe the signal out completely. This band is in the ultrahigh frequency range of 460 megahertz (MHz) to 470 megahertz (MHz).

The band which most CBers use lies in the 27-MHz range, extending from 26.965 MHz to 27.225 MHz. Within this range, there are 23 "channels," each being 10 kilohertz apart. On a busy day in most any sizable city, you'll find stations operating on all of the channels, sometimes ten-deep on a given channel at a given moment.

The channels are actually specific frequency assignments, just like those of the broadcasting stations in the band of frequencies you tune in with an ordinary radio. The stations there, too, are 10 kilohertz apart. However, unlike the situation on CB, on the broadcast band a station has just *one* channel to which it is permanently assigned, instead of being allowed a choice among 23 channels.

UNLIMITED CHANNELS

Now—and this is a very important difference—the radio amateur, or "ham" as he usually prefers to call himself, has a number of different bands which he can use, depending in part upon the type of license which he holds. Furthermore, he has literally hundreds of channels (frequencies) which he can use. He accomplishes this either by switching crystals, as on a CB set, or by adjusting the dial on a device called a vfo (variable frequency oscillator) which serves the same frequency-determining purpose as does a crystal.

The ham chooses the *band* he wants in order to pick one which is best for covering a particular distance at a given time of day or night. He picks a *frequency* within a band which he feels will be reasonably free from interference or, in many cases, to coincide with that of the ham station with whom he wants to make contact. Notice that the frequency must be within the band; for example, in the case of the popular 80-meter band, within the range of 3.5 MHz to 4 MHz.

In operating, hams slide around in frequency quite often, particularly when there are many stations on the air, and each operator is hoping to find a spot which has less interference.

WHERE THE BANDS LIE

Let's get the big picture first and see where the ham bands lie in the spectrum of radio frequencies. The drawing in Fig.

1-1 is not to scale but is intended to give you a rough picture of the ham bands in relation to some other bands—the standard radio broadcast band; the 27-MHz Citizens band; and the tv band.

Within this wide range of frequencies, there are innumerable things going on. Here you will find point-to-point overseas telegraph and telephone service. Most of the propaganda-laden stations like Radio Moscow are in this part of the spectrum. At any hour of the day or night, at least some of the frequencies are buzzing with activity.

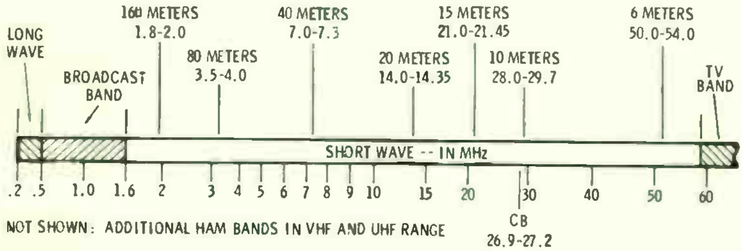


Fig. 1-1. Location of ham bands in shortwave spectrum.

The ham bands are actually modest slices of a fairly large "pie" and represent frequencies carefully selected to give a wide variety of operating conditions. Let us examine the ham bands a bit more closely.

Notice that just a short distance above the broadcast band in frequency is the first of the ham bands, the 160-meter band. Because this band is very close to frequencies used by Loran, an important navigational aid, the government has restricted power output and placed other limitations on operation in this band. This is one of the reasons why it is not used as much these days as it was years ago. Furthermore, in some areas the Loran creates severe interference with ham equipment. Finally, many "ham-band only" receivers will not tune the 160-meter band at all, although it is usually well within the range of the "general coverage" receivers. Let's assume for the moment that we have such a receiver. Later on we will consider the difference between "general-coverage" and "ham-band only" sets.

160-METER BAND (1.8 to 2 MHz)

As is true on most of the ham bands, transmitting and receiving conditions on the 160-meter band are quite different during the day than at night. In the daytime, the operating range is fairly short. Normally, 50 miles is considered good. At night, though, the range is much greater. Hams with 100-watt rigs often communicate 2000 miles or more. Virtually all of the transmissions are on radiophones, and some of these may still be "a-m"—which means that they are "amplitude modulated" and can be received like the stations you pick up on an ordinary radio or CB set.

Unfortunately, more and more 160-meter stations are ssb (single sideband) transmission. This type of transmission results from modern, efficient transmitters—but tuning them in requires special equipment and special receiving techniques which will be described in Chapter 3.

Assume that we do have a receiver which will tune to the 160-meter band, which lies between 1.8 MHz and 2 MHz, and assume that Loran interference in our area is not severe. When we do locate the band, chances are we will encounter some of the Loran stations, which emit a horrible, buzzing sound. The interference from Loran, plus the static crashes which plague 160 meters during the summer months, particularly at night, naturally limits the use of the band. Even so, the band is a good one and is seeing increased use. It is an ideal band for daytime short-range mobile work (with a small vertical antenna fitted with a large loading coil), and a reliable nighttime mobile band for even greater distance, sometimes up to 400 miles or so.

EAVESDROPPING

First of all, we will ignore the stations which sound like frustrated buzz saws—Loran. Secondly, we will pass up the stations which seem to be engaged in some sort of double-talk —which we can *almost* understand, but not quite. These are ssb stations—more about these later.

Hopefully, we will find at least one a-m (amplitude modulated) station which is as easy to tune in as an ordinary station in the broadcast band. As you listen to such a ham station, you may hear almost anything except bad language, which is illegal. And some of the operating techniques used may be familiar if you have operated CB—others may not.

For example, you may hear something like this:

"CQ, CQ, CQ. Calling CQ One-Sixty. W-Zero Love, Baker, Victor, Denver, Colorado, calling One-Sixty, and 'by on the band.' "

Freely translated, this means:

CQ—A general call, indicating willingness to talk to anybody ready to strike up a conversation.

CQ One-Sixty—A trifle redundant, since the listener must be tuned to 160 meters in order to pick up the station. But this is a common way of sending a general call—and indicating the band in use.

W-Zero Love, Baker, Victor—Just as in CB, words are used to make the call letters easier to understand. Actually, this means "L" as in Love; "B" as in "Baker"; and "V" as in Victor.

"by on the band"—indicating WØLBV has stopped transmitting and will be "standing by" and listening for a reply. If all goes well, you may hear another station come on the air with something like this:

"WØLBV, WØLBV, WOLBV. Hello WØLBV. WØWO calling. W—zero, W—Washington, O—Ohio, also in Denver. Reading me OM?" "WØLBV, WØLBV, WØLBV, WØLBV. Hello WØLBV"—the call is repeated several times.

WØWO calling—indicating the calling station.

W—Washington, etc.—Again using easily understood words to make the call letters easy to copy.

Reading me?—this is a way of saying, "Have you tuned me in and are you copying my signals okay?"

OM—An abbreviation overlapping from code operation. "OM" means "Old Man." "YL"—young lady. "XYL"—married woman, etc. At the end of this book is a table giving these abbreviations and many more.

When the two stations make contact, you will next hear something like this:

WØWO, WØLBV returning. Good evening, and thanks for the call. You are 20 dB over S-9 here, even with the antenna trimmer detuned. You must be pretty close by.

Where do you live in Denver?"

WØLBV returning—returning the call.

20 dB over S-9—the meaning is the same in CB—the signal strength as indicated by an "S" meter on the receiver.

At this point, WØWO will come back, and the conversation will start, usually with WØWO answering the question first, then giving a signal report on WØLBV's signal. From here on they may talk about almost anything imaginable, depending, as in most conversations, on what common interests they discover.

Now that you have an idea of what takes place in a typical ham contact, let's move up in frequency and try out the 80-meter band.

80-METER BAND (3.5 to 4 MHz)

This is the next ham band higher in frequency than the 160-meter band, and here you will meet up with a phenomenon which has a tremendous effect upon all ham bands, and for that matter much of the radio spectrum—the eleven-year sunspot cycle.

Experience has shown that the distances which can be covered readily on the 80-meter band vary from year to year. Furthermore, this variation follows a pattern, or cycle. Scientists have determined that this cycle is caused by the number of spots which appear on the face of the sun.

In times when there are relatively few sunspots visible on the sun, the lower frequency amateur bands, such as 80 meters, become useful for transmitting over long distances, or "DX" as hams call it. At low sunspot activity, the bands which in periods of high sunspot activity are excellent for DX, for example 10 meters, become very poor. In 1964, a year of minimum sunspot activity, DX on 80 meters was very good, but the 10-meter band was completely dead most of the time.

Assuming that we have found the 80-meter band on the receiver, let's start tuning at the low frequency end—3.5 MHz. Fig. 1-2 shows how the band is divided up among different types of amateur activity.

Moving up from 3.5 MHz, we should tune in a number of code stations, particularly if a bfo is available on the receiver. (See Chapter 3 for details.) When you tune above 3775 kHz

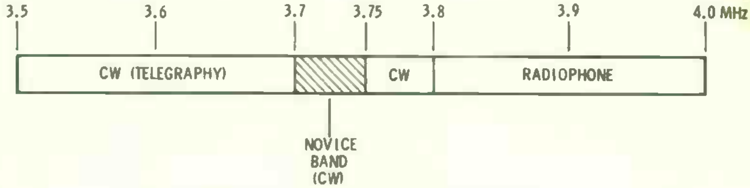


Fig. 1-2. The 80-meter ham band.

(3.775 MHz), you may be lucky enough to pick up an amateur a-m phone station. This will sound all right on the receiver, and you can kibitz and find out where the other station is located. Chances are that if you are listening during the day, it will be nearby—perhaps right in your city. Or it may be fifty or a hundred miles away. However, if you are listening at night, the station you are receiving could be as far as 3000 miles away.

From the preceding, you will get a pretty good idea of the kind of operation possible on 80 meters—excellent short-haul work in the day, and at night, under good conditions, even DX (distance).

MONKEY CHATTER

In tuning over the band, particularly up toward the 4-MHz end, you will encounter many stations which do not seem to be intelligible at all. They emit what is sometimes called "monkey chatter"—and it is just as hard to understand. These stations are using the special transmission method called single sideband (ssb) mentioned previously, which is gaining universal popularity. This is true despite the fact that ssb requires highly-specialized transmitting and receiving equipment. Later on, in Chapter 3, we will learn how to unscramble the monkey chatter and turn it into understandable speech.

40-METER BAND (7 to 7.3 MHz)

We might as well start out tuning this band in the daytime, because even during the daylight hours 500-mile transmissions are easy, even with low-powered equipment. Just as on 80 meters, the low end of the band is filled with code stations. As you tune higher, you pick up phone stations (Fig. 1-3).

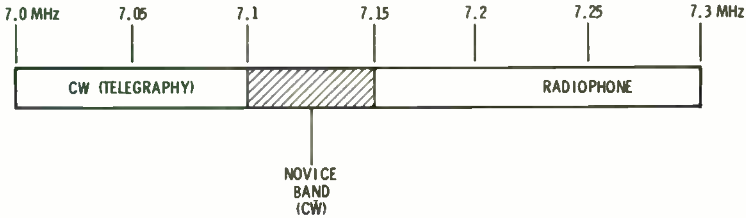


Fig. 1-3. The 40-meter ham band.

Probably all of the phone stations will be ssb. And if we are able to tune in these stations, we would discover that thanks to the skip effect, signals travel a considerable distance before coming back to earth (Fig. 1-4).

On 40 meters, during the daytime, this skip distance is often 300 miles or more and at night may become a lot more than that. Thus, when a ham wants to talk at night to a ham only 50 miles away, he will not ordinarily use 40 meters, but rather will go up to 80 meters, or even 160 meters.

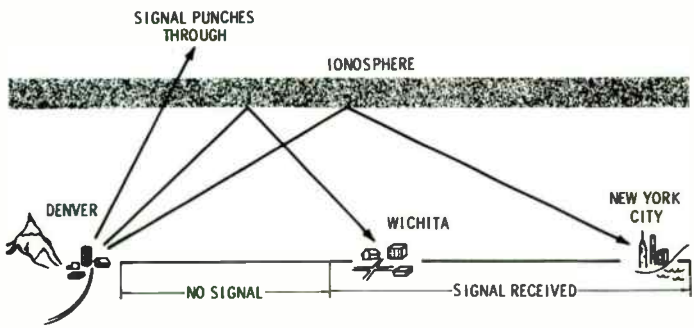


Fig. 1-4. Skip effect on 40-meter band.

20-METER BAND (14 to 14.4 MHz)

Like 40 meters, 20 meters has both code and phone stations (Fig. 1-5). The skip effect really comes into its own on this band; in fact, it may be 1000 miles or more during the daytime.

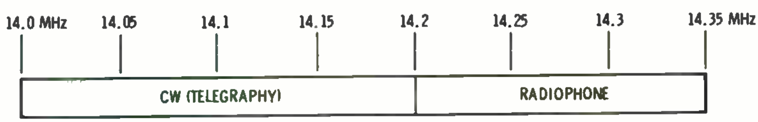


Fig. 1-5. The 20-meter ham band.

DX, under good conditions, is outstanding; transatlantic conversations at high noon are commonplace. At night extreme DX may take place, for example, talking to India the "long way" around the world. Other times, as the sun goes down, for instance, the band may drop out suddenly because the signals punch through the ionosphere and go out into space.

15-METER BAND (21 to 21.45 MHz)

At certain points in the sunspot cycle, this band is virtually dead day and night—with "openings" occurring occasionally during midday. However, with a favorable sunspot cycle, the band allows world-wide DX, even with low power. It has segments for both phone and code, including a popular segment of frequencies for operation by Novice code stations where Novices can work real DX. Fig. 1-6 shows the layout of the band.

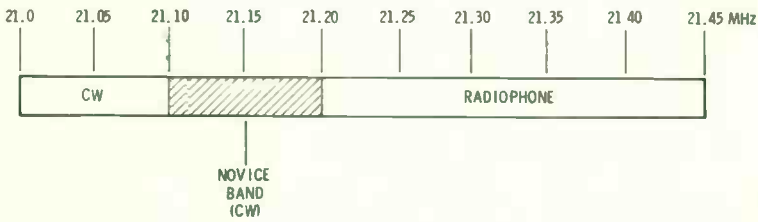


Fig. 1-6. The 15-meter ham band.

10-METER BAND (28 to 29.7 MHz)

If you are a CBer, you will feel right at home tuning around in this band, which is just a whisker away from the 11-meter CB band. As a matter of fact, in the old days (before CB) hams operated in the 11-meter band, with many of them working the band with the same equipment they used on 10 meters (Fig. 1-7).

The 10-meter band, like 11 meters, is ideal for local work, producing excellent signals for up to 20 miles or so, even with low-power gear. Of course, on the ham bands as much as 2000 watts of pep (peak-envelope-power) is allowable. And you can have as complicated and powerful an antenna as you have space, money, and time to erect. Such an antenna may increase power 20 times. Needless to say, this helps in getting out.

EASY DX

When the sunspot cycle is right, the "skip" which some CBers dream about (despite the fact that working skip on the CB band is illegal), is a day-in-day-out occurrence. In this writer's home city of Denver, for example, when the 10-meter band is open, European stations come in at 8:00 to 10:00 A.M. An hour later, "Wl's" in New England, and the "W4's" in Florida come through. As the day progresses, the band is jammed with signals from the midwest and east, including some as close as Ohio.

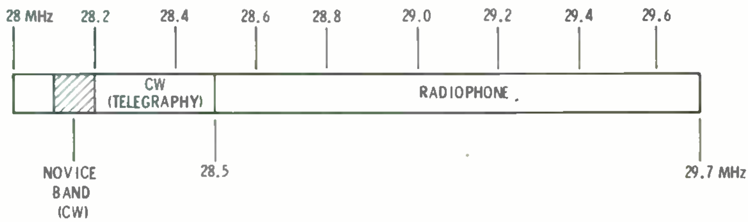


Fig. 1-7. The 10-meter ham band.

At midday, oftentimes, there are South African and South American stations to make the day more interesting. As the sun goes down, the eastern stations fade out, but Hawaii begins to hammer in. Shortly afterwards, you will often hear far Pacific islands such as Guam and Japan. Finally, before the band goes dead for the night, you will pick up New Zealand and Australia. Of course, local contacts take place year in and year out, just as on the 11-meter CB band. All in all, the band is a good band, and Novice hams were delighted when a small segment (28.1 to 28.2 MHz) was opened up to Novices in 1972.

SHORT SKIP

In addition to the regular skip, there is a phenomenon on 10 meters called "short skip" which ordinarily occurs twice a year, at least to some degree. This happens most frequently during a couple of weeks in June and again in December, although it may occur in other months. During such periods, on the high-frequency bands—10, 15 and 20 meters—there are skips over fairly short distances. From Denver, for example, this writer has talked to stations as close as western Kansas and Albuquerque, New Mexico. Short skip signals are frequently quite fluttery, and may be weak as well, but they do give the 10-meter operator a chance to work nearby states. This is often deemed most important, because one of the certificates which many hams try to get is awarded to those who have made "W. A. S."—have worked all states. There is another coveted certificate for those who "W. A. C."—work all continents.

WHO OPERATES WHERE

From the foregoing descriptions of the ham bands it is apparent that there are many frequencies available to the radio amateur. There is a bit of a catch to it—not *all* hams can operate on *all* amateur bands. The limitation lies in the "class" of license which the user holds.

The "class" of license is determined primarily by the difficulty of the exam required to obtain it. The simplest exam is for the Novice license, and this book is devoted to helping the reader learn what he needs to know to obtain such a license and go on the air in the Novice bands.

For the Novice license, there is a relatively simple multiple-choice test, plus a code test of 5 words per minute. This is a very slow speed, considerably slower than even Novice hams ordinarily use. Suggestions on learning the code, and information regarding obtaining the license, are covered later in the book.

With the Novice license, a ham can operate in the four bands indicated in Figs. 1-2, 1-3, 1-6, and 1-7. There are *no* Novice radiotelephone bands.

Next step up from the Novice license is the Technician license, which has the same code speed requirement but a much more difficult technical exam. The reward is freedom to operate on radiophone in two popular very-high frequency bands—2 meters, and 6 meters.

Moving on up the scale, there is the General Class, which requires code speed of 13 words per minute; the Advanced

Class, with the same code speed, plus additional technical requirements; and finally the Amateur Extra Class, which allows operation on all amateur bands.

LEARN AS YOU OPERATE

While there is nothing to stop the electronics fan from going after the Advanced Class license as the first move, this very seldom actually happens, for the reason that obtaining the Advanced license requires considerable technical know-how, much of which is best obtained from practical experience. In addition, learning code is largely a matter of practice, and the best way to get the practice is to go on the air and "talk" to other hams. By this process, the operator builds up code speed virtually automatically, and has a lot more fun than simply listening to code records or tapes.

WHY CODE

If you are an experienced CBer, code (radio telegraphy) transmission may seem a bit cumbersome. But when you actually do it, you will find that cw has a fascination of its own, so much so that many hams with Advanced Class licenses, permitted phone operation in choice bands, never use phone at all, but instead spend their transmitting energies on cw.

Continuous-wave (cw) transmission has some real advantages. In the first place, the equipment required is far simpler—and far less expensive—than radiophone gear. Transmitters in particular are relatively easily homemade. This is one of the reasons that so many foreign hams are strictly cw, which means that if you want to talk to them you have to operate cw also. Another advantage of cw is that it is a more precise method of communication. Voice communications, particularly under difficult receiving conditions, can be very inaccurate. Cw is far more reliable, which makes it very useful when hams are called upon to supply communication when some kind of disaster such as a flood knocks out phone lines. Finally, the requirement for a code test—even for the ham who intends to operate only on phone—is made uniform in the international treaty by which our government and other governments of the world have divided up the available frequencies. Were it not for this international agreement, conflicts of interest among the users of the bands would long ago have reduced operating to utter chaos.

Under the international agreement (article 41 of the Radio Regulations Geneva Edition of 1968) a few—very few—countries do not allow amateur communication. Some countries permit amateur-to-amateur contacts only; that is, handling of messages for others is not allowed.

LEARN BY DOING

Yes, you will need a license to get started. It is generally agreed upon that the best way to start out is to obtain a Novice license, go on the air, and build up code speed and technical know how before moving up to the next class of license. For that reason, this book is devoted primarily to the prospective Novice Class ham.

However, before you start out to obtain a license, there are some things to do which will make the project a lot easier—and more fun. Chapter 2 will help you take the first step.

2

Choosing a Communications Receiver

Now that you have some idea of what to expect in tuning the ham bands, the next step is to obtain a receiver so we can actually "listen in."

Your CB rig is most probably a *transceiver*, which means that the same unit is used for both transmitting and receiving simply by turning a switch. Designing equipment in this fashion helps keep the cost down, and also simplifies installation.

There *are* transceivers available for the ham bands. However, most of those manufactured to date are primarily for single-sideband phone use, a type of service which requires a General Class license. To obtain this license, you must pass a fairly difficult technical exam and demonstrate that you can send and receive code at 13 words per minute. As mentioned previously, this latter requirement is *far* easier to meet if you go on the air first as a Novice ham (which requires only 5 words per minute code speed) and get sufficient on-the-air practice to build your speed up to 13 words per minute.

The usual Novice station consists of a communications receiver, plus a small transmitter for the Novice bands. We will assume that this is the path which you wish to follow; so the first step is to select a suitable receiver.

COMMUNICATIONS RECEIVERS ARE DIFFERENT

The first time you look at a communications receiver you will probably be impressed with its formidable appearance. Usually it has an all-metal cabinet, and the front panel is covered with a bewildering array of knobs and controls (Fig. 2-1). It *looks* a great deal more complicated than the usual home radio. If you can read a circuit diagram and compare the diagram of the communications receiver with that of an ordinary radio, you will quickly find that your suspicions are true. It *is* a lot more complicated.

This is necessary for many reasons. For example, stations in the broadcast band, like those in the CB band, are neatly lined up 10 kilohertz apart to avoid interfering with each other. On CB, the interference created when several stations come on the same channel at the same time is not nearly as confusing as when several ham phone stations, or code stations, try to operate a kilohertz or two apart. To the multiple signal problems there may be added a new problem—a barrage of whistles called *heterodynes*. To dig a phone signal out of such a mess takes a highly selective receiver. And to receive code—which is *all* whistle—the problem is even more severe.

Furthermore, a communications set must be stable, both to receive code and to unscramble single-sideband phone. If the receiver drifts (detunes) as it warms up, the ssb signal may become unintelligible unless the operator retunes constantly. So, you want to buy a *good* receiver.

Courtesy Swan Electronics

Fig. 2-1. Communications receiver.

It may come as a surprise to the beginner, but the transmitter does not have to be nearly as good as the receiver, particularly for Novice band code operation. A $75.00 transmitter, built up from a kit, will do the job very nicely. Later in the book is a transmitter which you can build for less than $50.00. If you have any extra money to spend, by all means invest it in a better-quality receiver.

Before making your choice there is one thing to consider—communications receivers come in two types, "general coverage" and "ham-band only."

HAM BAND VERSUS GENERAL COVERAGE RECEIVERS

The general coverage receivers have the advantage of allowing you to tune in other stations in the shortwave spectrum besides the ham bands. In fact, some of them cover everything from 1.6 MHz up to 55 MHz.

However, this frequency range is achieved at a price, if not in money, then at least in operating convenience. One of the shortcomings of general coverage receivers is that some of them do not have provision for spreading the ham bands over a large portion of a dial. (Some general coverage receivers partially solve this problem by providing an extra dial for the ham bands.)

The second difficulty which arises is that simply *locating* the ham bands on the dial can be pretty confusing, particularly so for the beginner.

For the reasons given above, plus others, *most* experienced hams choose the ham-band-only receivers. However, if you have a burning desire to listen to foreign broadcasting stations, or to your neighbor's radio-equipped boat, you may want to pick out a general coverage set. If you do, select a *good* one, matching it up against the check points given later in this chapter.

NEW OR USED

In ham radio today, many operators trade in their equipment fairly frequently, using it as partial payment for new gear, just as people trade used cars in on new ones. This means that there is a fairly constant supply of used receivers, available at considerably less than the new receiver price. And *good* communications receivers are virtually ageless—many a ham station uses a receiver 20 years old.

Naturally, if you can afford it, you will want to buy the latest in new receivers. However, if doing so will dent your budget, you can wind up with equipment almost as good by buying second-hand equipment, making certain that the models chosen measure up to the standards which follow. Also, of course, you improve your chances of coming out well by buying a standard brand of receiver from a reputable dealer.

You *will* have to plan on spending a reasonable sum of money—at least $75.00, even if you buy a kit (Fig. 2-2) and put the receiver together yourself. In buying a used, manufactured receiver, plan on spending $100.00 or so, unless you run into a real bargain. In the new receiver class, $150.00 is about the minimum for a set which has the features you really ought to have.

Courtesy Heath Co.

Fig. 2-2. Communications receiver available in kit form.

FEATURES TO WATCH FOR

Selecting a good receiver is *most* important. Many Novice hams have become too discouraged to go on with their hobby, simply because the receiver they chose was so confusing to tune and so unstable and cranky that it took the fun out of hamming.

Stability

In the commercial receiver this is extremely important because the receiver must "stay put" once you have tuned in the signal. Actually, there are two quite different things which affect stability tremendously. These are the ability of the receiver to compensate for temperature changes within the set as tubes and various other components warm up and the mechanical stability of parts and cabinet. One of the advantages of the newer "solid state" (transistor) receivers is that they show less tendency to drift.

Many different techniques are used to achieve electronic stability, including such things as temperature-compensating capacitors and the use of a crystal-controlled oscillator stage.

On the mechanical side, the important thing is for everything to be built in a very sturdy fashion. For example, it is commonplace for a good communications receiver to have a heavy steel front panel.

In the matter of stability, here is a rule of thumb—the data supplied in the advertising or brochures describing a good receiver will usually indicate the number of hertz of drift during warm-up. One quality receiver, for example, will drift only 400 hertz from a cold start. Receivers for which little can be said in the way of stability usually duck the matter completely in the specifications literature, or the advertising makes some vague claim such as "good stability."

One practical test of stability which hams sometimes apply to a receiver is that of tuning in a long-winded ssb phone station on as high a frequency as possible and then seeing how much retuning is necessary to keep the signal in tune and intelligible.

Another rough-and-ready test is to tune in a code station, or an a-m station with the bfo on (See Chapter 3 for details), and then lift one corner of the set off the table, and allow it to drop an inch or two to the table. A *good* receiver will take this kind of treatment without serious detuning.

Sensitivity

Any quality receiver today usually has an rf stage, and you can look for this in the specifications. The rf stage helps achieve the second criterion—good signal-to-noise ratio.

Signal-to-noise ratio is usually printed in the specifications for the receiver. Typically, a good receiver will give 1 microvolt sensitivity (a signal with only 1 microvolt of strength is mighty weak) in order to achieve 10 dB signal-to-noise ratio.

Often this is written as "sensitivity 1 microvolt for 10 dB S/N." Actually, 1.5 microvolts for 10 dB S/N is good, but some receivers will have *less* than *one* microvolt sensitivity. Sensitivity is important because it is an absolute necessity if you are to be able to pull in weak DX stations.

