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NEW! UPDATED & REVISED EDITION

CITIZENS BAND RADIO HANDBOOK

by DAVID E. HICKS

The complete guide to Citizens Band Radio. Tells how to select, install, operate, maintain, and adjust all types of CB equipment. Describes the latest equipment and FCC regulations.

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REVISED EDITION

by DAVID E. HICKS

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PREFACE

In the years since its introduction, radio has become one of the most useful and versatile inventions of our time. Its most common form, of course, is to provide entertainment and mass communications. However, the uses of radio in business, industry, national defense, and scientific exploration are practically unlimited.

Until a few years ago, FCC authorizations for two-way radiocommunications, were available only to certain governmental and commercial agencies, and to those who could qualify as amateur radio operators. The introduction of the Citizens Radio Service, however, made two-way radio available to the general public. Since that time the interest and enthusiasm concerning Citizens band radio have made it the fastest growing and most popular two-way radio service in existence.

This volume, now completely updated and revised, is intended to introduce you to all phases of this service; it contains the answers to the many questions and problems confronting those who now use, or who intend to use, CB equipment, as well as those who install and maintain the equipment. The content not only gives you the facts concerning the Citizens Radio Service, its purpose, and how to obtain a license, but it also includes many examples of commercial equipment and accessories. Pictures and descriptions are included to guide you in making your own selection for specific application. For the more technical reader, circuit analyses, troubleshooting hints, and servicing data are included.

If this book gives you a better understanding of Citizens radio, and helps you to profit by getting the most value from its use, its purpose will have been accomplished.

David E. Hicks

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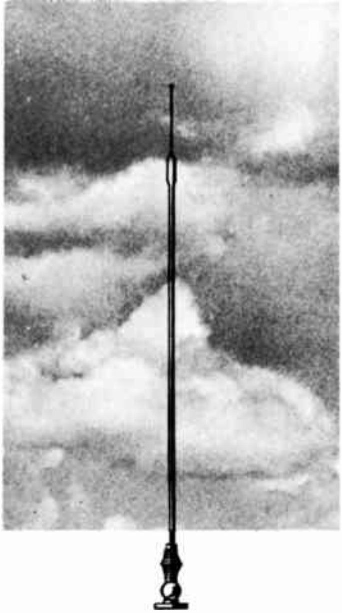


1 The Citizens Radio Service

At one time, two-way radiocommunication was reserved only for those services operating in the interest of public safety, necessity, and convenience. In recent years there has been widespread interest in two-way radio and with the advent of Citizens band radio, this medium has been made available to the general public.

WHAT IS CITIZENS RADIO?

The Citizens Radio Service was established in 1947 by the Federal Communications Commission (FCC) to permit personal short-distance radiocommunications, signaling, and remote control by radio signals—all designed to fulfill a definite need in connection with both business and personal activities. This service made available to the general public, for the first time, the long-awaited convenience of a two-way radiotelephone system that could be used by practically anyone.

At this time, however, only two classes of licenses—A and B—were available. The frequencies allocated for both classes were in a band 10 megacycles (mc) wide (from 460-470 mc) in the ultrahigh frequency (UHF) region. Fig. 1-1 shows the position of this band in the frequency spectrum as it appears today. To the left, between 450 and 460 mc, is another band assigned to remote pickup, industrial, land transportation, public safety, and domestic public services. Frequencies extending downward from 450 mc are assigned to amateur radio. To the right of the initial 460-470 mc band are the UHF television channels.

The Class-A and -B Citizens band (CB) stations were intended to provide two-way radiotelephone wherever the need arose. For example, a business could use CB radio for dispatching its delivery trucks, or an individual in his automobile could communicate with his home—possibly just to inform his wife that company was coming for dinner.

Although its uses were practically unlimited, CB radio was rather slow in gaining acceptance. The two principal reasons for this were the cost of the equipment and the limited range of communications. Class-A stations could operate with much higher transmitter power than those with Class-B ratings, but the equip-

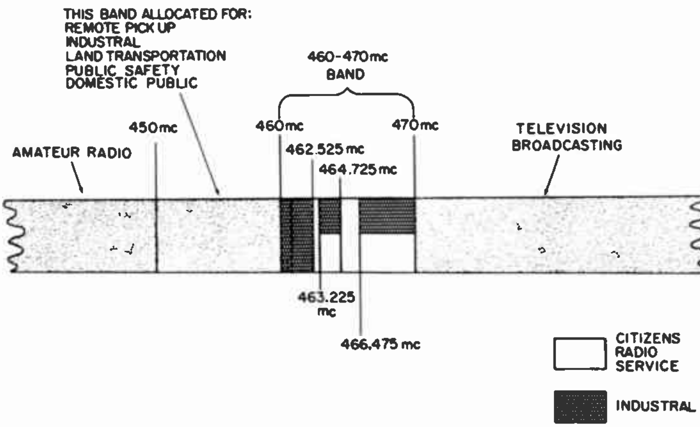


Fig. 1-1. Position of Class-A and -B channels in the frequency spectrum.

ment was also much more complex and expensive. Conversely, although some Class-B equipment marketed was reasonably priced, there was still the problem of its limited range.

One of the many factors that determine the range of a transmitter is its operating frequency. At UHF frequencies, radio waves tend to travel in a straight line between transmitting and receiving antennas; they do not reflect and bend as much as the lower-frequency waves do and they are attenuated more rapidly. This is illustrated in Fig. 1-2; the UHF signal travels more or less in a line-of-sight path between the two antennas. Intervening terrain or objects such as trees or buildings will greatly attenuate, and sometimes completely block, the signal. This, of course, limits the usable communicating range at these frequencies. The lower-frequency signal is reflected and reaches the receiving antenna with little loss. (This is discussed at length in Chapter 4.)

Shortly after the Class-A and -B services were introduced, a third class was announced. Known as Class C, it was reserved for remote control of such devices as model airplanes, garage doors, etc. (radiotelephone communications are not permitted).

Realizing the shortcomings of UHF communications and the need for practical Citizens-band radio, the FCC in 1958 allocated a number of channels for use by a new service labeled Class D. This is the class that accounts for the recent widespread popularity of CB radio. Now, frequencies formerly assigned in the 11-

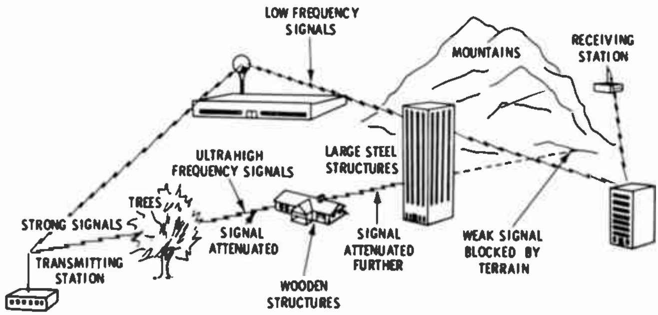


Fig. 1-2. An example of the UHF signal's line-of-sight characteristics.

meter amateur band have been reallocated for Class-D stations, and at these lower frequencies more reliable communications can be obtained. Furthermore, Class-D equipment is readily available in a variety of styles and at reasonable prices.

USES OF CB RADIO

CB radio's uses are practically unlimited. Equipment can be permanently installed at a fixed location, in vehicles, or carried in the hand. In a car, CB radio can provide communications with your home or office; doctors may use it to communicate with the hospital as well. It can be used in boats and airplanes, on hunting, fishing, or camping trips, or even on a golf cart. Businesses are finding CB radio helpful. Much time and money can be saved with radio-dispatched service and delivery trucks—to say nothing of the more efficient service. Countless others are finding Citizens radio equally as helpful—radio and TV technicians, plumbers, police and fire departments, surveyors and highway maintenance crews, to name just a few.

Each day new ways of utilizing this versatile medium are being discovered. More and more CB antennas are appearing atop such business establishments as hotels, motels, restaurants, service stations, and garages. You can make reservations at a motel or hotel or order your dinner while traveling along the highway. If you are stranded along the road with car trouble, help is no further away than your CB microphone. In many areas, local CB clubs have posted signs on the outskirts of the city listing the CB channels that are monitored.

OBTAINING THE LICENSE

Since the CB transmitter, like thousands of other devices and equipment, radiates energy which utilizes the radio-frequency spectrum, it comes under the jurisdiction of the Federal Communications Commission. Before such a transmitter can be placed on the air, a station license must be obtained from this governmental agency. Unlike most other radio services, however, a CB license is fairly easy to obtain and no examination is required. On the other hand, the FCC has set up specific rules and regulations for the operation of CB equipment; failure to comply can result in a fine, and/or suspension or revocation of the station license. One of the limitations concerns the amount of transmitter power allowed, stated, as "so many watts of input or output." The word input refers to the plate input power to the final RF stage of the transmitter—a product of the plate voltage and plate current of this stage. The actual output power of a transmitter is always less than the input to the final stage. CB stations (except Class A and one Class-C channel) are permitted the relatively low input power of 5 watts and an output power of 4 watts. CB transmitters that operate with a power input of 100 *milliwatts* or less require no license whatsoever. Most of the small hand-carried transistorized units fall into this category.

Who Is Eligible?

Any citizen of the United States, male or female and 18 years or older, is eligible for a Citizens-band license. Persons under 18 may operate CB radio equipment—but only under the supervision of a licensee who assumes full responsibility for proper station operation. Applicants for a Class-C Citizens-band license (used for remote-control) need only be 12 years of age or older to obtain a license.

Applicants are not required to learn code, nor to take any oral or written examination. No operator's license is required—only a station license authorizing the installation and operation of the equipment. (Equipment maintenance is subject to certain restrictions to be discussed later.)

A Citizens radio license is not granted to aliens, nor to any person representing an alien. The same is true for a representative of a foreign government or to any corporation in which a director or officer is an alien.

Filing the Application

All applications for CB licenses are made on standard FCC forms. Form 400 is used for Class-A station licenses and Form 505 for Class-B, -C, and -D licenses. These forms are usually included with new CB gear; however, they can be obtained by writing the nearest FCC Field Engineering Office (listed in the Appendix).

One entry requires you to signify that you possess a *current* copy of Part 95 of the *FCC Rules and Regulations* governing the Citizens Radio Service. These are included in Volume VI, which can be purchased for $1.25 by writing the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. Part 95 of the rules and regulations is included in the Appendix for your convenience.

All applicable questions on the form must be answered. Failure to do so may result in the application being marked "incomplete" and returned. One of the questions concerns the number of transmitters to be operated. Any number can be covered by a single license as long as they are all under the control of the licensee and in the same geographical area; however, only one applicant (which can be a corporate group or company) can be licensed for the same equipment. The actual number of transmitters (the FCC is not concerned with receivers) must be listed on the application. If more transmitters are to be added after issuance of the license, an application for license modification must be submitted.

After all questions on the form have been answered, you must sign it. Notarization is not necessary; however, making willful false statements is punishable by fine and imprisonment. The completed application for a Class-B, -C, or -D station license should be mailed to the FCC office at 334 York Street, Gettysburg, Pennsylvania. Class-A station applications, special requests, or correspondence relating to applications for any CB license should be mailed directly to the FCC office at Washington 25, D.C. At the time this book was written, nearly 500,000 CB licenses had been issued, and the FCC was still receiving approximately 10,000 applications per month. It is not unusual for processing to require several weeks.

Many persons purchase CB equipment before obtaining a license. This is all right, as long as they do not try to operate it. The license must be in the applicant's possession before he can operate the equipment. The mere fact that an application for a license has been submitted does not constitute authorization to begin operation. Wait until you receive the license before you press that microphone button.

License Fees

Except as provided in § 1.1115(b) of the FCC regulations, a fee of $10.00 must accompany the application for a new, renewal, or modification of a Class-A license. The fee for Class-B, -C, or -D stations is $8.00.

Renewals and Modifications

All licenses are issued for a period of five years from the date of original issuance or renewal. Application for renewal of a CB license is made on the same form as for a new station license and should be filed at least 60 days before the license expires.

From time to time certain changes in equipment, location, etc., may be desired. Should any such changes conflict with the terms on the current license, an application for modification must be submitted to the FCC. An application for license modification is made in the same manner as an application for a new station license. As in the case of renewals the same application is employed. Upon receipt of the revised license, the applicant must forward the old one to the FCC.

The following changes require filing for a license modification:

1. A change in the station licensee's address.
2. A change in location of a fixed transmitter or control point.
3. Relocating or changing the height of, or erecting an antenna structure requiring prior FCC approval.
4. Increasing the over-all number of authorized transmitters.
5. Changes which may affect transmitter operation.
6. Addition or deletion of control point(s) for presently authorized transmitters.
7. A change or increase in the area of operation for a Class-A station.
8. A change in the operating frequency of a Class-A station.

CB LICENSE CLASSES

Class-A License

The Class-A license permits the user a much higher plate input power than Class B, and also provides a variety of operating frequencies from which to choose. Moreover, the antenna height is not nearly as restricted as for Class B.

Frequency Allocations—A variety of frequencies are available for Class-A assignments on a shared basis with other stations in the Citizens radio service. All frequencies are contained in four segments of the 460 to 470 mc band as shown previously in Fig. 1-1. These segments are further subdivided into 48 specific fre-

Table 1-1. Class-A frequencies.

462.525-463.225 mc Channel	464.725-466.475 mc Channel	
462.55	464.75	465.65
462.60	464.80	465.70
462.65	464.85	465.75
462.70	464.90	465.80
462.75	464.95	465.85
462.80	465.05	465.90
462.85	465.10	465.95
462.90	465.15	466.00
462.95	465.20	466.05
463.00	465.25	466.10
463.05	465.30	466.15
463.10	465.35	466.20
463.15	465.40	466.25
463.20	465.45	466.30
	465.50	466.35
	465.55	466.40
	465.60	466.45

All frequencies in mc.

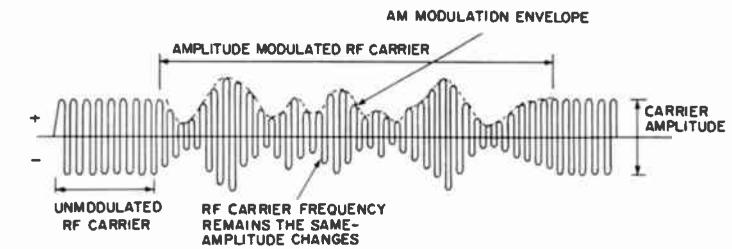
quencies (listed in Table 1-1). Each station is separated by 50 kc—enough to prevent properly operating equipment from introducing interference on adjacent frequencies. A Class-A station is assigned one frequency only, and prior FCC approval must be obtained before it can be changed. Fig. 1-3 is an example of a present-day two-way radiotelephone type accepted for Class-A operation.

Power Limitations—The maximum plate input power is 60 watts for a Class-A station (48 watts output). This is the highest permitted any class in the Citizens Radio Service.

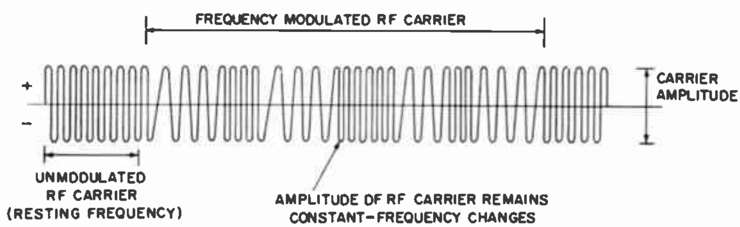
(Courtesy Kaar Engineering Corp.)

Fig. 1-3. A two-way radiotelephone transceiver, FCC-approved for Class-A operation.

Emission—Class-A units are normally authorized to transmit radiotelephone only, although other types of transmissions may be permitted if there is sufficient reason. Application for such authorization must be submitted to the FCC, stating not only the emission desired, but also why it is needed and what bandwidth will be required to provide satisfactory communications. Each Class-A license lists not only the type of emission authorized, but also the maximum bandwidth it can occupy. Practically all Class-A stations transmit either AM (amplitude modulation)



(A) Amplitude modulation (AM).



(B) Frequency modulation (FM).

Fig. 1-4. Two types of modulation used in CB radiotelephone communications.

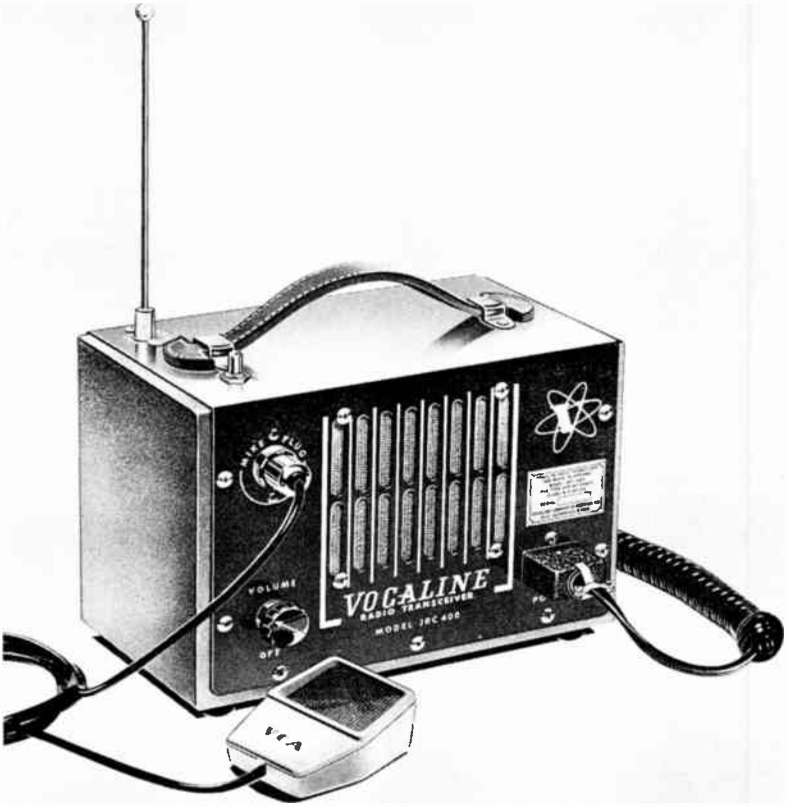
or FM (frequency modulation) radiotelephone. The differences between the two, illustrated in Fig. 1-4, are as follows: In an AM transmitter, the *frequency* of the carrier remains constant and its *amplitude* is changed in intensity, or modulated, by the voice signal (Fig. 1-4A). The amount of change is designated as the percentage of modulation.

In an FM transmitter, the *amplitude* of the RF carrier remains constant, and the frequency is varied above and below its normal value by the voice signal (Fig. 1-4B). As you can see, the names *amplitude* and *frequency* modulation are quite descriptive.

Class-B License

Shortly after Class-B operation was started, several manufacturers made equipment available at a price that appealed to almost everyone. This accounted for much of the popularity of Class-B instruments during CB radio's infancy.

While the equipment was simpler, the maximum permissible power input was not nearly as high as for Class A. One example of a Class-B UHF transceiver is shown in Fig. 1-5.



(Courtesy Vocaline Co. of America, Inc.)

Fig. 1-5. A Class-B AM transceiver.

The big problem of range confronted Class-B stations to a greater degree because of the power limitations. Many purchasers of Class-B equipment were disappointed at the results. Not understanding the problems at UHF frequencies, they expected too much. To add to the troubles of both the FCC and equipment manufacturers, unqualified persons often attempted to adjust or modify their equipment in hopes of improving performance. This usually resulted in off-frequency operation or a completely inoperative unit.

Frequency Allocations—Class-B stations are authorized to operate on 465 mc only, unless the equipment has been type-accepted for Class-A operation. In this event, the station may also be operated on any of the Class-A frequencies. Equipment that is not crystal controlled must have a type-acceptance number which signifies it meets all FCC technical requirements. Some manufacturers often request type-acceptance for crystal-controlled equipment as well.

Power Limitations—Maximum plate power input for a Class-B station is 5 watts—quite a bit less than the 60 allowed a Class-A station. The actual output power of the transmitter is limited to 4 watts. However, it may be only 3 watts, or only a fraction of a watt, depending largely on the efficiency of the transmitter.

Emission—Class-B stations are permitted to use either AM or FM radiotelephone, and can also use a modulated or interrupted unmodulated carrier for operating radio-controlled devices.

Class-C License

Shortly after the opening of Classes A and B in the 460-470 mc band, an additional frequency (27.255 mc) was added for remote control purposes only. Labeled Class C, it was not authorized for any type of radiotelephone operation whatsoever, but was to be used solely for radio control of such devices as garage doors, model airplanes, boats, etc.

Frequency Allocations—Class C was initially allocated only one frequency (27.255 mc). However, in September 1958 the FCC allocated five additional operating frequencies. The frequencies now available for Class-C operation are 26.995 mc, 27.045 mc, 27.095 mc, 27.145 mc, 27.195 mc, and 27.225 mc. The initial frequency of 27.255 mc is shared by stations in other services, and stations operating on any of these frequencies can expect no protection from interference caused by scientific, medical, and industrial equipment operating in the 26.96 to 27.28-mc band.

Power Limitations—Maximum plate power input permitted a Class-C station is 5 watts (4-watts output), except on the original frequency of 27.255 mc where maximum allowable input is 30 watts (24-watts output).

Emission—Only two types of emission are permitted for Class-C operation—amplitude tone modulation, and on-off unmodulated carrier. No intelligence can be transmitted in this band; it is reserved for remote-control uses only.

Class-D License

Class-D Citizens radio has taken the spotlight away from all other classes. In fact, many had never heard of Citizens radio until this service was announced.

One of the inherent disadvantages of the Class-A and -B services is that they operate in the UHF region. This presents problems in equipment design and in the reliability of the communicating range. The Class-D service, assigned much lower frequencies, overcomes to some degree the line-of-sight characteristics in the higher 460-470 mc band. This new class not only extends the reliable communicating range, but also adds to the usefulness of the equipment itself, giving new hope to persons

Fig. 1-6. The "Ray-Tel" TWR-3 is typical of the Class-D equipment now being produced. It provides 10-channel crystal-controlled operation and employs a dual-conversion superhet receiver that can be variably-tuned over the entire band. It also has a solid-state frequency synthesizer which permits the same crystal to be used for transmitting and receiving.

(Courtesy Raytheon Co.)

previously discouraged by operation of the equipment in the old band. Furthermore, a large variety of Class-D equipment, capable of meeting almost every need, is now available in either kit or factory-wired form at prices well within almost any budget. Most of the Class-D radio equipment is of the transceiver type similar to the unit shown in Fig. 1-6. Many examples of this type of equipment are contained in Chapter 2.

Frequency Allocations—When the FCC established the Class-D service, it allocated a group of frequencies formerly assigned to the 11-meter amateur band. This assignment gave Class-D stations 22 channels on which to operate exclusively. Since then a

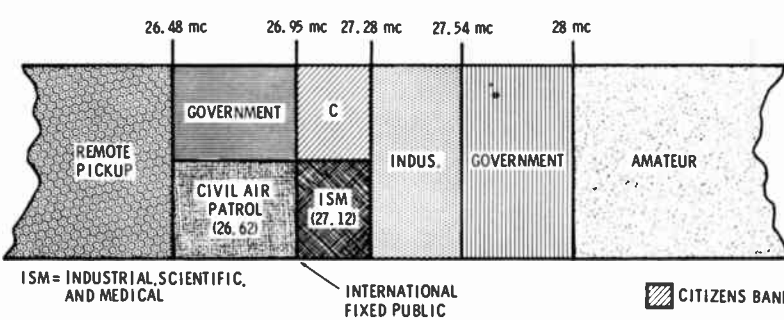


Fig. 1-7. Position of Class-D channels in the frequency spectrum.

23rd channel (27.255 mc) has been made available on a shared basis with stations in other services. Fig. 1-7 shows the location of the Class-D frequencies in the radio spectrum. Table 1-2 lists all 23 Class-D channels and corresponding operating frequencies. Note that they are 10 kc apart except where separated by Class-C channels.

Table 1-2. Class-D frequencies.