Electrical Bandspread

This means that some provision has been made which allows an amateur band to be spread across most of the tuning dial. This is usually accomplished by providing an extra set of tuning capacitors.

Good bandspread is most important because tuning in the ham bands becomes very critical unless the receiver has this feature. Inexpensive all-band receivers sometimes depend upon some sort of mechanical bandspread. This is actually a kind of gearing-down arrangement of the dial to give the bandspread effect, but such techniques are makeshift at best and are not recommended.

Selectivity

Communications receivers must have very good selectivity—much better than the usual home radio. For example, for code reception it is most helpful if the receiver can provide selectivity of at least 600 Hz. For single-sideband phone reception, 2.5-kHz selectivity is often provided. For regular a-m phone, selectivity should be from 2.5 to 5 kHz.

This selectivity may be achieved in a number of different ways. One method is with a "Q multiplier," which allows continuously variable selectivity of from 600 hertz to perhaps 7 kHz. With this range of selectivity, the operator can choose a value which makes it easier to separate signals on the crowded ham bands.

Some receivers provide for this choice of selectivity by means of a switch on the panel which selects filter and/or transformer coupling combinations which give different bandwidths. As a typical example, the National NC-270 receiver has a 600-Hz position for cw (code); two 2.5-kHz positions (upper and lower sideband) for ssb; plus a 3-kHz and a 5-kHz position for a-m phone. As another example, on the Drake 2-B receiver there is a 500-Hz position plus a 2.1-kHz position and a 3.6-kHz position.

One pitfall to avoid when buying a receiver is to make certain that the selectivity feature (for example a "Q Multiplier") can be used at the *same* time as the bfo. Unless this is true, just when you may need it the most, you may not have adjustable selectivity for ssb or cw reception.

Calibrator

You can operate a receiver without a calibrator, but you will be far happier if your set has one. The purpose of the device is to allow you to set your tuning dial so that when the dial indicates a certain frequency, you are actually close to that frequency. This is of tremendous help not only in locating the band in the first place, but also in indicating where the edges of the band are located. Some sets have the calibrator built in. Others use it as an accessory which can be added. The former arrangement is somewhat more convenient than when added as an accessory.

BFO

All communications receivers must have this device which, as was mentioned previously, is needed for both code (cw) and single-sideband (ssb) reception. Very low price receivers sometimes achieve a sort of bfo effect by making one of the i-f stages regenerative. Such receivers should be avoided. Always insist on a separate bfo stage. Ordinarily, this can be determined by reading over the tube line-up. There should be a tube (or part of a multipurpose tube) or a transistor specifically assigned to the bfo function.

Noise Limiter

Again, a standard feature on good communication sets. Limiters are a lot of help in cutting down static bursts on the lower frequencies and ignition noise on the 20, 15, and 10-meter bands.

S-Meters

You may be well acquainted with this device from CB work (Fig. 2-3). It is far from a necessity, but is useful. It is standard on all of the better sets, or available as an accessory. An S-meter makes it easy to give accurate reports on incoming signals.

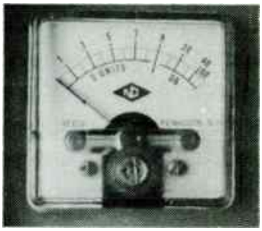


Fig. 2-3. An S-meter on a communications receiver.

AVC (Automatic Volume Control)

This is a standard feature, as will be some switching arrangement to shift to manual volume control. Avc is a circuit technique which helps to keep the output signal constant under varying input-signal conditions.

Selectable Sideband

This is a feature that is very useful, but not necessary, for receiving a-m phone or code. It is extremely helpful for ssb reception.

Product Detector

This is an advanced type of circuitry which has been perfected for ssb reception, although it is also helpful on code. It makes ssb tuning easier and the signals clearer. Virtually a "must."

Slot Filter

A slot filter takes a variety of forms in different receivers. Its purpose is to provide a way of removing the strongest interfering signal. Ideally, the slot-filter circuit should be entirely separate from the selectivity adjustment. Some less expensive receivers have only a "Q" multiplier which, while it is used as a slot device, cannot be used for adjusting selectivity at the same time.

A BUYING CHECK CHART

The foregoing is intended to help you understand the basic features of a good communications receiver. Chart 2-1 provides a convenient check to use in actually considering a specific receiver.

Chart 2-1. Buyer's Check Chart

SELECTIVITY

Necessary

- ☐ Minimum of 2 i-f stages.
- ☐ "Q" multiplier or some other type variable selectivity feature providing a range of approximately 500 Hz to 5 kHz.

Very Desirable

- ☐ Provision for selecting upper or lower sideband.
- ☐ Slot filter *separate* from adjustable selectivity circuit.

SENSITIVITY

Necessary

- ☐ 1.5 microvolt or better for 10 dB S/N ratio.

Desirable

- ☐ Antenna tuner on panel.

STABILITY

Necessary

- ☐ Voltage regulator tube in power supply (unless receiver is all solid state).
- ☐ Mechanically strong cabinet.

Desirable

- ☐ Drift of 500 Hz or less during warmup.

BANDSPREAD

Necessary

- ☐ Electrical bandspread.
- ☐ Smooth-working dial with a minimum of backlash.

BFO

Necessary

- ☐ Separate bfo circuit—not a regenerative i-f without a bfo.
- ☐ Variable frequency adjustable from panel.

OTHER FEATURES

Necessary

- ☐ Noise Limiter
- ☐ Avc

Very Desirable

- ☐ Product Detector

Desirable

- ☐ Calibrator

Other features frequently found in quality receivers are double or triple conversion circuitry, one or more crystal-controlled oscillators, and a logging scale.

If you will apply the preceding check chart in going over the specifications sheet on a receiver, you are pretty well assured of acquiring a good receiver. Again, of course, a "name" brand and a reputable dealer are also important.

The latter is particularly important when buying a used receiver. In just about every sizable city there is at least one electronics supply firm which makes a real effort to serve the radio amateur trade, and such a company usually has a department managed by an active ham. Simply dropping in and getting acquainted with such a ham can get you a lot of free—and usually good—advice, particularly if you will work with him and use the Buying Check Chart in selecting a good, reliable receiver.

PURCHASING BY MAIL

If you live in a small town, you can still buy a used set by corresponding with one of the large mail order firms which specialize in handling trade-in amateur equipment. Most of these firms have established a reputation for fair dealing and usually offer the equipment on trial.

Likewise, if you are short on cash, they generally have time payment plans. Like most such plans, the interest rate is fairly high, but for many hams the pay-as-you-operate system has meant the difference between having satisfactory equipment and struggling along with inadequate gear.

Some readers may wish that this book listed desirable receivers. However, since new models are constantly coming on the market, any such list is apt to be out of date by the time it is printed. Rather, here is a list of manufacturers, all of whom do or have made at least *some* models of receivers which do measure up to the standards set up previously.

Radio Shack	Yaesu	Ten-Tec
Collins	Swan	National
Drake	Hammarlund	Multi-Elmac
Hallicrafters	Kenwood	Hammarlund
	Lafayette	

TUBES OR SOLID STATE

The older, used receivers use tubes. More and more, new equipment is designed with transistors. With proper design, either approach is good, but every year transistors improve and seem certain to obsolete all tubes.

There are kits, too, which are satisfactory. One kit maker which has several quality receivers is Heath Company.

STANDARDS TOO TOUGH

When you discuss the check chart with a ham, or with the ham salesman in a supply company, he may tell you that it is a bit on the tough side, so tough, in fact, that some of the lower-priced new sets do not have all of the features labeled desirable. It is the writer's firm conviction that the beginner is far better off buying a good, used receiver which has everything needed, than to spend the money for a shiny new one which does not quite measure up. Also, just as in used cars, some of the depreciation is already gone from the used set; so the price will be more favorable.

A DIFFERENT TYPE OF RECEIVER

All of the receivers described so far in this chapter have been "superheterodynes." There are other basic types but only one, the "synchrodyne" or "direct conversion" receiver has seen much use in communications circles in recent years.

The synchrodyne has its limitations, but it also has some real advantages, including simplicity, low cost, and ease of tuning. For example, it makes tuning in a ssb signal almost as easy as tuning an ordinary broadcast set.

The photo in Fig. 2-4 shows one such set of current design. This receiver was actually used on the air in a simple Novice station described later in the book.

Because the direct conversion idea is basically sound, there will probably be other synchrodynes on the market over the next several years. Here are the specifications for the one illustrated, specifications which will give you a yardstick to apply to other similar sets.

Frequency Range:

Band	Frequency
80 Meters—	3.5- 4.0 MHz
40 Meters—	7.0- 7.3 MHz
20 Meters—	14.0-14.6 MHz
15 Meters—	21.0-21.9 MHz

Courtesy Ten-Tec, Inc.

Fig. 2-4. A synchrodyne type of communications receiver.

Modes of operation: USB, LSB, CW, AM.
Sensitivity: Less than 1 μV provides readable signal.
Stability: Less than 100-Hz drift. No warm-up.
Audio Output: 3 volts across 1000-ohm load (for headphones).
Antenna Impedance: 50-75 ohms, unbalanced.
Selectivity: 2 kHz @ 6-dB down points
Controls: Band Selector; Audio gain; Antenna Tune; Power On-Off; Main Tune.

A receiver of this type is limited in what is called "front-end selectivity," which may result in overload and interference from nearby broadcasting stations, or even powerful ham stations. This problem is greatly reduced if the antenna is tuned or matched to the frequency of reception. One way to do this if the antenna is a single wire is to use an antenna tuner, the TEN-TEC Model AC5, manufactured by the same company which makes the receiver. The unit is inexpensive.

For strictly cw work, the audio selectivity can be improved, if desired, by adding a low-cost audio filter.

3

Using a Communications Receiver

Let's assume now that you have bought your receiver which happens to be an NC-270, a set typical of the older, good-quality communication sets in its price class. Although the receiver is no longer manufactured, it measures up very nicely to the standards set up in the check chart. Because it is a discontinued model and has been used, you were able to buy it for less than $100.00, although the original price was $279.00.

Another factor which helped lower the price was that the Novice ham who owned the receiver now has a General Class License, and has decided to go on sideband phone, using a 5-band transceiver. He traded the receiver in on the new piece of equipment.

To use the receiver, first of all we need some kind of antenna. Eventually, you will want to put up some kind of multiband antenna, like one of those described later in the book. However, if you are in a hurry to start listening you can string a piece of flexible wire around two sides of the room near the ceiling, and tape it to the wall (Fig. 3-1). Before going overboard on this idea, though, try the tape *on* the wall, to see if it can be removed *without* lifting the painted surface or the wallpaper. If it looks like you are going to have trouble, use thumbtacks instead of tape.

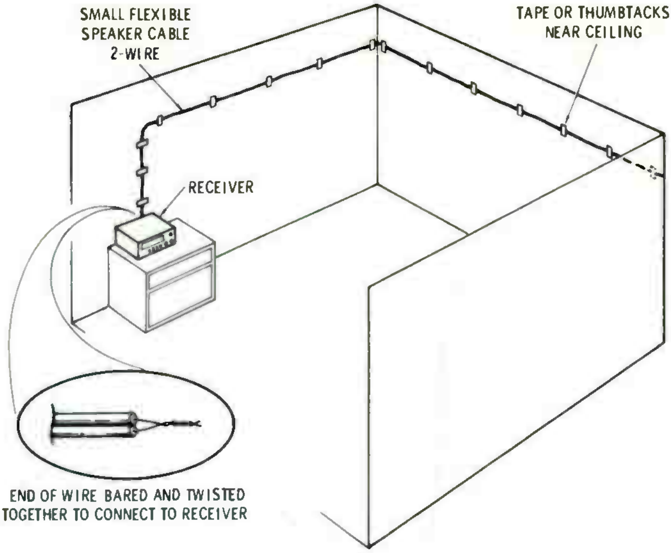


Fig. 3-1. A temporary room antenna.

HOOKING UP AN ANTENNA

The antenna hooks to the antenna terminal on the back of the receiver. Sets differ somewhat—some will simply have two screw terminals, one for the antenna and one for ground. Figs. 3-2 and 3-3 show how to hook up both a single-wire antenna and a coaxial cable antenna. If an outside antenna is used, to protect the set from lightning you need either lightning arresters, as shown, or some kind of knife switch.

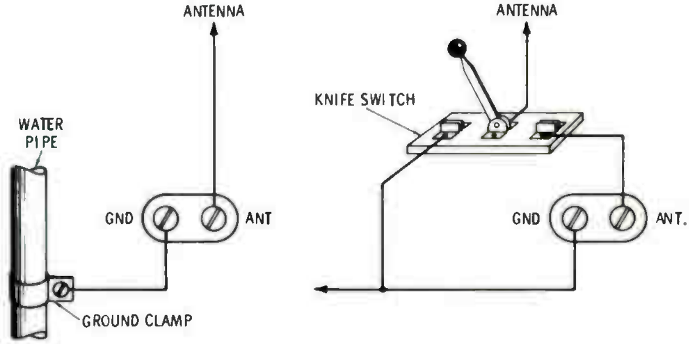


Fig. 3-2. Connections for single-wire antenna.

In case you are using the simple indoor antenna, as illustrated in Fig. 3-1, you will also need to connect to some type of ground. Ideally, this should be to a nearby cold water pipe, with a hot water pipe as the second choice. Use a clamp to hook onto the pipe (Fig. 3-4). Other possibilities include using a tv antenna grounding rod driven into the ground outside of the house, or connecting to a metal heating duct or the pipes of a hot water heating system. In the case of the heating run, be certain that the metal face plate actually connects, by means of a screw or bolt, to the metal duct behind it and isn't simply attached to the plaster wall.

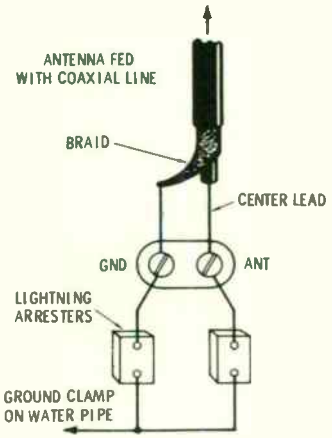


Fig. 3-3. Connections for coaxial-cable antenna.

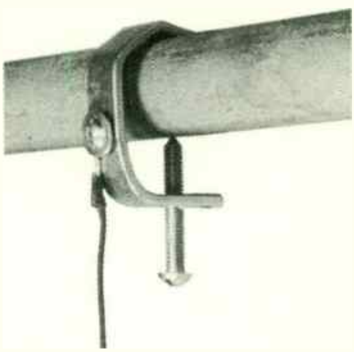


Fig. 3-4. Use clamp to ground wire to pipe.

SPEAKER

Most communications sets do not have a built-in loudspeaker. This means you will have to supply one. An 8-ohm speaker is usually required. Simply connect it to the terminals usually provided on the back of the set. Communications sets also have an output jack for headphones.

IDENTIFYING THE KNOBS

Speaker hooked up? Now, plug the power plug into the wall socket, and you are ready to turn the set on. One nice thing about a communications set is that most of the knobs, bars, or switches carry some kind of identification label, either on or near them.

The first thing to look for is the volume control, which on most sets is also the on-off switch, just as on a radio or tv set. On a communications set, this control is usually labeled af gain or a.f.g. (Fig. 3-5) which is short for audio frequency gain control. Turn the knob. A tube set should come on in half a minute or so—a solid-state receiver, instantly.

Fig. 3-5. On/off volume control.

The stby-rec switch (standby-receive) makes it possible to quiet the receiver while transmitting, without turning the tube filaments off. This is important in ham-band conversations because you want to be able to turn the receiver on instantly when it is your turn to listen.

If the set does not turn on, chances are you have no serious problem. Probably all that is wrong is that somebody has left the stby-rec switch in the stby position.

Next, we need to decide which band we want to tune. The 40-meter band is usually a good one, since there is usually some activity any time of the day or night, although signals are stronger and a lot more plentiful at night.

The band is selected by turning the band switch. On a ham-band-only receiver the bands are usually specified right on the panel (Fig. 3-6). On general-coverage receivers the bands are often labeled "A," "B," "C," etc., and you will have to determine where the ham band falls, either from an instruction book with the set or, usually, by reading the main tuning dial. The amateur 40-meter band is usually in band "B."

Fig. 3-6. Bands specified on the panel.

NOISE LEVEL CAN BE USEFUL

Turn the af gain control in a clockwise direction until it is on about three-quarters of maximum rotation. Next, advance the rf gain (r. f. g.) control (Fig. 3-7) until you begin to hear a fairly strong crackling sound in the loudspeaker. This is called the "noise-level" which is simply the level of stray noises created in the atmosphere, and by the various interference-producing devices in the neighborhood in which you live.

Next, we want to locate precisely the 40-meter band. On a ham-band-only set like the NC-270 this is fairly easy, because the dials illustrate only the ham bands. But notice this. With the band switch on "40" we are interested only in reading *one line* of the dial, that which corresponds to the right of the

Fig. 3-7. The rf gain control.

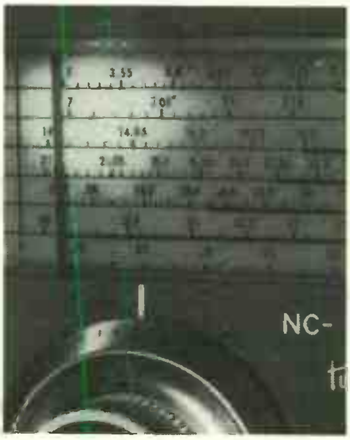


Fig. 3-8. Set dial slightly below 7 MHz.

he figures on the typical slide rule type
, and we have already learned that the
7 MHz to 7.3 MHz. So the first step is to
elow 7 MHz, as shown in Fig. 3-8.
o use is the one which is generally marked
serves to "peak up" the receiver to the
results in much more sensitivity than would
ntenna were left untuned. Simply rotate this
control ... noise level is the strongest. It may be that this makes too much noise for comfort, in which case, back down the rf gain control a bit.

SELECTIVITY CONTROL

Set the selectivity control to approximately 5 kHz, if it is thus marked. On some sets there is no marking (those without separate selectivity and notching circuits) and in this case, ordinarily, the control is turned to the maximum counterclockwise position. Turn the tuning dial until the pointer reads 7 MHz, which indicates 7 MHz, the low end of the 40-meter band.

LISTEN IN

At this point you will probably want to listen for a while, to see what is going on in the band. First turn the "mode" control switch to cw (Fig. 3-9). Also, reduce the receiver bandwidth by turning the selectivity control. Switching the selectivity control to the 3-kHz position will make the set more selective (Fig. 3-10).

Now we'll tune in some cw (code) transmissions. As indicated with the NC-270 receiver, this only requires turning the "mode" switch to "cw-ssb" position. On other receivers you may have to accomplish the same thing by setting the following switches: (1) Put the bfo (beat frequency oscillator) switch to the on position. (2) Switch the avc switch to off.

Set the bfo control to the middle of its range. Now, tuning very slowly, start at the 7-MHz end of the dial and SLOWLY tune up the band (toward 7 MHz).

Probably, close to the 7-MHz point, you will pick up your first code station, which will sound like a high-pitched whistle keyed at a fairly rapid rate. As you tune up the dial, you will find a lot of stations. Between 7100 and 7150, you will pick up the slow speed code typical of amateurs who hold the beginning class of license—the Novice.

Notice that as you tune across a code station, the pitch of the signal changes. In tuning, the usual practice is to tune to a point which gives a tone pleasing to the ear.

Fig. 3-9. Set mode control to the cw setting.

Fig. 3-10. Set selector to 3 kHz to improve selectivity.

You will also find that by turning the knob of the bfo control you can change the pitch. Often, this is done to get exactly the right tone on the code signal you are copying. In addition, it makes it easier to separate the desired signal from an interfering signal.

USING THE HIGH SELECTIVITY POSITION

Up to this point we have been receiving signals with the bandwidth switch set for what is actually a phone position and fairly broad. When the going is really rough, the cw operator often narrows the bandwidth down to a very narrow bandpass, perhaps as low as 600 hertz. This makes tuning a bit difficult and often imparts a hollow, ringing sound to the signal, but these things are mild handicaps compared with the advantage of dropping off interfering signals.

As mentioned before—but cannot be emphasized enough—tuning must be very slow. This is particularly true with a selectivity setting in the 600-hertz range. Practice at *slow* tuning is most useful, because you must be able to do it as second nature in order to tackle receiving ssb stations—the kind of reception which separates the hams from shortwave listeners.

TUNING SSB

With the NC-270 receiver and similar advanced receivers, tuning ssb is made easier by the fact that the operator can select the upper or low sideband. Doing this will be discussed later. However, this set, like most other communications receivers, can be used for ssb *without* taking advantage of the sideband selection feature. So we will tackle the job the hard way first.

Step-by-Step Procedure

Because tuning ssb is a tricky business until you get the hang of it, we'll break the procedure down into a number of steps:

1. Set the bfo control a few degrees off dead center.
2. Throw the mode switch to a-m. (In some cases this simply means turning *off* the bfo and throwing the avc switch to the avc position.)
3. Listen to the loudspeaker and slowly tune in one of the stronger monkey-chatter type phone stations. Watch the "S" meter, if your receiver has one, to help you tune for maximum—otherwise tune for loudest signal. Notice that an ssb station causes the meter to swing wildly—the proper tuning point is that at which the meter needle swings over the widest range.
4. Throw the mode switch to cw or to ssb if the receiver has this position (Fig. 3-9).
5. Turn the af gain control pretty far *on*, while decreasing volume with the rf gain control until the signal is fairly low.
6. Very *very,* slowly turn the frequency control on the bfo until the speech becomes natural. This adjustment will be found to be *highly critical.*
7. If volume is too low, bring it up with the rf gain control, unless this introduces distortion. In this case, bring it up with the af gain control.

Notice that after the signal is tuned in by means of the S-meter (or by tuning for maximum sound if no S-meter is available) the main tuning is left alone. The bfo control provides the final tuning adjustment, and this must be done *with great care.* Moving the control one thirty-second of an inch may be sufficient to throw the signal in and out of tune.

Cautions

There are several things about the procedure which are extremely important. In the first place, with most receivers, the rf gain must be kept quite *low* during the initial tune-up procedure, which in turn usually means that the af gain setting should be quite high. And as mentioned—but cannot be mentioned too often—extremely careful tuning of the bfo control is absolutely essential.

Above all else, the procedure takes practice. Don't be discouraged if you spend half an hour before you get your first really understandable signal. Many an experienced ham, shifting from a-m to sideband, took longer than that to learn how to tune ssb. But once you get the knack of the method, a signal can be tuned in a matter of seconds.

Tuning with Selectable Sideband

As mentioned previously, tuning is greatly simplified if the receiver has provision for selecting the upper or lower sideband. In this case, follow the procedure outlined here:

1. Set the bfo control at the midpoint position.
2. With the mode switch, set the receiver for the sideband probably in use. Ordinarily, this is the *lower* sideband (lssb) on 80 meters and 40 meters, and the upper sideband (ussb) on 20, 15, and 10 meters.
3. Very slowly, with the main tuning dial, tune in the station. Get it as intelligible as possible with the main tuning.
4. If you have considerable difficulty in clearing up the speech, try backing down on the rf gain. Doing so will usually make tuning a lot less critical.
5. Use the bfo knob *very* slowly until the signal is the clearest. This will complete the job of making the signal intelligible.
6. As a quick check, switch the mode switch to the other sideband. Ordinarily, this will virtually kill the signal. If it does not, the operator at the other end has for some

reason chosen the opposite-to-normal sideband, or you have tuned in a station which isn't sideband at all, but rather is an ordinary a-m phone station, and should be tuned in the usual way, with the bfo off and the avc control in the "on" position.

USING A NOTCH CONTROL

The more advanced types of receivers will have some provision for "notching" or "nulling" out interfering signals. The control is of great help when the interfering signal is very close to, but not quite on, the signal you are trying to hear.

Because there are several ways of providing this type of control, general instructions are a bit hard to supply—see the instructions with your receiver. In every case, tune in the desired signal first, then try to eliminate the interference.

Some of the less-expensive receivers have a "Q" multiplier which can be used either as a variable selectivity device, or for nulling an interfering signal—but not for both purposes at the same time. This is a disadvantage because you may want to get the bandwidth down as far as possible, and then slide the interference into a notch as well.

CRYSTAL CALIBRATOR

The more advanced sets usually have this unit built in. In the lower-priced sets it is often available as an accessory.

The purpose of the calibrator, as was explained briefly in Chapter 2, is to enable you to make certain that when the dial on the receiver reads a given frequency (say 3.5 MHz) the receiver actually is tuned to that frequency. Some frequency drift occurs with every receiver, and the less expensive ones may drift quite a bit.

The calibrator, in effect, produces a cw (continuous wave) signal of *known* frequency, to serve as a frequency standard. The oscillator is crystal controlled to hold it to the proper frequency. Also the circuitry is such that the output signal is rich in harmonics, which in practical terms means that you will pick up the signal every 100 kHz on the dial. Since ordinarily the dial won't be anywhere near *that* far off, identifying the calibrating signal is not difficult.

Using a Calibrator

First switch the calibrator on (Fig. 3-11). The receiver mode switch should be set on cw, and if the avc is on a separate control turn it off.

Tune slowly slightly above and below 3.5 MHz. (The frequency 3.5 MHz is a convenient point only—you can use any multiple of 100 kHz. For example, 7000 kilohertz (7 MHz), 14,000 kilohertz (14 MHz) etc. As you tune, some place in the range, usually fairly close to the dial marking, you will pick up a strong, steady heterodyne whistle like a code station which isn't being keyed. Switch the calibrator off and on to make certain it is actually the calibrator signal you are picking up. If it is, slowly tune in the signal. As you tune across from one side, the signal will drop off (become lower and lower in tone) and will finally disappear. Then, as you keep turning the dial *in the same direction*, you will begin to hear the signal again, first as a low tone, then as a higher and higher tone as you keep tuning, and then it will finally disappear.

Fig. 3-11. Turn calibrator on.

Fig. 3-12. Dial can be shifted with set control.

Zero Beat

The quiet spot between the two whistles is the "zero beat," the point at which the receiver is exactly in tune with the calibrating signal. If the dial reads 3.5 MHz, you are in business. If as is usually the case, the dial reads slightly off, the next move is to adjust the dial setting by means of another control so that it does read properly. This can be accomplished in different ways, both mechanically and electrically. On the receiver illustrated, there is a control marked Set (Fig. 3-12). With this control the dial setting can be made to correspond exactly with the calibrating signal.

S-METER

An S-meter may be an integral part of your receiver, or it can be added later as an accessory. You may already be familiar with it from CB operation. If not, there is nothing very complicated about an S-meter; essentially, it is a device which indicates by a meter reading how strong an incoming signal actually is.

Using the "S" meter ordinarily requires that the mode switch be set in the avc position. Usually, there is an adjustment some place on the set, usually on the back, which allows setting the meter for some particular value.