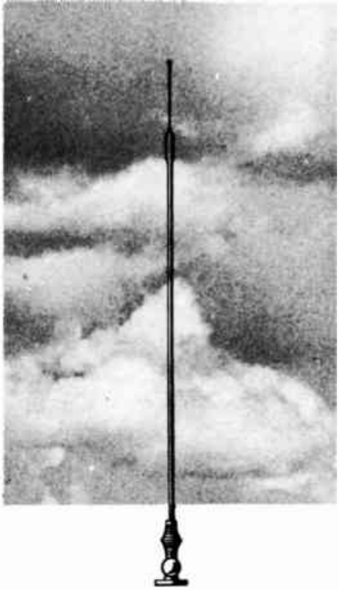
Channel	Freq. (Mc)	Channel	Freq. (Mc)	Channel	Freq. (Mc)
1	26.965	9	27.065	17	27.165
2	26.975	10	27.075	18	27.175
3	26.985	11	27.085	19	27.185
4	27.005	12	27.105	20	27.205
5	27.015	13	27.115	21	27.215
6	27.025	14	27.125	22	27.225
7	27.035	15	27.135	23	27.255*
8	27.055	16	27.155		

* Shared with stations in other services.

Class-D equipment that is not crystal controlled must have an FCC type-acceptance number. (Some transceivers are type-accepted even though they are crystal controlled.) As with Class C, there is no guarantee against interference originated by industrial, medical, and scientific devices operating in the 26.96 to 27.28-mc band. Effective November 1, 1964, communications between different stations are permitted on Channels 9, 10, 11, 12, 13, 14, and 23. The other channels are reserved for communications between units operating on the same license.

Power Limitations—Class-D equipment is allowed a maximum plate power input of 5 watts and maximum power output of 4 watts. Although seemingly limited, this meager input can provide communications over surprising distances. (Power is not the only factor that determines communicating range, as will be discussed later.)

Emission—The only emission permitted for Class-D operation is amplitude-modulated (AM) radiotelephone. Frequency modulation is *not* permitted for this reason: AM transmitters in this service are permitted a bandwidth of only 8 kc; an FM transmitter would require almost five times this frequency spread. Obviously, the excessive space taken up by FM would cut down the number of channels available within the allocated bandwidth.



2

Citizens Band Equipment

An almost unlimited variety of Citizens band equipment is available today. There are sets for every conceivable type of operation, and many of them can be purchased either in kit form or as factory-wired and tested assemblies. Some ingenious individuals may even consider building their own. Regardless of who designs and constructs the equipment, it must conform with certain FCC requirements before it can be put on the air.

TECHNICAL REQUIREMENTS

Frequency Tolerance

All CB transmitters must operate within a specified frequency tolerance, which depends not only on the class of station but also on the type of operation (mobile, fixed, or base) and the plate input power. For example, the frequency tolerance of a Class-A fixed or base station is .001 per cent, but mobile equipment in the same class is allowed a tolerance of .005 per cent if its plate input power is 3 watts or less (only .001 per cent if over 3 watts). Class-B equipment is authorized for mobile operation only, and must conform to a frequency tolerance of 0.5 per cent if its plate input power is 3 watts or less, and 0.3 per cent if over 3 watts. Class-C and -D units must operate with a frequency tolerance of .005 per cent whether maximum plate input power is used or not.

Modulation

The RF carrier of an AM transmitter cannot be modulated over 100 per cent. Exceeding this amount not only would distort the signal, but would also introduce harmonic frequencies which may extend outside the assigned channels. This, of course, is not permitted. Most CB transmitters therefore include some form of self limiting to prevent overmodulation. The frequency deviation of any FM transmitter used for CB operation (except Class-B stations operating on 465 mc) must not exceed ±15 kc.

Emission

The bandwidth occupied by the emission from an AM transmitter (except Class-B stations operating on 465 mc) must not exceed 8 kc, and from an FM station, 40 kc. Any emission extending beyond the carrier by at least 50, but not more than 100, per cent of the maximum authorized bandwidth must be attenuated 25 db or more below the unmodulated carrier level. Moreover, harmonics or other spurious emissions extending beyond the carrier frequency by 100 per cent or more of the maximum authorized bandwidth must be attenuated below the unmodulated carrier level by at least 50 db if the plate input power is over 3 watts, and 40 db if 3 watts or less. Should any emission from a Class-B station operating with a maximum RF final plate input power of 3 watts or less fall within a band assigned to industrial, scientific, or medical equipment, it must be attenuated 30 db or more below the unmodulated carrier.

FCC Type Approval

Type approval signifies that the equipment adheres to FCC technical requirements. Most Citizens band equipment is crystal-controlled to insure frequency stability. However, equipment that is not crystal-controlled may also be used. Such units must have an FCC type-approval number stamped on an attached nameplate. Manufacturers desiring type-approval for CB equipment must first submit a written request to the Secretary of the FCC. The request will usually not be considered unless at least 100 units are scheduled to be manufactured.

Assuming the request is approved, a working model is then submitted to the FCC laboratory at Laurel, Maryland. Here it undergoes extensive testing to determine its performance capabilities under various conditions, such as prolonged exposure to temperatures of anywhere from 0° to 125°F., and humidities ranging from 20 to 95 per cent. Other tests include operation under the voltage variations encountered during normal usage, and also the effect on operation when the position of the equipment and surrounding objects is changed. Occasionally these tests are performed by a cooperating governmental department rather than by the Commission itself.

Before equipment is approved or rejected, the test results are forwarded to the Commission—they, in turn, confidentially advise the manufacturer of the decision. Naturally, all other production models must duplicate the original as closely as possible, and the design or construction must not be changed without approval from the Commission. For his own benefit, a manufacturer may request type-acceptance for crystal-controlled equipment.

SPECIFICATIONS

The best way to determine what a particular Citizens band unit has to offer is to carefully examine its specification sheet, which shows at a glance what would ordinarily take hours to determine by an analysis of the equipment itself. However, unless you are able to interpret the meaning of these specifications, they will be of little value to you. If you are not able to check the operation of the equipment before you buy it—and this is usually the case—you must rely on the specifications alone. Table 2-1 shows a typical specification sheet for a Citizens band transceiver.

Many of the entries are self explanatory. Under "General Information" you'll find the power requirements as well as the power consumed during both the transmitting and receiving functions. Power consumption is almost always higher when transmitting, so this figure will be of particular importance if a special power source such as an inverter is to be used. (Inverters are

Table 2-1. Typical equipment specification sheet.

SPECIFICATIONS

General Information	
Power supply	115 volts AC, 60 cycles.
Power consumption	Receive, 25 watts; transmit, 40 watts.
Weight	11½ lbs. approximately.
Dimensions	6" X 8½" X 10½.
Receiver—Dual-conversion superheterodyne	
Tunable	Class-D Channels 1 through 22.
Sensitivity	Usable to 1 microvolt.
Selectivity	15 db down at 10 kc, and 60 db down at 30 kc.
Image rejection	Better than 45 db down.
Squelch	Adjustable carrier-operated (reliable at 5 microvolts or less).
Noise limiter	Automatic series gate type.
Audio output	2.5 watts working into 4-6 ohms.
Speaker impedance	4-6 ohms.
Transmitter	
RF power input	5 watts.
Frequency stability	.005 per cent.
Single-channel crystal-controlled	Any Class-D Channel 1 through 22.
Modulation	Capable of 90 per cent (self-limiting).
Microphone	High-impedance crystal type with push-to-talk button.
Controls	
Controls—On-off volume, Squelch, Tuning.	

covered in Chapter 5.) Dimensions of the equipment are also given as general information, and should be considered when space is at a premium. Usually, weight will present no problem.

The next section of the specification sheet concerns the receiver, which our example describes as a dual-conversion superheterodyne employing continuous tuning over Class-D Channels 1 through 22. Next is sensitivity, or the ability to receive weak signals and amplify them to a sufficient level. Often this is stated as so many microvolts for a given signal-to-noise ratio, usually 10 db. This particular receiver is capable of amplifying to a useable level an input signal of only 1 microvolt (one millionth of a volt), which is a fairly good rating.

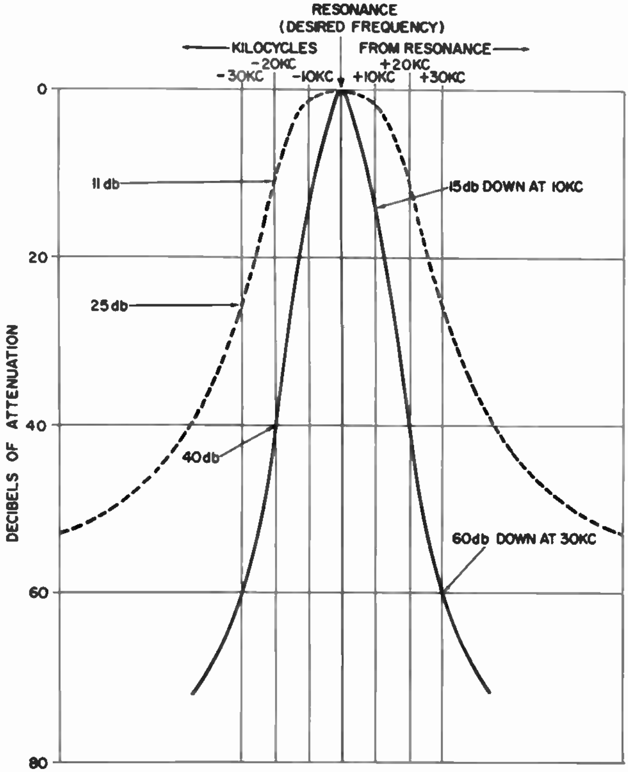


Fig. 2-1. A typical CB receiver selectivity curve.

The selectivity of a receiver is its ability to reproduce a desired signal while rejecting all others. This characteristic is described in terms of so many db down at a given frequency, and can be more easily understood by examining the selectivity curves in Fig. 2-1. The peak (maximum response) of the solid-line curve occurs at the desired frequency. Notice the steepness of the slope on either side of this maximum point. If another station were located within 30 kc of this peak, its signal would be attenuated by 60 db and thus offer negligible interference with the desired signal. The dotted line illustrates a poor selectivity curve. Here, a signal from a station located 10 kc from either side of the peak would be given practically the same amplification as the desired signal, resulting in two stations being heard at the same time. At 20 kc from the peak, the adjacent signal would be down approximately 11 db (compared with 40 db for the solid curve), and only 25 db at 30 kc—still not enough to prevent some interference. The latter response curve is somewhat exaggerated to show how a sharper response curve provides better selectivity—an important consideration in Class-D operation, where the channels are only 10 kc apart.

Another factor pertinent only to superhet circuits is the amount of image-frequency rejection. Briefly, during frequency conversion, an RF signal from the local oscillator is mixed with the incoming station signal to produce a third (IF) frequency—actually two frequencies, one above and one below the oscillator frequency. The higher one is the undesired image frequency, which must be attenuated sufficiently to prevent interference. From the specification sheet in Table 2-1, note that the image frequency is attenuated better than 45 db—enough to make interference negligible.

Also generally listed in the receiver specifications are the type of squelch circuit and its sensitivity, and the type of noise-limiter circuit employed. These circuits are covered in Chapter 3.

The audio-output power of the receiver in our example is 2.5 watts when working into 4 to 6 ohms. Maximum power will be transferred from the output of the receiver to the speaker when the impedances of two are the same. Therefore, using a speaker with an improper impedance would result in loss of power due to the mismatch. The figure in the specification sheet is the maximum power delivered when the audio-output amplifier of the receiver is terminated with the proper load (the 4- to 6-ohm impedance of the speaker).

The transmitter specifications usually include the amount of plate power input to the final stage—in our example, 5 watts (the maximum allowed by the FCC for a Class-D phone). You need not be too concerned about the frequency stability of commercial equipment, since it is made to conform with FCC requirements before being sold. (Of course, it will be your responsibility to see that it continues to operate within this tolerance.) The number of channels covered is usually given on the specifications sheet, sometimes along with the modulation capabilities. The example specifies a figure of 90 per cent. It is desirable for this percentage to approach 100 as closely as possible, since to some extent it determines the communicating range. In some instances the type of microphone employed will be specified, as well as the various operating controls (the control functions are fully explained in Chapter 8).

FACTORY-BUILT EQUIPMENT

Before making any snap decisions, it is advisable to examine the offerings of a number of manufacturers before purchasing any CB equipment. Since there are quite a number of Citizens band equipment manufacturers, it is virtually impossible to describe all of their instruments in this book. However, those which have been included are representative samples of what is available at the present time.

Either fixed-tuned or tunable units, or combinations thereof, are available. Furthermore, most transceivers are provided with a choice of power supplies. Some are designed strictly for 115-volt AC operation; others can be operated from either an AC or DC source.

Fig. 2-2. The Heathkit Model GW-12 Class-D transceiver has crystal-controlled transmitter and superheterodyne receiver for operation on any one of the 23 CB channels. It also has squelch and noise limiting.

(Courtesy Heath Co.)

Single-Channel Fixed-Tuned

In single-channel, fixed-tuned, Class-D equipment, both the transmitter and receiver are designed to operate on a specific channel. The transmitter (and usually the receiver) are crystal-controlled to insure frequency stability—at least within the specified tolerance. An example of a single-channel, fixed-tuned unit appears in Fig. 2-2.

Although a transceiver of this type can operate on only one channel at a time, it can easily be made to operate on any of the others in this class by simply inserting the appropriate set of crystals in the proper sockets on the chassis. Class-B stations, however, are fixed-tuned at 465 mc, and cannot be changed—unless, of course, the equipment has been type-accepted for Class-A operation. Even then prior approval is required from the FCC. A Class-D station can use any of the 23 Class-D channels without such permission.

Multichannel Fixed-Tuned

Perhaps the equipment is to be used in an application where several operating channels are needed, but with some means of instantly switching the proper crystals into the transmitter and receiver circuits. The multichannel, fixed-tuned transceiver is the answer. It can be either a unit in which a single control simultaneously selects transmitter and receiver crystals for the same channel, or one employing separate transmitter and receiver channel selection.

Two Class-D transceivers in the first category are illustrated in Figs. 2-3 and 2-4. Both employ crystal-controlled transmitters and superhet receivers. A selector on the front panel enables putting any one of several Class-D channels in operation by simultaneously switching the proper transmitter and receiver crystals into the circuit.

The unit shown in Fig. 2-5 employs a crystal-controlled transmitter and a superheterodyne receiver to provide multichannel operation. However, this one has a signal-level meter and an additional control labeled "Power Tuning." When receiving, this meter indicates the relative strength of incoming signals; when transmitting, the meter and the power-tuning control enable the operator to peak for maximum transmitter power output.

The Class-D transceivers pictured in Figs. 2-6 and 2-7 employ separate facilities for selecting the transmitter and receiver channels. Any one of several channels from 1 to 23 can be switched into operation with the *Transmit* selector. The receiver is crystal-controlled on all positions except one. When in the latter position, the receiver may be variably-tuned over the entire band. The approximate channel positions are indicated by the pointer on the control. Thus, this type of equipment can be used for cross-channel operation, where you transmit on one channel and receive on another. (See Chapter 8.)

Tunable

The units discussed so far have employed a fixed channel or facilities for selecting one of two or more channels by the flip of a switch. The transceiver pictured in Fig. 2-8 employs a strictly tunable receiver—no preset receive channels are available. The transmitter portion, however, is crystal controlled to insure frequency stability.

(Courtesy Globe Electronics Co.)

Fig. 2-3. The Globe Star Class-D transceiver has a five channel crystal-controlled transmitter and a dual conversion superhet receiver.

(Courtesy Webster Manufacturing.)

Fig. 2-4. The Webster Model 412 employs a dual conversion receiver with squelch and automatic noise-limiting features.

(Courtesy Kaar Engineering Corp.)

Fig. 2-5. The Kaar Model TR327 Class-D transceiver. A four-channel crystal-controlled transmitter and superheterodyne receiver with squelch and noise-limiter circuits.

(Courtesy International Crystal Mfg., Co., Inc.)

Fig. 2-6. The International Crystal "Executive" Class-D transceiver has crystal-controlled transmitter, dual-conversion superhet receiver with squelch, and universal power supply.

(Courtesy General Radiotelephone Co.)

Fig. 2-7. The General Radiotelephone Model MC-5 Class-D transceiver also provides for separate selection of transmit and receive channels, and employs a superheterodyne receiver that can either be crystal controlled or variably tuned.

(Courtesy Regency Division, I.D.E.A., Inc.)

Fig. 2-8. Regency Model CBM-27 Class-D transceiver has a dual-conversion tunable superhet receiver. The crystal-controlled transmitter includes automatic modulation control and adjustable speech-amplifier gain control.

(Courtesy Allied Radio Corp.)

Fig. 2-9. The Knight-Kit Model C-100 all-transistor Class-D transceiver. This compact transceiver is powered by self-contained batteries. No license is necessary to communicate with other similar unlicensed units.

(Courtesy Osborne Electronics Corp.)

Fig. 2-10. The Osborne "Duo-Com" 120 Class-D transceiver features all-transistor construction, crystal-controlled transmitter and dual conversion receiver with adjustable squelch. It is powered from self-contained batteries.

Transistorized Equipment

The transistor has made possible many changes in electronic devices. Two distinct advantages of transistors over vacuum tubes are their smaller size and lower power requirements. When CB radio was first introduced there was little if any transistorized equipment available. Now, however, about half of the equipment is transistorized, ranging from the small hand-carried "walkie-talkie" (Figs. 2-9 and 2-10) to the larger high-powered equipment. Some units use transistors exclusively and others in only part of the circuits.

The majority of the small hand-type transceivers operate with a transmitter input power of 1 watt or less. Since the primary function of these units is to provide short-range communications, they serve the purpose admirably. Depending on surrounding terrain and other factors, it is not uncommon for such low-powered units to provide communications up to two miles or more. Furthermore, no FCC license is required for units that operate with a transmitter power input of 100 milliwatts (one-tenth watt) or less. This class of equipment, however, must be used for communications with similar unlicensed equipment only.

Fig. 2-11 shows a large all-transistor unit that operates at the maximum permitted 5 watts input. This portable transceiver is battery powered and completely self contained. In addition to the portable transceivers, there are a number of all-transistor Class-D units designed for use as base stations or for installation in a vehicle. Figs. 2-12 and 2-13 are two examples of this type of equipment.

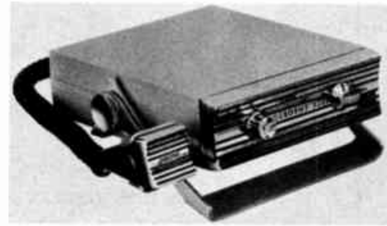
At first glance the unit in Fig. 2-14 appears to be a communications receiver of the type used in amateur radio, but it has several

(Courtesy Cadre Industries Corp.)

Fig. 2-11. The Cadre Model 510-1 is an example of an all-transistor hand-carried 5-watt transceiver for Class-D operation. This unit employs rechargeable batteries and has a total weight of 8 lbs.

(Courtesy The Hallicrafters Co.)

Fig. 2-12. The Hallicrafters Model CB-5 Mark II all-transistor Class-D transceiver. Features six-channel crystal-controlled transmitter and dual-conversion superhet receiver with squelch, AGC, and automatic noise-limiter circuits.



(Courtesy Osborne Electronics Corp.)

Fig. 2-13. The Osborne Model 320 all-transistor Class-D transceiver. This unit has a four-channel crystal-controlled transmitter and dual-conversion receiver with squelch, AGC, and noise limiter.

additional stages which enable it to act as a low-powered transmitter. Basically this unit is a single-conversion general-coverage receiver that is tunable from 540 kc to 30 mc; however, it also has a built-in crystal-controlled transmitter designed to operate at 5 watts input on either the Class-D Citizens band or the 10-meter amateur band.

(Courtesy Hammarlund Manufacturing Co.)

Fig. 2-14. The Hammarlund Model HQ-105TR has every feature you would expect to find in a high-quality communications receiver plus a built-in 5-watt Class-D transmitter.

(Courtesy The Sampson Co.)

Fig. 2-15. This Sampson base station includes a transmitter (T-110A), rereiver (R-101A), power-SWR meter (M-10A), and matching speaker (R-102A).

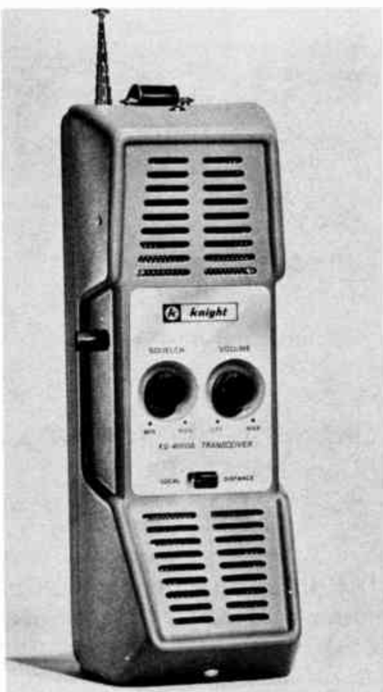
Although the majority of Class-D Citizens radio equipment is of the transceiver variety (transmitter and receiver combined with some circuits common to both) separate units are also available as illustrated by the example in Fig. 2-15. Here, the transmitter and receiver are completely separate units. The speaker is also mounted in a separate enclosure (center). The instrument on top of the speaker is a power-SWR meter for indicating relative transmitter power output and reflected power.

KITS

CB transceivers are also available in kit form. Critical circuits (such as the oscillator)—which might cause illegal operation if not assembled and adjusted correctly—are wired, pretuned, and sealed at the factory. This procedure is necessary to conform

(Courtesy EICO Electronic Instrument Co., Inc.)

Fig. 2-16. The EICO Model 772 Class-D transceiver is available in kit or factory-assembled form. It features a crystal-controlled transmitter and superhetrodyne receiver with automatic noise-limiter and squelch.



(Courtesy Allied Radio Corp.)

Fig. 2-17. The Knight-Kit Model KG-4000A all-transistor Class-D walkie-talkie employs a crystal-controlled transmitter and superhet receiver with adjustable squelch and an automatic noise limiter.

with FCC regulations, and to make it possible for a person with no commercial radiotelephone license to assemble the unit.

Two examples of Class-D Citizens-band transceivers available in kit form are given in Figs. 2-16 and 2-17. Some kits are assembled from individual components, while others are made up of prewired subassemblies that are put together by the builder. In practically all kits, the critical circuits have been pretuned and sealed at the factory to insure legal operation.

SPECIAL AND ACCESSORY EQUIPMENT

In addition to the basic Citizens band equipment (transmitter and receiver) there are a number of accessories. Some of these are required for station operation—others are merely refinements to improve performance, add versatility, or in some other way enhance the equipment.

Converters

Basically, the converter is a tuner (usually containing its own power supply) designed to cover specific frequencies. Used with a standard AM broadcast receiver (either home or automobile type), it selects the desired signal and converts its frequency into one which can be tuned in on a broadcast receiver. Some CB equipment is available with a separate transmitter and receiver. Hence, should you have a transmitter but no receiver, or if you simply desire an additional receiver (to monitor CB transmissions in your car, for example), the converter offers the ideal solution.

Transverters

The transverter, as its name implies, is a combination transmitter and converter. The transmitter section must be crystal-controlled if it is to be used for Class-D operation, and must conform in all other ways to the FCC regulations governing equipment design. The converter section is operated in conjunction with a standard broadcast receiver.

Coded Calling Systems

The CB bands are becoming very crowded. Listening to all the other stations to make sure that you receive your calls can be very tiring. Consequently, methods have been devised to prevent all but the desired signals from being received.

One type of coding system, called tone squelch, is provided on some CB equipment to reject all transmissions other than those within a controlled network. Each station within the network transmits a coding tone in addition to the voice signal. Some systems transmit a tone (made inaudible by filters) during the entire message; others transmit only a brief tone when the mike button is first depressed. Each receiver is equipped with a decoder that responds only to the tone transmitted from stations within the network.

Fig. 2-18. The Poly-Comm Senior 23 provides crystal-controlled operation over all 23 Class-D channels. Includes such other features as built-in tone squelch, dual-conversion superhetrodyne receiver, nuvistor RF and mixer stages, and adjustable modulation.

(Courtesy Polytronics Laboratories, Inc.)

The transceiver in Fig. 2-18 has a built-in tone squelch system, while the unit in Fig. 2-19 can be attached to most CB radio equipment. Another tone squelch device is illustrated in Fig. 2-20. This system employs a resonant-reed relay that provides four different tone signals plus a Monitor All position. An indicator lamp on the front panel lights and an audible tone is heard from the transceiver when a call is coming in. In addition, provisions for activating signaling devices, such as a horn, buzzer, bell, etc., are provided. One tone squelch unit is required for each trans-

Fig. 2-19. The "Tone Alert" selective-calling system produced by the E. F. Johnson Company.

(Courtesy E. F. Johnson Co.)

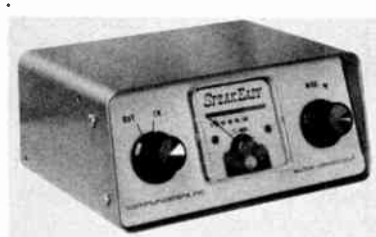
ceiver. The selector switch on the front panel permits any one of four tones to actuate the transceiver. In the Monitor All position, all tones are monitored and any of them will permit messages to be received.

Audio Limiters and Compressors

The primary function of speech limiters and audio compressors is to permit as high a level of modulation as possible while at the same time preventing overmodulation. The modulation percentage is at its highest on voice peaks, for example as you emphasize a word or syllable. At the same time, however, the average audio level may be well below the 100% value. Thus, by amplifying the average audio level and at the same time either clipping or compressing the audio peaks to prevent overmodulation, more "talk power" can be derived from a CB transceiver. Increasing the amount of audio (as long as it is below 100%) definately improves communications. Therefore, it is desirable that the modulation percentage approach 100 as nearly as possible.

(Courtesy Heath Co.)

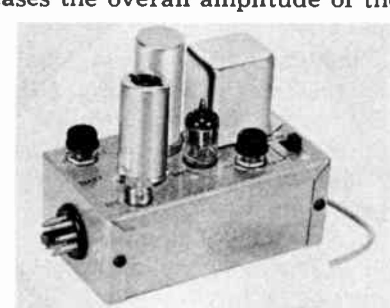
Fig. 2-20. Heathkit tone squelch kit Model GD-162.



(Courtesy Instruments and Communications, Inc.)

Fig. 2-21. The "SpeakEasy" audio compressor amplifier.

Fig. 2-21 shows one type of speech compressor amplifier. This device compresses the peaks and at the same time "rides gain" to prevent undermodulation. In addition, it incorporates a meter that provides a visual indication of modulation percentage. The *Speech Booster* (Fig. 2-22) increases the overall amplitude of the



(Courtesy GC Electronics Co.)

Fig. 2-22. Globe Model FCL-1 "Speech Booster."

signal and then *clips* rather than compresses the tops and bottoms of peaks that exceed a preset level. It also attenuates frequencies above 2,500 cycles and below 300 cycles.

Phone Patches

Phone patches are also available for CB radio stations. Basically a phone patch (Fig. 2-23) is a device that links landline telephone to a radio system. When such communication is desirable, the base station operator places the call and then lays the telephone handset into the receptical provided, automatically turning the unit on. A voice-operated relay automatically keys the base station transmitter as the party on the telephone talks. When he pauses, the station automatically switches to the receive mode

(Courtesy Business Radio, Inc.)

Fig. 2-23. The "Patch-A-Call" Model 301 is designed to permit telephone-to-mobile communications.

and replies from the mobile unit can take place. An external speaker permits the base station operator to monitor both sides of the conversation.

MICROPHONES

The microphone is an important part of any communications system. It converts sound variations into the corresponding electrical impulses which are to be conveyed by the transmitter. Microphones come in many shapes and sizes (Fig. 2-24); however, the most important part is the inner element.

Dynamic

The dynamic, or moving-coil, type microphone is internally constructed as shown in Fig. 2-25. A coil connected to a diaphragm is free to move over a permanent-magnet pole piece. Sound waves entering the microphone cause the diaphragm and coil to move. The movement of the coil through the magnetic field produces the signal voltage.

In some CB equipment, the speaker also serves as the microphone. The dynamic speaker (Fig. 2-26), like the microphone, has a moving coil mounted over a magnetic pole piece and operates on the same principle. During reception, however, the electrical

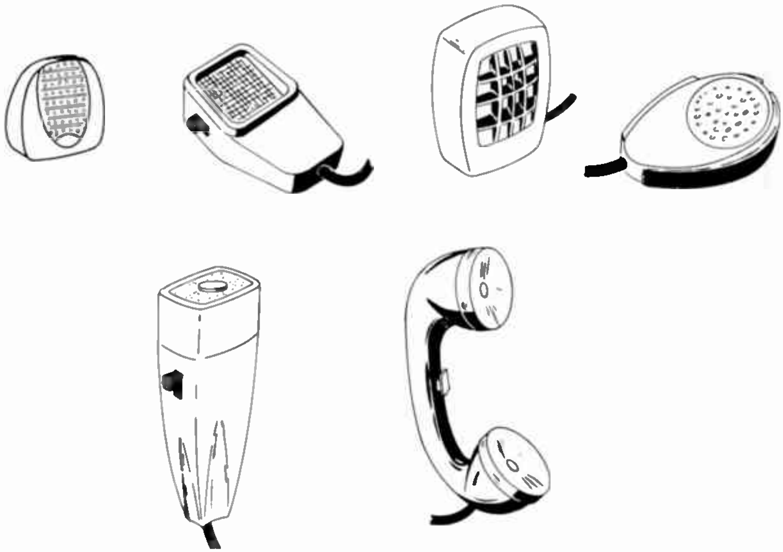


Fig. 2-24. Various types of microphones used in CB equipment.

signals pass through the coil and set up a varying magnetic field around it. The interaction between this field and the one generated by the permanent magnet causes the speaker cone to move, producing the sound waves.

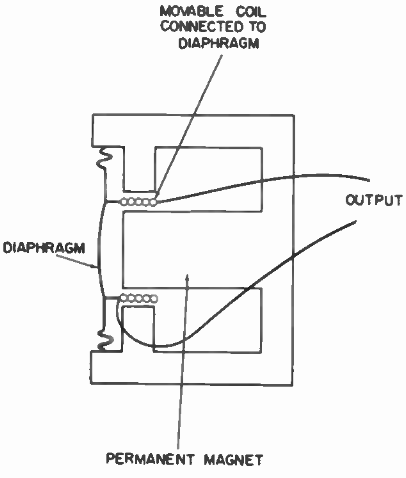


Fig. 2-25. Cross-sectional view of a dynamic microphone.

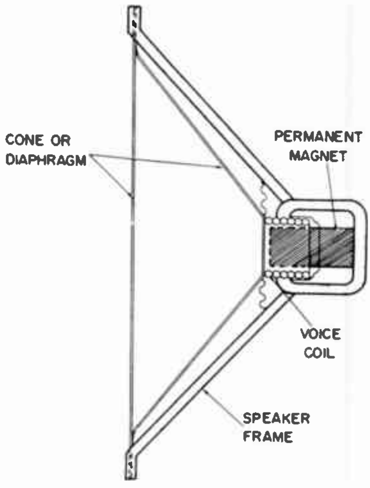


Fig. 2-26. Cross-sectional view of a PM dynamic speaker.

Crystal or Ceramic

Some CB microphones employ a crystal or ceramic slab as the voltage-generating element. The theory of operation is basically the same for both types, as shown by the cross-sectional view in

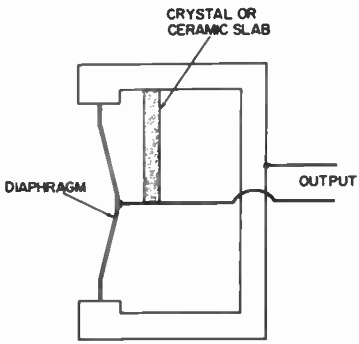
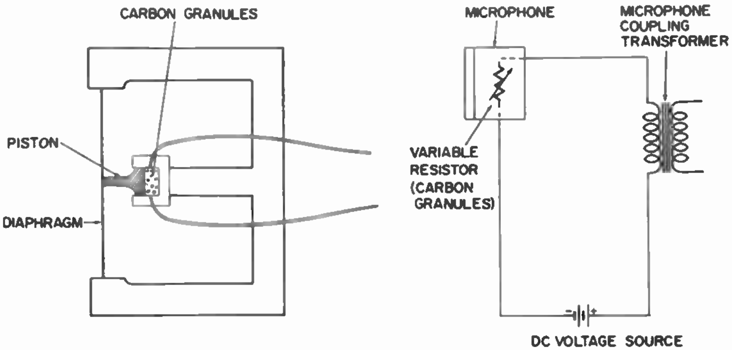


Fig. 2-27. Basic construction of a crystal or ceramic microphone.

Fig. 2-27. An inherent characteristic of the ceramic or crystal slab is its ability to generate a minute voltage when twisted or bent. As the sound waves move the diaphragm back and forth, the slab bends and produces a corresponding voltage. Crystals cannot withstand prolonged temperatures above approximately 120°F. This important point should be kept in mind when choosing equipment which uses such a microphone.

Carbon

The carbon microphone (Fig. 2-28A) employs the variable-resistance method of operation. Instead of generating a voltage, a DC voltage is applied across carbon granules. Any change in



(A) Construction. (B) Equivalent circuit.

Fig. 2-28. Carbon microphone.

the resistance offered by the carbon will affect the DC current accordingly (Fig. 2-28B). Sound waves striking the diaphragm set it and the attached piston into motion. This action varies the pressure applied to the carbon "button," as it is called. This variation in resistance varies the DC current in accordance with the frequency and intensity of the sound waves.

Other Considerations

All microphones are not as simple as those illustrated here. Some, for example, contain built-in transistor amplifiers. Thus, when this microphone is used you are adding another stage of amplification. They may also have controls for varying the tone quality and the amount of output.

The output impedance differs for various microphones. Usually, equipment is provided with the type that most nearly matches the characteristics of the transmitter input circuit, the signal voltage requirements, etc. Hence, replacing a microphone with one of different impedance may cause a loss in efficiency.

EQUIPMENT SELECTION

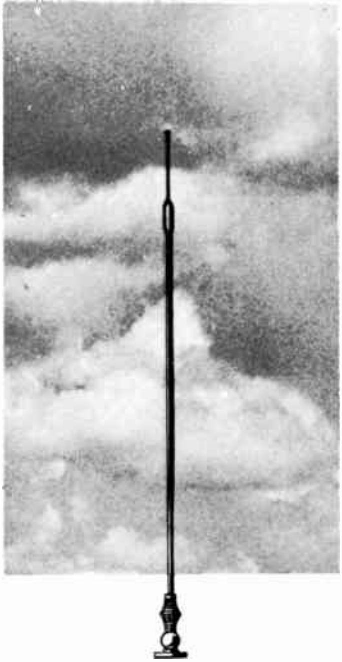
The first consideration is the power source. Make sure that the unit will operate on the type power (6 or 12-volts DC, or 117-volts AC) that you plan to use now and in the future.

Another factor to be considered when choosing equipment is the terrain surrounding the area in which it is to be used. A transceiver having less than the maximum allowable plate input power would hardly be satisfactory where maximum distance is desired, yet the same unit might be entirely adequate for shorter distances—particularly over level terrain or water. Hunters, foresters, or anyone requiring short-distance communications away from normal power facilities will find a smaller transistor portable with self-contained batteries more desirable than a larger transceiver with its cumbersome battery supply. Also, in areas where channel traffic is very light, the receiver need not be too selective —but you should consider the possibility that the channel may some day become quite crowded. A receiver with good selectivity as well as squelch and noise-limiter circuits is a requisite for good reception in the larger metropolitan areas where channel traffic is heavy. If the transceiver is to be used in a car, a mike with a push-to-talk button, allowing one-hand operation, should be employed.

As you can see, there are many questions to be answered before you can make a satisfactory selection. The pointers offered in this chapter will serve to guide you in selecting the equipment best suited for the job.

3

Receiver and Transmitter Circuitry



The previous chapter covered only the physical aspects of Citizens band equipment. Here we are concerned with actual transmitter and receiver circuits and their principles of operation. Most of today's CB equipment is of the transceiver variety, in which both the transmitter and receiver are combined on a single chassis and one or more stages are common to both sections. Therefore, it is desirable to first have some understanding of how these sections function as a unit before discussing individual circuits.

In the following discussion, the transceivers are classified according to the type of receiver circuit. Basically, there are two types employed in present-day CB transceivers—superregenerative and the more common superheterodyne. The operation of each will be discussed separately, followed by an analysis of various transmitter and receiver circuits.

SUPERREGENERATIVE TRANSCEIVERS

The heart of this transceiver is a superregenerative detector circuit used in the receiver. In this circuit a controlled amount of RF energy from the plate is fed back, with the proper phase, to the control-grid circuit, causing regeneration and thereby greatly increasing the amplification. This feedback must be properly controlled; otherwise the entire stage will oscillate. A quenching frequency is generated at regular intervals within this circuit to prevent such oscillation. (A separate quenching stage can also be used, but the self-quenching detector seems to be the most popular in CB equipment.)

The superregenerative circuit provides fair sensitivity with a minimum of components. An interesting characteristic of this circuit is its tendency to "hang on to" a signal, thereby acting much like an AFC-controlled circuit. Most Class-B and many Class-D transceivers employ this type of circuit. A schematic of a superregenerative Class-B transceiver (excluding the power supply) is shown in Fig. 3-1. Only three tubes are used in this unit. The transmitter and receiver circuits are both fixed-tuned to operate on 465 mc, and neither section is crystal-controlled.

When the push-to-talk button is released V1, V2, and V3 function as part of the receiver. Depressing this button causes them to become part of the transmitter circuit.

In transmitting, V1 (a high-frequency triode) operates as a power oscillator, using a section of balanced transmission line as the resonant element. Terminating this line is a small capacitance formed by copper end-plates (see C3A and C3B in Fig. 3-1). An inductive link (L1) mounted within the resonant line couples the power oscillator to the antenna, while an adjustable network matches the transmitter output to a 50-ohm resistance load.

The audio-amplifier section, comprising preamplifier V2 (6AV6) and V3 (6AS5), is connected to the microphone when switch M2 is placed in the "transmit" position. The plate of the power oscillator is connected, through switch M2B, to the plate of V3, and audio-output transformer T1 functions as a modulation choke. R2 and R3 are grounded by switch M2A, rendering the quench oscillator circuit inactive and at the same time providing proper grid-leak resistance for V1. Switch M2D opens the output-transformer secondary, disabling the speaker.

Releasing the push-to-talk button opens switch M2A, ungrounding resistors R2 and R3 to provide the proper resistive values for the V1 grid circuit; and power oscillator V1 now becomes a self-quenched superregenerative detector.

V1 operates primarily as a Hartley oscillator at a low radio frequency. It oscillates momentarily at the regular 465-mc rate during positive grid excursions of the low-frequency RF oscillation, but is quenched during the negative portions. The amplitude of the lower-frequency oscillation is much higher than the ultra-high frequency.

The audio signal is developed across R5; and C9, C12, and R6 filter out the quench-frequency component from the output. Tubes V2 and V3 function as a conventional audio amplifier and power-output stage when the set is receiving. This entire circuit transition is accomplished by actuating a single multiple-contact slide switch (M2 in Fig. 3-1).

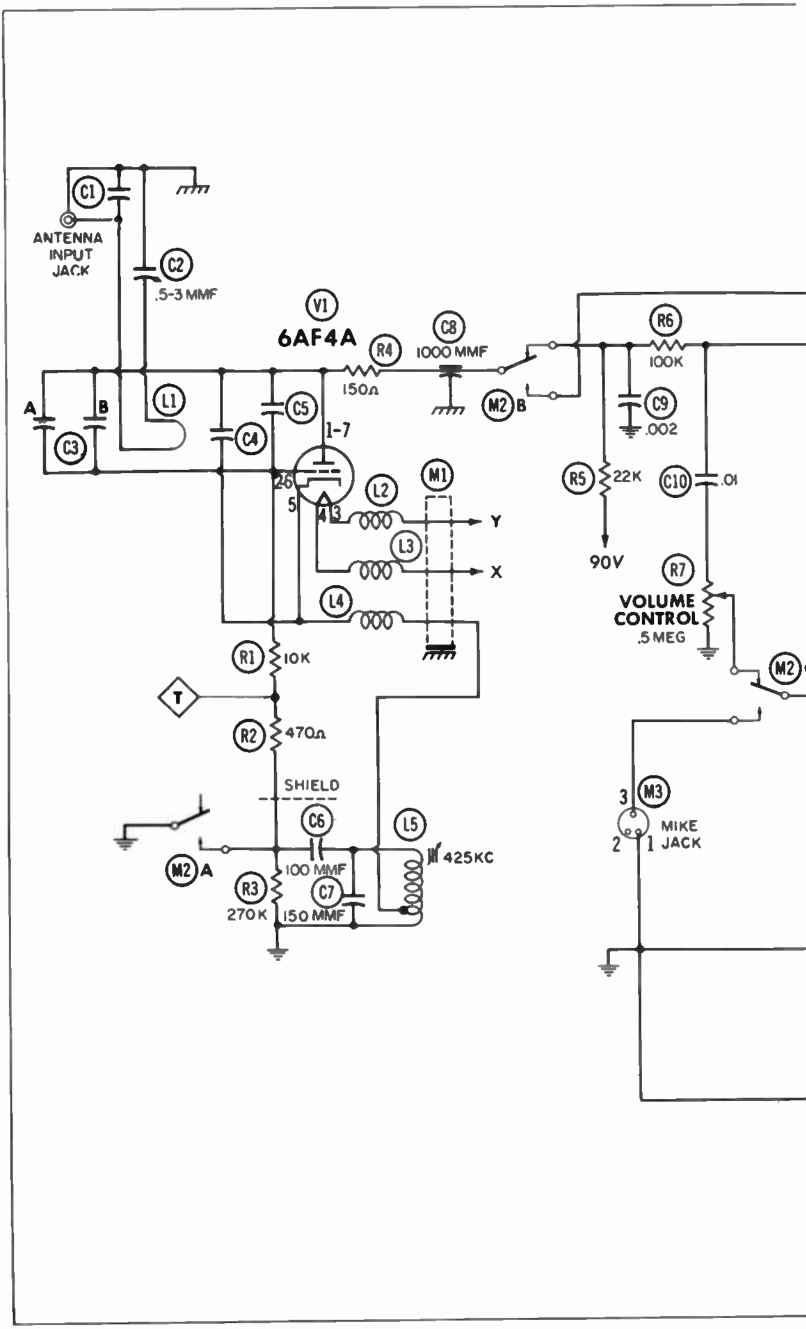
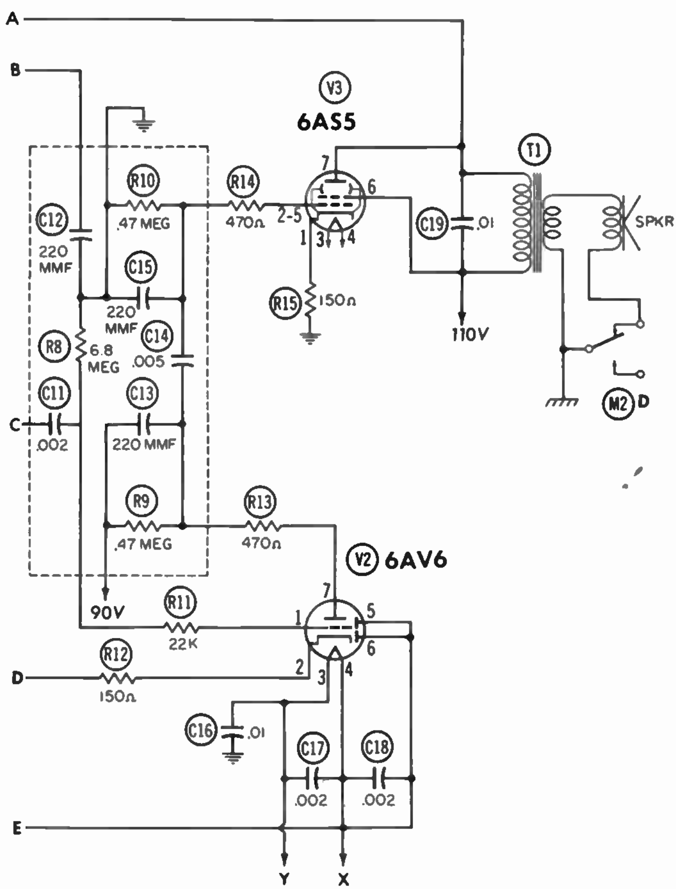


Fig. 3-1. Schematic of a Class-B transceiver



using a superregenerative receiver circuit.

SUPERHETERODYNE TRANSCEIVERS

The superheterodyne circuit is more complex than the super-regenerative type, and through proper design it can be made to provide the ultimate in sensitivity and selectivity. This circuit, widely used in CB transceivers, derives its name from the heterodyne method employed for frequency conversion. Basically, this conversion process is accomplished by mixing an RF signal (produced by a local oscillator within the receiver) with the desired incoming station signal. In doing so, a beat frequency different from either of the originals is produced. Known as the intermediate frequency (IF), it is the difference frequency between those of the oscillator and the incoming signal. (Actually, other frequencies are also produced during this process, but here we need consider only the one at the desired IF value.) Two advantages of the superhet circuit are the greater sensitivity and selectivity that can be achieved when only one frequency (the IF) is amplified. The frequency of the local-oscillator signal is always different from that of the station signal (either above or below) by the IF value. Therefore, the frequency of the signal to be amplified is always the same after conversion, regardless of the channel being received.

The IF signal from the converter is next fed through one or more intermediate-frequency amplifiers to a detector stage. Here the audio signal is separated from the carrier and sent on to the audio amplifier, where it is given the additional boost in power required to operate the speaker.

Single-Conversion Superheterodyne

Fig. 3-2 shows a block diagram of a Class-D transceiver incorporating a crystal-controlled transmitter and a single-conversion tunable superheterodyne receiver. To simplify the analysis, it is desirable to view the stage layout as a block diagram. Switch M1 represents the push-to-talk button. In the "receive" (R) position, the antenna is connected to the receiver circuits. At the same time, power is supplied only to the superhet tuner and audio-amplifier stages, and the speaker is connected into the circuit, thereby completing the chain. Notice that the receiver is comprised of two sections—the RF tuner and the audio section—split to show how the audio portion is utilized as a speech amplifier and modulator when transmitting. When M1 is in the "T" position, the antenna is connected to the transmitter, and the power-supply output is switched from the receiver to the transmitter. The speaker is disabled and the microphone and preamp are connected to the audio system. Inasmuch as the audio section of a transceiver serves as part of both the receiver and the transmitter, it receives power during either operation. The voice signal follows a path from the microphone to its amplifier, through the audio-amplifier section (which now acts as a speech amplifier and modulator), then on to the final transmitter stage.

Fig. 3-3 shows the schematic for the superheterodyne receiver represented in Fig. 3-2 (the power supply is omitted to simplify the analysis). When switch M1A is in the "receive" position, the input signal is fed into L1, where it is stepped up to some degree by transformer action before being applied to the grid of RF amplifier V1. The amplified signal is developed across resonant plate load C6-L2, and then coupled via C8 to the grid of mixer tube V2A. Transformer L1 and resonant circuit C6-L2 are tuned broadly enough to accommodate the entire range of Class-D frequencies. The triode section of V2 acts as the local oscillator,

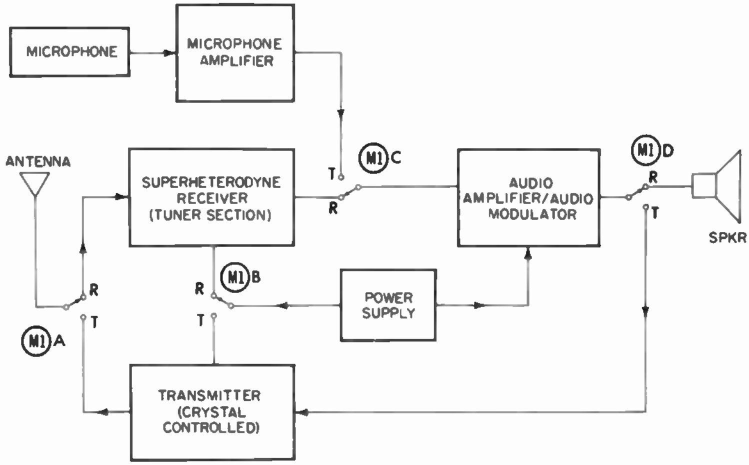


Fig. 3-2. Block diagram of a Class-D transceiver employing a superhet receiver.

which operates in conjunction with a tank circuit comprised of L3, C12, C13, and variable capacitor C14 (the receiver tuning control). The oscillator frequency tracks below the incoming signal by 1750-kc—the IF frequency. Hence, the oscillator frequencies range from 25.215 to 25.505 mc, corresponding to the 1750-kc difference between the Class-D channel frequencies extending from 26.965 to 27.255 mc. C9 couples the proper amount of oscillator signal to the grid of V2A. The mixer output consists of the RF input signal, plus the sum and difference frequencies of the oscillator. However, the first IF transformer (T1), and all those succeeding it, are tuned to the 1750-kc difference frequency and will pass and amplify only this frequency.