For example, the instructions with your receiver may suggest tuning to a quiet spot on the band and cranking up the rf gain until the noise level is heard clearly. The next step is to adjust the meter control so that the meter indicates S-1 on noise alone.

Using the Meter

In use, the meter swings over and stays roughly in a fixed position when an a-m phone station is tuned in. For example, a strong station may read S-9 on the dial. A weaker signal may read S-4. An extremely strong station, for example, a nearby local station, may give an S-9 plus signal. And when you tune in a station which reads about 30 dB over S-9, it may make your teeth rattle until you can turn down the rf or af gain.

There have been circuit developments to allow using the S-meter with ssb phone, but with most older sets this is not possible. However, the S-meter is most useful in identifying ssb stations, which are indicated by a wildly swinging meter. The meter will also help you get some indication of the strength of the incoming signal.

Helping Fellow Hams

The S-meter has another highly useful feature—it will enable you to help other amateurs in making adjustments of their transmitters or antennas in order to get maximum output. Often, hams will be interested in the signal drop-off or build-up as a beam antenna is rotated.

LOGGING SCALE

Like power-operated windows on a car, this is one of those little luxuries which makes life a bit easier. The purpose of a logging scale is to make it possible to tune in a station and then later to tune back to the same frequency and find the station. This will happen, of course, only if the station is crystal controlled or has a very accurate vfo—and manages to stay *on* frequency.

This kind of accuracy cannot be achieved, ordinarily, with the main tuning dial because it cannot be read to a fine enough degree. The logging scale is a supplementary scale to the main dial, and frequently is marked 0-100. Often, it is also supplemented by markings on the main tuning knob.

In use, the operator may note that the station is tuned in with the main logging scale set at a fixed figure, say "54," and the scale on the main tuning knob set at another figure, say "61." This combination of numbers is jotted down in the log book in the ham station and makes it possible to return to the same frequency later. Of course, for such logging to be done accurately, the main dial must be calibrated with the 100-kHz calibrator *before* the reading is taken.

The logging scale is particularly useful in Novice band operation since all stations must be crystal controlled. It is also handy for "net" operation where a number of stations want to operate on the same frequency.

4

Learning by Doing

To pass the Federal Technical Examination needed for you to become a radio amateur, you must learn a few technical things. The details of the kind of questions you can expect, including the answers, are covered in a later chapter in this book. However, you can learn a good deal of what you want to know with a minimum amount of study, providing you do what amounts to simple "lab" work much like the laboratory sessions which accompany virtually any kind of science course taught in schools.

The nice thing about this approach is that it is virtually painless. You acquire the knowledge you need as a by-product of some very simple experiments which are interesting and fun to do. You'll find also that actually working with equipment gives you a sense of confidence—not to mention understanding—which is almost impossible to acquire simply by reading.

What we will be doing in this chapter is covering these basic lab experiments, and then, in Chapter 6, we can apply much of the same knowledge in building and testing a very simple amateur transmitter.

The writer strongly urges that you at least buy the inexpensive piece of test equipment required for these experiments and carry them out regardless of whether you actually build the transmitter.

All of these experiments are built around the use of a pocket-size volt-ohm-milliammeter (vom) tester of the 1000-ohms-per-volt type. One such typical instrument, which cost only $6.95, is shown in Fig. 4-1.

Despite the low cost of the 1000 ohms-per-volt meter, it is a highly useful piece of test equipment. Many professional servicemen with literally thousands of dollars worth of test equipment prefer to use inexpensive ohmmeters of this type

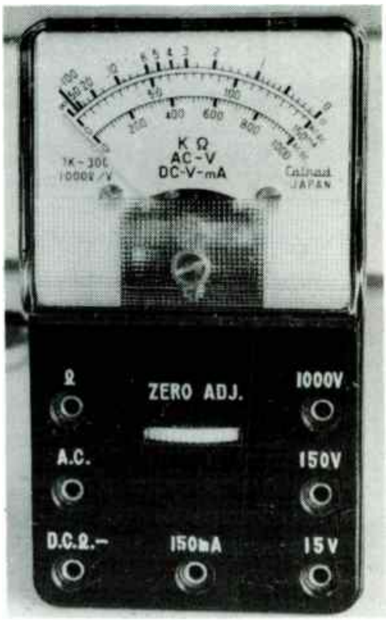


Fig. 4-1. A typical inexpensive vom.

for basic checks of such equipment as power supplies. The danger of burning out the instrument is considerably less than is the case with most expensive 20,000 ohms-per-volt units, and the accuracy obtained is good enough for a great deal of service work. This means that when you buy the little tester it is probably a piece of equipment you will keep and use for many years. Furthermore, it is ideal for testing the transmitter which is the project in Chapter 6, because most troubleshooting tests on the transmitter are easily accomplished by this small meter.

SELECTING A LOW COST VOM

The meters in the low price range are invariably imported, and they come in various designs. The simplest type is the one illustrated in which the various instrument settings are obtained simply by inserting the test leads into the proper jacks on the face of the meter. The more complicated, and usually more expensive, units have a switching device which accomplishes the same thing. Actually, for the beginner, the writer prefers the type illustrated because there is less apt to be a mistake in plugging the test leads into the jacks than would be the case when there is a switch to rotate.

Because these meters come in various brands and designs, perhaps the best way to help you buy one is to describe the scales which they normally cover. Usually, they will test up to 1000 volts in either the ac or dc mode. In addition, they will measure plate current up to 100 milliamps, or perhaps 150 milliamps, and will measure resistance up to 150,000 ohms (150K). The most common method of identification is that they are vom's with a "1000 ohms-per-volt" meter movement. Not only is such a meter useful for electronic work, it has many other applications. For example, if you are trying to hook up trailer lights to your car, the meter makes it easy to identify the proper connections.

In the following discussions we will use the meter shown in Fig. 4-1 for reference.

INTERPRETING THE SCALES

At first, the scales on the dial look a little confusing (Fig. 4-2). In the one shown, for example, the top scale identified by the Greek sign omega (Ω) reads resistance. However, you have to multiply the figure on the dial by 1000 to get the actual measurement. For example, if the meter reads "2" the resistance scale is multiplied by 1000, and the resistor under check is 2000 ohms.

The next scale is for measuring current and ac or dc voltage, depending upon which is under test. Note that the scale reads 150. This corresponds to the 150-volt jack. When the red test lead is plugged into the 15-volt jack, the 150 reading is divided by 10. In other words, the scale indicates 15 volts full scale.

The bottom scale, which reads 1000, reads directly, and is the simplest one to use.

Now let's take a look at the other jacks which appear on the front of the instrument (Fig. 4-1). (If a switch is provided for making the changes in meter setting, the switch sequence will be much the same as the jack layout on the instrument shown.) Notice, at the top left, there is the Greek omega symbol again. This means that if we are going to test for resistance, one of our test leads should be plugged into this jack. Since normally the black lead is the "common" lead for test purposes, the red lead is moved around for the various measurements, so the omega jack is the one used for the *red* test lead.

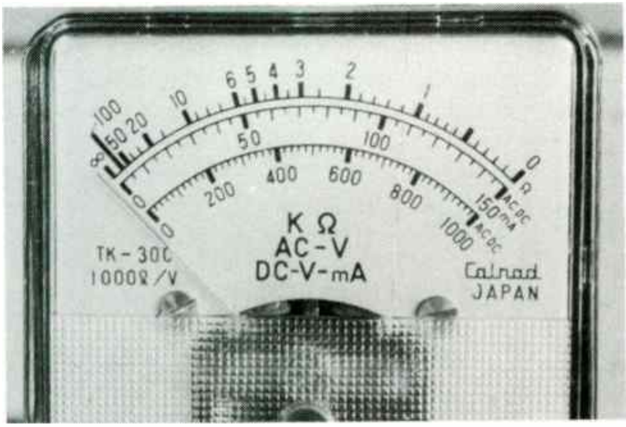


Fig. 4-2. Scales of the meter shown in Fig. 4-1.

Directly below it is the A.C. jack. This is for testing alternating current. You may know from lab work in school the difference between ac and dc, but this matter will be covered briefly, later. The bottom jack is the "common" jack for all dc or resistance measurements.

Looking at the jacks down the right side of the meter, we have a choice of three voltages—15 volts, 150 volts, and 1000 volts. Of course, when you are checking a piece of equipment which delivers voltage that falls within the 1000-volt range, you are dealing with voltage *which is high enough to kill you*, so you will want to be *very careful*. The *simplest* and safest thing to test is resistance, and so we will start out with that particular test.

MEASURING RESISTANCE

First of all, your meter will have to have some kind of battery installed in it. It may come equipped with a battery from the factory, or the battery may be packed separately, and you have to install it yourself, which is usually a very simple matter. The back of the meter is removed by backing off a few screws, and inserting the battery into place. It is absolutely necessary that the battery be in good shape, or you will not be able to measure resistance.

Remember what was pointed out before—plug the red lead into the jack which is marked "ohms" (Ω). Now plug the black lead into the jack marked D.C.Ω–. As the first step, touch the test leads together. This should immediately activate the meter, and the meter pointer moves to the right side (Fig. 4-3). It may, or may not, read zero. If it does not read zero, adjust the little dial which appears in the center of the meter marked "Zero Adj." until the meter scale *does* read zero.

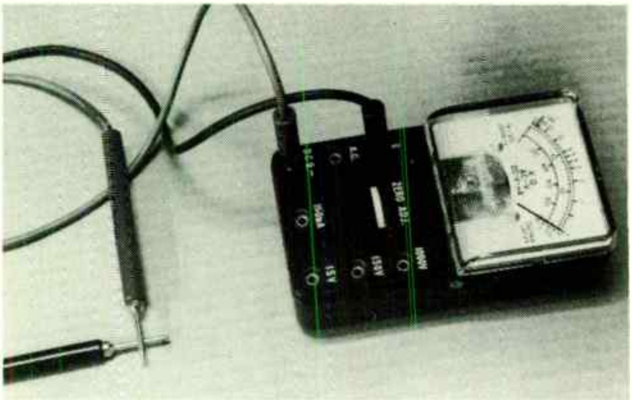


Fig. 4-3. Preparing meter for resistance measurements.

CONTINUITY TESTS

Note that when you touch the leads, the meter indicates that there is *no* resistance between the leads. This indication is extremely useful in test work. For example, if you want to check to see if there is a connection through an insulated wire which you think might be broken within the insulation, it is a simple matter to put the test leads on opposite ends of the wire. If the meter does *not* read full scale, you know that you have a broken wire. Such tests are called *continuity* tests and have many, many applications. For example, if you suspect a soldered connection is not satisfactory, you can place the test leads on either side of the connection and see if you do get the desired reading —namely, *no* resistance.

RESISTANCE CHECK

Now, let's make our first actual test on an electronic component. We will choose a small resistor which is color coded yellow-violet-red. The color code indicates that this resistor should have a resistance of approximately 4700 ohms.

Touch both meter leads to the resistor—one to each end as shown in Fig. 4-4. Be sure to press down *hard* against the leads so that there is a good connection, or form loops in the wire which will grip the leads, as illustrated.

Looking at our ohm scale at the top of the meter, we see that the reading is approximately 5. Multiply 5 by 1000; this means the resistor is approximately 5000 ohms.

Do not be alarmed if your meter does not read the exact resistance as specified by the color code on the resistor. In the first place, most resistors have a tolerance of plus or minus 10 percent which, of course, in the case of a 5000-ohm resistor is 500 ohms. Furthermore, a simple test meter of this type will have a built-in error of its own which may add or subtract

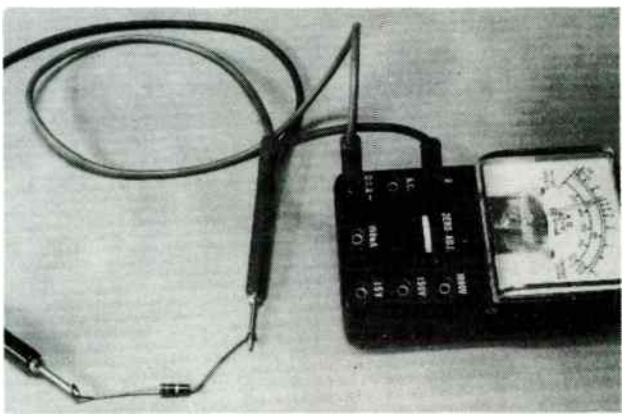


Fig. 4-4. Checking the resistance of a resistor.

to the resistance of the resistor under test. The meter is far more accurate in reading voltages than it is in measuring resistance. However, only rarely do you need to be able to measure a resistor with extreme accuracy. When this is necessary, it is done with voltohmmeters with 20,000 ohms-per-volt or more resistance or with a vacuum-tube voltmeter. Both pieces of equipment are far more expensive and delicate than the one with which we are now working.

AC/DC

The next test is interesting because it illustrates a very important principle in connection with the process of changing alternating current as it comes from the wall socket in the house into direct current, for use in electronic equipment. This process is absolutely vital in virtually every piece of electronic equipment in use.

It is not the intention of this book to get into such things as the intricacies of alternating current versus direct current. However, there are a few simple concepts which should be understood and which will be useful to you in your Novice exam.

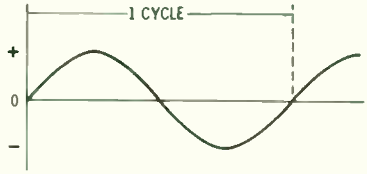


Fig. 4-5. Representation of alternating current.

Since no one can "see" electricity, there has to be some practical way of representing it by diagram. Normally, alternating current, which is the type which you have in your home, is indicated as shown in Fig. 4-5. What the drawing represents is that the polarity of the voltage is constantly changing from plus to minus, and swinging through the cycle sixty times per second—assuming we are dealing with the common 60-hertz alternating current. The reference line in the middle is neither positive nor negative. What we want to do is to keep everything above or below the line so that we have simply direct current and not alternating current.

This is accomplished in electronics by a component known as a rectifier. A *rectifier (diode) passes current very easily one way, but has very high resistance to the flow of current in the opposite direction.*

This is easily demonstrated with our meter and an axial-lead rectifier. Two of these are used in the transmitter to be described in the next chapter, and if you intend to build the transmitter, by all means buy one of the rectifiers of the type specified. If you are buying it simply for test purposes, almost any rectifier will do. For the transmitter, what you want to buy is an "axial" lead rectifier rated at 1000 prv, 500 mA, or higher. What these specifications mean is that the rectifier will handle a thousand volts peak reverse voltage, with up to ½ ampere (500 milliamps) of current.

TESTING A RECTIFIER

We make our test exactly as we did with the resistors, touching our test leads to the two leads on the rectifier (Fig. 4-6). However, this time you will discover that with the leads connected one way, you will get a fairly low reading—perhaps 2500 ohms. Then, simply reversing the leads will result in no reading whatsoever. What this means is that the rectifier

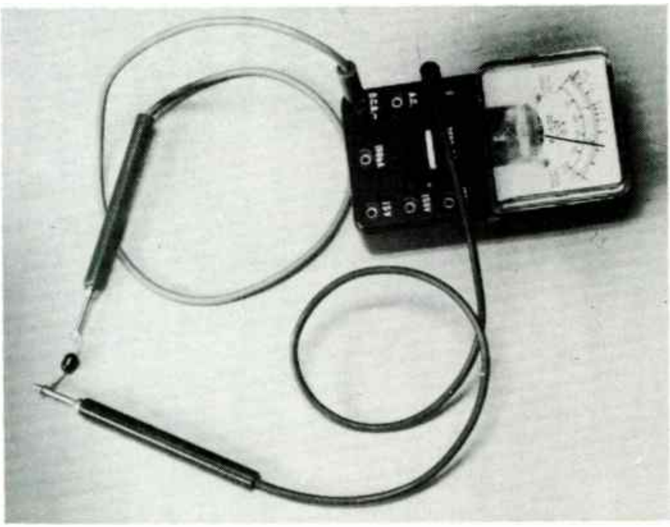


Fig. 4-6. Checking front-to-back ratio of a diode.

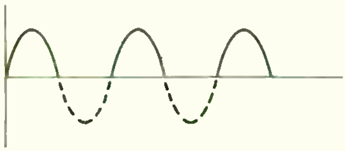


Fig. 4-7. Representation of output current of a half-wave rectifier.

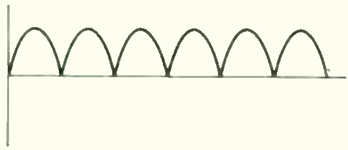


Fig. 4-8. Output current from a full-wave rectifier.

passes current readily in one direction, but offers extremely high resistance to the passage of current in the other direction.

Our drawing of output current from a diode now looks like that shown in Fig. 4-7. Notice that now everything is above the line, and we have only *direct* current. Actually, it is pretty rough direct current because there are gaps between the half cycles shown, and this is the result of our using only a half-wave rectifier. More sophisticated rectifier systems are possible, and one of these is used in the transmitter. A full wave rectifier results in a current flow which looks like that shown in Fig. 4-8.

We can further improve upon this with *filter* capacitors that tend to fill in the valleys, and, for all practical purposes, the resulting current flow is indicated by a straight line as in Fig. 4-9.

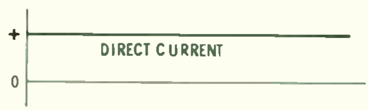


Fig. 4-9. Filtered output of a full-wave rectifier.

MEASURING DC VOLTAGE

Now, let's measure some voltage. We'll start out with a safe and simple one—a flashlight battery. As before, our black test lead is plugged into the DC minus.

There is a positive and a negative terminal on the flashlight battery. You can simply touch the test lead prods to the battery—no need to solder on loops as we have done for photographic purposes in Fig. 4-10.

Ideally, we would have a lower scale than 15 volts available to measure the battery voltage, but our meter provides only this scale, so we have to make our test with what we have available. Always, the point is to plug the meter test lead, or

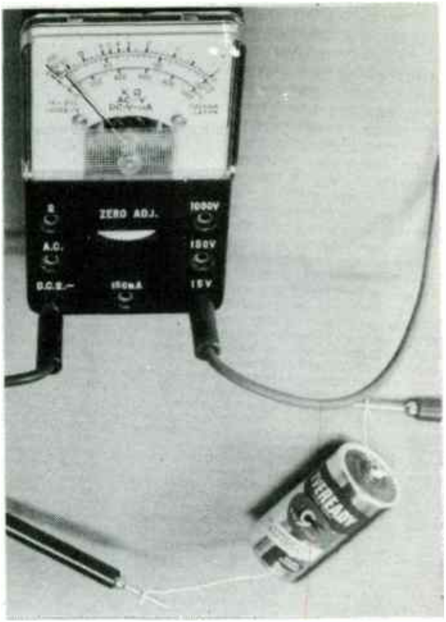


Fig. 4-10. Measuring battery voltage.

set the range dial on the meter to the voltage known to be close to what you expect to be reading. If in doubt in using *any* kind of instrument, you always set it for a high voltage range first, and then gradually move down to a lower range. This helps avoid possible burn-up of a meter movement.

READING THE SCALE

You'll find that our voltmeter requires a bit of interpreting because we have to read on the 150 scale this time. We divide this by 10 to get the 15 volts for full scale. This means that the flashlight battery should read something less than "50" on the scale (50 divided by 10—or 5 volts), and, of course, this is exactly what happens. As mentioned before, voltage readings are more accurate than resistance readings with our meter, and you will find that the meter comes pretty close to indicating a volt and a half—assuming that the flashlight battery is new.

Actually, low-ohms-per-volt meters like our vom are ideal for testing flashlight batteries because they put enough current drain on the battery so that if it is weak it will normally lose voltage rather rapidly and the meter reading will fall off. A high resistance meter, while it will give a somewhat more accurate voltage reading, places so little load on the battery that there is always the danger a battery will indicate better condition than it actually is. Normally, a battery should read within at least 10 percent of its stated voltage, and usually a good battery will read slightly higher. For example, any 9-volt battery of the type used in a transistor radio, which you can also test very easily, should read approximately 9 volts. If it's more than a half volt less than that, the chances are the battery is weak and should be replaced.

If a 9-volt transistor battery is available, a good test is to connect to it and see how it shows up on the scale. You will see that it indicates approximately 90 (90 divided by 10—or 9 volts).

MEASURING AC VOLTAGE

We saved the more *dangerous* test for last. The idea is that you have gained a little experience with the meter and are now equipped to make a test which could be *lethal* if you do not do it properly. This time we are going to test ac voltage.

The black test lead is inserted into the A.C. jack on the meter. The red test lead is connected to the 1000-volt jack on the meter.

We are now ready to check the voltage which actually appears at the wall socket of the house. Since we are dealing with 115 volts ac, we must be cautious. Insert the black test lead probe into one half of the wall socket receptacle. Then, and *very carefully*, insert the red lead into the other half (Fig. 4-11). You may have to jiggle the test leads a bit to get connection, but the meter should indicate approximately 115 volts on the 1000-volt scale.

As mentioned previously, we have deliberately started out with the meter set at a higher scale than the voltage we expect to encounter. Now, pull both test leads out of the wall socket. Move the one test lead from the 1000-volt jack to the 150-volt jack. This means that we will now have a scale on the meter closer to what is actually to be measured in the way of voltage. Hence, this setup is more accurate.

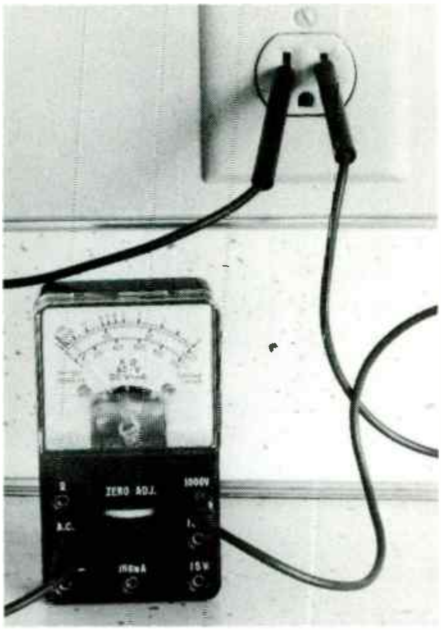


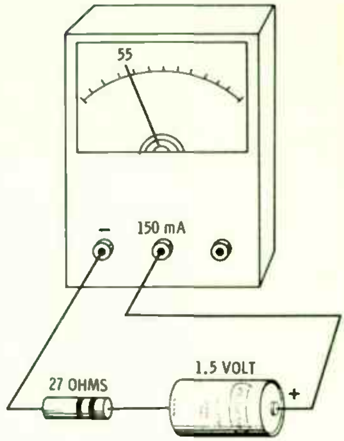
Fig. 4-11. Measuring ac line voltage.

Now, go through the same process as before, again being very careful. You will find that on the 150-volt scale the reading is somewhat different because of the greater accuracy. You will also discover if you do this several times a day, that there will be a voltage fluctuation from time to time within the typical home or apartment. The power company would like to avoid this, but there are power demands at various times of the day which make it unavoidable.

MEASURING CURRENT

Our final test is for current. This is another very useful measurement, as will be demonstrated in tuning up the transmitter in Chapter 6. The drawing in Fig. 4-12 shows how to set up our meter for current measurement, using a 1½-volt flashlight battery and a 27-ohm resistor. The current reading we will get can be predicted mathematically by the application of Ohm's law, one of the basic mathematical formulas used in electronics. On the basis of Ohm's law, *resistance equals voltage divided by current* ($R = E/I$). Various modifications

Fig. 4-12. Setup for measuring current.



can be made in this formula, as will be apparent to any algebra student.

In our test, we have this situation: 27 ohms = 1.5/I. Solving for "I" using 1.5/27, we get .055 which equals .055 amperes. A milliampere, which is what our meter reads, is *1/1000th of an ampere;* so .055 is 55 milliamperes. Our meter will indicate approximately this reading, the exact reading dependent upon the cell voltage, accuracy of resistors, and accuracy of the meter.

If you have conducted the foregoing tests you already have learned some of the key things you need to know to obtain your Novice license. But before going further with the licensing project, let's become acquainted with another key piece of equipment in a ham station—the ham transmitter.

5

Selecting a Transmitter

First, let us take a look at the elements which go to make up a ham station. In the diagram of Fig. 5-1, note that there is shown a receiver, transmitter, and antenna. In most stations, the same antenna is used for both transmitting and receiving, with some kind of switch being provided to shift the antenna from receiver to transmitter at the proper time. As mentioned before, some ham stations on ssb phone use transceivers, but for Novice band, separate units are required even though they may be in the same case.

MANUFACTURED, KIT, OR HOMEMADE

Just as with receivers, there are excellent transmitters on the market, wired and ready to go. If your time is limited, or you feel that building a transmitter is too formidable a job, then by all means buy a manufactured unit (Fig. 5-2).

However, and this fact comes as a surprise to many people, a cw transmitter is much easier to build than a receiver. Unlike a receiver, which requires expensive test equipment for aligning a number of critical circuits, a transmitter can be tuned up, usually, with nothing more than the plate milliammeter or output indicator which is usually built-in. So even if you have never built electronic equipment, it is not only

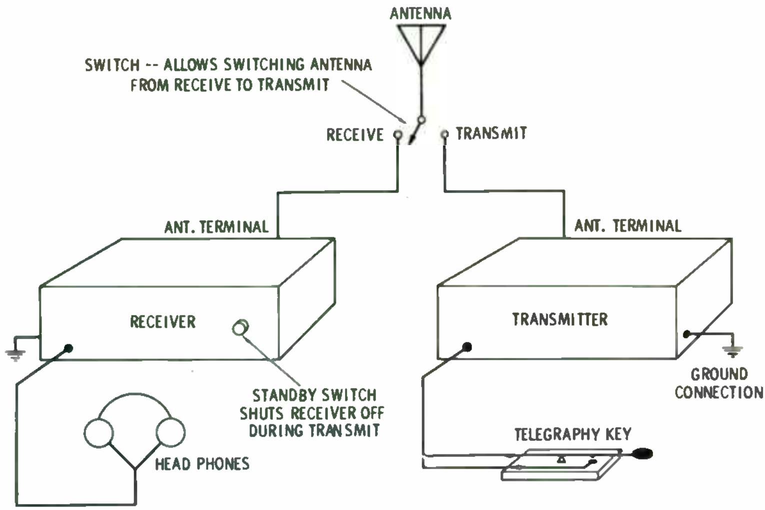


Fig. 5-1. Block diagram of a simple Novice station.

practical but fairly easy to build a transmitter from one of the excellent kits available, such as that illustrated in Fig. 5-3.

Building from a kit will help you gain practical know-how, helpful in the exam for your Novice license. The cost will be lower than a manufactured unit, and in most cases will be less

Courtesy R. L. Drake Co.

Fig. 5-2. Example of a manufactured transmitter.

than the price of a used receiver of adequate quality. A home-made transmitter can be built for as little as $50.00. Such a transmitter is illustrated in Fig. 5-4, and described in Chapter 6.