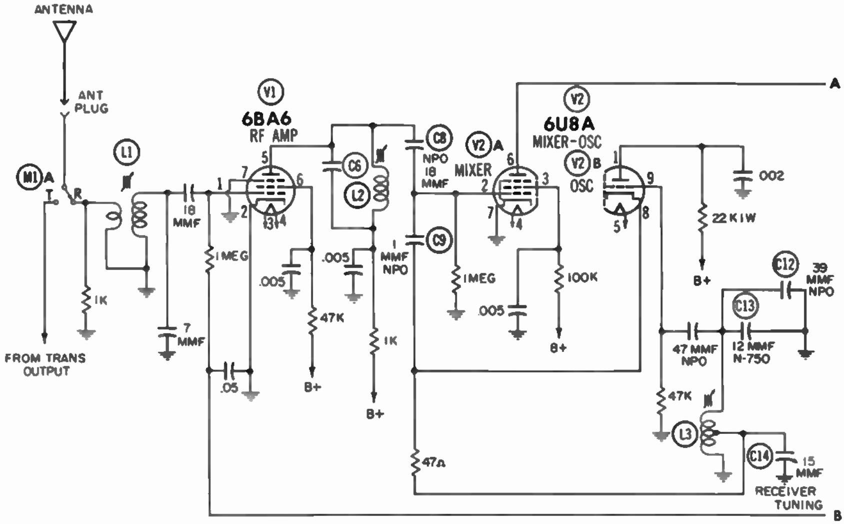
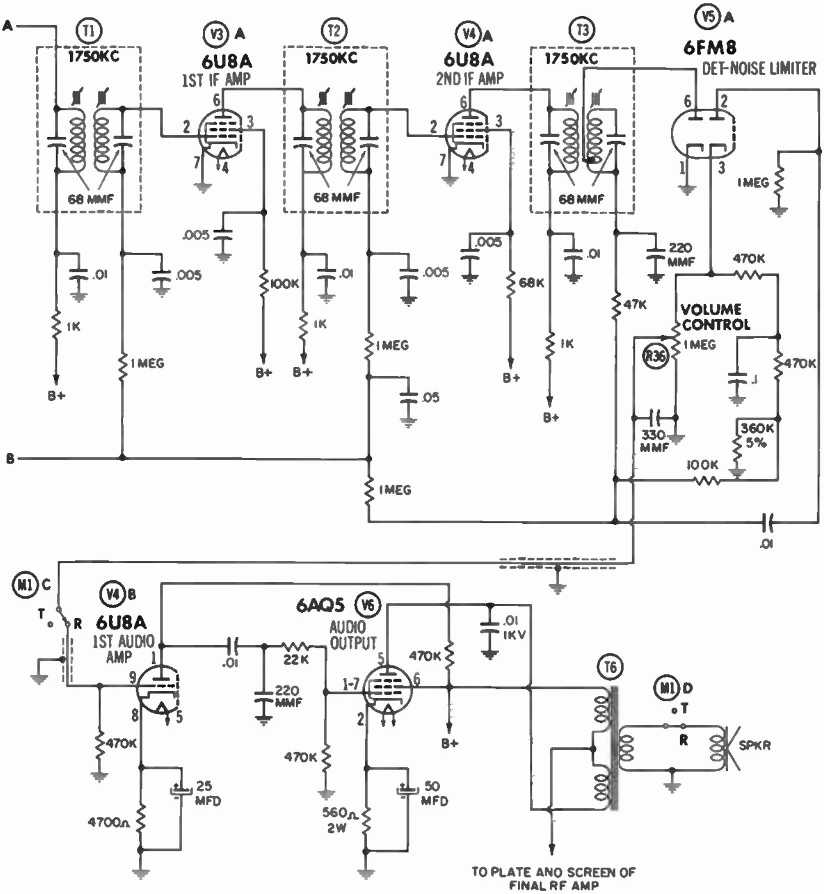


Fig. 3-3. Schematic of the



superhet receiver in Fig. 3-2.

As tuning capacitor C14 is rotated through its range, all Class-D frequencies 1750 kc above the local-oscillator frequency will be received and converted to the 1750-kc IF signal. This signal is amplified by V3A (coupled to the mixer-oscillator stage by IF transformer T1), and then by V4A (coupled to V3A by T2). A third IF transformer (T3) feeds the signal to the first section of V5A (pins 1 and 6) which serves as a series diode detector. The second diode section of this tube (pins 2 and 3) and its asssociated components form a series noise-limiter circuit that filters out interference.

The detected audio signal is developed across volume control R36 and applied to first audio amplifier V4B. This stage, in conjunction with V6, operates as a conventional triode voltage amplifier driving a pentode output stage. Notice that audio-output transformer T6 has a tapped primary which enables it to serve as a modulation transformer when transmitting.

Dual-Conversion Superheterodyne

Another superhet circuit, widely used in Citizens band equipment and some of the more expensive communications receivers, incorporates two frequency-conversion stages. The additional stage provides greater selectivity (rejection of unwanted signals on adjacent frequencies).

Fig. 3-4 shows the stage arrangement in a typical Class-D transceiver employing a dual-conversion superhet receiver. The signal, after entering the antenna, is fed into a conventional RF amplifier stage, where the approximate 27-mc channel frequency is selected and given initial amplification. It is then injected into the first converter stage and mixed with the proper oscillator frequency to produce a beat signal of 1.605 mc. This, in turn, is fed into the second converter stage where a similar action occurs, this time producing the desired IF frequency of 465 kc.

The remainder of the stages operate much like the single-conversion circuits discussed previously: When switch M2 is in the receive (R) position, stage *A* and *B* are part of the receiver circuit. With M1 in the transmit position, these two stages no longer act as part of the receiver, but combine with stage *C* to form the transmitter.

TRANSISTORIZED TRANSCEIVERS

The transistor offers many advantages over tubes, particularly in mobile and portable equipment. Consequently, they are quite popular in CB equipment. Some units use transistors exclusively; others employ both vacuum tubes and transistors, the latter primarily in the power-supply and output stages.

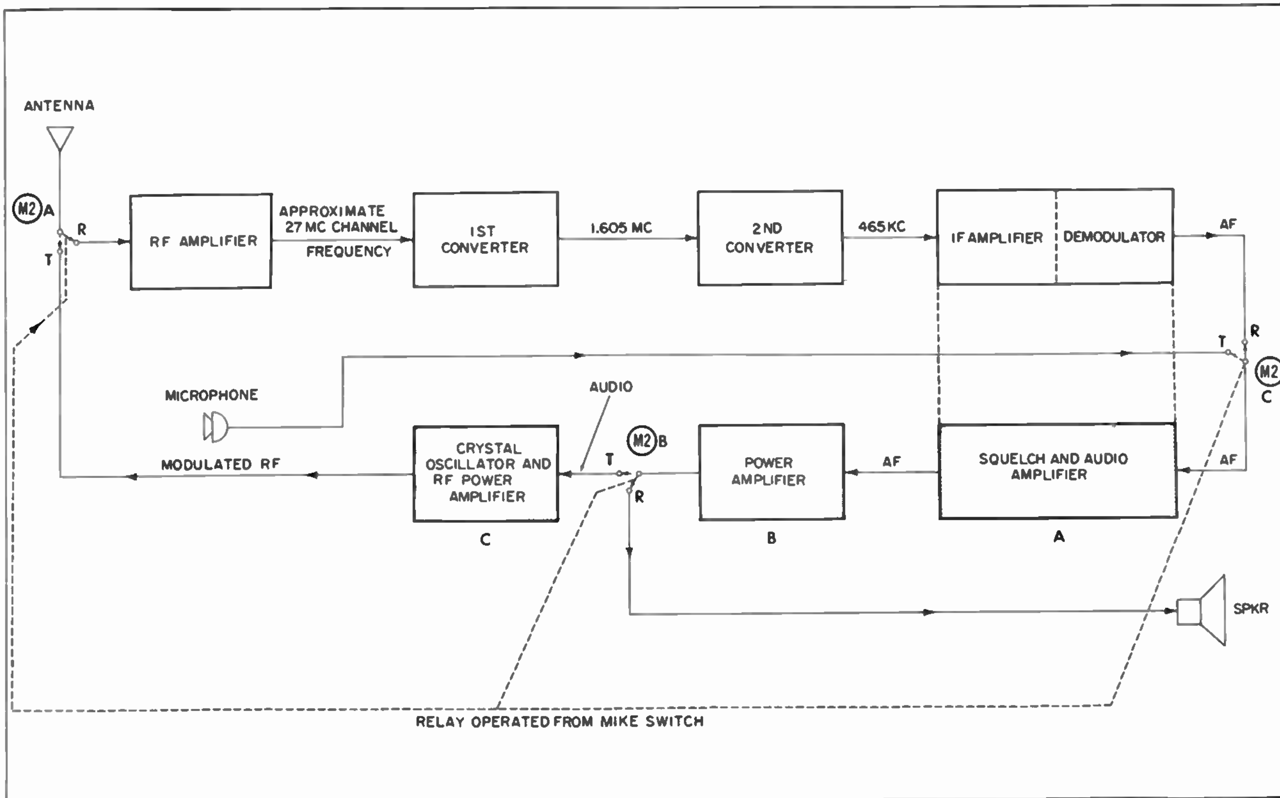


Fig. 3-4. Block diagram of a transceiver employing a dual-conversion superhet circuit.

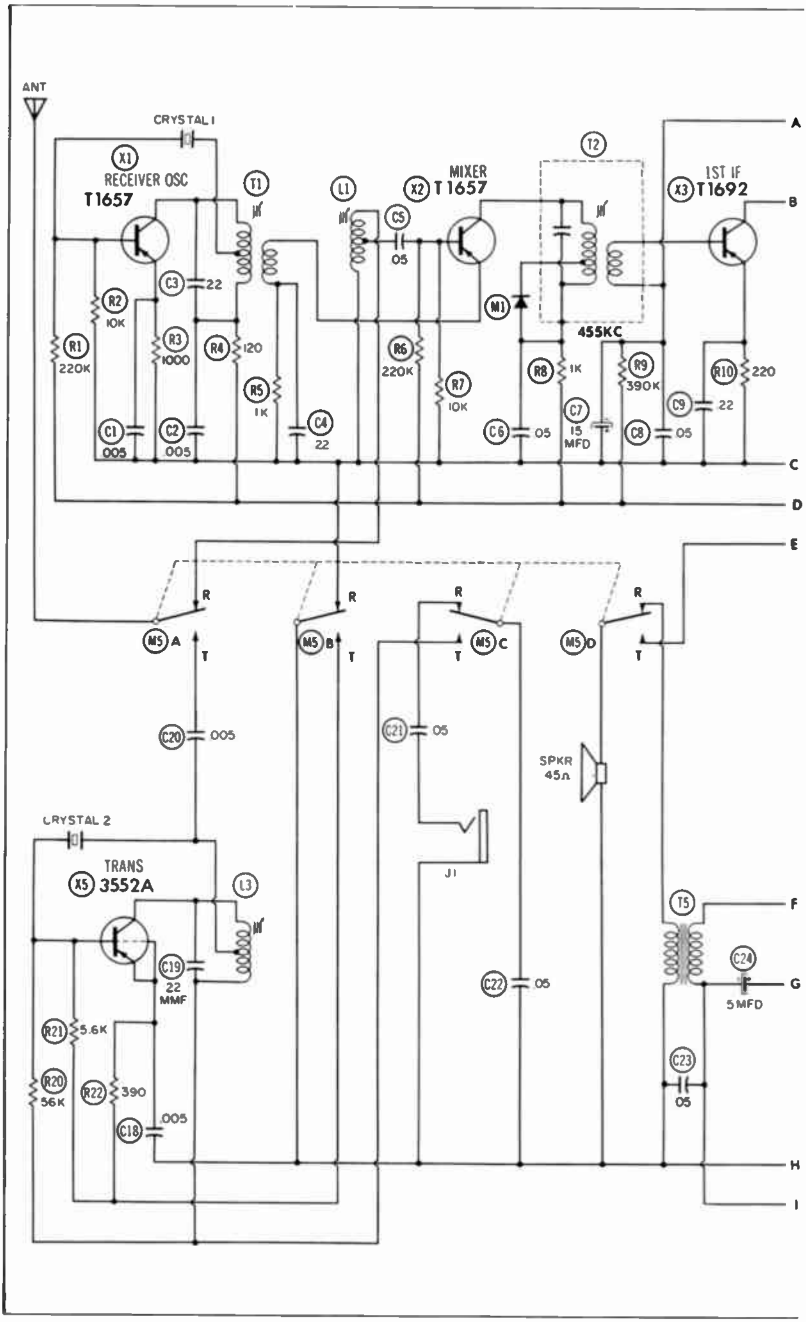
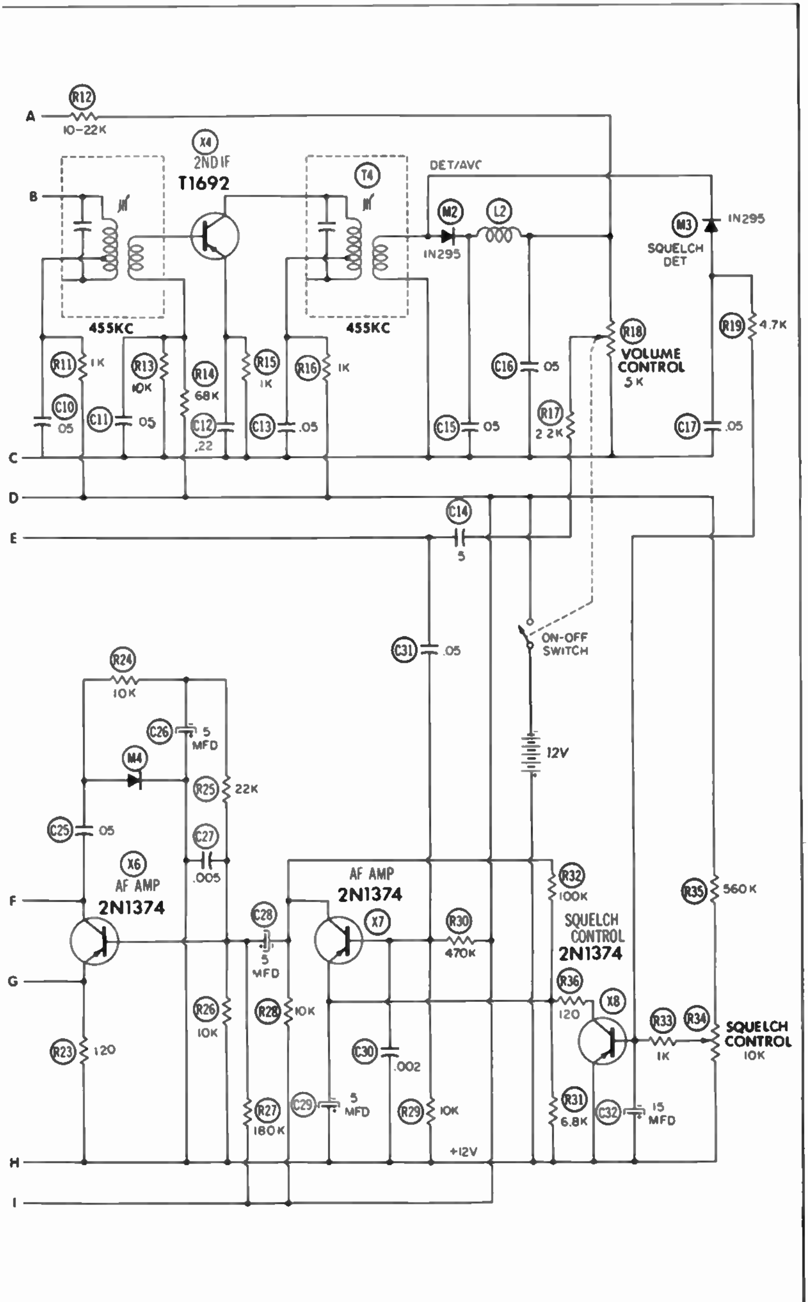


Fig. 3-5. Schematic of an



all-transistor transceiver.

Most of the smaller all-transistor units do not operate at the full 5 watts plate input power permitted; they are designed for compactness and minimum current drain from their batteries.

A schematic of an all-transistor transceiver appears in Fig. 3-5. This circuit employs eight transistors and four semiconductor diodes. No RF amplifier stage is used; the received signal at the antenna is connected directly to L1 in the mixer circuit. Crystal-controlled local oscillator X1 produces the desired RF signal and injects it into the base-emitter circuit of mixer stage X2. Two succeeding IF stages amplify the signal before it is detected by diode M2, which also provides the AVC voltage. The AF signal is developed across volume control R18 and passed through audio-amplifier stages X7 and X6 before being coupled to the speaker by T5. Earphone jack J1 is provided to permit private listening. Also notice the squelch circuit (X8); rarely will you find one used in smaller transistorized equipment.

Another interesting feature is that the speaker also doubles as the microphone when switch M5D is in the transmitting (T) position. Its output signal is fed back to audio-amplifier stages X7 and X6 before being coupled to X5, the crystal-controlled transmitter oscillator circuit.

Despite the miniature components and wiring used in portable transistorized equipment, circuit operation is basically the same as for larger transceivers. Of course, many of the component values will not be the same because transistors have replaced the vacuum tubes, and power is supplied by one or more batteries. Since the output from the latter is already pure DC and need not be converted or stepped up, no cumbersome transformer is needed.

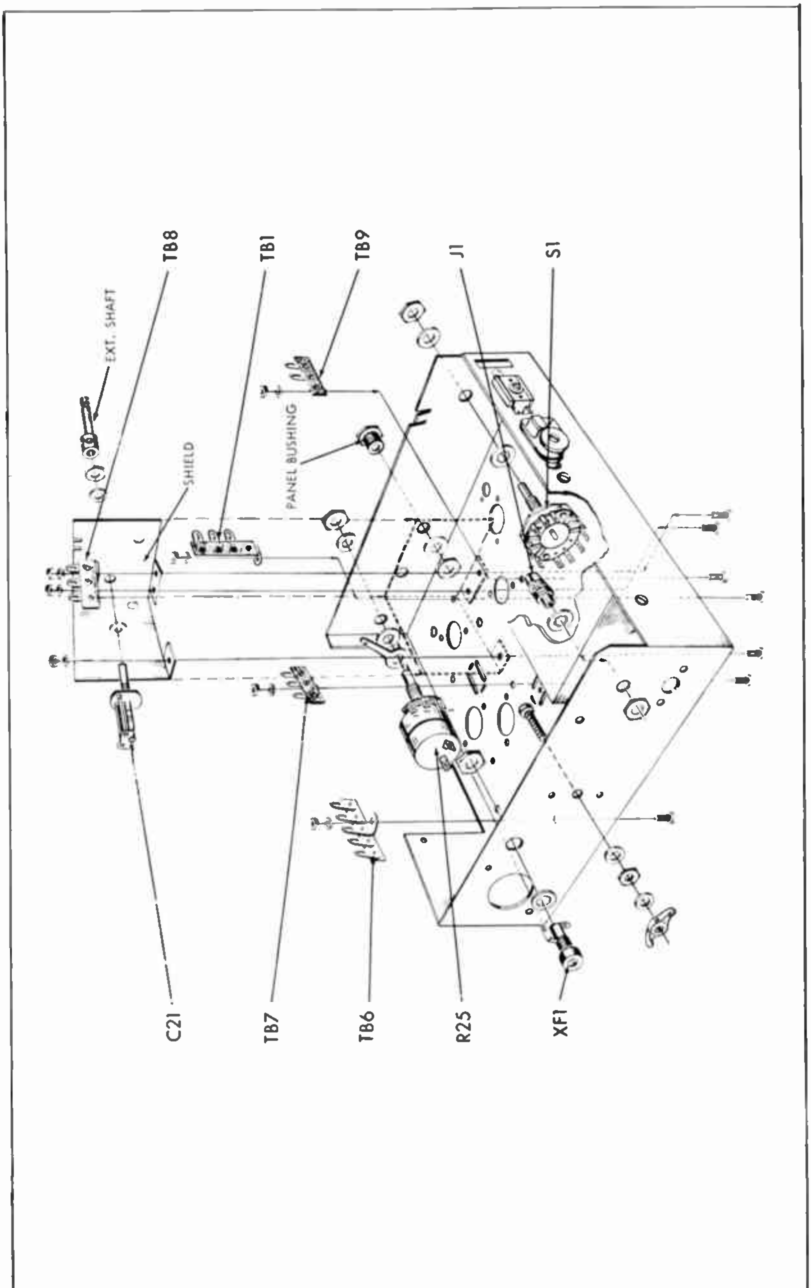
Although the circuits in transistorized equipment perform the same basic function as those in vacuum-tube transceivers, extra precautions must be observed when testing and replacing components in the former circuits. (See Chapter 6 for a discussion of transistor-circuit troubleshooting.)

KITS

The do-it-yourself fad undoubtedly accounts for the tremendous upswing in electronic kit sales, and Citizens band gear is no exception. A number of reliable manufacturers are producing some very efficient transceivers that can be easily assembled by persons with little or no previous experience.

Construction

Some kits are comprised of individual components which must be properly connected to form the completed circuit. Other manu-

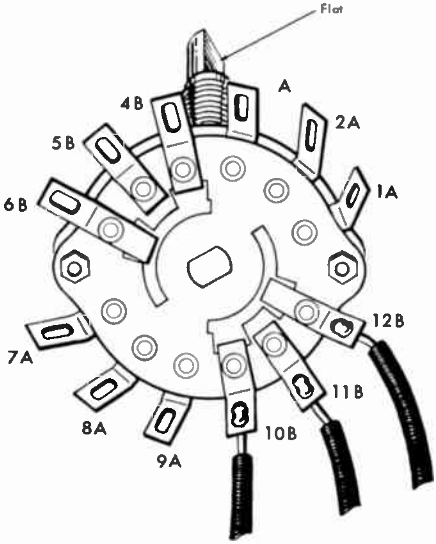


(Courtesy EICO Electronic Instrument Co., Inc.)

Fig. 3-6. A pictorial diagram used in kit construction.

facturers offer kits composed of printed-board subassemblies (converter, IF, audio sections, etc.) which have been prewired, adjusted, and tested at the factory. All the builder has to do is to mount and interconnect the subassemblies. The experience derived from either type of construction will prove beneficial to the builder, especially if he is thinking of more complicated future projects.

Practically all kit manufacturers provide some type of simplified diagram to guide even the most inexperienced builder through the step-by-step construction with a minimum of effort. Fig. 3-6 shows the simplified method used by one manufacturer to illustrate how and where to mount various underchassis components. A complete schematic of the finished transceiver circuit is included with most kits, to be used in conjunction with the pictorial diagrams. When it becomes necessary to wire a component having a number of contacts, such as a rotary switch, a close-up view similar to that of Fig. 3-7 will eliminate any confusion as to

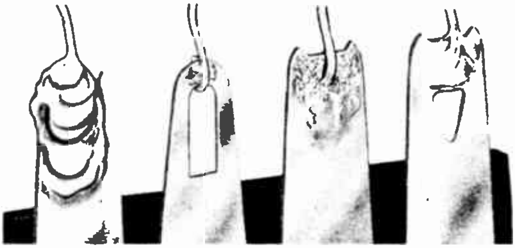


(Courtesy EICO Electronic Instrument Co., Inc.)

Fig. 3-7. A detailed diagram showing multielement-switch connections.

where proper connections should be made. Even the length of the wires between connecting points is given in the instructions. This is important in equipment operating at high frequencies, because even a short wire represents an appreciable amount of inductance. Therefore, wiring should be kept as near as possible to the length specified in the instructions. Improper lead dress or component placement, and excessively long leads, are just a few of the things to avoid during assembly.

Another pitfall that seems to be prevalent—especially among inexperienced builders—is poor soldering. Fig. 3-8 shows several types of soldered joints—obviously, only one is desirable. Too much solder on a connection is not only a waste, but may also result in a short circuit. Likewise, a cold-solder joint or one with insufficient solder can pull loose and cause intermittent operation. However, by closely following the construction procedure outlined in the instruction manual, and by observing the precautions



(Courtesy EICO Electronic Instrument Co., Inc.)

Fig. 3-8. Properly soldered connections are a must in kit construction

just mentioned, you should have little trouble assembling a unit that will provide many hours of dependable operation.

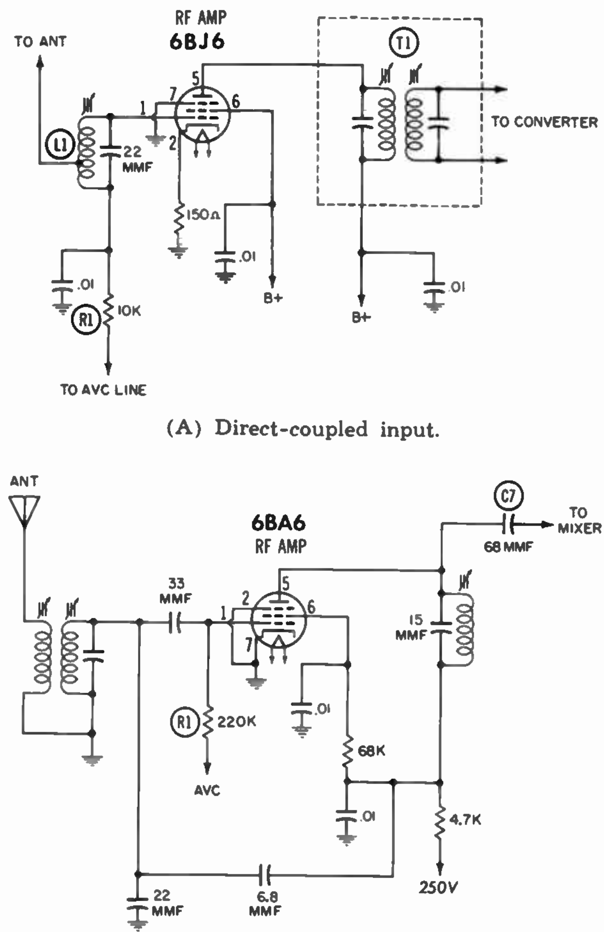
RECEIVER CIRCUITS

This discussion is concerned with some of the circuits in the receiver section of CB transceivers. Many of these are standard, differing only in component values or in the method of coupling to other stages, and hence need no explanation. Such stages as the mixer, IF amplifier, and detector are usually of conventional design and will not receive special attention in this chapter. By referring to the superheterodyne schematic in Fig. 3-3, you can see the type of circuitry usually employed in these stages. You will find variations from unit to unit—perhaps a semiconductor diode instead of vacuum tube in the detector stage—but the theory of operation remains basically the same.

RF Amplifier

It is highly desirable to amplify the antenna input signal before it is fed to the converter or mixer stage. The conversion stage provides little or no signal gain; moreover, the noise introduced by its operation is considerable. The RF amplifier provides the gain needed to override the inherent noise level of the converter stage, thereby increasing the signal-to-noise ratio. Both triode and pentode tubes are used as RF amplifiers. There are advantages and disadvantages to both: The triode does not provide as much gain as the pentode, but has a relatively low noise factor; the pentode, on the other hand, provides more gain, but its noise factor is also higher. The pentode is used almost exclusively in CB equipment, since gain is the major factor to be considered.

In the superregenerative receiver, a properly neutralized RF amplifier is desirable because it acts as a buffer between the antenna and superregenerative detector stage. If it were not used, detector radiation might feed back into the antenna and cause interference in other receivers.



(A) Direct-coupled input.

(B) Inductively-coupled input.

Fig. 3-9. Typical RF-amplifier stages employed in CB transceivers.

The typical pentode RF amplifier stage in Fig. 3-9A employs a 6BJ6 tube. The input signal is coupled through L1 to the grid, which is returned through R1 to the AVC line. Voltage from this line varies the bias and subsequent gain of the stage in proportion to the carrier level of the incoming station signal. The amplified signal at the plate of this tube is developed across T1, which serves as both a plate load and a coupling device. T1 is tuned to respond only to a desired range of frequencies; that is, it acts as a high impedance to only the signals for which it is tuned. The desired signals are dropped across the primary the same as if it were a load resistor. These signals are then inductively coupled through the secondary to the converter stage.

Another pentode RF-amplifier stage, shown in Fig. 3-9B, employs a 6BA6 tube, but unlike the previous example, is capacitively coupled to the mixer stage through C7. Also, the antenna input is inductively coupled to the RF-amplifier grid circuit instead of by the direct method in Fig. 3-9A.

Oscillators

Most oscillators in CB equipment are crystal-controlled, especially in transmitter circuits. You will find receivers that are not crystal-controlled, and others that are controlled only on some channels and tunable over the remainder of the band.

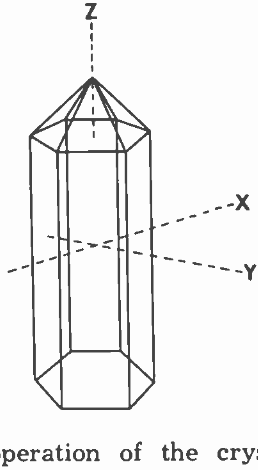


Fig. 3-10. The quartz crystal in its natural state.

Crystals—Before getting into the operation of the crystal-controlled oscillator, it is desirable to have a basic understanding of what crystals are and how they control the oscillator frequency.

A number of years ago, early experimenters discovered that certain crystalline substances, in their natural state, exhibit an electrical charge when subjected to mechanical strain. Later it was found that the opposite effect also held true—a small plate properly cut from this crystal and placed between two electrodes will exhibit a mechanical strain when a voltage is applied to the electrodes. This is known as piezoelectric effect, meaning "pressure electricity."

There are a number of materials having such properties, two of which are Rochelle salt and quartz. The latter crystal has been proven superior in performance and is presently the most popular in this application.

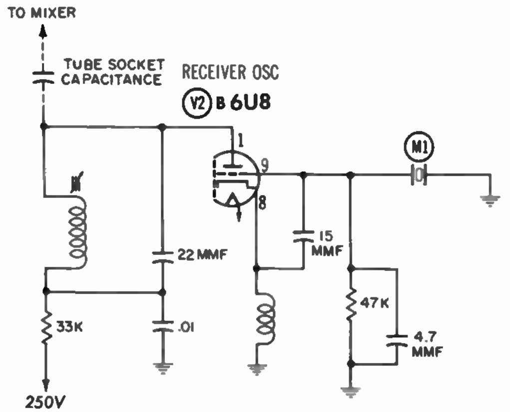
Quartz, which is silicon dioxide in its natural state, is found in hard crystallized six-sided prisms resembling glass (Fig. 3-10). Each crystal has three axes—X, Y, and Z. The angle and direction at which the crystal slabs are cut from the raw stone help determine the characteristics of the finished crystal. After being cut

Fig. 3-11. One type of crystal frequently employed in Citizens band equipment.

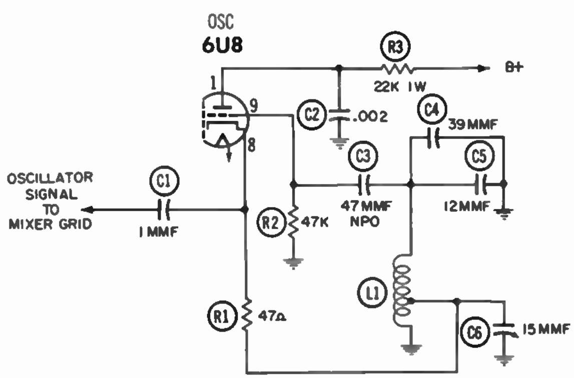
and ground to the proper specifications, the crystal is mounted in a holder. Fig. 3-11 shows one type of crystal assembly widely used in CB equipment.

Fixed-Tuned Oscillator—The operation of an RF generator (oscillator) can be precisely controlled by using a crystal as the frequency-controlling element. Fig. 3-12A shows a crystal-controlled Colpitts oscillator with frequency doubling in the plate stage. Half of a 6U8 tube is used as the oscillator; the other half (not shown) serves as the mixer. The oscillator output is coupled to the mixer section of the 6U8 tube via the interelement capacitance of the tube socket. The crystal (M1) in the grid circuit determines the oscillating frequency of the circuit.

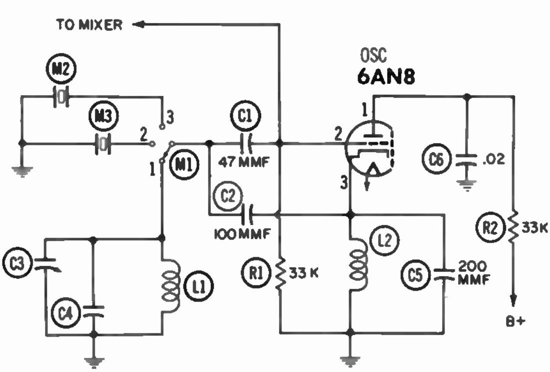
Continuously Tunable Oscillator—Some receiver oscillators are not crystal-controlled. Instead, they may use a continuously variable tuned-oscillator circuit like the one in Fig. 3-12B. This circuit, like that of Fig. 3-12A, employs the triode section of a 6U8. You will notice, however, that a tank circuit consisting of L1, C4,



(A) Single-channel, crystal controlled.



(B) Continuously tunable.



(C) Combination fixed-tuned and tunable.

Fig. 3-12. Typical oscillator circuits in CB receivers.

C5, and C6 is used in the oscillator grid circuit in place of a crystal. The resonant frequency of this tank, and the subsequent RF output applied to the mixer, can be varied by changing the setting of receiver tuning control C6.

Combination Fixed-Tuned and Tunable—Fig. 3-12C shows a combination oscillator circuit employing half of a 6AN8 tube. When switch M1 is in position 3, the oscillator is fixed-tuned at a frequency determined by crystal M2. When the switch is in position 2, crystal M3 is connected into the grid circuit and determines the oscillator frequency. In position 1, an adjustable tank circuit comprised of C3, C4, and L1 is connected into the grid circuit, thus providing a tunable oscillator. The frequency is changed by means of tuning capacitor C3.

Audio Amplifiers

The circuit requirements for the audio-amplifier section of the CB transceiver are far from exacting. Most commercial broadcasting stations transmit a relatively high-fidelity signal that occupies a wide band of frequencies. In order to reproduce the transmitted signal with a high degree of quality, the broadcast

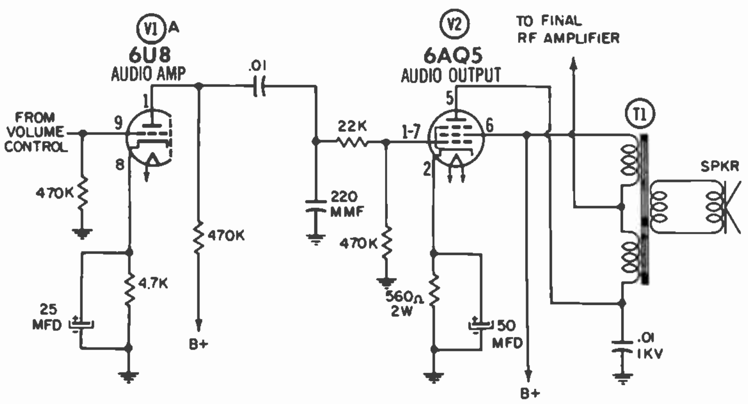


Fig. 3-13. A conventional audio section.

receiver must also employ circuitry with wide response characteristics. However, for strictly voice transmissions, such high-quality response is not needed and would only take up unnecessary space in the frequency spectrum. Therefore, the FCC has limited the amount of space that can be occupied by the emission from a CB transmitter as stated in Chapter 2.

Generally, you will find that a conventional two-stage audio section comparable to that in Fig. 3-13 is used in units with no squelch circuit. The audio section shown here is straightforward, using half of a 6U8 (V1A) as a voltage amplifier driving a 6AQ5 pentode power-output stage. Transformer T1 serves as both audio and modulation transformer. The audio-amplifier section of a receiver employing a squelch circuit will differ from the conventional arrangement just shown; this will be covered when squelch circuits are discussed.

Single-ended output stages are used in most transceivers, although you will also find some of the double-ended (push-pull) variety. Fig. 3-14 shows a push-pull audio system from an all-transistor unit.

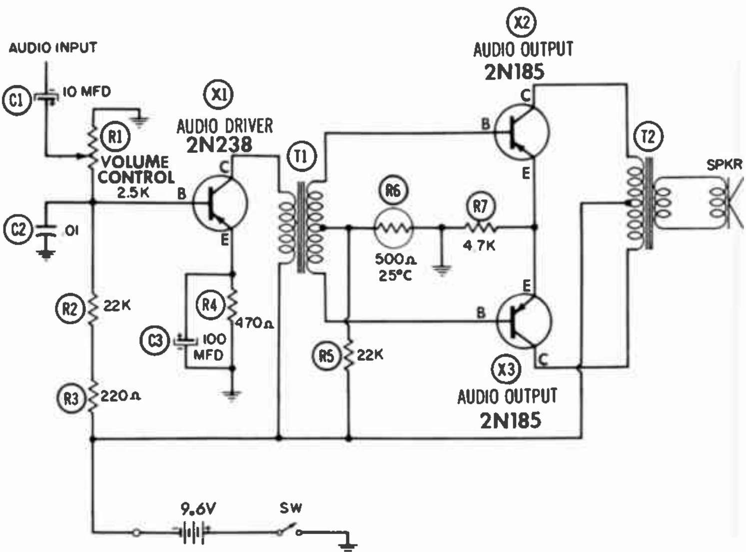


Fig. 3-14. A typical transistorized push-pull audio-output circuit.

A 2N238 PNP transistor serves as a voltage amplifier, or driver, for the output stage. It is connected in a common-emitter configuration, and the bias is set by a voltage divider comprised of R1 and R2. Notice that the audio signal is fed to volume control R1 through the movable arm, instead of by the usual manner in which a portion of the signal voltage dropped across the resistance is tapped off and fed to the amplifier. The arrangement shown here allows the resistance of R1 to remain constant regardless of the position of the movable contact. Hence, the resistance offered the audio input signal will vary with the control setting, while the total resistance across R1 remains constant in order for it to function as part of the bias network.

The DC operating point of the emitter is determined by the value of R4, and emitter bypass capacitor C3 is used to prevent degeneration. Collector voltage for transistor X1 is obtained from the −9.6-volt source through the primary of the driver transformer (T1).

The output stage employs a matched pair of 2N185 transistors (X2 and X3) connected in a push-pull arrangement. The base bias, determined by the combined value of R5 and R6, is applied through the secondary of driver transformer T1. Thermistor R6 serves as a means of temperature compensation to stabilize circuit operation over a wide ambient-temperature range with a minimum of distortion. R7, a common emitter resistor for X2 and X3, compensates for circuit or output variations.

Automatic Volume Control

Automatic volume control (AVC) provides a means of controlling the receiver gain so it will vary in inverse proportion to the strength of the incoming signal. This is a desirable circuit feature because it maintains the receiver output at a relatively constant level as the input signal varies. In other words, if you were receiving a transmission and the strength of the signal entering the antenna dropped, the AVC circuit would automatically increase the gain of certain stages within the receiver to compensate for the loss. In this way a constant volume level is maintained at the speaker. Such decreases in signal strength are likely to occur on weak signals, for example, when a unit is transmitting from a moving vehicle in an area where buildings and other obstructions are blocking the signal.

Usually the RF amplifier and one or more IF stages are controlled. The more stages under control, the more efficient the AVC action. It is desirable that at least two stages of the receiver be controlled.

AVC voltage can be derived from either the second-detector diode or a separate AVC rectifier. Fig. 3-15 shows an automatic volume-control circuit using the first method. Here M1 serves as both the second detector and AVC diode. In this circuit the diode is connected so that the negative half of the signal is detected. By doing so, the diode can also be used to produce the desired AVC voltage. The audio signal, available at point *A*, is passed on through succeeding circuitry to the next stage. R5 is the AVC load resistor; it and C5 form an AVC filter to remove the AC component. At the output of this network, a negative DC voltage varies in accordance with the average carrier level of the station being received. The AVC voltage derived from this circuit is fed to the grids of the RF amplifier and second mixer stages to vary the bias and subsequently the gain of the stage.

Circuits using a separate AVC diode will be somewhat similar to Fig. 3-16. Here, a portion of the IF signal is tapped off at the

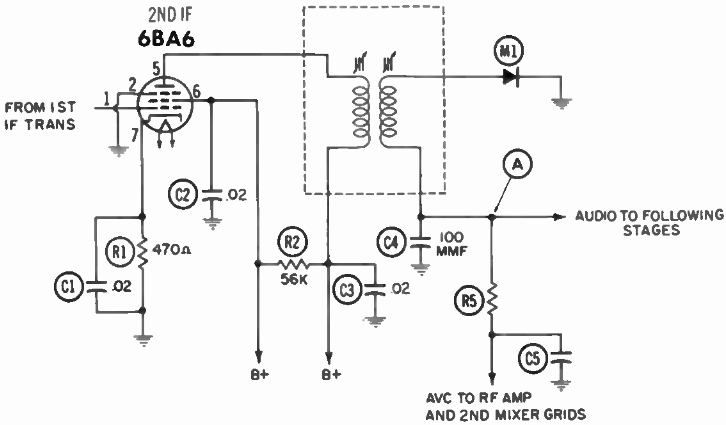


Fig. 3-15. An AVC system using the second detector as the rectifier.

secondary of transformer T2 and applied to diode V6A (half of a 6AL5). Variations in the rectified signal are filtered by C21 and R26 before the AVC voltage is applied to the controlled stages.

One variation of the automatic volume-control circuit is delayed AVC. It stands to reason that an AVC control voltage is not needed on the weaker signals. In fact, the full sensitivity of the receiver must be utilized to provide sufficient amplification. In

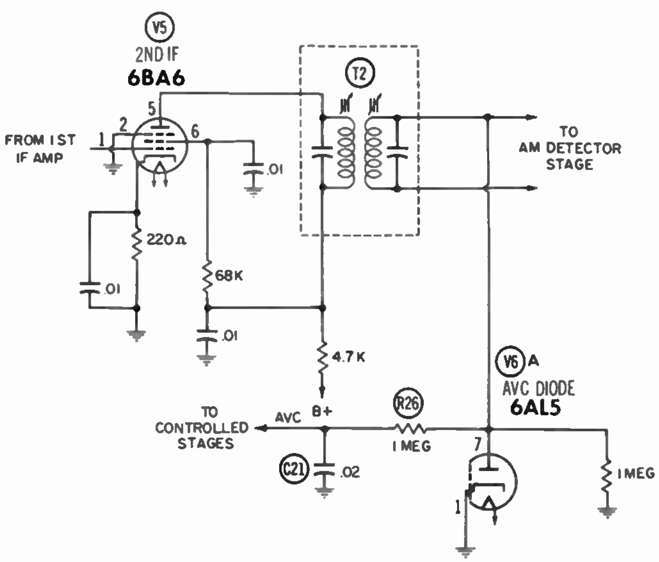


Fig. 3-16. An AVC system employing a separate rectifier tube.

the previous arrangement, some signal attenuation will occur even on weak signals. With the delayed AVC circuit, however, the control voltage is not developed until the incoming signal strength is above a certain level. In this way the weaker signals will receive full amplification. The method used to delay the circuit action is really quite simple and merely involves applying a DC voltage in series with the AVC diode load resistor. This voltage is applied in such a way that the plate of the diode is maintained more negative than the cathode while no signal is being received, thereby preventing the tube from conducting. Should a weak signal be received, it would obtain the full amplification since no AVC voltage is being produced. If an incoming signal produces an RF voltage higher than the delay voltage, the plate of the diode will be driven positive and cause the tube to conduct, thereby producing the AVC voltage.

A separate AVC diode tube must be used with a delayed circuit of this type. Using the audio detector diode would prevent demodulation of the weaker signals and cause distortion of the audio signal.

Squelch

The purpose of the squelch circuit is to block the speaker output when no signal is being received. This feature is included in the majority of Citizens band equipment. Without it, background noise can be heard from the speaker at all times except when a signal of sufficient magnitude is being received. A squelch circuit is especially desirable in those mobile- or fixed-station applications where the noise may cause undue listener fatigue. If the equipment is to be used for only brief intervals, such a circuit may not be necessary—but such noise would be quite objectionable to, say, a radio dispatcher who is required to monitor a channel for any length of time.

Two types of squelch circuits are used. One is the signal-operated type that depends on the strength of the incoming signal; the other is the noise-operated circuit that utilizes the background noise present during no-signal conditions. The former type is by far the most common, although the latter is used occasionally. Our discussion here will be concerned with only the signal-operated circuit.

A typical signal-operated squelch circuit is shown in Fig. 3-17. Here, audio amplifier V2B is disabled by the squelch control voltage. This occurs when the received carrier amplitude falls below a certain level, as determined by the setting of squelch control R3. A portion of the RF signal is taken off at the output of the second IF-amplifier stage and coupled through C3 to squelch rectifier V1. This tube rectifies the carrier signal, thereby developing a negative voltage which varies according to the strength of the carrier signal. This voltage is then fed to the grid of the squelch control tube, where it opposes the positive voltage applied to this element by R3. When a normal signal is being received, the total voltage to ground is sufficiently negative to prevent V2A from conducting. Under this condition, audio amplifier V2B oper-

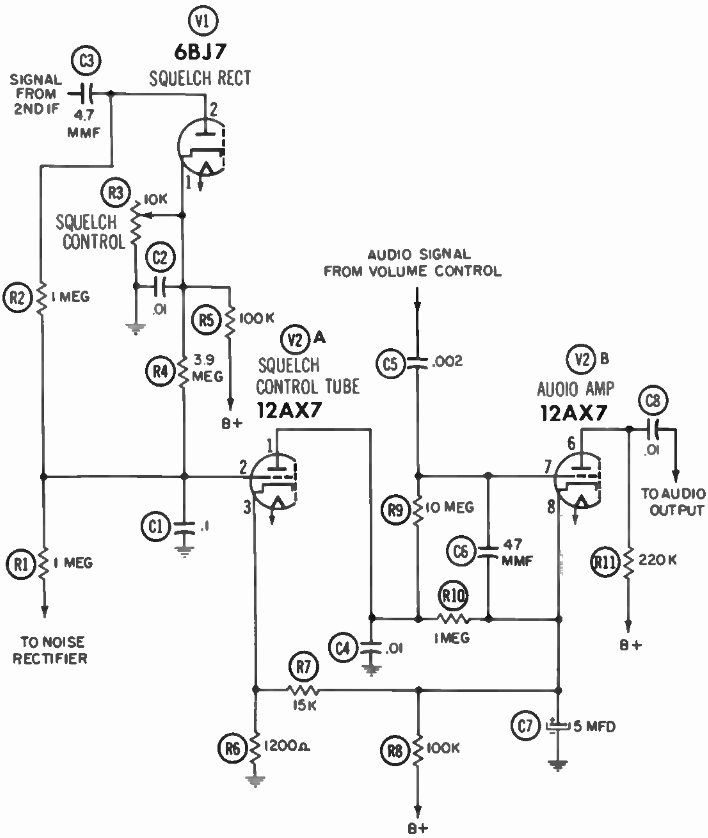


Fig. 3-17. A typical signal-operated squelch circuit.

ates as a conventional R-C coupled voltage-amplifier stage. Bias is obtained as a result of the contact potential current flowing through R9. Should the incoming carrier signal be removed or its level drop below the value designated by the setting of R3, the bias for V2A will become more positive, thereby allowing V2A to conduct. The resultant plate current of squelch control tube V2A flows to B+ through resistors R10 and R8, producing across R10 a voltage drop that biases audio amplifier V2B beyond cutoff.

This of course blocks (squelches) the audio signal and nothing will be heard from the speaker until the arrival of a signal strong enough to overcome the squelch voltage.

Noise Limiters

The majority of CB equipment employs some type of noise-limiting circuit. Its purpose is to prevent noise pulses from reaching the audio amplifier and causing objectionable interference in the speaker output. This circuit can be a simple arrangement or it can be complex. Either one will perform the same job, but its efficiency is influenced to a great extent by circuit design.

Automobile ignition systems are just one source of noise-pulse interference you will encounter. Atmospheric disturbances and devices such as electric fans, drills, sweepers, mixers, and relay contacts are common sources, to name just a few. These pulses affect the amplitude of the radio signal; hence, they are especially troublesome in AM equipment. The FM signal, even in the presence of such interference, remains relatively unaffected by it. This is due primarily to the action of the limiter circuit, which clips amplitude variations from the signal.

The noise limiter reacts to the interfering pulses by momentarily blocking the signal during the time they occur. So instantaneous is this action that it will be unnoticed. Some transceivers have provision for switching the noise limiter out of the circuit when the existing interference is not strong enough to be objectionable.