Just as with a receiver, there are certain things to look for in an amateur transmitter. As you will see from the list which

Courtesy Heath Co.

Fig. 5-3. Transmitter available in kit form.

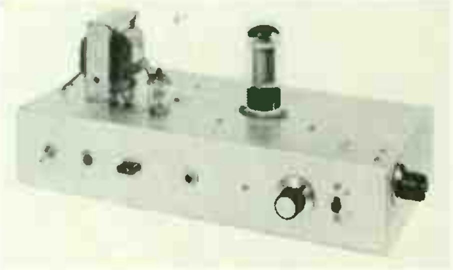
follows, though, there are not nearly as many as in the case of a receiver.

POWER

The Novice ham transmitter is limited to 75 watts power input. With a good antenna, this is more than adequate for the bands. Most of the "cw-only" and other low-priced transmitters are in this power range. *Some* are somewhat higher powered, but have the plate milliammeter marked so that by tuning the transmitter as directed, you keep the input down to the legal maximum. Some hams buy the bigger rigs because they intend to continue to operate cw when they go on up to a General Class license, which allows input up to 1000 watts.

If 75 watts is the maximum, what is the minimum? In the writer's opinion, an input of 25 watts is about the minimum power a Novice should use. While it is perfectly possible to communicate "around the world" with 5 watts, the task had best be left to an experienced ham with a very good antenna.

Fig. 5-4. A homemade transmitter.



Furthermore, "input" is not the whole story. For example, if the transmitter has only an oscillator coupled direct to an antenna, overall efficiency is probably not over 50 percent at best. But an oscillator/amplifier hookup, the more common arrangement, will have about 70-percent efficiency. Thus, a 15-watt rig, which is oscillator only, will have an *output* of only 7½ watts. But a 25-watt rig, which is oscillator/amplifier, will have an *output* of over 17 watts—and *output* is what the other station hears.

So, pick a transmitter which has an oscillator/amplifier circuit, with at least 25 watts input.

NEUTRALIZATION AND HARMONICS

With a transmitter it is important that it generate rf (radio frequency) energy only on the frequencies for which it is intended, *not* on *spurious frequencies* which may cause interference. One of the ways to guard against such problems is to include *neutralizing* as an ingredient of the design. This is particularly true in the case of 5-band transmitters, which without neutralization may become unstable on the higher frequencies. The better transmitters will usually include some type of neutralization, usually fixed and requiring no adjustment on the part of the operator.

Another approach is to use an untuned oscillator, as was done with the transmitter in this book. This also helps reduce the possibility of spurious signals because of *harmonics*. Harmonics occur at some multiple of the basic frequency in tuned oscillator circuits. For example, an oscillator operating on 7 MHz may have some output on 14 MHz and 21 MHz. If this unwanted output reaches the antenna, it may result in the signal being picked up outside the band intended and can even cause the operator problems with the FCC.

It is sufficient to say that transmitters of good design are developed with these problems in mind.

TVI PROOFING

Even a low-power Novice band transmitter can cause interference with a nearby television set, particularly in tv fringe areas. Again, this problem is dealt with through good design: for example, rf filter capacitors on the power line input, good shielding, etc. In extreme cases, it may be necessary to add a *low-pass* filter in series with the antenna feed line of the transmitter, and a somewhat similar filter at the antenna terminals of the tv set. Some transmitters have low-pass filters built in.

PHONE

Some of the low-priced transmitters boast of "phone as well as cw operation." Actually, this is a marginal advantage, since the phone is invariably some type of controlled-carrier a-m, which means that it is very low powered, and furthermore is useless in most of the phone bands where ssb (single sideband) has taken over. About the only practical spot for such a transmitter is on 10 meters, where with the help of a good, high gain beam antenna you may be able to "get out"—and on 6 meters, where in some areas there is still some low power a-m phone work. Ssb is taking over so rapidly, though, that the simple a-m phone transmitter is becoming a thing of the past.

So, if "phone" is thrown in at little additional cost—good. But in choosing a transmitter for the Novice cw bands, whether or not the transmitter can be used for phone is not an important factor in choosing a good rig.

PI NETWORK COUPLER

Most transmitters today utilize some type of pi network to make it easy to couple to low impedance lines—usually 52 ohms or 72 ohms.

KEYING

It is important that the keying circuit is so arranged that no high voltage appears on the key, where it might give a nasty or even fatal shock.

One answer to this problem is cathode circuit keying, as was done in the transmitter in this book. Another approach is to use what is known as grid-block keying—an excellent approach. A further refinement is provision for "break in," which means that contacts can be more like a normal conversation than a series of monologues. However, Novice operation tends to be of the latter variety.

VFO PROVISION

Vfo (variable frequency oscillator) operation is now permitted for the Novice, although most Novice rigs are crystal-controlled as is done in the CB bands. However, if you intend to use the same transmitter when you move up to the General class license, this feature is desirable.

SHOULD YOU BUILD YOUR OWN

Most experienced hams feel that there is a real advantage to building at least some of the equipment you use—the experience gained is priceless and makes the hobby that much more enjoyable. The transmitter which follows in the next chapter was designed to be built by the beginner, and if you can follow step-by-step instructions, you can build it, even with no previous experience. However, the project will go more smoothly if you have built some simpler pieces of electronic equipment previously and have learned how to solder, read color codes, etc.

6

Building a Transmitter

Chapter 5 discussed the pros and cons of building your own transmitter. We'll assume that you have decided to take on this project yourself.

The photograph in Fig. 6-1 shows a very simple 25-watt transmitter designed especially for the Novice and covering two popular Novice bands—80 and 40 meters. The 15-meter band was omitted because to add the necessary parts for multiplying the crystal oscillator frequency and get a 21-MHz output would make the unit more complicated. It could be done, though, at a later date, and 10 meters could also be added.

The transmitter is an oscillator/amplifier hookup with an untuned oscillator and an amplifier operating on the same frequency. While this kind of circuit is somewhat more complicated than the oscillator/only type of rig sometimes recommended for Novice bands, it has the advantage of being far more efficient overall and has greater output.

Obtaining parts today can be a problem, and this fact was carefully considered in the transmitter design. For example, the transmitter utilizes two very inexpensive broadcast-band type variable capacitors which are widely available. The coils are hand-made, being wound of hookup wire on plastic pill boxes obtainable at almost any drug store. The rest of the components are all standard radio and television replacement parts.

In addition, power supply voltage is fairly low, which makes transmitting-type components unnecessary and also adds some safety value. However, it should be pointed out that "low" voltage in this transmitter is approximately 275 volts—more than enough to kill you if you are careless with it. As another safety measure, the time-tried 6L6G tube was used, rather than the more common tv sweep tubes—which are fed high voltage to an external cap. On this transmitter, all high voltage points are *under* the chassis.

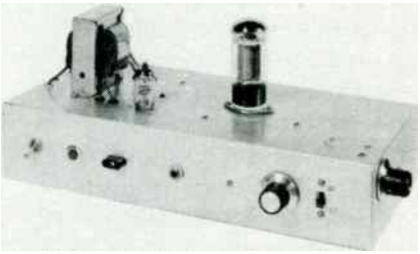


Fig. 6-1. A very simple 25-watt transmitter.

The transmitter has an open, point-to-point wiring layout with all the parts visible, simplifying step-by-step wiring instructions. Furthermore, the design is such that the builder can test sections of the transmitter as he builds. This technique of building makes troubleshooting far easier; if the section just completed does not work, you know exactly what area of the project is giving the trouble. One of the difficulties which beginners have in building is that they sometimes make several mistakes, and then even an experienced ham may have difficulty in locating the problem.

In electronic equipment servicing, you ordinarily proceed on the assumption that there is only one thing wrong at a time, although this is not always true of course.

BUYING PARTS

The first thing we have to do is obtain the parts. If you live in a sizable city, the chances are good for locating an electronic parts supplier which will have them all in stock. If you live in a small town, you probably will need to get parts by mail.

A list of the parts required is given in Table 6-1.

Table 6-1. Transmitter Parts List

Quantity	Description	In Drawing, Part Labeled:
1	2 conductor jack (closed circuit)	J1
2	Homemade coils	L1, L2 (see text)
1	20-ohm, 10-watt resistor	R1
1	150K (150,000)-ohm, 2-watt resistor	R2
1	150-ohm, 10-watt resistor	R3
1	47K (47,000)-ohm, 1/2-watt resistor	R4
1	22K (22,000)-ohm, 2-watt resistor	R5
1	22K (22,000)-ohm, 1/2-watt resistor	R6
1	2.5-mH rf choke	RFC
1	Single-pole single-throw toggle switch	SW1
1	Double-pole double-throw slide switch	SW2
1	2.7-40 pF ceramic trimmer	TR
1	3-amp pigtail fuse	F1
1	Power Transformer—Primary 115 V; Secondary 115 V @ 80 mA, or more Separate Filament 6.3 V @ 2.9 amp. (Suitable: Burstein Applebee No. 18A1386; Can be used: Stancor PA8 421)	T1
8	Rubber grommets	GR1 thru GR8
8	Soldering lug terminal strips	See Fig. 6-4
1	Ac power cord with plug	Pwr
2	.001-μF, 1000-volt ceramic disc capacitors 1000 Vdcw (1 kV)	C1, C2
2	30-μF, 350-volt electrolytic capacitors	C3, C4
1	20-μF, 600-volt electrolytic capacitor	C5
4	.01-μF, 600-volt ceramic disc capacitors	C6, C7, C8, C9
2	100-pF, 500-volt mica capacitors	C10, C11
1	.005-μF, 1000-volt ceramic capacitor	C12
2	365-pF midget variable capacitors, broadcast receiver type	VC1, VC2
1	Neon panel indicator light assembly for 115-V ac	NE1
1	Crystal socket .095D pins 0.487 space for FT-243 holder	CR
1	RCA-type phono jack	J2
1	Neon bulb, Type NE2	NE2
1	7 × 15 × 3 aluminum chassis	
1	6L6G tube	
1	12AT7 tube	
2	.5 amp 1000 piv diodes	RC1, RC2
1	8 pin octal socket	SK2
1	9 pin miniature socket	SK1
Misc.	Hardware including 1 Fahnestock clip and supply of 6-32 bolts and nuts, soldering lugs	
2	Knobs	

MOUNTING THE PARTS

Figs. 6-2 and 6-3 show where to mount the various parts. For most parts, exact location is unimportant. Other parts, for example the variable capacitors, must be positioned with considerable accuracy. In the case of the variable capacitors, since the different manufacturers may have somewhat different dimensions, the best thing to do is to make a small paper templet of the capacitors to locate the mounting holes, then transfer this data to the chassis. Actually, mounting the capacitor is the only difficult task—the rest is simply a matter of drilling the holes in approximately the positions indicated in the photographs.

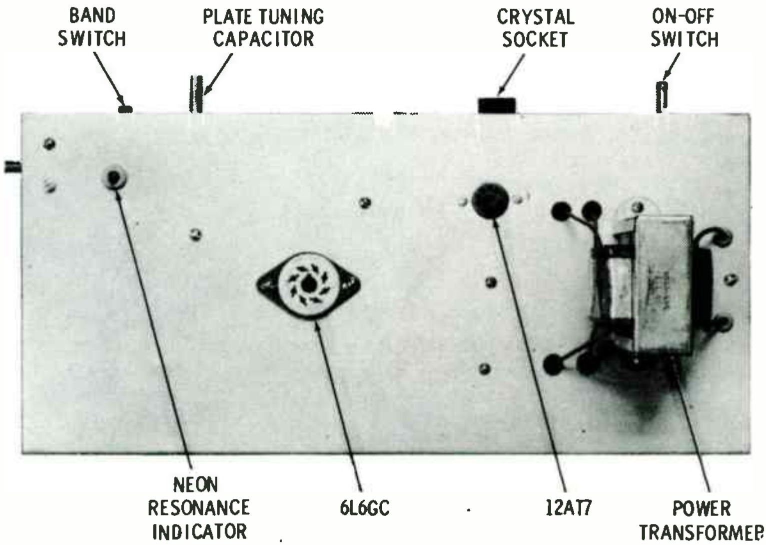


Fig. 6-2. Top view of chassis.

If you know a radio amateur or other electronic experimenter who does considerable building, you can probably borrow socket punches to be used in making holes for the sockets. As an alternative, you can drill the hole with the biggest drill you have and enlarge it with a round file, or, in the case of the larger socket, simply drill a whole series of small holes close to the perimeter of the diameter needed and then finish the hole off with a rattail file. A very small rattail file is a highly useful device in case you miscalculate the location of a small hole. Usually, the hole can be slotted enough to allow mounting the part.

Fig. 6-3 shows all the main parts mounted and ready for wiring. Note the soldering lugs under the bolts mounting the tube sockets. Wiring is done with No. 18 plastic-covered hookup

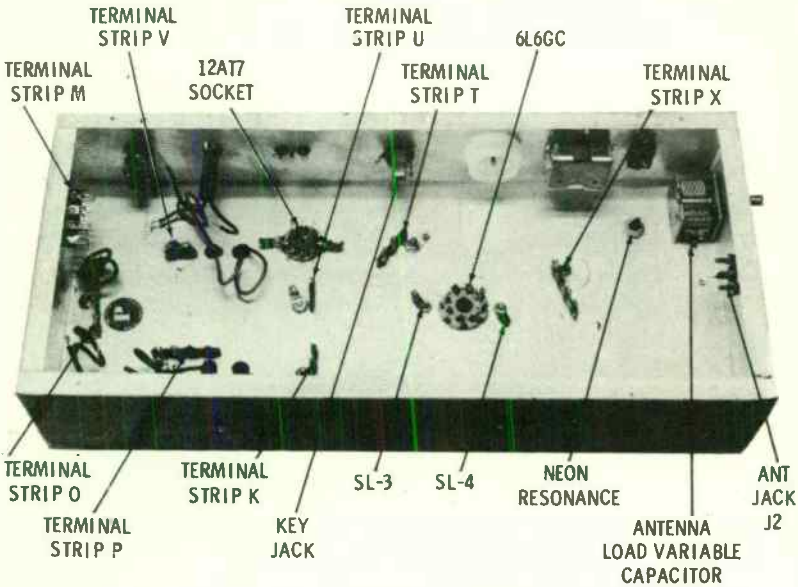


Fig. 6-3. Bottom view of chassis.

wire. Use 60/40 solder and a *clean*, hot soldering iron. In the instructions (S) means *solder;* (DS) means connect—but *don't solder yet*. A subsequent instruction will indicate when to solder.

WIRING THE POWER TRANSFORMER CIRCUIT (FIG. 6-4)

- ☐ Push power cord through grommet GR1. Tie a knot in the cord and leave sufficient length leads to make connections.
- ☐ Run one of the power line leads to lug M1. Hook fuse F1 to lug M1. (S)
- ☐ Hook one of the black leads from the transformer—the one coming through grommet GR2—to lug M2. (DS)
- ☐ Hook the free end of fuse F1 to lug M2. (DS)

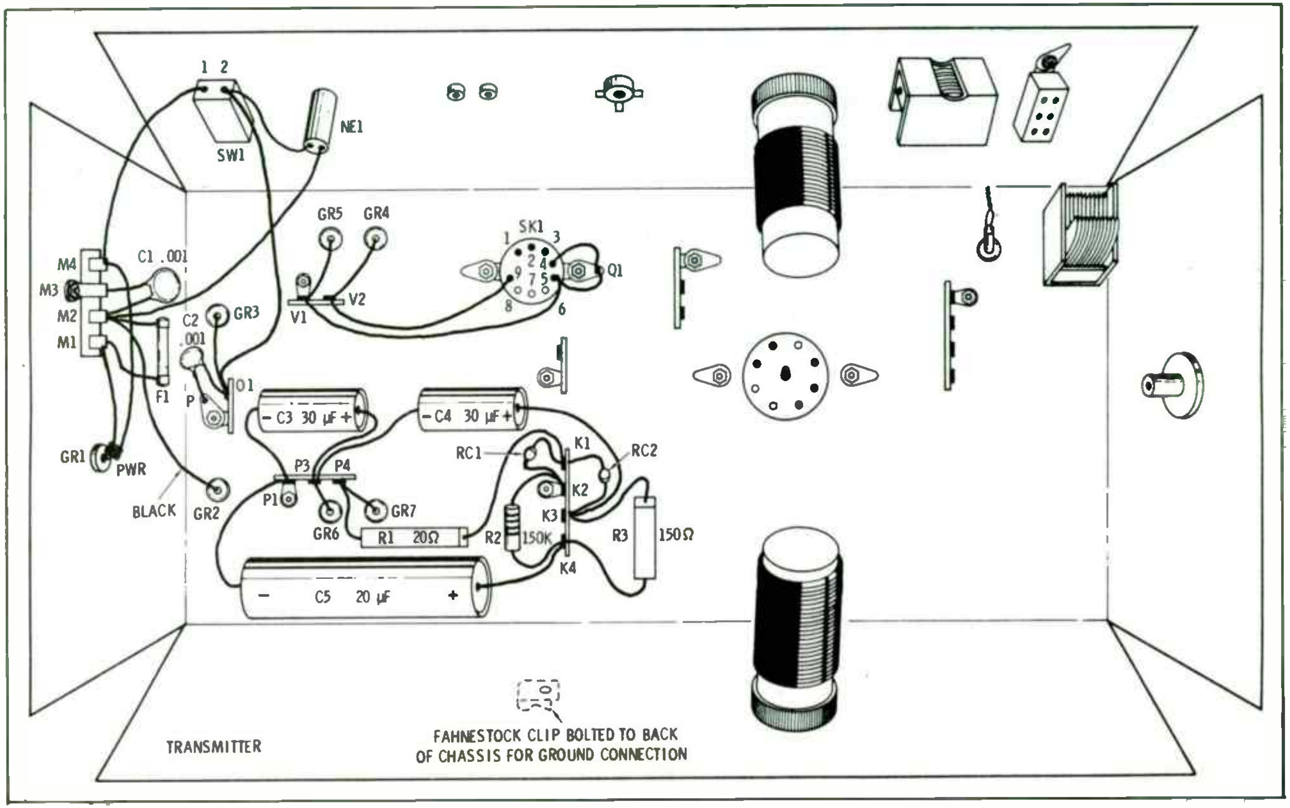


Fig. 6-4. Wiring the power supply circuit.

- ☐ Hook one end of .01-microfarad capacitor C1 to lug M2. (DS)
- ☐ Hook the other end of C1 to lug M3. (S) Note lug M3 is grounded to the chassis through the mounting bolt. If a different type of terminal strip is used, provide a grounded lug separately.
- ☐ Hook the remaining lead from the line cord to lug M4. (DS)
- ☐ Fasten a 2-inch length of hookup wire to lug M4. (S)
- ☐ Connect the other end of the lead to terminal 1 on switch SW1. (S)
- ☐ Connect one lead from the indicator bulb NE1 to terminal M2. (S)
- ☐ Connect the other lead to terminal 2 of SW1. (DS)
- ☐ Run the black lead coming up through the chassis from grommet GR3 to lug O1. (DS)
- ☐ From terminal 2 of SW1 (S) run a lead to lug O1. (DS)
- ☐ Hook one end of capacitor C2 to ground lug P which is bolted to the chassis. (S)
- ☐ The other lead from capacitor C2 goes to terminal O1. (S)

Note that the two .001-microfarad capacitors are connected to the primary winding of the transformer. The purpose of these capacitors is to allow an easy path to ground for the radio-frequency energy generated, and thus help reduce the possibility of causing interference with nearby television sets.

- ☐ The green lead from the transformer, which is one of the "heater" leads, goes to terminal V2. (DS)
- ☐ The other green lead goes to terminal V1 which "grounds" to the chassis through a bolt. (DS)
- ☐ Solder a lead to lug V1 and run it to pin 5 on the bottom of 12AT7 socket SK1. (DS)
- ☐ Solder a lead to pin 5 of SK1 and connect to lug Q1. (DS)
- ☐ Solder a lead to terminal V2 and run it to pin 9 of SK1. (S)
- ☐ From Q1 (S) run a lead to pin 4 of socket SK1. (S)

First Test Procedure

At this point we have connected the power transformer to the power cord, have provided a switch and neon indicator light on the panel, and have supplied "heater" voltage to the 12AT7 tube. We can be certain that everything is wired satisfactorily, so far, by some simple tests.

First, plug the power cord in the wall socket and observe the indicator light when the switch SW1 is thrown. The neon bulb should light up. Turn SW1 to off.

As the next test, plug the 12AT7 tube into the socket and turn the power supply on. After a few seconds, the tube should warm up and begin to glow, although quite weakly.

These tests indicate that we have the power transformer wired properly, so that there are 6.3 volts available to warm up the tube heaters.

POWER SUPPLY WIRING CONTINUED (FIG. 6-4)

- ☐ Connect the red lead from the power transformer coming through grommet GR6 to terminal P3. (DS)
- ☐ To this same terminal, connect the negative end of one of the 30-microfarad (30-μF) filter capacitors (C4) and the positive end of the other 30-μF filter capacitor (C3). Hook the negative end of C3 to lug P1. (DS) Note that P1 is bolted to chassis, which automatically puts it at the ground potential.
- ☐ Hook the negative end of the 20-microfarad capacitor (C5) to lug P1. (S)
- ☐ The positive end of the 30-microfarad capacitor (C4) goes to terminal K3. (DS)
- ☐ The red lead from the power transformer coming through the chassis via grommet GR7 is hooked to terminal P4. (DS)
- ☐ Solder one end of resistor R1 to P4.
- ☐ Hook the other end of resistor R1 to terminal K1. (DS)
- ☐ To K1, hook rectifier RC1 (end with line). *Notice that there is a small line on the end of the rectifier which indicates the proper polarity.* (DS)
- ☐ To K3 wire in rectifier RC2 (end with line), again observing the polarity sign. (DS)
- ☐ Hook the free end of 20-microfarad capacitor (C5) to terminal K4. (DS)
- ☐ Connect one end of R2, 150,000 ohm, 2-watt resistor, to K4. (DS)
- ☐ Connect one end of the 150-ohm, 10-watt resistor R3 to K4. (DS)
- ☐ Connect the free ends of RC1 and R2 to ground lug K2. (S)

☐ Secure the free end of rectifier RC2 to terminal K3. To this same terminal, connect the free end of the 150-ohm 10-watt resistor R3. (S)

Second Test Procedure—DANGER

We have now completed the wiring of the power supply which uses a voltage-doubler circuit. Approximately 115 volts are put out by the transformer, but this voltage is built up to over 250 volts at the output of the power supply.

We can test the power supply with the vom which should be set on the 1000-volt dc scale, if it is like the one shown in this book. We can also test with an ordinary neon bulb electrical tester, which will glow brightly if all is well.

Since we are dealing with 250 volts or more, we are definitely working with a voltage which under certain circumstances can easily *kill* the user. When working with voltages of this type, it pays to be careful—always.

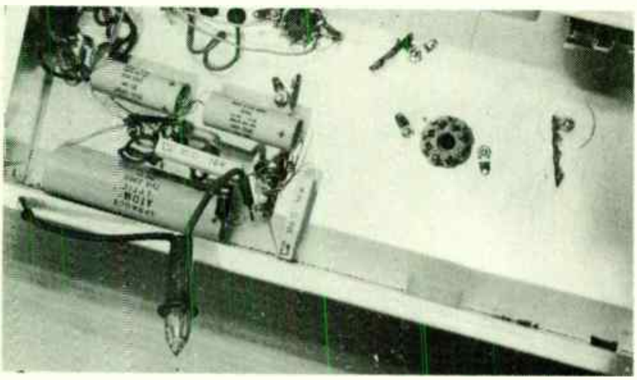


Fig. 6-5. Using neon tester to check for voltage.

Most important is to keep your head in the game. One little trick of the trade is to never use *both* hands at once. Fatal shocks may come because the current enters both hands and goes into the heart and lung area. If you *keep one hand in your pocket*, it is more difficult for such an accident to occur.

The photograph in Fig. 6-5 shows how the neon tester can be set up to check the voltage. One lead from the tester can simply be pushed through the hole in the chassis which is at negative potential. The plus potential, the critical one which we are testing, appears on terminal K4.

With the one test prod connected to the chassis, touch the other one to this high voltage point on K4. In doing this, keep the other hand *away* from the chassis—remember, carefully avoid any situation which would allow you to encounter voltage in both hands.

Neon bulb lights, or VOM reads 250 volts plus? We're ready to wire again.

WIRING THE OSCILLATOR (FIG. 6-6)

IMPORTANT: Keep all leads as *short* as possible.

- ☐ Connect a short lead to terminal 3 of J1. (S)
- ☐ Run the other end of the short lead to terminal 2. (DS)
- ☐ Connect one end of C6, a .01-microfarad ceramic capacitor, to terminal 2. (S)
- ☐ Connect the opposite end of capacitor C6 to terminal 1. (DS)
- ☐ Connect a short lead (2 inches) to terminal 1. (DS)
- ☐ Connect the other end of this lead to pin number 3 on socket SK1. (DS)
- ☐ Connect .01-μF capacitor C8 to crystal socket holder terminal CR1. (DS)
- ☐ Connect the other end of this capacitor to pin 1 on socket SK1. (DS)
- ☐ Connect one end of C10 to crystal socket holder terminal CR1. (S)
- ☐ Connect the other end of C10 to terminal T1. (DS)
- ☐ Connect a 2-inch length of wire to crystal socket holder terminal CR2. (S)
- ☐ Connect the other end of this wire to pin 2 of socket SK1. (DS)
- ☐ Solder a short (1-inch) stiff wire to one terminal of trimmer TR.
- ☐ Connect the other end of the wire to terminal 2 of socket SK1. (DS)
- ☐ Solder another short, stiff wire to the other terminal of trimmer TR.
- ☐ Connect the other end to grounding lug Q2. (DS)
- ☐ Connect one end of 47,000-ohm ½-watt resistor R4 to grounding lug Q2. (DS) The other end of resistor R4 goes to pin 2 of socket SK1. (S)

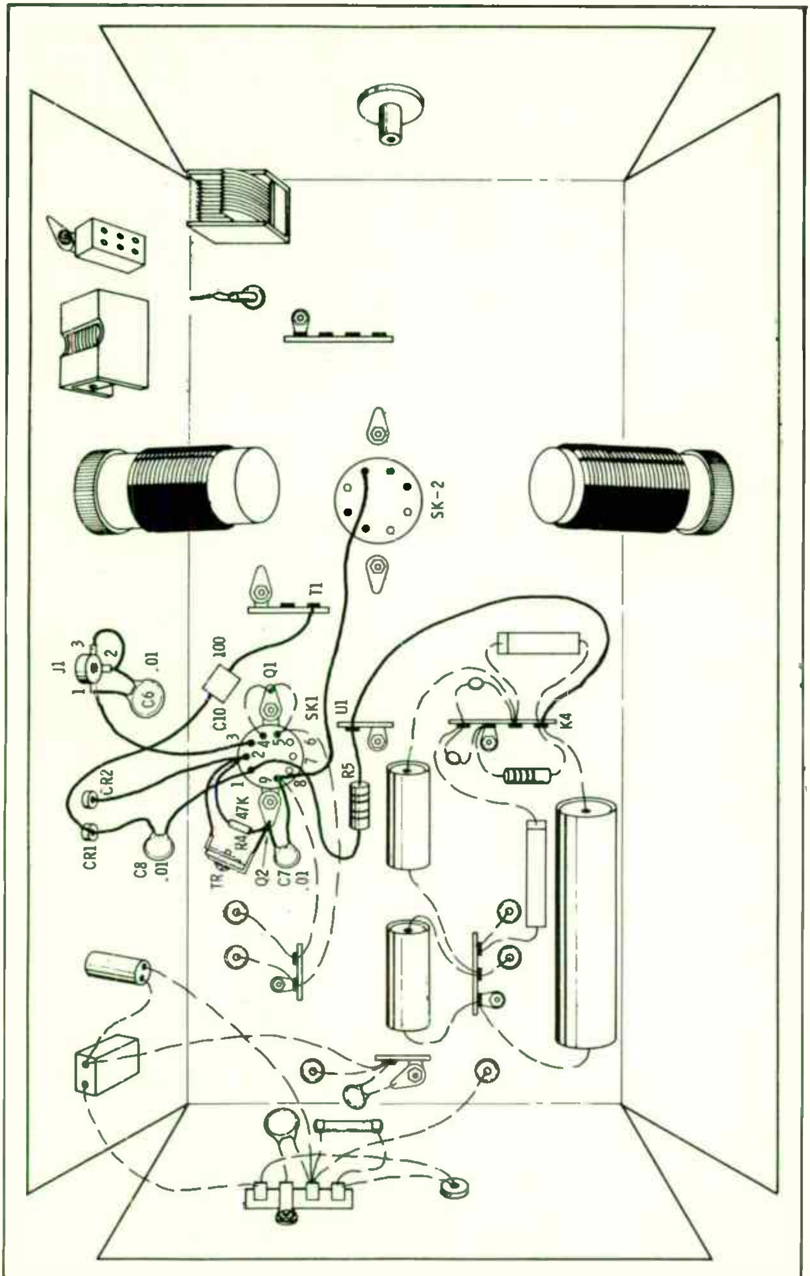


Fig. 6-6. Wiring the oscillator.

- ☐ Secure a lead to K4, which is the high voltage terminal we mentioned earlier. (S)
- ☐ Connect the other end of this lead to terminal U1. (DS)
- ☐ Connect one end of 22,000-ohm 2-watt resistor R5 to U1. (S)
- ☐ Connect the other end of R5 to pin 1 of SK1. (S)
- ☐ Connect one end of.01-μF capacitor C7 to pin 9 on socket SK1. (DS)
- ☐ Connect the other end of the capacitor to grounding lug Q2. (S)
- ☐ Connect one end of a 6-inch length of wire to pin 9 of SK1. (S)
- ☐ Connect the other end of wire to pin 2 of socket SK2. (S)
- ☐ From crystal socket CR1 (S), run a 100-picofarad capacitor (C10) to lug T1. (DS)

Testing the Oscillator

At this point, we have wired the power supply and the oscillator stage, which is one of the two stages of the transmitter. The oscillator will operate by itself—it serves as a driver stage to supply power to the rf amplifier, which boosts the power considerably. However, in keeping with our building practice, we will test the oscillator before wiring in the amplifier stage.

The first step is to turn on the receiver and try to set the receiver dial as close as possible to the frequency of the crystal. Frequency is normally marked on the crystal. For example, on the one on which the initial test was made, the crystal frequency was 7125 kHz. The receiver was turned on, and the mode switch put in the cw position.

Next, we turn on the transmitter and give it a little time to warm up. Now, tune the receiver across the dial close to the frequency indicated for the crystal. If the crystal stage has been wired properly, you will hear a very loud whistle in the receiver. We have assumed all along, of course, that the receiver is within 10 feet or so of the transmitter.

WIRING THE AMPLIFIER (FIG. 6-7)

If our oscillator stage is working properly, we're practically home free. The next step is to wire the final amplifier stage. This is a power-carrying unit, but the wiring is quite simple:

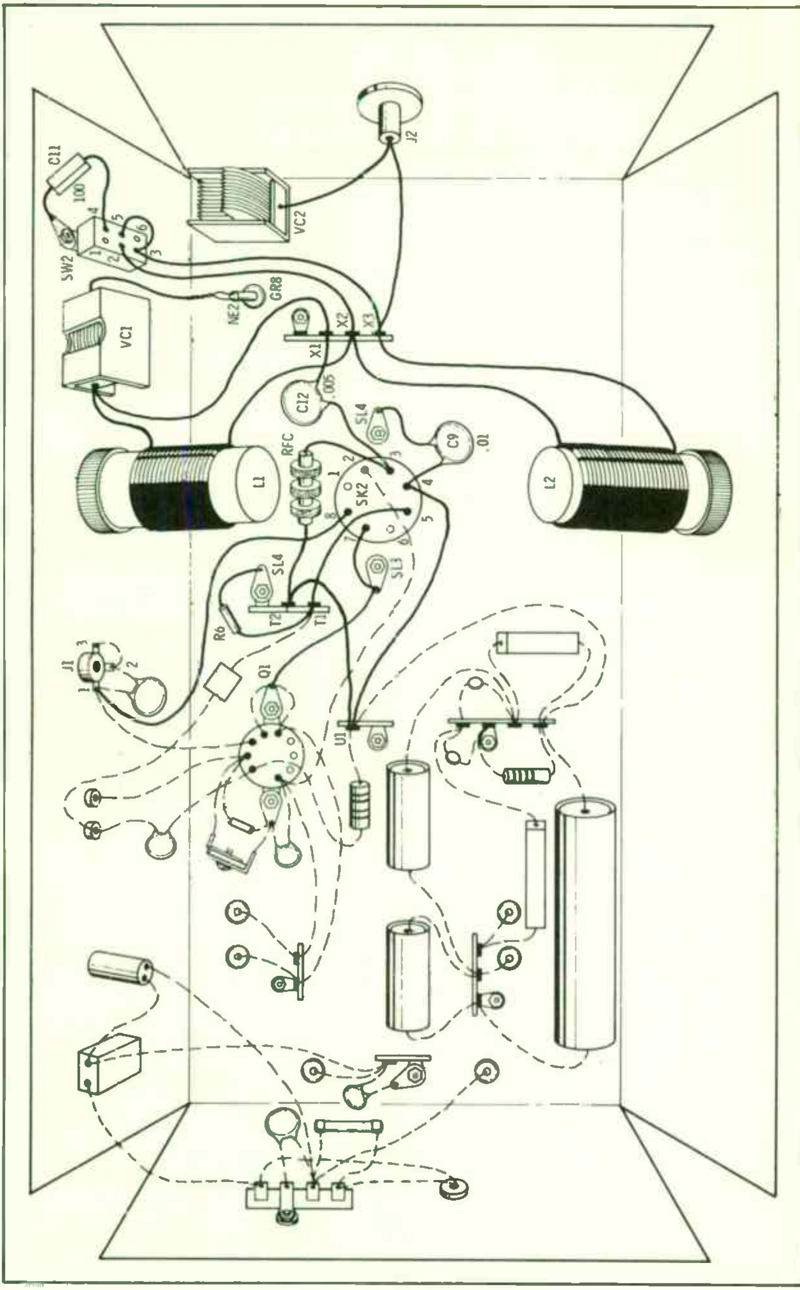


Fig. 6-7. Wiring the amplifier.

- [ ] Connect a wire between terminal 1 of J1 and pin 8 of socket SK2. (S)
- [ ] Bare approximately one inch on the end of a piece of hookup wire and start it through soldering lug SL3. The free end of the bared wire should go to the terminal 7 of the tube socket SK2. Solder the wire both at the socket pin and to soldering lug SL3.
- [ ] Run the other end of the wire to the soldering lug Q1 which is alongside the tube socket SK1. (S)
- [ ] Connect one end of resistor R6 to terminal T1. (S)
- [ ] Connect the other end of this resistor to solder lug SL4. (S)
- [ ] Solder a lead to terminal U1 long enough to reach to pin 4 on socket SK2.
- [ ] Connect the free end to pin 4 of SK2. (DS)
- [ ] Connect .01-μF capacitor C9 to pin 4 of socket SK2. (S)
- [ ] Connect the other end of capacitor C9 to soldering lug SL4. (S)
- [ ] Solder a 3-inch length of wire to terminal U1. (S)
- [ ] Connect the other end of the wire to terminal T2. (DS)
- [ ] Connect one end of choke RFC to pin 3 of socket SK2. (DS)
- [ ] Connect the other end of the choke to terminal T2. (DS)
- [ ] Connect one end of .005-μF capacitor C12 to pin 3 of socket SK2. (S)
- [ ] Connect the other end to terminal X1. (DS)
- [ ] Mount the two coils L1 and L2 in their respective positions. Notice that the coil form with the fewer turns (L1) is the one closer to the panel. (See Fig. 6-8 for coil detail.)
- [ ] Connect one lead of coil L1 to terminal X2. (DS)
- [ ] Connect one lead of coil L2 to terminal X2. (DS)
- [ ] Connect the other lead of L1 to the stator (stationary plate) terminal on the variable capacitor VC1. (DS)
- [ ] Connect the free lead of coil L2 to terminal X3. (DS)

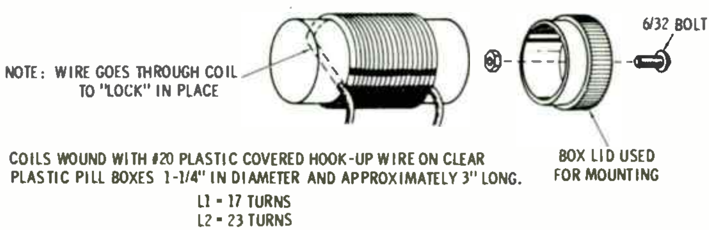


Fig. 6-8. Coil winding details.

- ☐ Connect one end of a piece of hookup wire to X3 (DS) and cut it to proper length to run to the center terminal of jack J2. Connect but do not solder.
- ☐ Bare one end of a piece of hookup wire and slip through terminals 3 and 5 of SW2. (S)
- ☐ Connect the other end of the wire to terminal X3. (S)
- ☐ Very carefully, using the minimum heat necessary to make the connection, solder a lead to the stator terminal of variable capacitor VC2.
- ☐ Run the other end of this lead to the center terminal of jack J2. (S)
- ☐ Solder one end of a piece of hookup wire to terminal 2 of SW2.
- ☐ Connect the other end of the wire to terminal X2, which is at the juncture of L1 and L2. (S)
- ☐ Very carefully, solder a lead on the empty terminal of the variable capacitor VC1.
- ☐ Solder the other end of this lead to the leads of the neon bulb NE2 mounted in grommet GR8. Twist bulb leads together and solder to *both* leads.
- ☐ Connect one end of a 100-picofarad mica capacitor to terminal 4 of SW2. (S)
- ☐ Connect the other end to the grounding lug under SW2 mounting nut. (S)

This completes the wiring of the transmitter. Recheck to be sure all the connections have been soldered. The schematic diagram of the transmitter is shown in Fig. 6-9.

TESTING THE TRANSMITTER

The first thing we need is some kind of dummy antenna to put a load on the transmitter. Fig. 6-10 shows how such a dummy antenna can be made up using a 15-watt appliance bulb. This type of bulb is about the right power capacity and has the added advantage of being clear—not frosted like an ordinary light bulb, so that we can see the filament glow. Note that one connection is made to the center pin of a phono plug which is inserted in the antenna jack. The other terminal on the bulb connects to a small clip which can be grounded to the chassis of the transmitter.

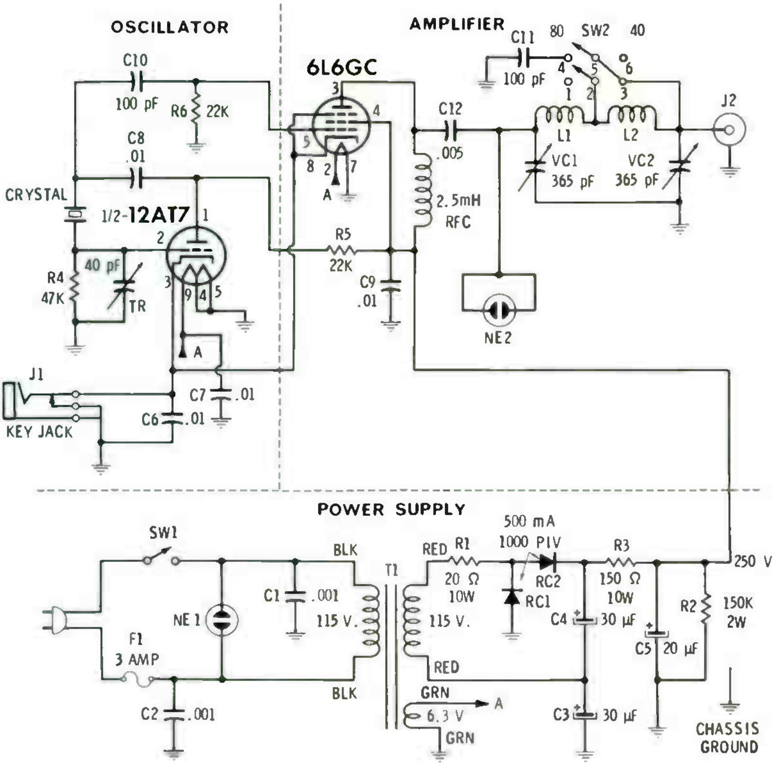


Fig. 6-9. Schematic diagram of the transmitter.

Once this dummy antenna is made up, it should be plugged into the antenna jack on the side of the transmitter chassis. At the same time, plug in a 7-MHz crystal. The matter of selecting crystals of proper frequency is covered in some detail in Chapter 9.

Adjust the variable capacitor at the side of the chassis (antenna loading) so that the plates are fully meshed. Then, slowly rotate the variable capacitor on the front panel. At some

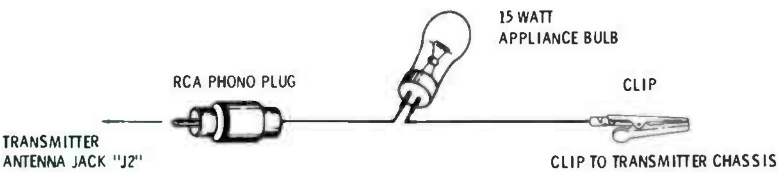


Fig. 6-10. Dummy antenna construction.

point in the range, actually about midrange, the neon bulb on the chassis should light up, indicating that the transmitter has been tuned to the frequency of the crystal. In all of this, it is assumed that switch SW2 is in the up position.

At this point, you will probably note also that the dummy antenna is beginning to indicate current by glowing faintly. Now, in small steps, decrease the capacity by opening up the plates of the antenna loading capacitor, each time repeaking the amplifier as indicated by the brightness of the neon bulb. As you work through this process, you'll note that opening the antenna loading capacitor up to a certain point increases the load on the transmitter and increases the amount of power put into the dummy antenna which becomes brighter. Beyond that point, decreasing the capacity of the capacitor does not load the amplifier any more. What actually is happening is that we are extracting all the power we can get from the transmitter.

Next, assuming our transmitter is generating output, the final test is how it sounds on the air. We *could* tune directly to the transmitter frequency and listen in, but the signal will be so strong that it may overload the receiver, even with no antenna and the rf gain control turned way down. A better idea is to listen to a harmonic—a multiple of the transmitter frequency. For example, if our crystal frequency is 7125, we can pick the transmitter up on three times the frequency, on the third harmonic, which is 21,375.

Now, connect a telegraph key like that shown in Fig. 6-11 to a standard phone plug which inserts in jack J1. Fig. 6-12 shows the hookup.

With the key down (or the switch on the key closed) tune in the signal. Open the key (or the switch) and key the trans-

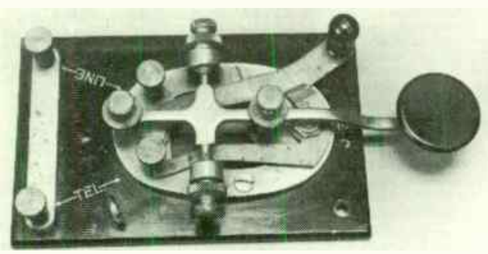


Fig. 6-11. Telegraph key.

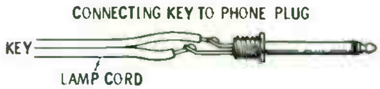


Fig. 6-12. Hookup of phone plug and key.

mitter, listening in your receiver. Make a series of dots. If the dots are "clean" (following the keying as they should), no further adjustment is necessary with the transmitter until we actually put it on the air. But if some of the dots seem to miss, adjust trimmer capacitor TR, starting with the screw all of the way in, and then testing the transmitter each half-turn as the screw is backed out. You will find an adjustment at which the keying is good. What we are doing is adjusting feedback at the oscillator, so that it operates properly.

Now, if you have an 80-meter Novice band crystal available, throw the band-changing switch SW2 to the down position, put the 80-meter crystal in the crystal socket, and again tune up the transmitter following the method outlined previously.

When making any adjustments on the underside of the transmitter, *TURN THE POWER OFF!*

7

Getting Your First Ham License

Most activities these days are governed by some sort of rules, and operating an amateur radio station is no exception. A federal license is required for operating an amateur station, just as one is required for Citizens band radio. These licenses vary in the complexity of the exam. In this book we will be concerned only with the Novice class license. This is the one which most beginners obtain and is usually the one which CB operators find the easiest for bridging the gap between CB operation and ham radio.

In order to obtain the license, two steps are necessary. First, the applicant must pass a very simple technical examination. The exam consists of twenty questions dealing largely with amateur regulations, plus a limited amount of relatively simple theory. The questions are all of the multiple-choice type. Anyone who can apply himself sufficiently to study the rules and pass the average driver's license exam can, by similar effort, learn enough to pass the technical part of the Novice exam quite readily. The second part of the exam *seems* a bit more difficult—the applicant must be able to send and receive code telegraphy at the rate of 5 words per minute.

HOW DIFFICULT IS CODE

For some reason which this writer has never fully understood, the mere mention of the word "code" seems to create a tremendous mental block in the minds of a surprising number of people. Actually, learning code at the rate of 5 words per minute is a great deal easier for most students than learning to type at the slow speed of 25 words per minute. Yet millions and millions of people have learned to type with little difficulty.

Furthermore, code teaching techniques have made tremendous progress in recent years. With a set of phonograph records or tape cassettes, learning the code sufficiently to pass the Novice exam becomes largely a matter of exercising enough self-discipline to spend a bit of time in practicing.

THE NOVICE BANDS

To review quickly, there are four segments of the standard amateur bands which are commonly used by the Novice class operator. These are:

3700 to 3750 kHz (80-meter band)
7100 to 7150 kHz (40-meter band)
21,100 to 21,200 kHz (15-meter band)
28,100 to 28,200 kHz (10-meter band)

A previous chapter covered in detail the type of operating conditions which exist on each of these bands. The band segments were chosen with care because they allow a "sampling" of most of the kinds of operation which hams experience.

As mentioned before, 80 and 40 meters allow communication up to 2000 miles or so, and on 15 and 10 meters, when conditions are good, worldwide communication is frequent. On these four bands, there are plenty of people to talk to—in fact, there are sometimes *too* many for comfortable operating.

Assume that you have decided to start out with a Novice band transmitter capable of operating on the 80-meter, 40-meter, and perhaps the 15-meter band. It may or may not be equipped for phone operation as well. At present this does not matter, because with only a Novice license you won't be able to use a phone legally on any band.

GETTING YOUR TECHNICAL INFORMATION

Supplying you with *all* the technical data you might like to have to pass the technical exam is beyond the scope of this book, particularly if you are the kind of person who likes to know a great deal more than will be asked on a test. If this is true, additional reading is recommended.

However, the data which follows is a short course in the key facts you need to know for the test. At the end of each section, typical questions and answers are given, so you can see what to expect when you take the test. (The correct answer is indicated in italic type in these examples.) Providing you *understand* the data given, chances are excellent that you will pass the exam with a satisfactory score. Your understanding will be strengthened if you have read Chapters 4 and 6—and, ideally, have performed the experiments and built a transmitter. Unless you have gained such practical experience, additional reading is strongly recommended.

REGULATIONS

Penalties. The penalties for failure to follow the regulations as set up by the Federal Communications Commission covering the operation of an amateur station are quite severe. There may be a fine of $500.00 levied for each day during which an offense occurs and/or suspension of the operator license and cancellation of the station license.

Input Power. Novice transmitters are limited to 75 watts of power *input.* Most Novice transmitters are designed so that they fall well below this maximum input figure of 75 watts in normal operation.

Frequencies Available. The frequencies available to the Novice ham are:

3700–3750 kHz
7150–7200 kHz
21,100–21,200 kHz
28,100–28,200 kHz
145–147 MHz

Giving Call Letters. Call letters of the station must be transmitted at least once every 10 minutes and also at the beginning and end of the transmission if the transmission lasts longer than 10 minutes.

Keeping a Log. All amateur stations are required to keep a log, just like a ship or an airplane. The log details the important things which happen in connection with the operation of the station. *Logs must be retained for at least one year after date of final entry.*

You can buy a log book which, in most cases, contains space for some data which are not required by regulations but are highly useful, particularly in the case of subsequent contacts with the same station. The regulations *do* require that the following data be kept for every transmission:

Date.
Time of beginning and end of transmission.
Call letters of station contacted.

When a station first goes on the air, and a significant change is made in frequency, power, and other aspects, the following data must be kept:

Frequency in use.
Type of emission (phone or cw).
Power input in watts.
Signature of operator.
Location of station.

When a station is being used as a mobile station—for example, in an automobile or on a boat—the log must list each significant change in location. If a number of stations are worked from the same general area, the time of beginning and ending of mobile operation is sufficient.

In the case of extended mobile or portable operation (for more than 15 days), the FCC engineer in charge of the district must be notified. In most cases this is done by mailing a post card or a brief letter.

Taking the Exam Over Again. The applicant who fails the exam once can take it over again. In fact, he can take it over every 30 days until he does pass.

Obscene Language. Heavy penalties may be levied for using obscene language on the air. The same penalties apply to the use of false or deceptive signals, false call letters, deliberate interference with other services, etc.

Life of License. A Novice class license is good for two years only, and it cannot be renewed. However, after a year has elapsed, you can take the test for a new license.

Who May Operate. Any amateur with a Novice class license *or higher* may operate a Novice station.

Identifying the Station. The call letters must be given by the operator at the beginning and end of the transmission each time the station goes on the air. This holds true *providing the transmissions do not exceed 10 minutes.* If the transmission does exceed 10 minutes, identification must be given. In "break-in" type operation, consisting of a series of short transmissions, the call letters can be given once every 10 minutes, as well as at the beginning and at the end of the series of transmissions.

Who May Use a Station. A visitor may "talk" over station equipment, providing a licensed operator maintains control.

Typical Exam Question and Answers

Regulations do *not* permit

1. Operating an amateur station in an auto.
2. Chatting on the air about matters of no great importance.
3. Relaying message from one amateur station to another.
4. *Using obscene, indecent or profane language.*
5. Sending at speeds faster than 5 words per minute.

TECHNICAL QUESTIONS

Frequency Control. A vfo (a tunable oscillator) is now permitted for Novice stations. However, the use of a crystal oscillator which locks the transmitter to one frequency is "safer" in the hands of the Novice operator. To change frequency, a different crystal is simply plugged into the transmitter by the operator.

Measuring Frequency. The law requires that the Novice make checks on the frequency of the transmitter. On a practical basis, this may be done by having the frequency checked by another amateur who has a calibrated receiver or by checking frequency with the receiver in the station, providing it has some accurate means of calibration.

Creating Interference to Nearby Radio and TV Sets. By regulation, the Novice transmitter should transmit only on the desired frequency within the Novice bands and should generate no spurious (unwanted) radiation. This includes creating any kind of interfering signals which will be picked up by receivers *of modern and efficient design*, tuned to frequencies *other* than that of the Novice transmitter. The spurious frequencies to be avoided include parasitic oscillations, which are oscillations at frequencies far removed from the normal frequency for the transmitter. For example, an 80-meter Novice transmitter *can*, through bad design or part failure, generate a very high frequency signal which will cause distortion of the picture image on nearby television sets. This high-frequency signal must be attenuated (reduced).

Harmonic Radiation. Radiation at some frequency which is a multiple of the fundamental frequency. To be avoided because it may create interference. Overcome by good transmitter design. Particularly important:

a. Keeping "drive" to amplifier output stage as low as possible.
b. Installing an antenna tuner between transmitter and antenna.

Typical Exam Question and Answers

The following best describes parasitic oscillation

1. An oscillation found in aircraft radio.
2. The type of oscillation used in the bfo of a receiver for receiving code and ssb.
3. Any oscillation which is not controlled by the crystal in the transmitter.
4. *An oscillation on some frequency other than the desired one.*
5. Oscillation so stable it can be used for frequency measurement.

Modulation. Modulation is the term applied to the process of varying the amplitude, frequency, or phase of the radio frequency output of the transmitter. It is the technique of superimposing a voice (or music, etc.) on the carrier wave in such a fashion that the wave is varied in accordance with the speech or other signal to be transmitted. Also, the term "modulation" is applied to such phenomena as that which occurs when the ripple in the power output supply is accidentally allowed to appear on the carrier, causing undesirable hum and buzz.

Percent of Modulation. The regulations require that the modulation of transmitters be limited to 100 percent. Anything higher than this is apt to cause spurious sidebands or "splatter" which may create serious interference with other amateur stations or even with stations far outside the amateur bands.

Key Clicks. Keying a transmitter may create spurious radiation of a type commonly known as key clicks. This may show up as "thuds" on nearby radios or as visual interference on a tv picture. Usually a key-click filter will halt this type of interference, and many modern transmitters have built-in key-click filters.

Meters. Voltage (electrical potential) is measured by a voltmeter. For measuring current the operator may use an ammeter, milliammeter, or a microammeter. A wattmeter is used to measure electrical power. Electrical energy consumed is measured by a watt-hour meter. (The "meter" which serves as a basis of your light bill is a watt-hour meter.)

Typical Exam Question and Answers

Plate current in an amateur transmitter is measured by a(n)

1. Altimeter
2. Tachometer
3. *Milliammeter*
4. Watt-hour meter
5. Voltmeter

Demodulation. This refers to the detection of the transmitted signal—"extracting" the audio signal (usually voice) from the carrier wave of the transmitter. This is the phenomenon which occurs when you tune a radio to a station.

Chokes—Radio Frequency, Audio, and Filter. All chokes have the same basic purpose—to oppose the flow of some currents and to allow others to pass. The radio frequency choke resists radio frequency current, but it allows direct current or audio signals to pass freely. Audio chokes allow direct current to flow, but they resist audio currents. The filter choke resists *all* frequencies but allows direct current to pass. In this fashion it "filters" out 60-Hz hum and other unwanted frequencies.