Fig. 3-18 shows a noise-limiter circuit. The output from diode detector V4B is applied through R28 to the plate of V4A. The voltage at this element is such that V4A conducts when normal signals are received. Should noise pulses cause the audio peaks to exceed a certain negative value, the plate will become more negative than the cathode and the tube will cease to conduct, thereby blocking both the audio signal and the noise pulse at that particular instant. The junction of R26 and R29 is bypassed for audio by C21 and serves as a reference for bias of the diode. The time constant here is short enough that the bias will follow changes in the AVC voltage. The audio signal passed by this stage is developed across volume control R3 and fed to the first AF amplifier.

A vacuum tube does not always have to be employed in a circuit of this type. Fig. 3-19 illustrates a simple method of blocking the unwanted noise pulses with a neon lamp. This lamp (M1) is connected from the plate of V4 to B+; therefore the voltage developed across the primary of T2 will be applied to it. When the signal is normal, the voltage applied to M1 will not be sufficient to trigger it. However, if a noise pulse of sufficient amplitude is dropped across the primary of T2, it will develop enough voltage

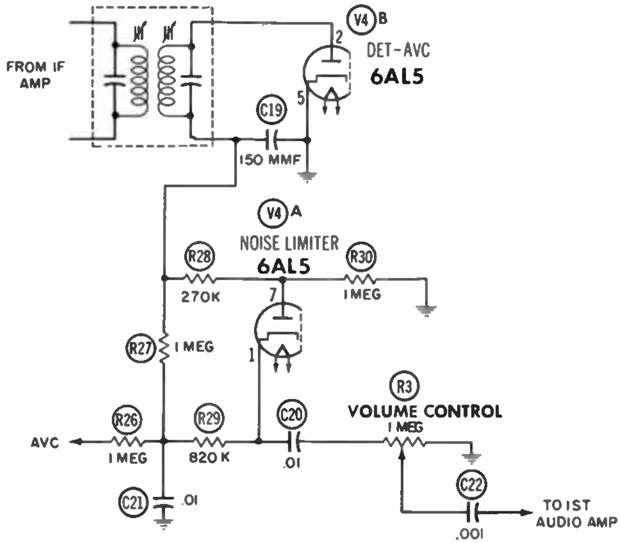


Fig. 3-18. A popular noise-limiting circuit.

to ionize M1, thereby shorting the primary of T2 and subsequently blocking both the signal and the pulse at that instant.

TRANSMITTER CIRCUITS

Transmitter circuits are relatively simple in comparison with those of the receiver. In fact, a single RF oscillator stage properly connected to an antenna is capable of radiating an RF carrier into space. Additional stages are needed, of course, if any modu-

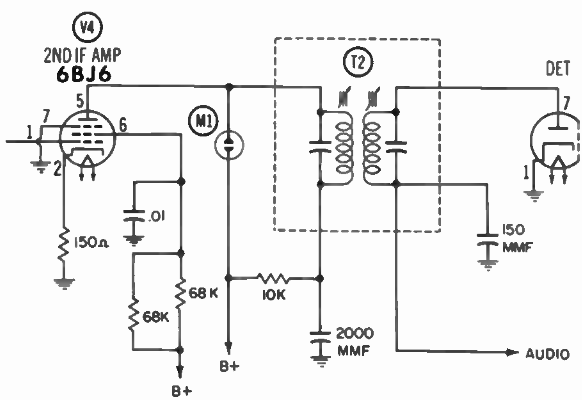


Fig. 3-19. A simple noise-clipping circuit using a neon bulb.

lation is to be impressed on this signal. The number of stages will depend on the power output desired, the fidelity of the signal, etc. A commercial station, for example, will probably include several RF power-amplifier stages to boost the carrier strength before it is fed to the antenna. With Citizens band equipment such power is not required; nor is audio fidelity of any great concern. CB transmitters are generally comprised of four basic stages—speech amplifier, modulator, RF oscillator, and RF power output. Some also include a microphone preamp ahead of the speech amplifier. Fig. 3-20 shows a functional block diagram of a typical transmitter using these stages. Some do not include the final RF power-

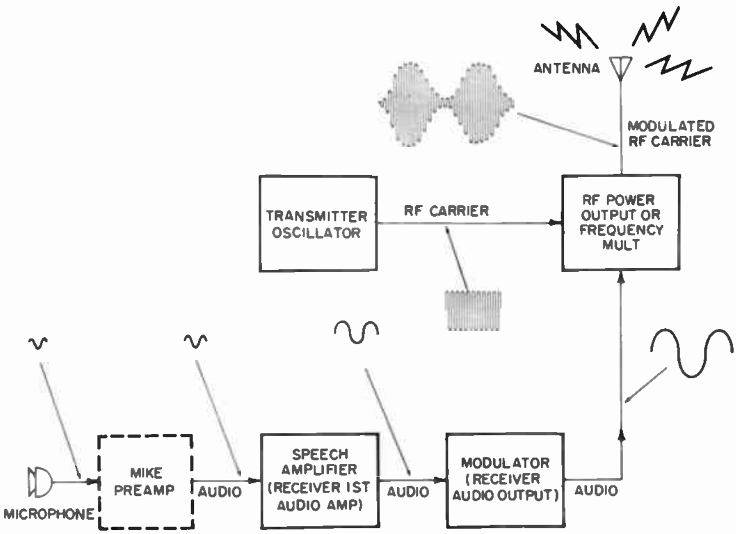


Fig. 3-20. Functional block diagram of a typical Class-D transmitter.

output circuit, in which case the oscillator stage feeds the antenna. The latter then becomes the final stage, and the modulator output is fed to it.

Speech Amplifier

A separate speech-amplifier circuit can be used, but normally the audio amplifier, or driver, of the receiver doubles as a speech amplifier when transmitting. This stage employs conventional circuitry in practically all transceivers, and its purpose remains unchanged—it serves as a voltage amplifier to provide an audio-signal output of sufficient magnitude to drive the power-output stage. Now, however, instead of amplifying the receiver signal, its input circuit is fed a small audio voltage produced by the microphone.

Fig. 3-21 is a typical example of a receiver audio section designed to function as part of the transmitter. In this circuit the microphone output is first coupled through L6 to the grid of V4B, a microphone preamp stage. Here it receives an initial boost in strength before being coupled through C22 to the input of speech amplifier V3B. Theoretically, the microphone preamp could be classed as a speech amplifier since it also precedes the modulator.

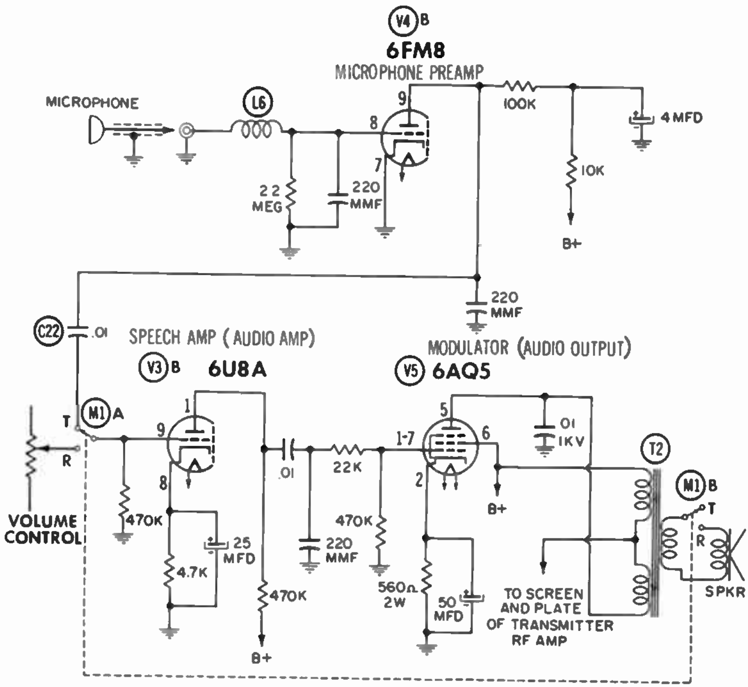


Fig. 3-21. The transmitter audio-amplifier section.

Modulator

Continuing with the audio section shown in Fig. 3-21, we see that after passing through the voltage amplifier, the signal is RC-coupled to a conventional audio power-output stage which now serves as the modulator. Present at the output is the original audio signal from the microphone, amplified many times above its original value and of sufficient power to perform its intended function of varying the RF carrier level in accordance with the signal from the microphone. Both the speech amplifier and the modulator circuits operate in a straightforward manner, treating the incoming microphone signal as if it were coming from the detector stage of the receiver. Here again a separate tube can be used as the modulator, but you will find that most units draft the existing audio-output stage to perform a dual function. In this circuit, the primary of output transformer T2 is center tapped to permit it to serve also as an autotransformer for modulation purposes. The audio-output voltage from V5 is developed across the primary and fed through the center tap to the plate and screen of a pentode RF power amplifier.

Oscillator

The audio signal from the microphone could be passed through stage after stage of amplification until it reached great proportions —yet if it were applied to the transmitting antenna, it would not be radiated into space like the station signal. Why is this so? Simply because it lacks an RF carrier. Signals in the RF (radio-frequency) range have the ability to radiate from a conductor into free space. Since the audio signal is the one desired at the receiving station, it is superimposed on the RF signal before the latter is transmitted from the antenna. Hence, the RF signal is known as the carrier. At the receiver the two are separated and the carrier is disposed of, while the microphone signal is amplified and then reproduced by the speaker.

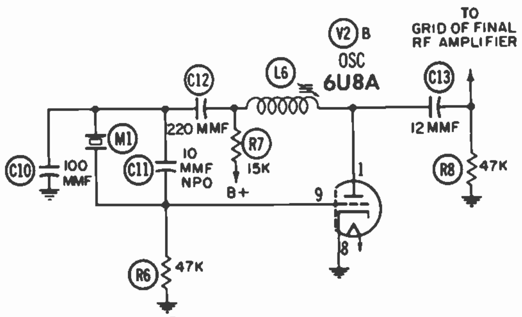


Fig. 3-22. A crystal-controlled transmitter oscillator circuit.

The purpose of the transmitter oscillator is to generate the RF carrier signal. Fig. 3-22 shows the circuit of a crystal-controlled oscillator for a Class-D transmitter.

This circuit employs the triode section of a 6U8A tube as an RF oscillator, the frequency of which is controlled by crystal M1 in the grid circuit. Tunable inductor L6, together with its parallel stray capacity, forms a tuned plate load. An optimum load for third-harmonic operation on all CB channels can be obtained by tuning L6 to resonate with its stray capacity, at the center of the Class-D frequency range. C11, in parallel with the crystal, adds to the shunt capacity across it, thereby providing the proper crystal load. Positive feedback to the grid is derived from the

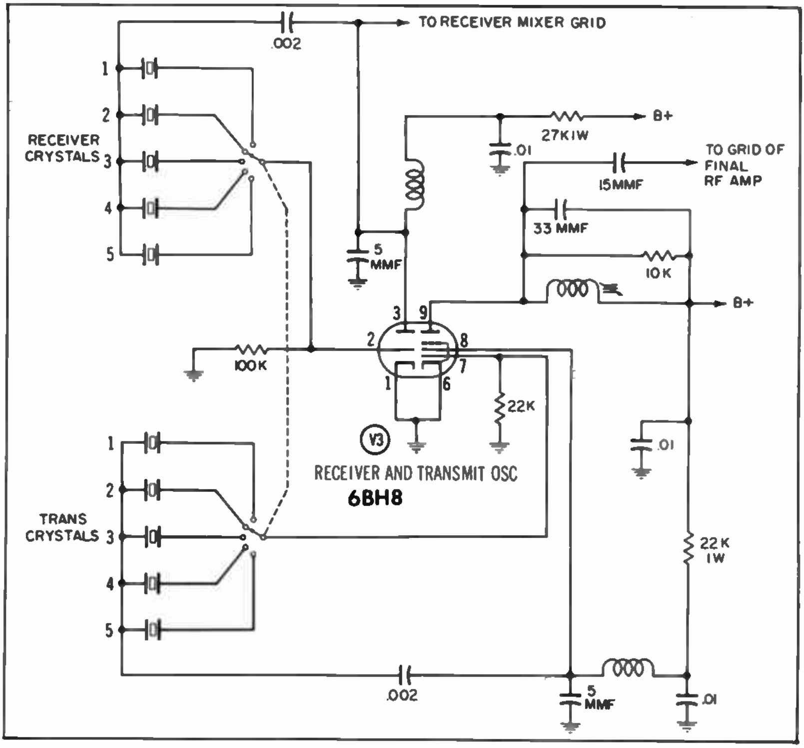


Fig. 3-23. A circuit incorporating the transmitter and receiver oscillators in in the same tube.

voltage-divider network comprised of C12 and C10, and is used to increase the amount of drive. The RF output from this circuit is then fed to the grid of the final RF amplifier.

Fig. 3-23 illustrates an interesting oscillator arrangement—a dual-purpose 6BH8 tube is used for the transmitter and receiver oscillators. The triode section functions as a five-channel crystal-controlled oscillator for the receiver, and its output is coupled to a separate mixer tube. Unlike in the previous circuit, a pentode (the second half of V3) instead of a triode is employed as the transmitter oscillator. It, too, is crystal-controlled for five-channel operation. A ganged switching arrangement is used for simultaneous selection of the desired transmitter and receiver crystals. The output of the transmitter oscillator is fed to a 6AQ5 final RF amplifier.

RF Power Output

So far, we have followed the audio signal from the microphone, through the various stages of amplification, up to the output of the modulator, and we have seen how the RF carrier is produced by the oscillator. Here, however, we are concerned with the final RF-amplifier stage, where both of these signals are injected to produce the modulated carrier.

Most transceivers employ some form of plate modulation, which must always occur in the final RF stage of the transmitter. As mentioned previously, not all transceivers have an RF power output; the transmitter oscillator feeds the antenna and is therefore the final RF stage. It should be pointed out that the modulator stage merely provides the proper audio signal. The modulation process itself occurs elsewhere—in this circuit, the RF power output stage.

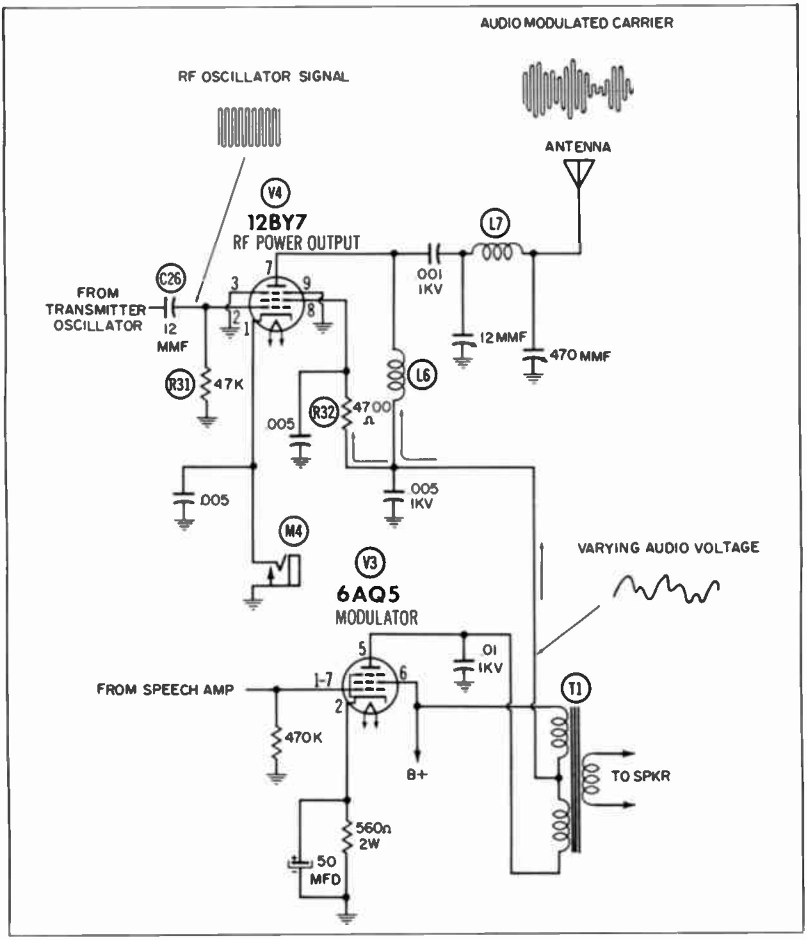


Fig. 3-24. A typical RF power-output stage.

Fig. 3-24 shows a circuit using a popular method of plate modulation. Here the RF oscillator signal is injected through C26 into the grid of the RF power-output tube. Audio modulator V3, operating as a conventional Class-A power-output stage, develops the desired audio signal across the primary of T1. This transformer serves as the audio output when receiving, and as an autotransformer for the modulating function. Notice how the plate and screen of V4 receive B+. The plate of modulator V3 is supplied through the primary of T1, whereas V4 is supplied from the primary center tap. Now, with the Transmit button depressed and no sound entering the microphone, the carrier generated by the oscillator will be amplified by V4 and radiated from the antenna in its original, unmodulated form. The B+ supplied to V4 will be constant.

When an audio signal is introduced, the varying plate current of V3 will develop a corresponding voltage drop across the primary of T1. This will alternately add to and subtract from the plate and screen voltages of V4, causing the RF output to vary above and below its normal level in accordance with the audio signal.

In this circuit, the screen and plate of the final tube are both used to modulate the carrier. This is generally done when pentodes or beam tetrodes are used, because of the higher percentage of modulation obtained.

You will also find RF power-output stages that operate as Class-C amplifiers. The advantage here is that the plate efficiency is increased—in short, a somewhat higher power output is provided for a given input.

SINGLE SIDEBAND

The congested band conditions in various radio services has dictated the need for radio equipment that will occupy less operating space in the frequency spectrum. This need has been met by the introduction of single-sideband equipment. In conventional AM radio transmission, the carrier signal and *two* sidebands are transmitted. One sideband is presented on each side of the carrier and both contain the same intelligence—the desired voice signal. From this it is obvious that the same information can be conveyed by transmitting only one of the sidebands, and only half as much space in the frequency spectrum is occupied by such a signal.

With single sideband the carrier is suppressed before transmission, so all power is concentrated within the one sideband. The absence of a carrier also eliminates interference. However, a carrier is reinserted at the receiver to permit demodulation.

(Courtesy Mark Products Co.)

Fig. 3-25. The Mark "Sidewinder" (Model SSB-27) single-sideband CB transceiver with provision for upper or lower sideband selection.

Fig. 3-25 shows a single-sideband CB transceiver. This unit has provision for selecting either the upper or the lower sideband for transmissions. It also has a 5 position channel selector which makes 10 channels available (5 on upper and 5 on lower sideband). It is possible for two single sidebands units to transmit simultaneously on the same CB channel without interfering with each other. This particular unit is designed to operate from a 12-volt DC source; however, a power supply is available as an accessory which will permit operation from 117-volts AC.

POWER SUPPLIES

In most Citizens band equipment, you have a choice of power supplies. Equipment is available to operate on self-contained batteries, or from external 6-, 12-, or 24-volts DC, or 115- or 230-volts AC. Many units have provisions for a choice of sources.

AC Supplies

Receivers designed to operate from 115-volts AC only will usually employ a conventional power transformer and rectifier to supply the high-voltage DC necessary for proper operation of the various stages. Other units employ silicon, selenium, or germanium rectifiers. All are very similar to the power supplies employed in broadcast radio or TV receivers.

DC Supplies

Equipment designed strictly for operation from a DC source will include one of three types of power supplies—battery, vibrator, or transistorized.

Battery—The compact, portable all-transistor phones operating at relatively small outputs use self-contained batteries exclusively. Since the current drain is light, and high DC voltages are not required for transistor operation, batteries are all that are needed to provide many hours of dependable operation.

Vibrator Supply—Larger equipment using vacuum tubes, requires a higher DC voltage for operation, and will probably incorporate a vibrator power supply (Fig. 3-26). Here, we already have DC at the input, but must convert it into a form of AC before it can be stepped up by transformer T1.

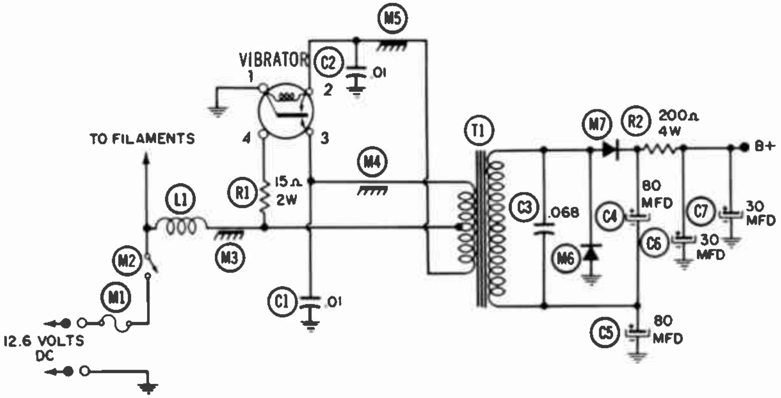


Fig. 3-26. Vibrator power supply employed for DC operation.

The purpose of the vibrator is to chop up the steady DC current in order to produce square-wave DC pulses in the transformer primary. The square waves appear as a high-voltage AC sinewave across the secondary, which is then applied to the rectifier and filter section of the supply. Semiconductor diodes M6 and M7 are used for rectification and, together with C4 and C5, form a voltage-doubler arrangement. The pulsating DC output from the rectifier is fed to the filter section, where it is handled in the same manner as in an AC supply. From a meager 12 volts DC at the input of this circuit, an output of approximately 250 volts DC is achieved.

Universal Supply—In addition to the single-voltage power supplies discussed, equipment can be obtained with a combination, or universal, supply that will operate from either AC or DC. Many of the CB units on the market (some of them were shown in Chapter 2) have this feature.

The power supply shown in Fig. 3-27 operates from 117-volts AC and from both 6 and 12 volts DC. A conventional full-wave AC power supply is located at the bottom of the schematic. Directly above it is a vibrator circuit that is common for both

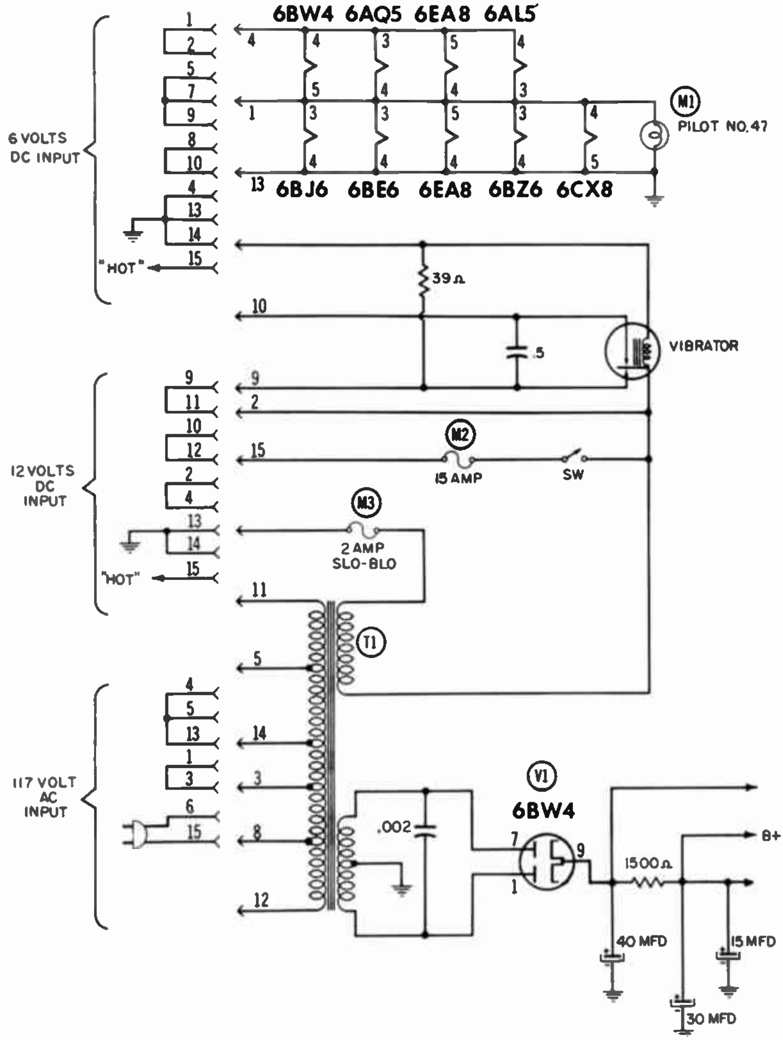


Fig. 3-27. Schematic of a universal power supply.