Rectifiers and Filters. All Novice transmitters must have an adequately filtered power supply. Some type of rectifier (today, usually silicon diodes) changes the alternating current (ac) supplied by a power transformer to *direct current* (dc). This direct current may be further filtered by means of a filter choke, and filter capacitor or condenser. If these are of the proper values, they operate so efficiently that the direct current available at the power supply output approaches in smoothness the direct current delivered by a battery.

Typical Exam Question and Answers

Direct current can be obtained from an ac-operated transformer through the use of a

1. Modulator.
2. Harmonic generator.
3. *Rectifier and filter.*
4. Filter choke.
5. Capacitor.

MATHEMATICAL PROBLEMS

The mathematics required to pass the Novice license exam is not difficult; simple arithmetic is sufficient for most of the problems given. Also, the exam will usually have only one or two mathematical problems. If you understand how to do the following problems, you should have no difficulty with those on the exam.

Relating Hertz, Kilohertz, and Megahertz. The basic unit is hertz, which means the *same* thing as cycle(s) per second, the older term. One kilohertz equals *1000* hertz. One megahertz equals 1000 kilohertz, or 1,000,000 hertz. For simplicity in writing or in labeling diagrams, it is commonplace for kilohertz to be translated into megahertz. This usually involves writing the frequency as a decimal, for example:

1700 kilohertz equals 1.7 megahertz (1.7×1000)
14,000 kilohertz equals 14 megahertz (14×1000)

Ohm's Law. This formula, found in every physics book, is very useful in electronics. It expresses this relationship:

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

Usually this is expressed as:

$$I = \frac{E}{R}$$

where,
I is the current in amperes,
E is the voltage in volts,
R is the resistance in ohms.

By using very simple algebra, the equation can be transposed to solve for voltage or resistance:

$$E = IR$$

$$R = \frac{E}{I}$$

Using Ohm's Law. Assume that in a circuit the current is .1 ampere (which, of course, is 100 milliamperes), and the voltage is 100. What is the resistance in the circuit?

$$R = \frac{\text{E (voltage)}}{\text{I (current)}}$$

$$R = \frac{100}{.1}$$

$$R = 1000$$

Figuring Harmonics. A harmonic may appear at any *multiple* (twice, three times, four times, etc.) of the fundamental frequency. For example, a 500-kilohertz transmitter (unless special techniques are utilized to avoid it) will have a second harmonic at 1000 kilohertz (500 × 2), a third harmonic at 1500 kilohertz (500 × 3), etc. Notice that to get the harmonic frequency, the fundamental frequency is simply multiplied by the number of the harmonic.

If the harmonic frequency is known, it is easy to find the base frequency. For example, if the second harmonic is at 1000 kilohertz, the fundamental frequency is 1000/2, or 500 kilohertz.

Power input. Power input in watts is determined by multiplying the plate voltage by the plate current. As an example: a transmitter which has 250 volts of plate voltage—and draws 100 milliamperes (0.1 ampere) of plate current.

$$\begin{array}{r} 250 \\ \times \quad .1 \\ \hline 25.0 \end{array} \text{ or 25 watts}$$

Plate voltage is measured between the B-plus connection and the cathode of the final amplifier tube.

Frequency/Wavelength. The *frequency* in *hertz* can be determined, when the *wavelength* in *meters* is known, by using this formula:

$$f = \frac{300{,}000{,}000}{\text{wavelength}}$$

Example: wavelength 100 meters

$$f = \frac{300{,}000{,}000}{100} \text{ or } 3{,}000{,}000$$

3,000,000 *hertz* equals 3000 *kilohertz* (a kilohertz is 1000 hertz) Revising the formula to determine wavelength when frequency is known:

$$\text{wavelength} = \frac{300{,}000{,}000}{f.}$$

Typical Exam Question and Answers

Two megahertz (also written 2 megacycles per second) equals

1. 0.002 kilohertz.
2. 0.2 kilohertz.
3. 2,000,000 kilohertz.
4. *2000 kilohertz.*
5. 0.000001 kilohertz.

ABBREVIATIONS AND DEFINITIONS

In any technical field, learning the "language" is often one of the more difficult things because unless the words being used are understood, it is virtually impossible to understand the overall meaning of what is asked. Thus, the following list of common terms and abbreviations has been compiled.

A-m—Abbreviation for amplitude modulation.

Amplification—Occurs in an electronic circuit designed to "step up" the strength of a signal. In an audio amplifier (for example, a stereo set) the weak signal from the record player is amplified sufficiently to operate a speaker. In a Novice transmitter the amplifier stage (output stage) will increase the 1 watt output from the crystal oscillator to as much as 50 watts output for exciting (powering) the antenna.

Attenuation—Reduction in amplitude or strength.

A1—Code (radio telegraphy) transmission (cw) achieved by keying the carrier (on-off keying).

A3—Phone transmission achieved by modulation of the carrier.

Bleeder resistors—Resistors placed across the output of a power supply to "bleed off" the charge and help avoid accidental shocks.

Capacitor—Same as condenser.

Carrier—An unmodulated signal (wave) put out by a transmitter.

Cw—Abbreviation for continuous wave (code).

Demodulation—Refers to the detection of the transmitted signal—extracting the audio (voice) signal from the carrier wave of the transmitter, usually by a diode.

Emission—Refers to the signal being transmitted. Often used as "type of emission," referring to whether it is phone, code, or other.

EST—Eastern Standard Time.

Fm—Abbreviation for frequency modulation.

Frequency meter—(also called wavemeter). Used to check frequency, for example, to see if the transmitter is "within" the authorized frequency band.

Frequency multiplier—Usually refers to a special type of amplifier (for example, a "doubler" or a "tripler") used to deliberately amplify the harmonic of the frequency applied to the input of the amplifier. For example, such circuits are used to get a 7-megahertz output from a 3.5-megahertz crystal.

GMT—Abbreviation for Greenwich Mean Time.

kHz—Abbreviation for kilohertz. Kilohertz and kilocycle(s) per second mean same thing.

MHz—Abbreviation for megahertz (megacycle(s) per second).

Power level—Strength of the signal.

Q—A measure of the design efficiency of a radio-frequency amplifier. High "Q" is desirable in an amplifier to help eliminate harmonics.

Radio frequency, audio, and filter chokes—All have the same basic purpose: to oppose the flow of some currents and to allow others to pass. The radio frequency choke resists radio frequency current, but it allows direct current or audio signals to pass freely. The audio choke allows direct current to flow, but it resists audio currents. The filter choke blocks all alternating currents but allows direct current to pass. In this fashion it "filters" out 60-Hz hum and other unwanted frequencies.

Rectifiers and filters—A rectifier changes the *alternating* current supplied by a transformer to *direct* current. A filter choke, plus a filter capacitor, further smooth out the pulsations of direct current.

Ripple—The pulsations which occur in the output of a power supply that has not been filtered sufficiently.

Splatter—A type of interference created by a phone transmitter modulated more than 100 percent. Modulation in excess of 100 percent is illegal.

Spurious—Unwanted. Often applied to unwanted signals produced by a transmitter—spurious emissions which create interference.

Traffic handling—Refers to the transmittal of messages free for others.

Wave trap—A unit which functions to reject or receive signals of a certain frequency. Wave traps are often applied to shortwave receivers in order to prevent interference from nearby broadcast station transmitters or to shortwave transmitters in order to block off harmonics which might cause interference.

THE MECHANICS OF GETTING YOUR LICENSE

The higher classes of Amateur licenses require appearing at a Federal Communications Commission office and taking the examination. The Novice license is simpler—the examination papers are sent to you by mail, and you take the code test and the technical exam under the direction of a "volunteer examiner," usually a ham.

Your examiner gives you the 5 words per minute code test. *If* you pass the code test, you are allowed to open the envelope containing the multiple-choice technical questions; then you complete the test under the watchful eye of your examiner. The papers are mailed to the FCC. If you pass the test, within a month or two you receive your license to go on the air.

LOCATING A "VOLUNTEER EXAMINER"

The FCC requires that the examiner who gives you your Novice test meet one or more of these criteria:

1. Holds a current (not expired) amateur license of General, Advanced, or Extra-Class level.
2. Holds an unexpired FCC commercial radiotelegraph license.
3. Is currently the operator of a manually operated radiotelegraph station belonging to the U. S. Government. (This provision is helpful to servicemen overseas.)

Normally, your best bet is to locate a ham. You may know of one, or perhaps you have spotted a house in your neighborhood with an elaborate "beam" antenna. If so, make it your business to become acquainted with the station operator. Don't be hesitant to do so, since *most* hams will go to considerable effort to assist beginners—or at least to put them in contact with a ham who will help.

The local electronics parts store frequently can tell you the name of a ham, or better yet, an amateur club. Other possibilities are the local radio station (simply call the station and ask for the radio engineer).

If all else fails, buy a copy of the magazine QST (75¢), which is published by the ARRL (American Radio Relay League), 225 Main Street, Newington, Connecticut, and write to the

Section Communication Manager nearest you. The listing is in front of the magazine on page 6. QST is a magazine you will probably want to subscribe to and read every month. Most hams subscribe because it is filled with news about amateur radio and excellent technical articles. Other good magazines include "73," "CQ," and "Ham Radio."

The ham you meet may, if you are lucky, offer to help you with code, or tell you where there are local code-practice classes. At any rate, the next step is to learn code, which is the subject of Chapter 8.

Once you are certain that you know the code thoroughly, you are ready to write to the FCC office nearest you and request the application blank needed. A list of FCC offices appears in the appendix of this book. Simply request application form No. 610, and give the name, address, and call letters (if any) of the person whom you have selected to give you the exam. Within a week or so you will receive the application blank and instructions. The blank is self-explanatory if *you read it carefully.* Unfortunately, not everyone does, and precious time is lost because incomplete or inaccurate applications must be returned to the sender. Follow the instructions to the letter. Remember that you are dealing with the Federal government, and the FCC takes a very dim view of anyone who cheats on an exam.

You will note that you take the code test *first.* Thus, if you flunk it, the written test can be returned unopened to the FCC. Should you fail the test, you can be re-examined in 30 days.

8

Learning the Code

Learning the code is much easier if you have some idea of what is generally considered the most practical way to go about the task. You will note that this book does not contain the usual chart showing that "A" is a dot and a dash, or "E" is a dot, etc. Rather, the chart included at the end of this chapter shows the letters in the form of "dit" which means a dot, or "dah" which stands for a dash. There is a very good reason for this. If you begin to memorize a table of dots and dashes, about all you will accomplish is to create a mental block for learning the code the way the code must be learned—by *sound.*

Actually, learning the code is very much like learning a language. The normal way that a child learns a language is by sound. The child hears parents and others around him speak, gradually learns to imitate the sounds, and eventually the sounds have meaning. It is usually several years before the child learns the alphabet, much less written words.

Code is much the same thing. You want to begin by learning the sound and avoid having to translate the sound into some other form. As an example of how this works, this writer can type approximately seventy words per minute. When in practice, he can receive code at the rate of twenty words per minute or better, but he has to copy code in pencil. On a typewriter, despite the fact that he can type much faster than he can write with a pencil, he can copy code only at a very slow speed or not at all.

The reason for this is that upon hearing dit-dah, he first must translate the sound into "A," remember where "A" is on the typewriter, and *then* punch the key. While all this is going on, half a dozen letters will be lost. This story demonstrates that if you want to learn to copy code on the typewriter, you should use the typewriter initially and not bother to use the pencil at all. Almost everyone agrees that there is neither time nor need for mental translation in copying code. When the sound of a "dit-dah" is heard, this immediately should activate the pencil to write the letter "A."

If we agree that the way to learn code is by sound, because that is the way it will finally be received, what is the easiest way to go about it? The easiest way to learn typing is to join a typing class and receive instruction and help along with the competitive activity that goes with learning something alongside other people; similarly, the easiest way to learn code is to join a class. In larger cities there are frequent code classes. Sometimes these are in schools as an offshoot of a science project or something similar. More often, the classes are operated by hams who unselfishly devote their time to teaching beginners the code. Sometimes these classes are in the form of actual person-to person teaching in a classroom. More often, the classes are held "on the air" by the radio amateur. For example, in some cities, there are regular code classes on the 10-meter band, and sometimes on the 2-meter band.

FINDING THE CLASS

Your first task is to find out where such classes are; and a first step is to contact a radio amateur in the area who can either tell you where to go or can give you the name of another ham interested in such projects.

If you find, for example, that there are code classes on the 10-meter band at a certain time of the evening, you must determine the frequency of the transmissions and then locate that spot on your dial. Since the code transmissions are usually in the phone part of the band, the instructions are usually given by voice, and then the amateur running the class turns on a tape recorder or sends code by hand to provide practice.

If you are in a small town far from other amateurs or are endeavoring to learn code at a time of the year when there are no classes operating in your city, the only practical idea is to tackle the task yourself. Fortunately, this has been made relatively easy because today there are code courses available on records and tape cassettes.

The cassettes have several advantages over the records. First, the little cassette recorders can be carried most any place in the house; thus, they lend themselves to more frequent use in practice, and practice is the secret in learning the code. Some of the better tapes have helpful learning suggestions recorded right on the tape, so you experience the feeling of having an instructor with you.

One of the disadvantages of both tapes and records is that if you practice long enough, you tend to memorize the material. One practical solution is to get two sets of tapes, and when you begin to memorize one, change to the other. Change back and forth often enough that you have little opportunity to memorize the material.

LISTENING IN

In addition, you need to supplement your practice by using your receiver for some on-the-air listening. The best source for code practice is the transmissions of station W1AW. This is the headquarters station of the Amateur Radio Relay League, the national organization of radio amateurs. The station transmits code at various speeds, including speeds suitable for the training of the Novice.

The Radio Relay League is very much interested in helping new hams get started, and if you will send a stamped, self-addressed envelope to ARRL, Newington, Connecticut, 06111, and ask for a schedule of times and frequencies of code practice sessions, you will receive it promptly.

For a beginner, particularly one who has a receiver without a calibrator, one of the problems is to find the station within the band. One practical way to do this is to buy a crystal of the same frequency as the ARRL headquarters station. Plug the crystal into the crystal oscillator stage of the transmitter, and then locate the signal on the dial of your receiver. The dial may be a bit off because the crystal frequency may not be exactly that of the W1AW station. However, you will be close enough so that you will have no difficulty finding it.

The headquarters station is powerful, and on the proper frequency it will put down a signal that can be copied anywhere in the United States and in countries bordering the United States as well.

LISTENING TO NOVICES

You may also get good code practice by listening to the Novice bands. The only problem with this is that some of the Novices are really novices in sending code, and their keying will not be as easy to read as the very professional keying of the ARRL station. However, the Novice bands provide good practice because here are the kinds of signals you will want to begin copying once you transmit on the air yourself.

Again, an easy way to find the Novice stations is to use the crystal oscillator in your transmitter with the proper crystal for the Novice band. The signal that you hear on your receiver will give you a starting point for locating the Novice band on the dial. Of course, if you have a well-calibrated communications receiver, the dial reading itself will efficiently show you where the Novice band or the transmissions of WlAW are.

As mentioned before, learning the code is essentially a matter of practice. Your practice will be a lot easier if you have adequate equipment with which to do it and if you set aside thirty minutes per day for actual practice periods. Thirty minutes is the generally advised maximum time period. Learning code is the kind of thing that is better done in small batches of time, rather than extensive drill in one day.

In this writer's opinion another extremely important thing in learning code is to set up a situation in which it is easier for you to concentrate. Actually, one of the big differences between the ham who can copy code at high speed and one who has difficulty at slower speeds is in the ability to concentrate.

One very useful trick of the trade is to use headphones if at all possible. Headphones put the sound directly into your ears, and also shut out all extraneous sounds and distractions. For many hams, their speed of copying code from a loudspeaker cannot even approach their speed of copying from earphones. For that reason, do your practicing with headphones. You will find that it will help you concentrate on the incoming sound. One of the practical advantages of tape recorders over record players is that the tape recorders have provision for using an earphone.

Initially, you will probably discover that you can receive only part of the letters or perhaps only one out of four or five. However, don't let this worry you—this is the way almost everyone begins. When you hear a letter, write it down, preferably using a longhand letter rather than printing, because for most people writing in longhand is faster than printing. At first you may be able to copy only one letter out of five, but before long you will be copying one out of three, eventually you will be copying five letters in a row correctly. And then suddenly, almost without your realizing it, you'll be writing down words. The first time that you copy words as they are transmitted is a real thrill. It might be compared to hearing a sentence in a foreign language and suddenly understanding it for the first time.

In copying the Novice band transmissions you may feel that you are writing down everything that is being transmitted and yet are having difficulty making any sense of it. This can be true because of the widespread use of abbreviations. In a previous chapter some of these abbreviations were explained in detail, and there will be more data on the use of abbreviations in the chapter which follows.

LEARNING TO SEND

So far we have talked only about learning to receive. Once you have learned this, learning to send is relatively easy, because all you are trying to do then is to imitate the sounds as you hear them over the air. Thus, it is important that the transmissions to which you listen represent good quality sending; as mentioned previously, those of W1AW are highly professional.

If you are lucky enough to have a second tape recorder available, one useful technique is to play the tape on one recorder and record it on a second one. Then alternate the tape pickup with your own sending. This will quickly show you if your formation of letters is like those to which you have been listening.

To learn to send, of course, you need some kind of equipment. The simplest thing to acquire is a code practice set which consists of a kind of buzzer and a telegraph key. A much better idea is to have a little audio oscillator with a key. The audio oscillator is preferable because the sound created is a bit more like the actual sound on the air; furthermore, it is possible to use an audio oscillator with earphones, particularly if you build one as described in the instructions which follow.

BUILDING AN AUDIO OSCILLATOR

Code practice oscillators are available already assembled, and of course, this is the quickest way to get started. However, you can make one yourself for very little cost, thanks to the availability of what are called "code-oscillator modules."

These modules consist of two transistors, a resistor, and a capacitor mounted on a small piece of bakelite. The units are wired, and cost very little. They require only the addition of a key, a 1.5-volt battery, and some kind of a speaker. Ideally, the speaker should have an impedance of approximately 8 ohms. A little speaker like those in low-cost transistor radios is fine for the purpose; many households have some broken-down radios of this type which could be taken apart in order to utilize the speaker.

The hookup is shown in Fig. 8-1. Be careful not to short lead "C" to the other wires underneath the little mounting board. The best way to avoid this is either to tape it or slide on a piece of plastic cover from another piece of hookup wire.

The module can be mounted on a small board. If you do this, don't forget that as you turn the board over, leads "A," "C," and "B" will be switched. To avoid mistakes it is best to wire the hookup with the module upside down, and after the wiring is completed, simply turn it over and screw it to the board.

As mentioned previously, there is always an advantage to using headphones rather than a speaker. Unfortunately, headphones of the proper impedance are not plentiful. The usual set of headphones has an impedance in the range of 2000 to 4000 ohms, rather than the 2½ to 15 ohms needed, but stereo headphones *do* have the necessary impedance. Fig. 8-2 shows a small module utilized to build a deluxe code oscillator for running a pair of stereo headphones.

ASSEMBLY INSTRUCTIONS:

1. PLACE MODULE WITH WIRE LEADS FACING UP (REFER TO SCHEMATIC BELOW).
2. CONNECT MODULE LEAD A TO BATTERY POSITIVE; POSITIVE.
3. CONNECT MODULE LEAD B TO EITHER SPEAKER TERMINAL.
4. CONNECT MODULE LEAD C TO OTHER SPEAKER TERMINAL AND ALSO TO ONE TELEGRAPH KEY TERMINAL.
5. CONNECT OTHER TELEGRAPH KEY TERMINAL TO BATTERY NEGATIVE.

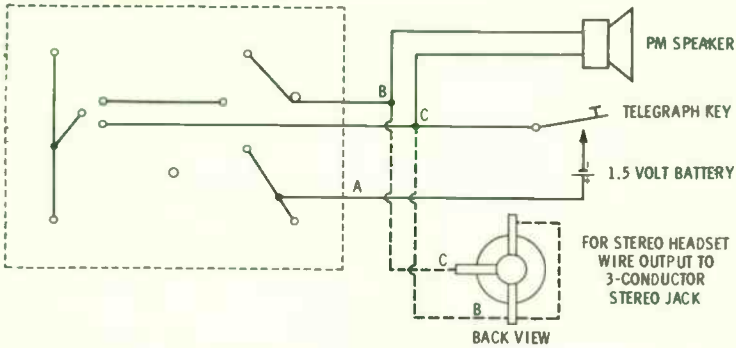


Fig. 8-1. Hookup for a code-practice oscillator.

Good stereo headphones are quite expensive, and you may be interested in them only if you already have a set. However, occasionally such earphones are available on sale at a fairly modest price. The ones shown in Fig. 8-2 cost only $6.95 and work very well. Because the headphones have two separate reproducing devices to provide the stereo effect, the jack connected to the end of the cord from the phones is three-conductor, instead of the normal two-conductor. Wiring up the three-conductor stereo jack is not complicated, and instructions are given in Fig. 8-1.

To complete the code-practice outfit you need a 1.5-volt battery, and a key. Since a standard flashlight battery generates 1.5 volts, it can be used. It is necessary to solder a lead on both ends of the battery. Don't forget that the center pole is always positive, and the case of the battery is negative. A flashlight battery will give fairly long use since a code oscillator usually does not see too many hours of service. A 1.5-volt dry cell may be used also and is a bit easier to hook up, since no soldering is necessary.

Now, a word about the key, which is a very important item. Since the key selected for the code oscillator should be good enough to use on your Novice transmitter, this is no place to save money. Although there are "bargain" telegraph keys which sell for as little as 69¢, you should buy a deluxe professional type key, which is the equivalent of the J38 Signal Corps key shown in Fig. 6-11. Sometimes these are available at surplus stores. However, there are some fine-quality commercial keys of this sort available for approximately $4.00. It is important that the key have multiple adjustments to allow setting it up for the proper feel. A good key will also have quality bearing pivots and a built-in switch to allow shorting out the key. The latter is quite helpful in tuning up the transmitter.

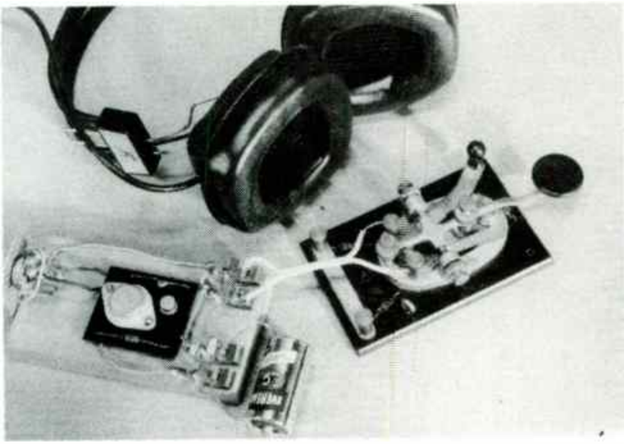


Fig. 8-2. Hookup for using headphones as output.

ADJUSTING THE KEY

Adjusting the key to the proper feel depends somewhat upon the person. This writer prefers to have some spring tension, but not much. This adjustment is near the handle of the key, and the bearings on both sides should be adjusted so that the key is well supported but does not "freeze" in the bearings. Finally, the adjustment on the forward end of the key should be turned until the key closes, and then backed off so the key opens up—perhaps $\frac{1}{32}$ of an inch.

Again, the proper adjustment depends a bit upon the feel of the operator, but the previous description should give you a starting point. The drawing in Fig. 8-3 shows the proper way to hold the key. If you grasp it as shown in the drawing, you will find you'll be able to push down or pull up with equal ease, which is most important.

Learning the code, as mentioned previously, finally comes down to *practice*. Some people have to practice more than others. This writer has found that those who are having trouble with code often are not too honest about the amount of time they have *actually* put into code *practice*. If you follow the instructions given here with concentrated effort you will find that you have mastered an entirely new skill in a surprisingly short time. One nice thing about learning code is that it is somewhat like riding a bicycle—once you learn it you never completely forget it. Your code speed may slow down if not used, but in a very short time you can renew and regain your top speed at any point in your lifetime. Many hams operate a phone for years and then return to cw for a while to brush up on their code, perhaps as a way to prepare for the coveted Extra Class license.

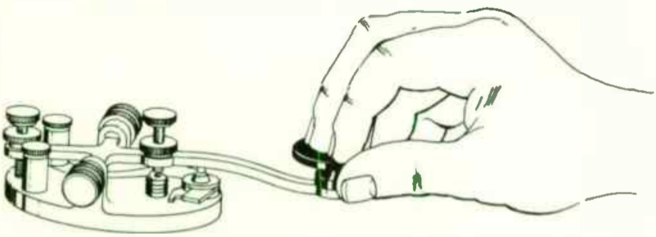


Fig. 8-3. Conventional grip used with a hand telegraph key.

Here is the list of the code sounds that you must learn. The "dash" between the "dit–dah" does not indicate a space but is provided, rather, to make the word easier to read. As a rule of thumb, code is easier to copy if the letter is made fairly rapidly, and then the actual code speed is determined by the spacing between the letters. In other words, do not drag out the formation of a letter to send slowly; instead, transmit the letter quickly and then provide a breathing spell between letters. If the length of the letter is prolonged too much, there is always danger that the person receiving it, instead of copying "dit-dah" as "A" will copy it as two different sounds—"dit," which is "E," and "dah," which is "T."

In listening to your record album or your tape recorder, try to get a very clear picture of how *good* code sounds, and then imitate it. Some Novices have surprisingly good "fists" right from the beginning. Others, although they send slowly, transmit code which is very difficult to copy.

The list in Chart 8-1 is intended for reference only. As stated before, the best way to learn code is to start out listening to it —ideally with a good tape cassette.

Chart 8-1. International Morse Code

Letters

A	dit-dah	N	dah-dit
B	dah-dit-dit-dit	O	dah-dah-dah
C	dah-dit-dah-dit	P	dit-dah-dah-dit
D	dah-dit-dit	Q	dah-dah-dit-dah
E	dit	R	dit-dah-dit
F	dit-dit-dah-dit	S	dit-dit-dit
G	dah-dah-dit	T	dah
H	dit-dit-dit-dit	U	dit-dit-dah
I	dit-dit	V	dit-dit-dit-dah
J	dit-dah-dah-dah	W	dit-dah-dah
K	dah-dit-dah	X	dah-dit-dit-dah
L	dit-dah-dit-dit	Y	dah-dit-dah-dah
M	dah-dah	Z	dah-dah-dit-dit

Numbers

1	dit-dah-dah-dah-dah	6	dah-dit-dit-dit-dit
2	dit-dit-dah-dah-dah	7	dah-dah-dit-dit-dit
3	dit-dit-dit-dah-dah	8	dah-dah-dah-dit-dit
4	dit-dit-dit-dit-dah	9	dah-dah-dah-dah-dit
5	dit-dit-dit-dit-dit	0	dah-dah-dah-dah-dah

Punctuation

Period	dit-dah-dit-dah-dit-dah
Comma	dah-dah-dit-dit-dah-dah

Others Often Used

End of message	dit-dah-dit-dah-dit
Invitation to transmit	dah-dit-dah (K)
Final transmission	dit-dit-dit-dah-dit-dah (SK)

9

How to Go on the Air

In Chapter 5, the various elements which make up the ham station are discussed in some detail, and a block diagram illustrates how the units all fit together.