6- and 12-volt DC operation. A single multielement socket on the transceiver accommodates all three inputs, although individual plugs (Fig. 3-28) are used between the voltage source and this connector. Each plug is marked with its intended function so that, when connected to the transceiver, it will provide the proper connections.

Transistor Supply—To minimize the current requirements of the transceiver, some manufacturers use a transistorized power

Fig. 3-28. Power cords used with the universal power supply in Fig. 3-27.

(Courtesy Utica Communications Corp.)

supply that performs basically like the power supplies discussed previously—the principal difference being the manner in which the DC is converted before being stepped up by the transformer.

Fig. 3-29 shows one example of a Class-D transceiver that employs a transistor power supply. The supply itself is shown schematically in Fig. 3-30. This particular supply will operate from either 12.6 volts DC or 117 volts AC. Basically, two matched power transistors (X1 and X2) operate as a push-pull oscillator when 12.6 volts DC is applied through the appropriate connector to P-1. The resultant alternating current is then applied to the

(Courtesy Pearce-Simpson, Inc.)

Fig. 3-29. The Pearce-Simpson "Companion" transceiver which provides 6-channel crystal-controlled operation and employs a superheterodyne receiver with noise limiter and squelch. It also features a transistor power supply to minimize power consumption.

transformer primary where it is stepped up, rectified, and filtered in the usual manner. When the supply is operated in the AC mode, power is applied directly to a separate primary winding.

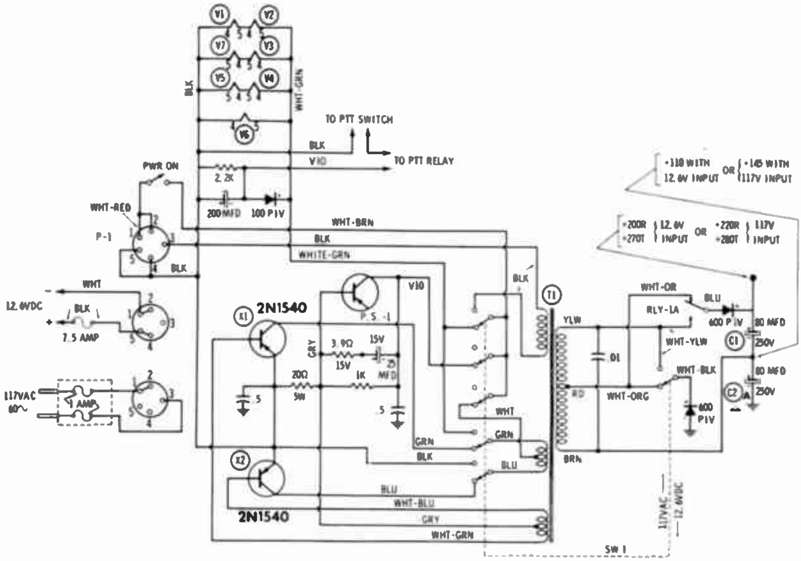
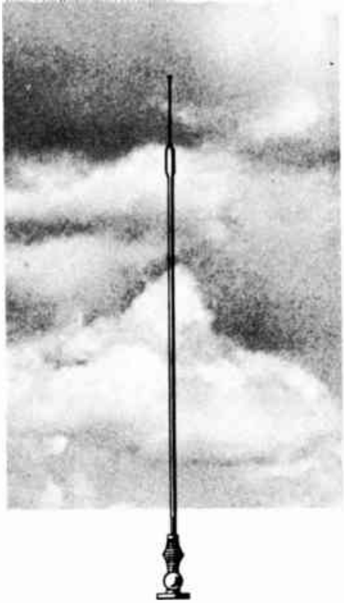


Fig. 3-30. Schematic of the transistor power supply used in the transceiver of Fig. 3-29.



4

Antenna Systems

The antenna is a vital link in the radio communications system; without some form of antenna, transmission and reception of signals would not be possible. All Citizens band equipment has provisions for some type. It may be anything from a simple plug-in stub antenna to a complex rotary beam—depending on how the equipment is to be used and how much the user can afford to invest. The important thing is, a good antenna is a requisite for reliable communications over any substantial distance.

One of the biggest problems facing CB radio today is limited range. In many instances it can be directly attributed to improper antenna selection and installation; thus, proper choice of an antenna is a must for efficient operation. This is understandable when you consider the relatively weak signals handled by CB equipment. Antenna height is also important; however, this is not a matter of choice, but is limited by FCC regulations. Class-A stations are not nearly as restricted on this point as those in the other classes.

Also to be considered are the characteristics of radio waves at the frequencies used for CB operation. A better understanding of the problems involved will give you some idea of what to expect in the way of communicating range.

CHARACTERISTICS OF RADIO WAVES

All radio waves are electromagnetic in nature—that is, they are formed in much the same manner as the magnetic field that exists around a conductor through which current is flowing. However, radio waves actually radiate into free space somewhat like sound waves only much faster—in fact, 186,000 miles a second. Depending on the frequency and intensity of the antenna currents that produce them, radio waves can travel distances ranging up to several thousand and even millions of miles before their energy is dissipated.

Because of their electromagnetic properties, the waves leaving the antenna will induce currents in any conductor they contact (Fig. 4-1). Furthermore, these induced currents will exhibit the

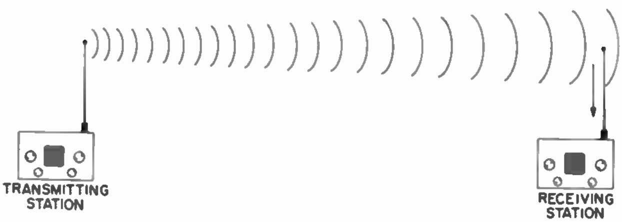


Fig. 4-1. Electromagnetic waves from the transmitter induce similar waves in the receiving antenna.

same characteristics as the currents originating at the transmitting station. From this, you might assume that the transmission and reception of radio waves is fairly simple; however, there are a few other factors that complicate the picture somewhat. For example, an antenna of just any length will not respond efficiently to radio waves of a particular frequency. The frequency of a

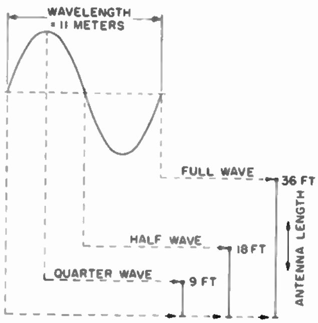


Fig. 4-2. Wavelength versus antenna length.

radio wave is determined by the number of cycles that occur each second, and the wavelength is the distance traveled during one cycle. This is illustrated in Fig. 4-2. Maximum current will be induced into the receiving antenna when its length has a specific mathematical relationship with the wavelength of the signal being received. The same relationship holds true with regard to the transmitted signal.

Wave Polarization

Wave polarization is determined by the angle at which radio waves leave the antenna. A perpendicular antenna will radiate vertically polarized waves; a horizontal antenna emits horizontally polarized waves. Vertical antennas are fairly nondirectional—that is, they radiate and receive signals equally well in all directions. On the other hand, horizontal antennas have directional characteristics. The important thing to remember is that signal transfer will be maximum only when both stations use antennas with the same polarization.

Wave Propagation

One of the peculiar characteristics of radio waves is their behavior at different frequencies. For example, a transmitter operating in the 14-mc range, even with relatively little power, is capable

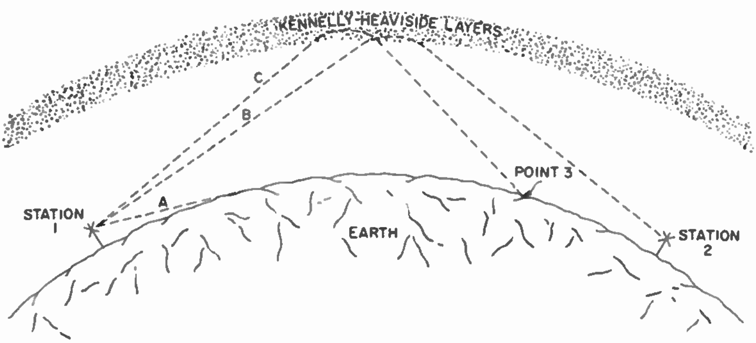


Fig. 4-3. Characteristics of high-frequency (HF) signals.

of communicating with stations thousands of miles away; others operating at UHF frequencies will have a more limited range.

There are two classifications for radio wave travel—ground and sky. Ground waves travel along the earth's surface, even to the extent of following its curvature to some degree. Sky waves can be explained more easily by referring to Fig. 4-3. If station 1, operating at approximately 14 mc, attempts to contact station 2, ground wave A may never reach its intended destination. However, far above the earth's surface are layers of ionized gases known as Kennelly-Heaviside layers. Under certain conditions, they will bend and reflect radio signals back to the earth. Thus, if conditions are right, signals from station 1 will follow path B to station 2.

Since the ionization properties as well as the position of these layers vary, conditions may easily change the reflected signal path so that station 1 cannot communicate with station 2. Instead, path C may be established, and a station in this location could pick up the signal which completely skipped this area when it followed path B.

UHF signals, such as those used by Class-A and -B stations, react quite differently. Wave travel is limited almost entirely to ground waves with line-of-sight characteristics—that is, they do not bend or curve, but follow a very straight path. With no obstructions between the transmitting and receiving antennas, communications can be achieved over surprising distances. However, intervening objects such as trees, buildings, terrain, etc., tend to diffuse the signal, and may even block it entirely. Fig. 4-4 better illustrates how UHF signals react. Ground waves from station 1 follow a line-of-sight path to station 2, providing good quality reception. However, the sky waves, unlike the lower-frequency signals in Fig. 4-3, are not bent back to earth by the ionized layers. Instead, they tend to travel straight through, or at best are deflected only slightly from their original course. If there

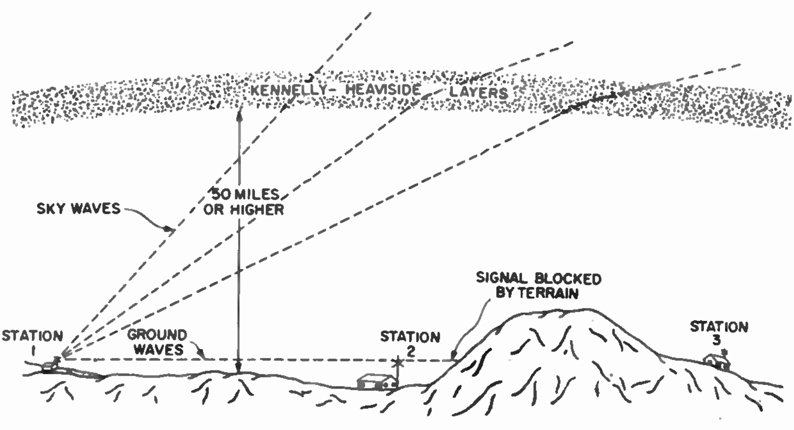


Fig. 4-4. Characteristics of ultra-high frequency (UHF) signals.

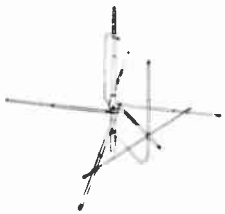
were small obstructions such as trees, wooden buildings, etc., between stations 1 and 2 in Fig. 4-4, chances are the signal would still be received at station 2, but it would be weaker—just as a beam of light is diffused when shining through a translucent substance. The amount of signal reduction depends on the number and type of intervening objects between the antennas. Obviously, the signal will be completely blocked as far as station 3 is concerned. At relatively close range, however, UHF signals are generally received regardless of obstructions.

Class-D frequencies are low enough to overcome some of the line-of-sight characteristics of UHF signals. Still, a direct path between antennas produces the best results; but because of the relatively lower frequencies used here, the ground waves have a greater tendency to reflect from intervening objects, thereby providing more reliable communications over a wider area. Even sky waves at these frequencies occasionally produce suprising results.

Antenna Gain

An antenna which is suitable for transmitting is equally effective as the receiving element. Some are designed with directional characteristics (Fig. 4-5); others are omnidirectional (respond to signals from any direction). The best way to determine the operational characteristics of an antenna is from its radiation pattern.

Fig. 4-5. The VGR-27 Class-D directional antenna.



(Courtesy Mosley Electronics, Inc.)

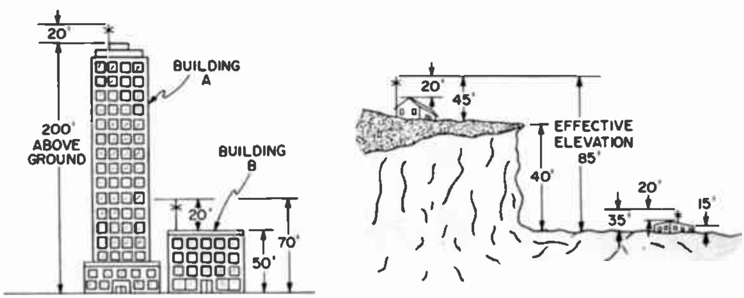
An antenna with directional characteristics provides a certain amount of gain. In fact, through careful design an omnidirectional antenna can also be made to provide gain. Although we speak of an antenna as having a certain gain, it should not be misinterpreted as meaning that it can actually amplify radio signals like a vacuum tube. No antenna can provide gain in that sense. However, through proper design, an antenna can be made to concentrate its radiated energy in such a way that it will appear to have been produced by a much stronger source. You cannot get something for nothing though, so increasing the field in one direction is only made possible by reducing it elsewhere.

Before any gain can be realized with an omnidirectional antenna it must be able to concentrate a portion of its radiated RF energy in such a manner as to add to, or reinforce, the existing energy already following the desired path. This is accomplished by lowering the angle of radiation so as to divert that energy which would normally be lost as sky waves.

The gain of an antenna is determined by comparing its performance with that of a standard antenna, and expressing this figure as a ratio of the power levels required to produce equivalent field strengths. The gain, then, in decibels equals ten times the log of this power ratio. An antenna that provides a 3 db gain, for example, will effectively double transmitter power. In other words, a transmitter with 3 watts' output feeding such an antenna, will "look" to the receiving station like a transmitter radiating 6 watts.

HEIGHT LIMITATIONS

Antenna height regulations adopted for the Citizens radio service are given in Section 95.37 of the FCC regulations (see Appendix). Class-A stations are permitted to use relatively high antenna structures, but are limited when such installations may become a hazard to air navigation. The antenna height of Class B, C, and D stations, however, cannot exceed 20 feet above the man-made or natural structure on which it is mounted. A further limitation to this rule stipulates that when a CB antenna is mounted on an existing antenna structure of another station (such as a tower), it cannot extend above it by *any* amount.



(A) Elevation provided by man-made structure.

(B) Elevation provided by natural formation.

Fig. 4-6. Examples of how antenna height compares with effective elevation.

Fig. 4-6 shows how the 20-foot restriction applies. The buildings in Fig. 4-6A are of unequal heights. Despite the difference, the antenna structure must not extend over 20 feet above its mounting. Both antennas have the maximum allowable height, yet the antenna on building A has an effective elevation of 220 feet as compared with 70 feet for the one on building B. Fig. 4-6B shows another example. The antenna in this case is mounted above a house situated on a hill, providing a much higher effective elevation than the station at the lower level using an installation of similar height. Fig. 4-7 shows the one exception to the 20-foot rule, where the antenna is mounted on the existing antenna structure

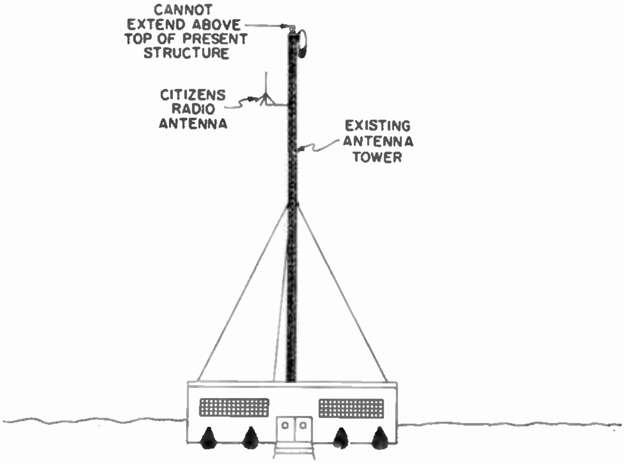


Fig. 4-7. The CB antenna mounted on the existing structure of another station.

of another station. It can be mounted at any point on this tower; however, it must not extend above it.

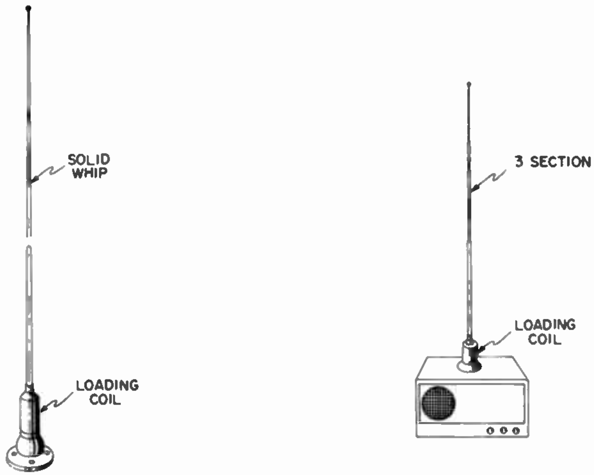
PHYSICAL ASPECTS

The type of CB operation you plan will undoubtedly influence your selection of an antenna. For example, if you intend to communicate only over an extremely short distance, perhaps with a neighbor who lives one or two blocks down the street or in the same building, you would hardly benefit from buying a beam antenna when a simple whip antenna will suffice. Moreover, the size of the antenna may also have a bearing on the type of installation you'll want.

Antennas are most effective when cut to a size equal to one wavelength or a submultiple (such as a half or quarter wavelength) of the signal frequency. Since the Class-D range covers a number of frequencies, the most practical solution is to use a compromise length, cut for the center of the band. A wavelength in the 27-mc Class-D range would be about 11 meters, or over 36 feet long. Obviously, an antenna of such length would be impractical for most installations. Thus, most 27-mc antennas are cut to either a half or quarter wavelength. Even so, an 11-meter half-wave antenna is approximately 18 feet long, and a quarter wave around 9 feet.

Loading Coils

The physical length of a vertical antenna can be made shorter by use of a loading coil, a device which effectively increases the

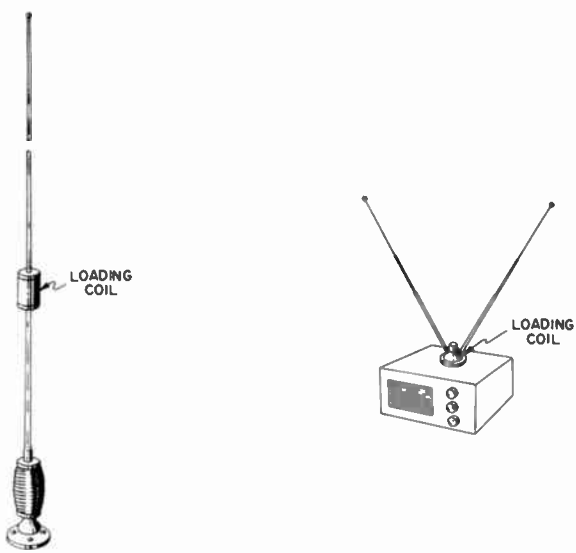


(A) Whip. (B) Telescopic

Fig. 4-8. 27-mc base-loaded vertical antennas.

electrical length of the antenna. Such an arrangement is not quite as efficient, but it does provide a solution where excessive length is a problem.

The loading coil may be located on the antenna itself or within the transceiver. Fig. 4-8 shows two types of base-loaded Class-D



(A) Whip. (B) Dipole.

Fig. 4-9. Examples of two 27-mc center-loaded antennas.

antennas. Fig. 4-8A illustrates a steel whip, the type used in mobile installations, with the loading coil encased in a waterproof housing at the base. Fig. 4-8B shows a vertical three-section telescopic unit that can be extended to about 57 inches, making an ideal indoor installation.

The loading device need not always be at the base. Fig. 4-9 illustrates two types of center-loaded units. One is a mobile whip like the one shown previously except for the location of the coil. The telescopic "rabbit ears" antenna in Fig. 4-9B appears to be base-loaded; however, this is a dipole and the loading coil is actually located at its center—the junction of the two elements.

ANTENNA SELECTION

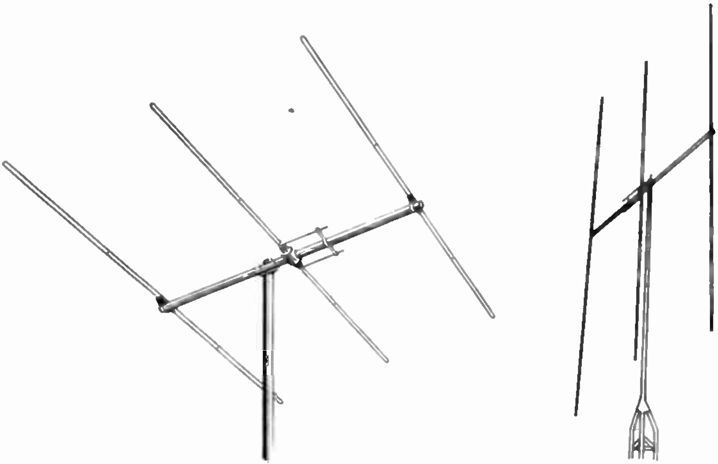
A variety of antennas are used for CB communications, most of which fall into one of four basic categories—whip, coaxial, ground plane, and beam. An antenna may be included with the CB gear when purchased, or it may be available as an accessory. Those included will usually be the simple plug-in type of fixed or adjustable length, and may or may not include a loading coil. Furthermore, some antennas are removable while others are actually a physical part of the transceiver itself, as in the case of some of the smaller transistorized units. These antennas are designed primarily for short-distance communications, and while they work quite well in the open, they may not provide satisfactory results for the type of coverage you desire.

Proper antenna length is important if the available transmitter power is to be used to the utmost advantage. If communications between two fixed stations is to be accomplished over a considerable distance, beam antennas can be used to great advantage. Not only do they provide a signal gain, but they generally discriminate against unwanted signals from other directions. When communications are desired between two stations only, the beams should be directed toward each other and permanently set in this position. Moreover, when communication with other stations is necessary, a rotator may be installed, permitting the antenna to be aimed in any direction.

Wave polarization must also be considered, since communications between stations using unlike polarization will be poor. Most beam antennas are designed to radiate and receive horizontally-polarized waves. Some, however, like the three-element 27-mc beam in Fig. 4-10, can be installed to provide either horizontal or vertical polarization.

When a fixed station is to communicate with mobile units, it must be equipped with an antenna that will provide equal response on all sides. Practically all mobile antennas are designed to radiate a vertically-polarized wave; therefore, the antenna at the base station must also be vertically polarized. A vertical beam type may do the job, but the ground plane in Fig. 4-11A or the coaxial antenna in Fig. 4-11B are used most often in this application.

The ground plane has a low angle of radiation which confines most of the signal to ground-wave paths and allows little energy to escape into the ionosphere. The popular coaxial antenna (some-



(Courtesy Hy-Gain Antenna Products.)

(A) Horizontal. (B) Vertical.

Fig. 4-10. The Model 113-B three-element beam antenna can be mounted either horizontally or vertically.

times referred to as a "thunderstick") also exhibits good omnidirectional characteristics and is used to advantage in fixed-station installations where space is a problem. In addition, it is very easy to install.

ANTENNA INSTALLATION

In many cases the simple vertical or dipole type of antenna will serve very well in the intended operation, and no special installation will be required. However, if an outside antenna is to be used, a certain amount of planning and physical labor will be required. This may be performed either by a service technician or by the licensee himself.