Fig. 9-1 shows an actual Novice station which was set up and put on the air. Notice that the transmitter sits on top of a U-shaped mount which is a shelf supported by two end pieces. This is a very handy way to arrange a small station because it enables the operator to have the transmitter and receiver close together. It also provides a place to mount the antenna change-over switch, if one is used.

The wooden shelf shown in the photograph was made up of three small pieces of wood of a grade known as "shelving," which can be obtained at a local lumber yard. A rough sketch had been made before calling on the lumber yard, so that it was easy to explain to the mill operator exactly what was wanted. The pieces were cut in the mill in order to obtain three pieces of wood which were cut very accurately and would fit together in a neat, square fashion.

Of course, the wood can be cut by hand at home, but it is rather difficult to make something of this kind unless a miter box or some other accurate means of cutting is available. The simplest way is to let the lumber yard do it for you. In this writer's case, the lumber yard charged only a dollar for making the necessary cuts.

You will note from Fig. 9-2 that a double-pole, double-throw switch is mounted on the end of the shelf. Actually, for the layout shown only one-half of the switch is used. The double-pole switch was provided in case it is desirable to use the switch to control a receiver for "standby" at the same time that the switch is thrown to change the antenna from the receiver to the transmitter. This is a very handy way to do it, if the receiver is so designed that there are connections provided for

Fig. 9-1. Low-cost Novice station.

the changeover. If the receiver does not have connections, it is a relatively simple matter to connect a two-wire lead to the standby switch, providing you do not mind opening up the receiver cabinet and getting under the chassis. The hookup, of course, should be such that when the knife switch is thrown to connect the antenna to the receiver, it also closes the receiver standby switch contacts. In effect, one side of the double-pole, double-throw switch simply *parallels* the standby switch on the receiver.

The antenna recommended for this transmitter and for your first Novice station is shown in Fig. 9-3. You will note that it uses only a single wire. More elaborate antennas are fed with a two-wire lead-in called an open-wire line or by a cable called a coaxial line.

A single-wire antenna was chosen because it is the simplest to erect, and also it is possible to tune it up using a simple dial-light bulb indicator. Antenna tune-up is a real problem for many beginners. With the average transmitter having a pi network filter in the output, it is possible to tune up the transmitter so that the meter on the transmitter *seems* to indicate that the transmitter is properly matched to the antenna. All

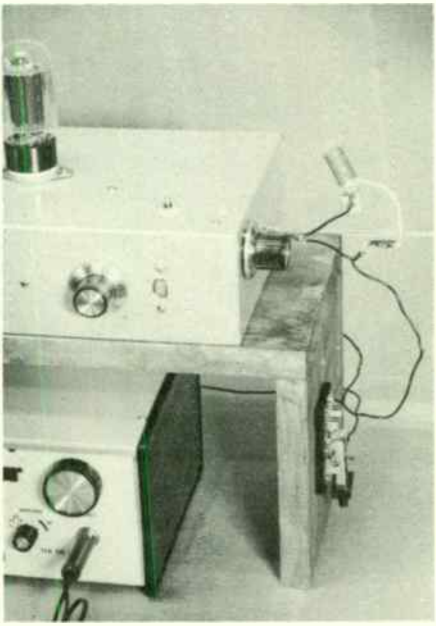


Fig. 9-2. Antenna switch mounted on base.

that actually occurs is that the plate output coil is being heated up and very little power is going out onto the air. If you use a single-wire antenna with a bulb connected in series with it, you *know* for certain that the antenna is actually taking power.

If you can possibly do it, try to erect an antenna like that shown in Fig. 9-3. This will ensure that you have a large enough radiating surface so that chances are good that the antenna will operate efficiently. Place it as *high* as possible—try for 45 feet.

If you are cramped for space—for example, your overall available space for the horizontal portion of the antenna is only 50 feet—you can make up the difference by means of a simple loading coil which is added near the end of the antenna

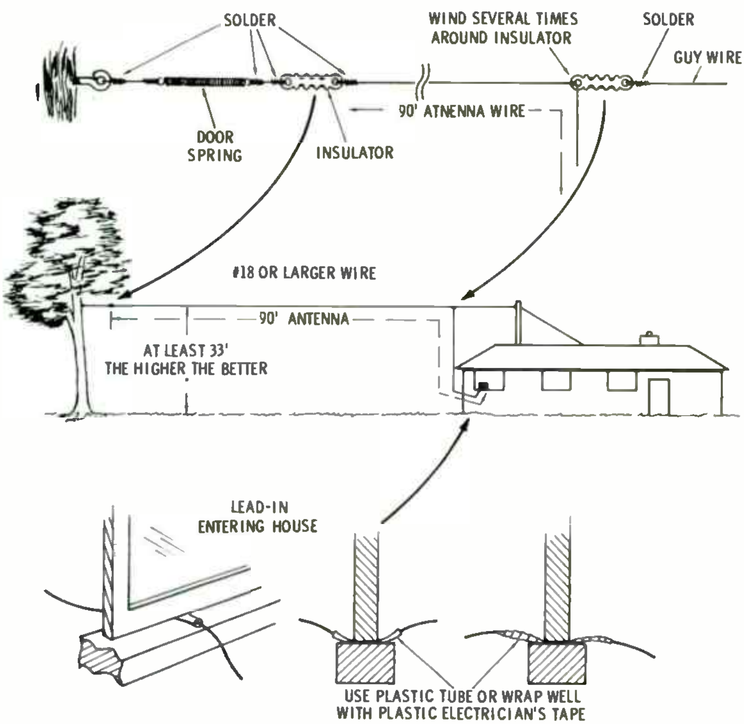


Fig. 9-3. Antenna installation for basic Novice station.

(Fig. 9-4). How to make this coil using ordinary hook-up wire and the ever-useful plastic bottles from the local drug store is shown in Fig. 9-5.

If possible, try to limit this loading coil to no more than 25 feet of wire, and 33 feet should be regarded as the absolute maximum. When you have the coil completed as mentioned in the drawing, tape the whole coil with electricians tape in order to keep moisture from creating problems. The problem should not be too severe because of the insulation on the hook-

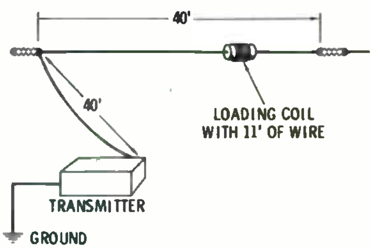


Fig. 9-4. Using a loading coil to shorten antenna length.

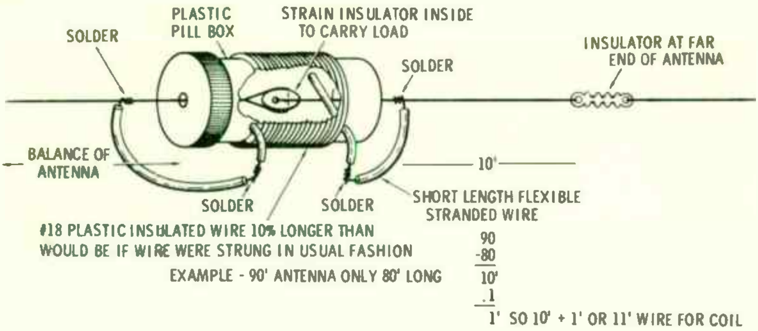


Fig. 9-5. Construction details for a loading coil.

up wire recommended, but if you live in a humid part of the United States, the tape is a helpful extra precaution.

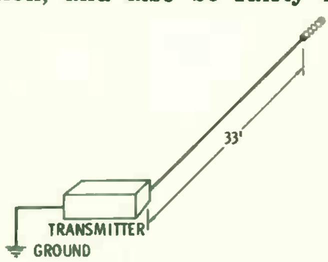
If you need more winding space than provided by the form, wind coil in two or more layers with electricians' tape between layers.

SHORT ON SPACE

What if you can't even find space for a 66-foot wire, and a loading coil, a total of 90 feet in effective length? If you are in this situation, you probably will not be able to operate on 80 meters at all, and the best thing to do is to confine your operation to 40 meters. On 40 meters, you can use a 33-foot wire which should be run vertically, or on a slant, as high as possible (Fig. 9-6). Also, if you can manage it, keep the antenna clear of other objects by at least 10 feet.

In addition, since the antenna is inherently rather inefficient, the quality of the ground connection becomes *extremely* important. In fact, it is far better to use another length of wire, identical in dimension, as a second element hooked to the chassis. Fig. 9-7 shows how this is done. Ideally, this wire should go off in another direction, and also be fairly high.

Fig. 9-6. A short 40-meter antenna.



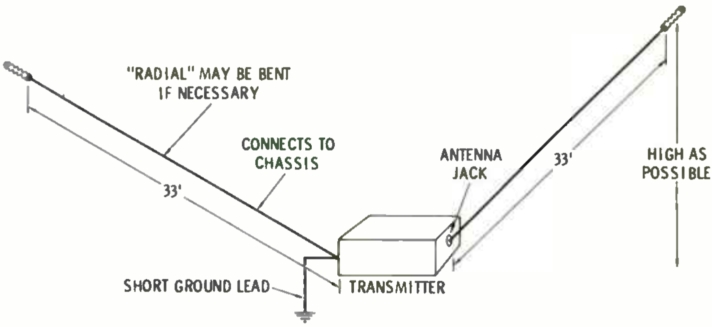


Fig. 9-7. Improving the short 40-meter antenna.

If you are unable to do this, the wire can be run around the house under the eaves, tacked around the base of the house high enough so that snow doesn't cover it, or, in extreme cases tacked around the baseboard of a room. If you have to mount the wire on some object—for example, the baseboard of a room or the foundation of a house—use well-insulated wire. High voltage tv cable, for example, has such good insulation that it will easily withstand any rf voltage which may develop on the line. The end of the wire should be taped to prevent any possibility of someone coming in contact with the bare end.

There is one way that you can operate on 80 meters with such a small antenna although it will not be very efficient. As shown in Fig. 9-8, a loading coil can be put in both legs of the antenna to make up the necessary dimension. This will be satisfactory for local calls, but the antenna will not work nearly as effectively as a full-sized antenna. Note that the coils are shorted out for 40-meter operation.

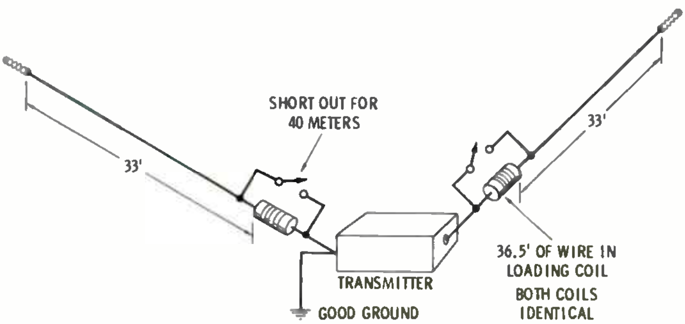


Fig. 9-8. A short 80-meter antenna.

With any single-wire antenna, the *ground* lead between the transmitter and the actual grounding point is important. If the transmitter is being used on 40 meters, ideally the ground lead should *not be more than 7 or 8 feet long*. The point at which the ground connects to a cold water pipe, or to a good grounding rod driven outside the window of the house should be as close to the transmitter as possible.

If you use a grounding rod, efficiency can be improved a great deal by what is known as a chemical ground (Fig. 9-9). The effectiveness of this kind of ground is surprising. In tests run by this writer, when the transmitter was shifted from a cold water pipe ground to a chemical ground the improvement in the signal received at the other end was equivalent to *doubling* the power of the transmitter.

What if you cannot get a *short* lead between the transmitter and the grounding point? In this case—regardless of whether you have a full 90-foot antenna or a shorter wire "loaded" to 90 feet—add a 33-foot "radial," which is the proper length for 40 meters. Then, run your ground lead from transmitter chassis to the cold water pipe, steam heating system, or whatever ground is available. The 33-foot radial connected to the chassis of the transmitter, as shown in Fig. 9-7, will improve the performance on 40 meters without seriously upsetting tuning on 80 meters.

TUNING THE ANTENNA

In a previous chapter a transmitter was tuned to a dummy antenna. The tune-up procedure with a real antenna is essen-

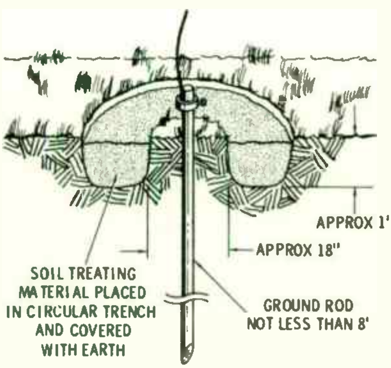


Fig. 9-9. A good chemical ground.

tially the same process. This time it is important to remember that the signal being transmitted may go a surprisingly long distance. For that reason, the tune-up procedure should be practiced with a dummy antenna, so that the actual on-the-air tune-up requires as little time as possible.

The first step is to make up some indicator bulbs, as shown in Fig. 9-10. Note that the lead which connects to the antenna also hooks to a short length of hook-up wire containing two bared, twisted loops. One end of this lead goes to the center conductor of an RCA-type phono connector. As is apparent from the illustrations, the idea is to provide two different points for tapping the wire. In effect, the bulb is in parallel with a short length of the wire. The bulb and its short leads should parallel the antenna wire for as short a distance as possible, yet some current flow, necessary to make the bulb glow, be obtained. Tune-up will be easiest on 40 meters.

As the first step, clip the bulb to the loop which is the longest path for current to flow. In the diagram this is labeled as loop "A." The antenna loading capacitor on the end of the chassis should be set so that the capacitor plates are fully meshed. Plug in a 40-meter crystal, and plug in the key. If the key has a switch, the switch should be closed. If it does not have a switch, as is true in the case of some of the low-cost keys, you can screw down the adjustment to the point where the key is closed. You can obtain the same effect by pulling the key plug out of the jack. The jack is so arranged that it makes contact when the plug is removed.

Now, rotate the variable capacitor on the front panel until the neon bulb on the chassis glows. This is the *resonance* point

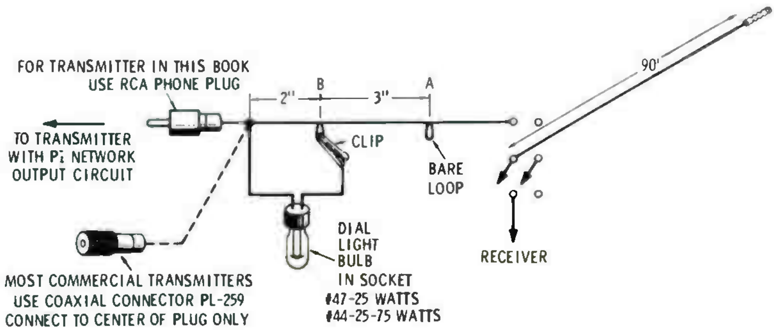


Fig. 9-10. Tuning indicator for single-wire antenna.

and is the point to which you *always* return as the final adjustment. You want the amplifier tuned to resonance at all times. This prevents the amplifier stage from drawing too much current.

Next, as was done before with the dummy antenna, begin to open up the antenna tuning capacitor, and retune the amplifier output to resonance with the main tuning capacitor. As you move along with this process step by step, the bulb in series with the antenna will begin to glow. This is what is really important, since it indicates current in the antenna. The idea is to arrive at a combination of adjustments of the variable capacitors which give the *maximum* glow on the flashlight bulb in series with the antenna. It may be, as you get close to this point, particularly on 80 meters, that the bulb begins to glow so brightly that there is danger of burning it out. In this case, move the clip back to the loop marked "B." This will decrease the amount of current flowing through the bulb.

In all of this process, it is assumed that you have a good ground connected to the transmitter. It is most important with electronic equipment of this type to have a ground on the equipment at all times. There is always the danger that some part will fail and put 110 volts or even higher voltage on the chassis, which could cause a fatal shock. If you always have the chassis grounded, the worst that can happen is that the fuses in the house will blow or the circuit breaker will open up. For the same reason, the receiver which you are using should always be grounded. While the ground on the receiver may make relatively little difference in the reception, it is a clear-cut safety factor to have the chassis grounded.

CRYSTALS

If you are starting out on the 40-meter band, try to have at least two crystals on different frequencies, and if possible, four. There is a good reason for this. It is always possible that you will go on the air at a frequency where many other stations are operating—perhaps most of them closer than you to an area of many active hams—and your signal will be buried. However, if you have several crystals, you can find your crystal frequency on the dial of your receiver by using the crystal oscillator as has been described in a previous chapter. Then, you can pick a spot which is not so heavily occupied.

Do not buy a crystal with a frequency which is too close to the edge of the band. Any crystal you buy should be at least two kilohertz from either the top or the bottom edge of the band, and another kilohertz is a nice margin of safety.

ON THE AIR

The great moment has arrived! If your antenna is taking power as described, you are ready to go on the air for the first time. Try it on Saturday morning on 40 meters, a good time for Novice operation.

The first thing to do is to determine the frequency of the transmitter in the amateur band, which can be done by listening to the transmitter. This is best done with the amplifier tube removed so that the transmitter doesn't block the receiver too severely.

If, when we locate our signal in the Novice band, that particular spot seems overcrowded, the next thing to do is to plug in a different crystal; hopefully this next crystal will be in a clearer spot. Then do some listening around this frequency. Sooner or later you probably will hear a station calling CQ, which, of course, is the general call meaning that the operator wishes to talk to anyone who will come back to him. The station will probably be transmitting something like this:

"CQ, CQ, CQ, CQ, de WØLBV, CQ, CQ, CQ, CQ, CQ, WØLBV, WØLBV, WØLBV, dit-dah-dit-dah-dit." The "dit-dah-dit-dah-dit" means that the station is standing by and listening for calls. The station may use dah-dit-dah (K) instead.

At this point, you swing into action and transmit WØLBV, WØLBV, WØLBV, WØLBV, de (your call) then repeat WØLBV, WØLBV, WØLBV, de (your call) (your call) (your call). Indicate with a "dah-dit-dah," ("K") that you are standing by and listening.

If all goes well, the station will come back and repeat your call several times. From there on the conversation initially will run along the lines of that outlined in Chapter 1.

This is an ideal situation—the chances of contacting the first station you call are fairly slim. One of the reasons for this is that there may be several other stations calling the same one you are attempting to contact. If one of them is closer and stronger than you are, it is likely that the station called will reply to the competing station. Perhaps your crystal frequency is somewhat higher than the station calling CQ, while the crystal frequency of a competing station is somewhat lower. If the station called happens to tune from the low side of his frequency up the dial, he will hear the other station first.

KEEP TRYING

Don't be discouraged if you don't make your first contact. If you average one contact out of two or three calls, you are doing very well, particularly as a beginner who has not yet had time to learn all the operating tricks. The important thing is to continue trying and if you find that you have no success on one crystal frequency, shift to another frequency. Sometimes you can be buried by a signal although you are not aware of it because you cannot hear it very well locally.

As suggested, the band to use in the daytime is 40 meters, and normally, from shortly after sunup until sundown, this is a fairly satisfactory band for a Novice operation. Unfortunately, at night the band may be clobbered by powerful shortwave broadcasting stations from overseas, in which case the best thing to do is to shift up to 80 meters with appropriate crystals. Also, the transmitter must be tuned to 80 meters, as was described earlier in the use of a dummy antenna. The 80-meter band can be quite crowded at night, but since it is of fairly limited range, ordinarily, you should have good luck getting out if you have a ham rig with a fairly decent antenna, as described in this book.

TUNING UP OTHER TYPES OF ANTENNAS

The single-wire antenna is the simplest for the beginner to use initially for the reason mentioned earlier—it is easy to put a bulb in series with the antenna and see what is happening. However, many commercial antennas are fed with coaxial lines, and these can also be used with the transmitter described, and with any of the commercial transmitters or transmitters made from kits. The tuning procedure for these antennas, however, is quite different.

Let's assume that you have a 40-meter doublet fed with a coaxial cable. For use with the transmitter in Chapter 6, this cable must terminate in an RCA phono plug like that used for the single-wire antenna; one exception is that the metal braid of the cable must be soldered to the outside of the plug, as shown in Fig. 9-11.

Fig. 9-11. Attaching coaxial cable to RCA phono plug.

You will tune up with the use of the little volt-ohm-milliammeter set up to serve as a milliammeter. The vom is connected across the telegraph key which is plugged into the transmitter (Fig. 9-12). When the transmitter is turned on and tuned up in the manner described earlier, the antenna tuning capacitor

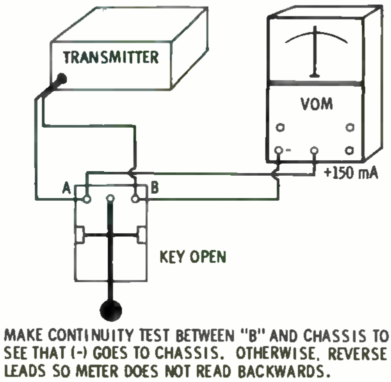


Fig. 9-12. Hookup for measuring plate current.

is fully closed. As you tune the amplifier tuning dial through resonance, there will be a sharp dip in the plate current. As you open up the antenna tuning capacitor, thereby increasing the load, this dip will become less and less pronounced.

Finally, you will get to the point where there is very little dip. This is about as far as you want to go. You may find that the dip does not correspond exactly to the resonance point as indicated by the neon bulb on the chassis, and the best output will be obtained if the amplifier tuning dial is adjusted for maximum brilliance on the neon bulb.

The following is a brief review:

1. Start with the antenna tuning capacitor completely closed.
2. Bring the transmitter to resonance, which will be indicated both by the neon bulb glowing and by a pronounced dip in the plate current as indicated on the milliammeter.
3. In small steps increase the antenna loading by opening up the antenna variable capacitor, and reestablishing the resonance point by adjusting the amplifier tuning dial.

As a final check key the transmitter, and listen to a transmitter harmonic to see if the keying is "clear." If it is not, make a minor adjustment of trimmer capacitor TR as was described in Chapter 6.

On 80 meters you may find that in order to tune up properly, you must increase the size of capacitor C11. This capacitor is adequate for the single-wire antenna specified, but for a doublet antenna, for example, which is fed with a coaxial line, you may need to increase the size of this capacitor to 300 picofarads. This is done simply by connecting a 200-pF capacitor across C11. Use an even larger capacitor if needed.

Don't be discouraged if it takes you a while to contact your first station. This is very common. As you work with the equipment, you will soon learn how to operate it in an efficient manner. Before long, you will be contacting stations on a regular basis, providing you have an antenna that is satisfactory. A good antenna is far more important than transmitter power—spend both effort and money, if necessary on the antenna.

CALLING CQ

After you have learned to call stations successfully, you may become more bold and call "CQ" yourself. If you go on the air and can't hear anyone, you may be able to "open up" the band by calling "CQ" yourself and enjoy the pleasure of hearing several stations calling you.

In calling CQ, this writer has found that the best idea is to call CQ at least five times and send your call letters twice. Repeat CQ five more times, and again send your call letters twice. Then call CQ an additional five times, and send your call three times, slowly and carefully; then stand by.

The idea is to call CQ enough times so that there is a good chance you will be heard, yet not overdo it. A few hams call CQ twenty-five times and then send their calls twice, in a sloppy fashion. This kind of practice does not generate many contacts!

WHAT COMES NEXT

If you have as much fun operating as do most Novice hams, soon you will want to obtain a higher class of license. This is easier after you have built up code speed and have added to your technical know-how by working with equipment and studying one of the many texts available for qualifying for the General class or other licenses. Almost before you know it, you may be on the air trading slow scan television pictures with a ham in Rio.

Meanwhile—good luck—and good DX!

10

Novice Band Antennas

The single-wire antennas described in the previous chapter are the simplest for the Novice ham to erect and tune. However, there are many other types of antennas suitable for use on the Novice bands, including some excellent commercial types which are readily available from ham suppliers.

First of all, a word about the importance of the height of antennas. The best transmitter on earth is worthless unless the antenna is efficient. Furthermore, the efficiency of a horizontal antenna depends, in part, upon the *height* at which the antenna is erected. This is particularly true in the amateur 40- and 80-meter bands.

Ideally, a horizontal antenna for 80 meters should be at least 66 feet above the ground, and a hundred feet would be even better. Of course, such heights are impractical for most applications, but even a 25-watt transmitter with a 40-meter antenna at least 45 feet above the ground will usually outperform a 75-watt transmitter with the antenna only 25 feet in the air. Regardless of what antenna you erect, get the *horizontal* portion of it as *high* as you possibly can.

To do this often requires building some type of a simple mast, which can be made out of wood, as shown in Fig. 10-1. In addition, today there are readily available tv antenna masts which, when suitably secured by guy wires, are excellent for supporting a ham antenna. You'll find these cataloged by most electronic parts companies. If you are affluent, you can even have the antenna support erected by a tv installation firm which will have the necessary ladders, mounting hardware, etc. for doing the job.

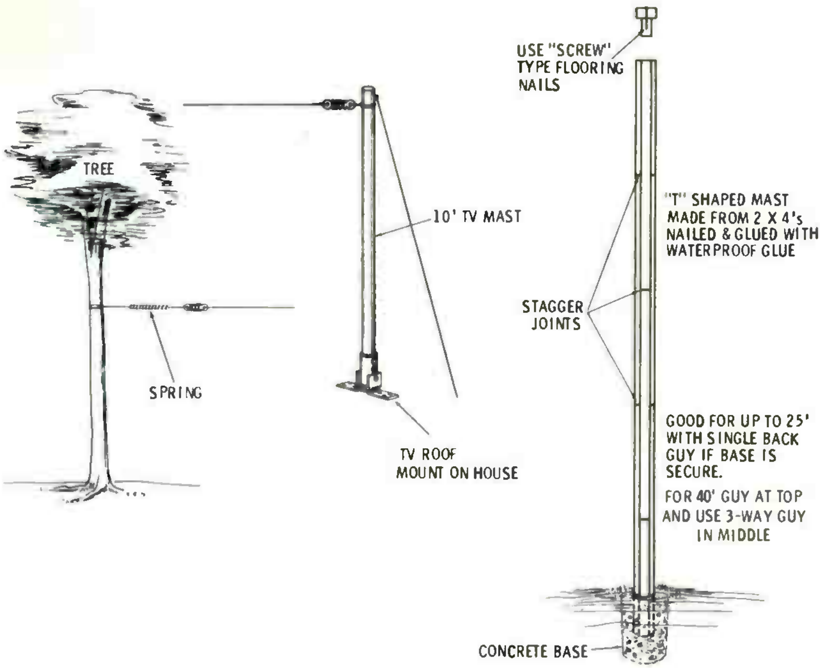


Fig. 10-1. Supporting the antenna.

HALF-WAVE DIPOLE ANTENNAS

The dipole antennas are the most common commercially, and a typical dipole is shown in Fig. 10-2. One of the biggest advantages of a dipole is that there is no loss of efficiency in the ground connection; if the dipole is properly tuned and the coaxial feedline is not too long, the overall efficiency of the antenna itself is quite good on 40 and 80 meters. The disadvantage of the dipole is that it must be fed in the center, which is often not the most convenient layout arrangement.

CONSTRUCTING A DIPOLE

The diagram in Fig. 10-3 shows how to make your own dipole for either 40 or 80 meters. Choose the proper length from

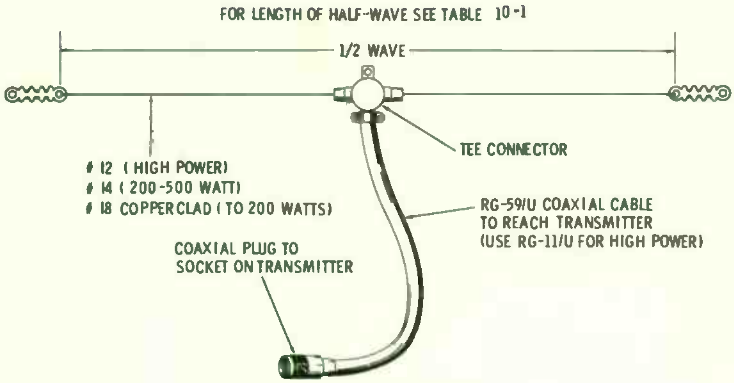
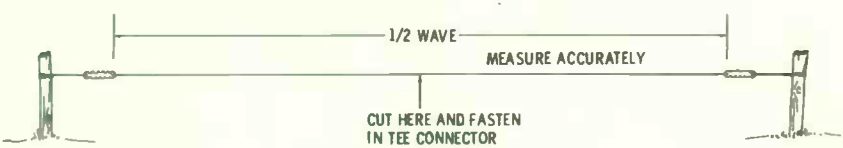


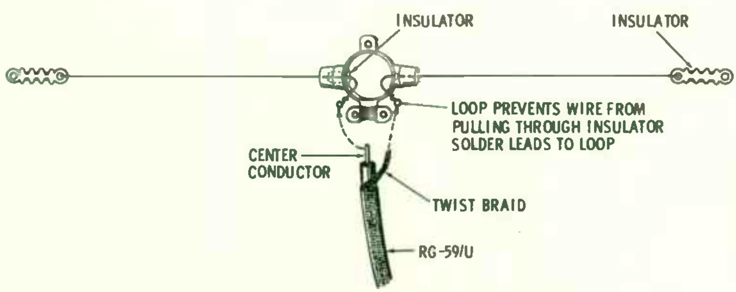
Fig. 10-2. Typical half-wave dipole.

Table 10-1. If you prefer, you can buy a dipole kit which includes the feedline, the center insulator, and sufficient wire for the radiating portion. Such a kit usually has enough antenna wire for 80 meters, and the extra wire is simply discarded if the antenna is used on 40 meters or one of the higher frequency bands.

Chapter 9 described briefly how to tune a coaxial-fed dipole by using a milliammeter. If it is done exactly as described, the chances are good that the procedure will result in a satisfac-



(A) Antenna being laid out.



(B) Connecting the coaxial cable to the antenna.

Fig. 10-3. Constructing a dipole.

Table 10-1. Half-Wave Antenna Lengths (For Quarter-Wave, Cut in Half)

Frequency	Length	Frequency	Length
80 meter (3.5 MHz)		14,200 kHz	32′-11 1/2″
3550 kHz	131′-10″	14,250 kHz	32′-10″
3600 kHz	130′	14,300 kHz	32′-8″
3650 kHz	128′-2″	14,350 kHz	32′-7″
3700 kHz	126′ 4″	15 meter (21 MHz)	
3725 kHz	125′-6″	21,050 kHz	22′-3″
3750 kHz	124′-8″	21,100 kHz	22′-2 1/4″
3800 kHz	123′	21,150 kHz	22′-1 1/2″
3850 kHz	121′-6″	21,200 kHz	22′-1″
3900 kHz	120′	22,250 kHz	22′-1/2″
3950 kHz	118′-6″	22,300 kHz	21′-11 1/2″
40 meter (7 MHz)		22,350 kHz	21′-11″
7050 kHz	66′-4″	22,400 kHz	21′-10 1/2″
7100 kHz	65′-11″	22,450 kHz	21′-10″
7175 kHz	65′	10 meter (28 MHz)	
7225 kHz	64′-9″	28,000 kHz	16′-8″
7275 kHz	64′-4″	28,200 kHz	16′-7″
20 meter (14 MHz)		28,400 kHz	16′-6″
14,050 kHz	33′-4″	28,600 kHz	
14,100 kHz	33′-2 1/2″	28,800 kHz	
14,150 kHz	33′-1″	29,000 kHz	

tory tune-up. However, unfortunately there is always the possibility that the tune-up will not be ideal because the "dip" in the plate current may not coincide exactly with the maximum output from the transmitter. If you are using a coaxial-cable fed antenna, it is well worth the investment to buy an swr meter which also has provision for measuring rf output (Fig. 10-4).

Fig. 10-4. An swr meter.

USING THE SWR METER

Without getting into the technical details, the prime purpose of an swr meter is the measurement of the "standing wave ratio" on the feedline. There is a good deal of technical witchcraft surrounding standing wave ratio—many hams incorrectly feel that if the swr is low, the antenna is *automatically* efficient. However, this is not true. The reading on the meter depends in part upon at what point in the line the meter is inserted. Often changing the length of the line by as little as 10 feet will make a profound difference in the swr reading.

The swr reading *is* important in some circumstances; for example, an swr ratio of 3 or 4 to 1 over a long feedline on 20 MHz means that much power is being wasted heating up the line. Yet on 80 and 40 meters the difference between an swr ratio of 1½ to 1, and even of 3 to 1 will not be discernable at the receiving end if the feed line is fairly short. Ideally, the swr should be held to 2.0 to 1.0 or less. *If* the swr is higher than this the remedy is to prune or lengthen the antenna. Fig. 10-5 shows how to hook up the swr output meter.

In effect, the meter is used exactly as the dial-light bulbs with the single wire antenna, as described in a previous chapter. Simply tune the transmitter to give maximum rf output as indicated on the meter. Ideally, this will coincide with the dip in plate current on the transmitter, but situations are not necessarily ideal. If you use any type of dipole antenna (including the various "trap" dipoles) your chances of "getting out" will be improved if you tune up with the meter *for maximum output*. These swr output units usually sell today in the $20.00 to $30.00 range.

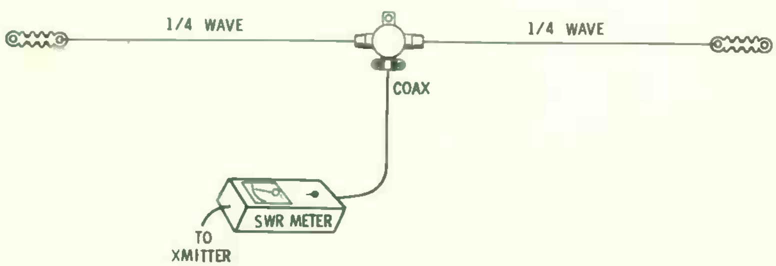


Fig. 10-5. Hookup for an swr meter.

Antennas of the horizontal variety are usually the best for Novice use on 80 and 40 meters, because they are effective over the rather short range which most Novices use on these frequencies. A horizontal antenna does take up considerable space and is not practical for the ham who does not have a sizable backyard. However, even with a small yard it is usually possible to squeeze in a 66-foot antenna of the type described earlier in this book.

INVERTED V ANTENNA

This antenna is a modification of the dipole. It has two small advantages; it requires only one antenna mast instead of two and it saves space (Fig. 10-6). The center support for 80 meters should ideally be about 60 feet high, although many hams use the antenna with a lower mast. At least 35 feet is recommended for 40 meters.

The antenna configuration makes the length somewhat more difficult to predict than with the simple dipole. The formula for calculating the length is:

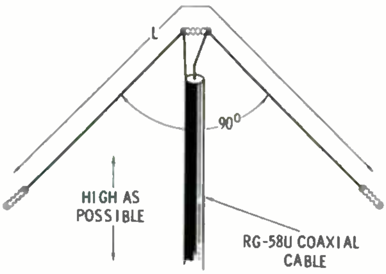


Fig. 10-6. Inverted V antenna.

$$\text{Length (feet)} = \frac{464}{\text{Frequency (MHz)}}$$

$$\text{Example: } \frac{464}{7.15} = 64.89 \text{ ft.}$$

For minimum standing wave ratio it is a good idea to cut the antenna a bit long, and then cut off a few inches from each end in order to achieve the lowest swr. However, cutting the antenna to the length indicated by formula should result in a satisfactory swr, providing the feed line is not too long.

MULTIBAND HORIZONTAL ANTENNAS

The dipoles described so far are one-band types, but there are a number of ways to make center-fed "dipole" antennas which will operate satisfactorily on two or more bands. One of the best ways is to use a dipole with an open-wire line and antenna tuner. However, this is a fairly complicated arrangement and is beyond the scope of this book.

One simple approach is to have a 40-meter dipole designed as shown in Fig. 10-7. Because the 21-MHz band and the 7-MHz band are at proper harmonic relationship, the same antenna can be used for both frequencies, and the antenna as shown will function very well on both bands.

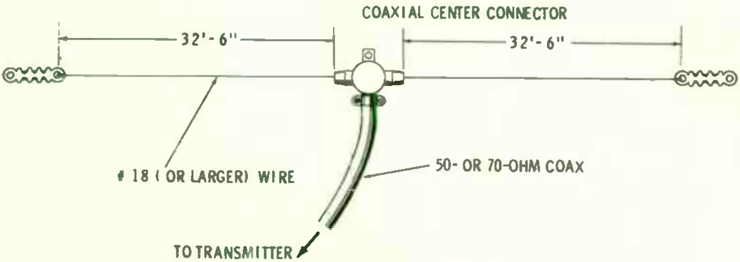


Fig. 10-7. The 40- and 15-meter antenna.

3-BAND DIPOLE

Shown in Fig. 10-8 is another way to build a multiband antenna, a design which is actually two different dipoles fed with a common feed-line. One is cut for the 80-meter Novice band, and the other is cut for 40 meters. The 40-meter antenna

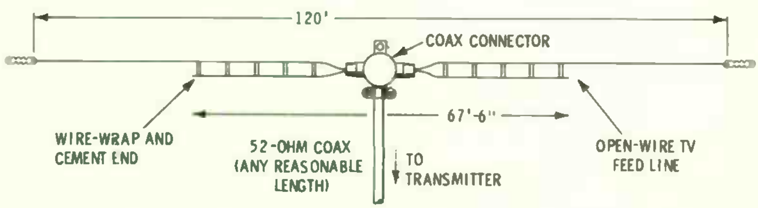


Fig. 10-8. Novice-band antenna for 80, 40, and 15 meters.

works on the third harmonic of 15 meters. A disadvantage of this antenna is that it requires an overall length of 120 feet.

If you make such an antenna, follow the instructions in the drawing to wire-wrap, cement, and tape the end where the shorter section of tv line is terminated. The only problem is that the antenna will blow about somewhat in the wind, and you may find after you put it up that the wire is coming loose from the insulator.

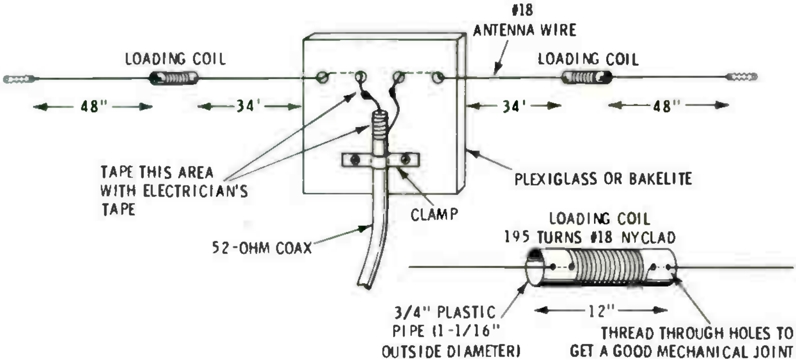


Fig. 10-9. Three-band antenna using loading coils.

Another approach, if you want to use a center-fed antenna on a Novice band and still keep the overall length within reasonable limits, is shown in Fig. 10-9. This antenna uses loading coils to make up the additional electrical "length" needed for proper tune-up. You can find this type of plastic pipe at the lumber yards in smaller cities or in the hardware stores of small towns located in rural areas particularly.

MULTIBAND VERTICAL ANTENNAS

It may be that you are *really* cramped for space, live in an area where there are building restrictions, or have downright unfriendly neighbors who take a dim view of anything unusual. In this case the best answer may be a vertical trap antenna (Fig. 10-10). These antennas are quite compact, requiring only a few inches of ground space. They are capable of satisfactory performance, provided an effective ground or radial system is used with them, and they are erected somewhat in the clear of other objects. For short-haul work a vertical antenna is *not* as effective as a horizontal antenna, but the vertical makes up for it by being effective for DX.

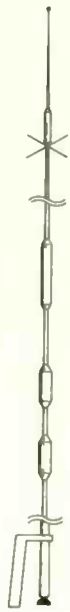


Fig. 10-10. A vertical trap antenna.

USING A GROUND

The most compact way to install a vertical is to use a ground connection. Most verticals are designed for clamping to a pipe which can be driven into the ground. While any such pipe will provide a ground of sorts, a chemical ground is highly recommended. Fig. 10-11 shows one way to accomplish this, in a fashion which is compact and neat as seen from the surface. Note that several chemicals are suggested as possibilities, and all will work well. However, do *not* use either of the sulfates if you are in an area where there are wells supplying drinking water—there is danger of poisoning the underground water supply. Salt does not present the same hazard, and has the advantage of being readily available. The low-cost salt of the type used for breaking up ice on sidewalks is satisfactory. Be certain to add water—and salt—to the pipe fairly regularly.

Instructions with the vertical antenna should indicate how to make the ground connection. The *braid* of the coaxial cable should be grounded to the top end of the pipe. Usually this connection is made automatically since the coaxial cable socket will be connected electrically to the mounting brackets.

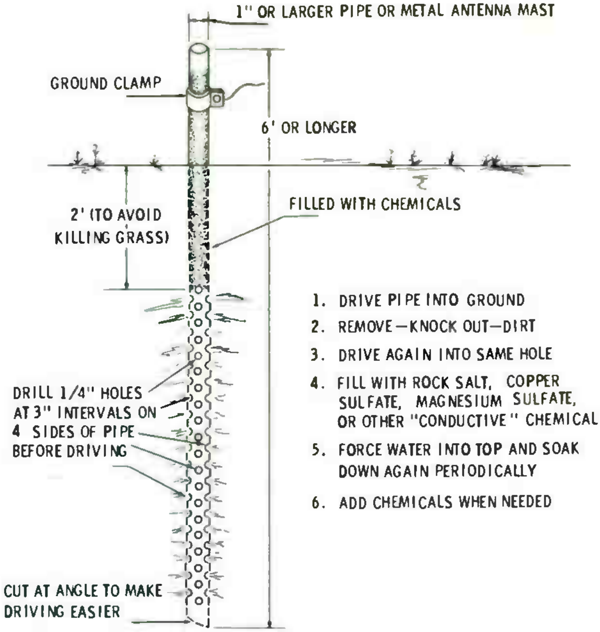


Fig. 10-11. A neat chemical ground.

USING RADIALS

Even with a *good* chemical ground there will be some loss of power, since no ground is electrically perfect. In addition, mounting the antenna on the ground frequently means that it is screened by nearby buildings, fences, trees, etc.—and these also reduce the efficiency of the antenna system.

To eliminate the need for a ground, many hams use radials, which are three or four wires going out from the base of the antenna; this technique makes it possible to mount the antenna high above ground. If you are familiar with CB antennas you have seen such systems—usually three rods extending horizontally from the base of the antenna.

Radials provide a kind of synthetic ground, and, in addition, decouple the antenna from the feedline to prevent the feedline from trying to act like part of the antenna system. It is important to accomplish this, because if the antenna and feedline interact, the angle of radiation may be raised considerably, which creates a severe loss of DX low-angle radiation.

If you buy a commercial vertical antenna, it will include instructions on how to set up the radials. It is generally *not* pointed out that there is no good reason why the radials cannot be put inside the attic of the house. This can make a big difference in the appearance of the antenna as viewed by neighbors.

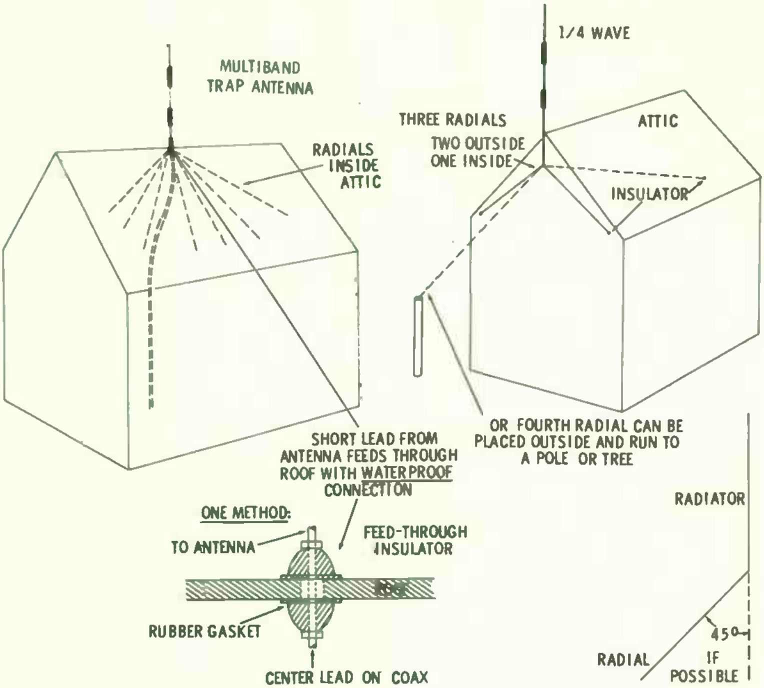


Fig. 10-12. Radials can be inside attic.

Fig. 10-12 shows some ideas for putting the radials inside. The roof will have virtually no effect on the performance.

SOME INSTALLATION IDEAS

Ideally, the vertical with radials should be mounted as high as you can get it. However, if you are in an area with sandy, rocky soil, you may achieve better luck with your vertical by using radials rather than an earth ground, even though the base of the antenna is close to the ground. Strive to put the antenna clear of other objects if possible. Furthermore, although the antenna will not work as well with fewer radials than three, in some installations even *one* radial will be better than a poor ground. Even in the worst location at least two radials are usually possible, and these should be positioned in the direction of preferred contacts, if this is at all possible.

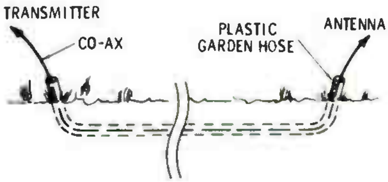


Fig. 10-13. Running coaxial cable underground.

One good aspect of coaxial feedline is that it can be buried in the ground, a few inches under the surface, thus allowing a neat installation between house and antenna. However, this writer prefers running the coaxial line through a length of low-cost plastic garden hose, to give the line additional protection (Fig. 10-13).

TUNE-UP

Tune-up with a multiband vertical is the same as with a dipole. It is best done with an swr meter set to indicate rf output. However, it can be accomplished by adjusting the output control on the transmitter in order to load up the rig and then "dipping" the plate current to indicate resonance. Normally, this is spelled out in considerable detail in the instruction manual which comes with the typical commercial transmitter.

Appendix

INTERNATIONAL "Q" SIGNALS

These three-letter abbreviations mean the same in any language, so they are extremely helpful in foreign contacts. Also, since they save a lot of time and effort, they are widely used for domestic contacts as well. We will give some of the more popular ones.

Q signals can be used *both* as a question and answer—the question being created by following the Q signal with a question mark.

Examples

Signal	Means	Typical Answer
QRG?	What is my exact frequency?	"Ur frequency is 7180 kHz."
QRM?	Is there interference on my signal?	"Vy bad QRM fm local."

Most Frequently Used Q Signals

Signal	Typical Usage
QRN	Atmospheric interference. (Static of sort heard on 80 meters during summer)
QRX?	Should I wait (stand by)? Example: "Pse QRX—have phone call."
QRS	Send slower (pse!).
QRT	Stop sending. (Often: "Must QRT for lunch.")

QRU?	Have you anything more for me?
QSB?	Signal fading? (Often: "QSB bd.")
QSL	Acknowledge receipt. (In the ham world this usually refers to "QSL" cards which hams may mail after contact.)
QSO	Can you communicate with . . . . (Hams often use this form: "Had fb qso with WØLBV—meaning had fine contact with WØLBV)
QST	General call—attention all stations.
QSY?	Should I change frequency?
QRZ?	Who is calling me? (Useful when you can't copy the other station's call letters the first time.)
QRRR	Serious emergency—stop sending and listen only.

RST SIGNAL-REPORTING SYSTEM

When you are in contact with another station, you will report on his signal, and he will report on yours. Example: "Ur sigs RST 559X hr in Denver, Colorado." The following list shows how to interpret this and other reports.

The RST System

Readability

1—Unreadable.
2—Barely readable, occasional words distinguishable.
3—Readable with considerable difficulty.
4—Readable with practically no difficulty.
5—Perfectly readable.

Signal Strength

1—Faint signals, barely perceptible.
2—Very weak signals.
3—Weak signals.
4—Fair signals.
5—Fairly good signals.
6—Good signals.
7—Moderately strong signals.
8—Strong signals.
9—Extremely strong signals.

Tone

1—Extremely rough hissing note.
2—Very rough ac note, no trace of musicality.
3—Rough low-pitched ac note, slightly musical.
4—Rather rough ac note, moderately musical.
5—Musically modulated note.
6—Modulated note, slight trace of whistle.
7—Near dc note, smooth ripple.
8—Good dc note, just a trace of ripple.
9—Purest dc note.

ABBREVIATIONS

Over the years both commercial and ham operators have developed abbreviations which are a kind of simple shorthand. Following are some of the more popular ones:

ABT	About
AGN	Again
BCI	Broadcast interference (as when picked up on neighbor's stereo).
CUL	See you later.
CU AGN	See you again.
FB	Fine business (a kind of "A-OK").
GA	Good afternoon.
GB	Goodbye.
GM	Good morning.
HI	*Not* a greeting. Expresses amusement—a kind of telegraphic smile.
HW	How.
NR	Number.
OM	Male ham of any age.
PSE	Please.
RPT	Repeat.
SKED	Schedule.
TNX	Thanks.
TVI	Television interference.
UR, URS	Your, yours.
WX	Weather.
XMTR	Transmitter.
YL	Young lady.
XYL	Ex-young lady or wife. (Use with caution!)
73	Best regards.
88	Love and kisses.

Sources For Electronic Parts

A special effort was made in preparing this book to specify parts available from your local distributor. *Try him first.* However, if you live in a small town, you may have to order by mail. There are numerous firms which offer catalogs of their products. Consult electronics or ham magazines for current offering. They not only serve as a good source for ordering parts, but also as a handy reference.

In the event trouble is encountered procuring parts for projects in this book, an up-to-date listing of sources for all items can be obtained by sending 25¢ plus a stamped, business-size envelope to:

Johnson Company
855 South Fillmore Street
Denver, Colorado 80209

FCC FIELD OFFICES

When you are ready to take your examination, write to the District FCC office closest to you. Mailing addresses for Commission Field Offices are listed below. Street addresses can be found in local directories under "United States Government." Address all communications to Engineer in Charge, FCC.

Alabama, Mobile 36602
Alaska, Anchorage (P.O. Box 644) 99501
California, Los Angeles 90014
California, San Diego 92101
California, San Francisco 94111
California, San Pedro 90731
Colorado, Denver 80202
District of Columbia, Washington 20554
Florida, Miami 33130
Florida, Tampa 33602
Georgia, Atlanta 30303
Georgia, Savannah (P.O. Box 77) 31402
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Illinois, Chicago 60604
Louisiana, New Orleans 70130
Maryland, Baltimore 21202
Massachusetts, Boston 02109
Michigan, Detroit 48226
Minnesota, St. Paul 55102
Missouri, Kansas City 64106
New York, Buffalo 14203
New York, New York 10014
Oregon, Portland 97205

Pennsylvania, Philadelphia 19106
Puerto Rico, San Juan (P.O. Box 2987) 00903
Texas, Beaumont 77701
Texas, Dallas 75202
Texas, Houston 77002
Virginia, Norfolk 23510
Washington, Seattle 98174

Index

from CB to HAM BEGINNER

by J. A. Stanley

Tired of listening to the same type of traffic on the CB band? Want to go on the air and work real DX: stations half-way around the world? You can do all of this by entering the world of the "ham."

Ham radio will enable you to enjoy skip transmission legally. On the ham bands you can talk about *anything* you please, as long as you want. You are not restricted to "business" use.

It was to help you make the transition from CB to ham radio that this book was written. And whether you are a CBer, an SWL, or *anyone* who wants to get started in amateur radio—this book puts it all together. In just *one* volume it tells and shows you how to:

- **select and tune a communications receiver**
- **listen in on the ham bands**
- **acquire technical know-how the easy, fun way—by building and experimenting**
- **learn to send and receive code**
- **pass your Novice Class license exam**
- **build or buy an amateur transmitter**
- **erect an effective antenna**
- **put a ham station on the air**

Like J. A. Stanley's previous books, *From CB to Ham Beginner* is easy to understand, and packed with photos and drawings which *really show you how*. No previous knowledge is needed. The book tells you everything you need to know to become a radio amateur.

About The Author

The byline "J. A. Stanley" first appeared when the author was 18 years old and wrote an article entitled "An Easy-To-Build Radio." At the time "Stan" had already been a ham for two years, and was enrolled in pre-engineering at a small college.

But the writing bug bit him hard. Eventually he shifted from engineering to journalism, receiving his degree from the famed "J" school of the University of Missouri. While he was still in school, writing articles for Popular Mechanics helped him pay bills.

After the university, Stan was in the Signal Corps for a time, where his studies included Communication Engineering, Applied Electronics (radar), and Airborne Radio.

Today, Stan is a corporate executive, whose troubleshooting assignments take him all over the world. But he still finds time for experimenting with electronic circuits and antennas, for operating his ham station [illegible], and for racing his sailboat. He is the author of *Electronics for the Beginner* and *Electronic Servicing for the Beginner*, both published by Howard W. Sams & Co., Inc.

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