Fixed Station

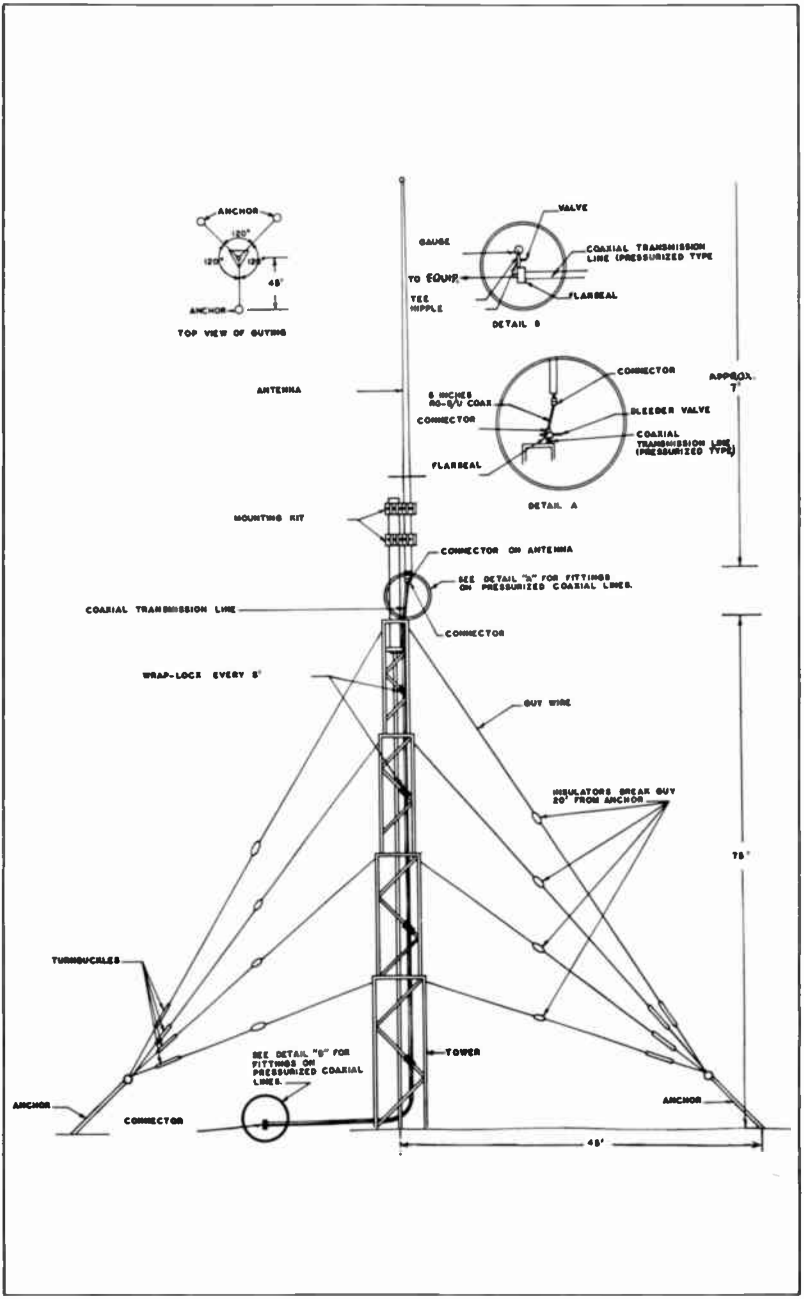
Since Class-A stations are not too restricted in the way of antenna height, they often employ rather complex structures which require special equipment to erect. An example of a typical base-station installation suitable for Class-A operation is shown in Fig. 4-12. Obviously one such as this must be properly guyed and anchored to withstand high winds. This one is guyed from three angles, as shown at the upper left in the illustration. Insulators are inserted into the guy wires about 20 feet above the anchors, and turnbuckles are provided to take up any slack. A coaxial cable of the proper impedance is placed along the inside of the tower and fastened about every six feet before being connected to the antenna mounted at the top. Here a vertical (non-directional) antenna is used; other types may be employed.

(Courtesy Mosley Electronics, Inc.)

(A) Vertical ground plane. (B) Coaxial.

Fig. 4-11. Two types of antennas commonly used in Class-D operation.

Class-B antenna installations are generally quite simple. Because of the high frequency involved (465 mc), the antenna elements are rather small. (The higher the frequency, the shorter the wavelength and subsequent size of the antenna.) For short-range communications, some Class-B transceivers use nothing more than a 6-inch vertical rod for an antenna. When greater range is required, a 465-mc ground-plane antenna similar to the one shown in Fig. 4-13 is usually employed.



(Courtesy Kaar Engineering Corp.)

Fig. 4-12. Typical antenna installation for a Class-A base station.

This antenna is easily installed on almost any type of small mast or rod with the use of two "U"-bolts. Some antennas of this type are supplied with rubber suction cups at the base, permitting temporary mounting on the metal top of a car or other smooth surface.

Outside antennas designed for Class-D operation are generally no more difficult to install than the average television antenna of equal height. The elements of the 27-mc unit are much longer than those of the Class-B ground plane shown previously, making it somewhat more awkward to handle during installation.

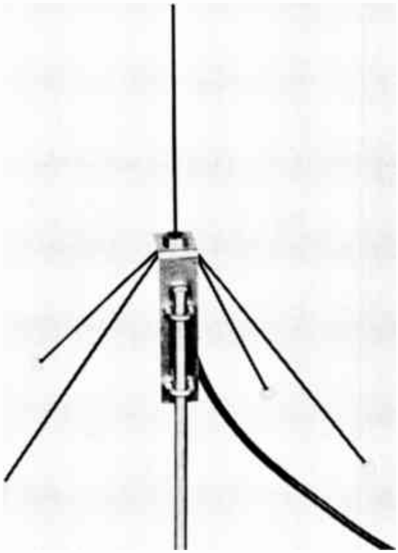
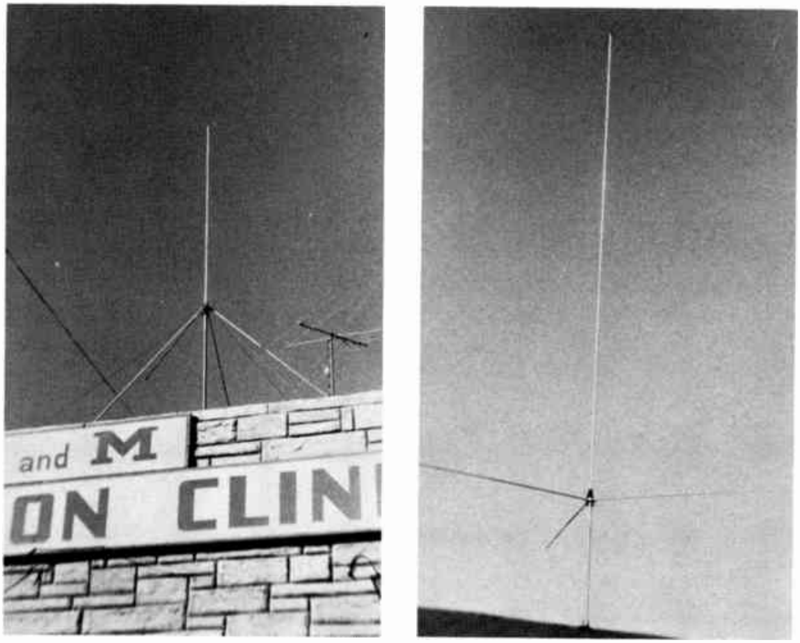


Fig. 4-13. A ground-plane antenna for 465-mc Class-B operation.

(Courtesy Vocaline Co. of America, Inc.)

It is naturally desirable that the antenna be erected as high as possible, especially in lower level areas where full advantage should be taken of the 20-foot height permitted. However, if the station is situated on a sufficiently high elevation to begin with, you may obtain satisfactory results with less than the full 20 feet —perhaps eliminating the need for a tall mast and guy wires. Fig. 4-14 shows two typical Class-D antenna installations. A heavy-duty ground-plane unit is used in Fig. 4-14A, and Fig. 4-14B shows a colinear type—a version of the ground plane in which the radials are placed at right angles with the vertical center element.



(Courtesy Hy-Gain Antenna Products.)

(A) Model GP-1 heavy-duty ground plane. (B) Model CLR colinear ground plane.

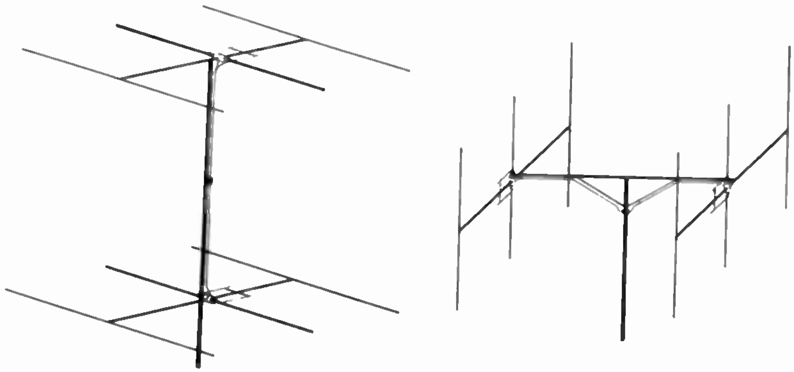
Fig. 4-14. Typical Class-D antenna installations.

To further increase operating efficiency, a stacked beam or ground-plane antenna can be used. Here, two separate units are placed one above the other on a single mast, in the same manner as many television receiving antennas. Fig. 4-15 shows a 3-element beam that can be stacked either horizontally (Fig. 4-15A) or vertically (Fig. 4-15B), depending on the polarization desired.

The ground plane can likewise be stacked, but only vertically. A dual arrangement of this type generally lowers the angle of radiation even further than the single unit.

Stacked arrays for Class-D operation can be purchased as a unit—that is, matching antennas complete with hardware and assembly instructions, or as separate units. So if a single-bay beam, for example, has already been installed and you now wish to add another bay, it should present no problem.

Although it is desirable for the antenna to be installed as high as possible within the legal limit, there is another factor that must be considered—the length of the coaxial cable between the transmitter and antenna (Fig. 4-16). This cable consists of a center conductor encased in polyethylene or similar type of dielectric



(Courtesy Hy-Gain Antenna Products.)

(A) Horizontal. (B) Vertical.

Fig. 4-15. A stacked 3-element beam antenna.

material. Around this is a braided shield, which in turn is covered by a vinyl jacket. The outside cover insulates the entire cable. The braided shield serves not only as the other conductor, but also as a shield against interference, and keeps the RF energy passing through the center conductor from being radiated before reaching the antenna.

The important factor here is the RF loss of the cable. The manufacturer's specifications usually state the loss of a particular cable as so many db of attenuation per 100 feet at a given frequency. The higher the frequency, the greater the RF loss; also, the longer the cable, the higher the loss.

If you plan to install your own antenna, be sure to check the equipment manual for the type of coax to be used. Maximum power is transferred between the transceiver and antenna when their impedances match. Using a type of coax other than that recommended can result in an impedance mismatch and subsequent loss of efficiency.

Since a longer transmission line introduces more signal attenuation, it should be kept as short as possible. However, if running a cable another 50 to 100 feet would increase the effective elevation of the antenna another 25 feet, the additional range—which may be as much as 50 per cent—would overshadow the additional RF cable loss.

Even though a certain amount of RF loss is incurred in the transmission line, it can often be offset to some degree by using

Fig. 4-16. Construction of a typical coaxial transmission line.

a more efficient antenna. Another solution is to reduce the length of the transmission line as much as possible by mounting the radio equipment at the base or near the top of the antenna support as shown in Fig. 4-17. It can then be operated from some remote location. Obviously steps will have to be taken to insure a waterproof installation; otherwise the transceiver could be damaged.

The term "remote control," when applied to the use or operation of a Citizens radio station, means control of that station's transmitter from any place other than the location of the transmitting equipment itself. Remote control of this type is allowed only to Class-A base or fixed stations; however, Classes B, C, and D can use direct mechanical control or even direct electrical

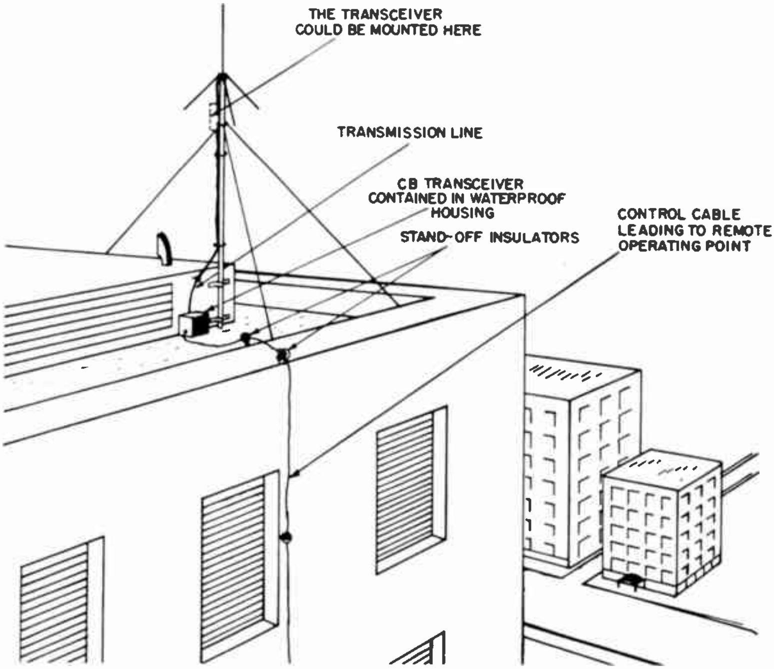


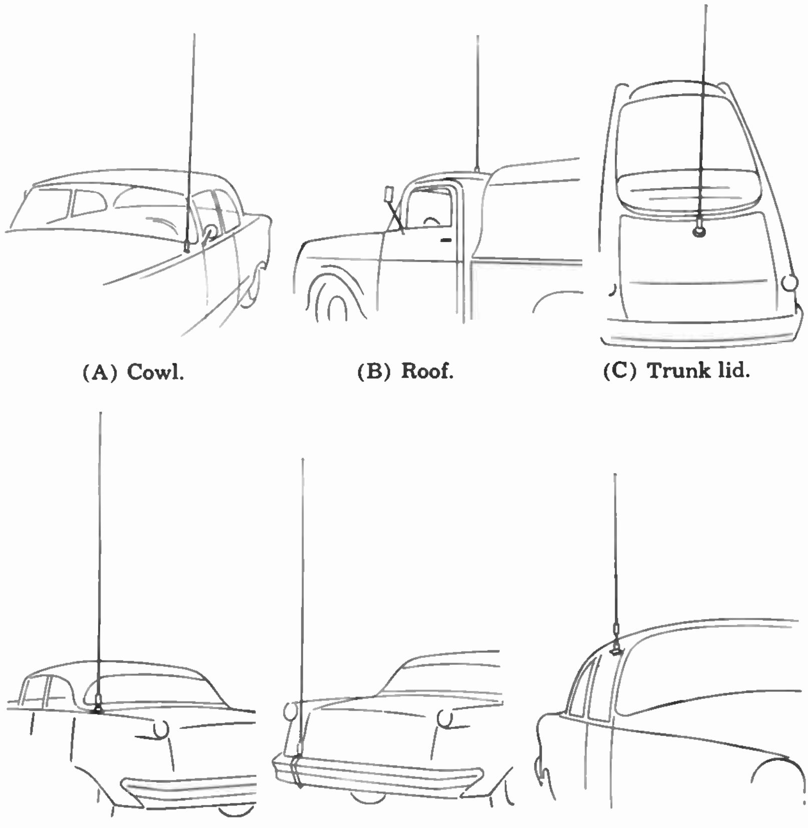
Fig. 4-17. A remote transceiver installation.

control by means of wired connections to the transmitter, as long as it is located on the same premises. For example, if another building on the same property will provide more height, the transceiver can be installed there and controlled (in the manner just described) at any other point on the same property. The transceiver illustrated in Fig. 4-17 is controlled from inside the building by means of a multiconductor cable. If the transceiver is mounted near the top of the mast, additional guying will be required.

Mobile

Mobile operation does not necessarily mean a station installed in a vehicle. It is defined as a station used while in motion or during halts at unspecified points. All units in Classes B, C, and D are classified as mobile stations, regardless of whether they are permanently located, or installed in a vehicle. However, since fixed stations have already been discussed, let's concentrate for the moment on vehicle installations.

Vertical whip antennas are most commonly employed in auto installations because they require little space and are easily installed. Many automobile whips employ some type of loading coil to reduce their physical length; otherwise, they would be rather awkward and could create a hazard around power lines.



(A) Cowl. (B) Roof. (C) Trunk lid.

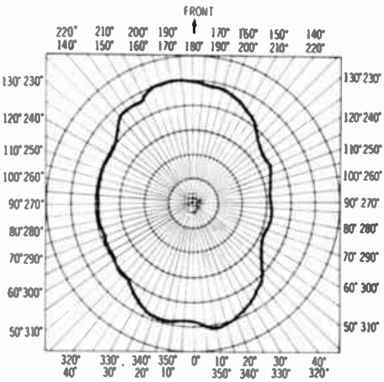
(D) Rear fender. (E) Bumper. (F) Drain gutter.

(Courtesy Hy-Gain Antenna Products)

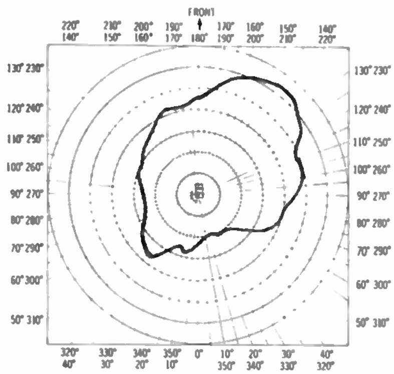
Fig. 4-18. Typical mobile whip mounting locations.

This type of antenna can be mounted in a variety of places, as shown in Fig. 4-18. The location will depend on the type of vehicle. The cowl mounting shown in Fig. 4-18A is no more trouble to install than a regular auto-radio antenna. A roof mount is illustrated in Fig. 4-18B; although it affords maximum height, it is prone to damage from striking trees and other objects while the vehicle is in motion. This mounting location is most desirable, however, and can be used to good advantage when a shortened (loaded) antenna is to be employed. The whip antenna can also be installed on the trunk deck of some cars (Fig. 4-18C). This installation, like the one in Fig. 4-18D, provides a compromise in overall antenna height between the roof mount (Fig. 4-18B) and the bumper mount (Fig. 4-18E).

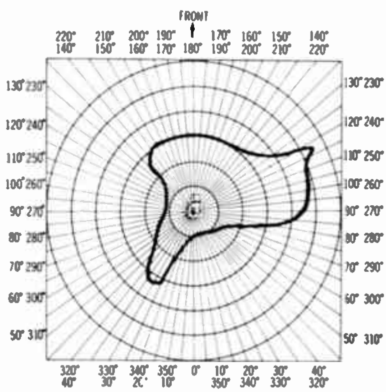
The bumper mount is illustrated in Fig. 4-18E. The whip and mounting are connected to a clamp or strap arrangement that



(A) On roof.



(B) On rear deck (left side).



(C) On rear bumper.

Fig. 4-19. Horizontal radiation patterns when whip antenna is mounted at various places on a car.

fastens around the bumper. This is one of the simplest whip installations and generally requires no hole drilling. The mounting arrangements in Figs. 4-18D and E are two of the most popular in use today. Fig. 4-18F shows a quick and easy whip installation for close-range operations. Here, the antenna is clamped to the gutter at the top of the door.

The mounting location has considerable effect on the performance of the antenna because the metal car body will influence the radiation and reception pattern as illustrated in Fig. 4-19. In all three cases a quarter-wave vertical whip antenna is employed; the only difference is the mounting location. Thus, it is obvious that the most desirable mounting location is the roof of the vehicle. However, this is not always possible. Much will depend on the type of vehicle, size of the antenna, etc.

Regardless of where the mounting is located, the antenna cable should be kept as short as possible and routed away from the engine, gauges, wiring, and other sources of interference. Even though shielded, the cable may pick up some interference due to poor connections, etc.

A standard automobile broadcast antenna should never be used with a CB transceiver. It will introduce considerable RF loss and result in inferior performance. These are, however, several antennas designed especially to serve the dual function of standard AM broadcast and CB radio antenna. These antennas are peaked for maximum CB performance but operate equally well on standard broadcast reception. Dividing harnesses permit either

Fig. 4-20. The "Sea Sprite" designed for Class-D marine installations.

(Courtesy Kaar Engineering Corp.)

separate or simultaneous operation of the CB transceiver and standard broadcast receiver.

A Class-D antenna designed especially for boat installations is pictured in Fig. 4-20. This one is five feet long and employs center loading. It is constructed of *Fiberglas* to resist the corrosion usually experienced in salt-water areas. This antenna can be obtained with either a permanent or temporary mounting. The former is a swivel-type mounting device similar to that used on many standard auto-radio antennas. The temporary mounting has rubber suction cups which allow it to be attached to any smooth surface—a great convenience if the radio equipment is to be used in more than one location.

COMMUNICATING RANGE

There are no set figures to indicate just how far Citizens-band transmissions will carry. Even for a given input power, the communicating range will vary greatly.

Range is determined by a number of factors, one of which is the type of CB equipment being used. A Class-B unit operating as a fixed station and with the proper antenna is capable of line-of-sight communications of up to 10 miles or more with similarly equipped stations—even though UHF frequencies are used and wave travel consists almost entirely of line-of-sight ground waves. Under adverse conditions, transmissions from the same station may be effective up to only a half mile or so if operating from a moving vehicle in an area where buildings and other obstructions are present. These can attenuate the UHF signal severely, although short-distance transmissions are usually effective despite such obstructions. Also, relocating the antenna even a slight distance away may improve UHF reception considerably.

Class-A equipment also operates in the UHF range, although at a higher input power. Communicating range, however, does not increase proportionately with power, especially at UHF frequencies. Many Class-A units are designed to operate at less than the maximum input power allowed, because full power operation will not produce a substantial increase in range.

Most Class-A equipment is capable of providing communications ranging from 10 to 20 miles or more. Even though the lower-powered Class-B units occasionally approach these figures, a Class-A station provides more reliable communications throughout its area of coverage.

With Class-D equipment, communications between fixed stations separated by 20 miles or more is not uncommon. Occasionally, atmospheric conditions are such that sky waves may be reflected back to earth hundreds of miles away.

The range of Class-D base-to-mobile communications is normally 5 to 10 miles. It may be less than one mile where there are obstructions to block the ground waves, or more than 10 miles when the mobile unit operates from an elevated area.

The range of mobile-to-mobile communications using Class-D equipment also varies greatly—generally about 1 to 5 miles on land, and around 10 to 12 miles across water. Again, these figures vary, depending on conditions.

Basically, seven factors determine the communicating range—type of equipment employed, transmitting power, operating frequency, surrounding terrain, amount of interference, type of antenna used, and antenna elevation. The latter does not necessarily mean the elevation of the antenna above ground, but rather its relative height with respect to the receiving antenna.

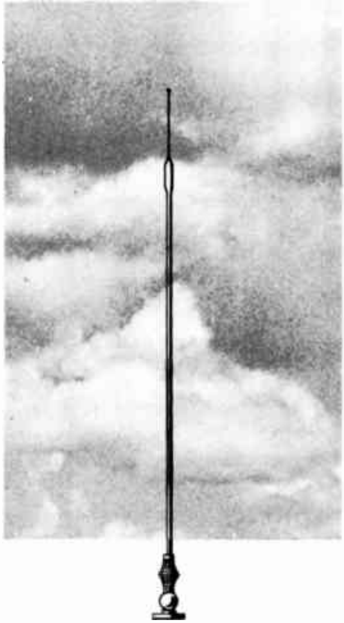
Does your intended equipment have the full plate input power permitted? And if so, is the efficiency of the transmitter such that a relatively high power output is obtained? The percentage of modulation also has some bearing on the output power and subsequent range. For example, a unit capable of 90 per cent modulation will have the edge over one providing only 50 per cent.

We have already discussed the effects of terrain and transmitting power on range, and have seen how signals react at various frequencies; but nothing has been mentioned about interference. One type, adjacent-channel, is troublesome in Class-D operation, where carrier frequencies are only 10 kc apart. Adjacent-channel interference can be eliminated in most instances by using a receiver with good selectivity. However, other forms of interference, over which you have no control, may also be present. Examples are stations operating on the same channel, atmospheric disturbances (lightning, etc., to which AM receivers are particularly susceptible), and interference from scientific, industrial, and medical equipment. Ignition and many other types of noise-pulse interference are more or less suppressed by the receiver's noise-limiter circuit (if one is used), but even it may not provide sufficient rejection under severe noise conditions.

The design of the antenna and its effective elevation also help to determine the communicating range. The type of antenna employed is a matter of personal choice; its height is limited by the FCC. For a more comprehensive discussion of CB antenna systems, refer to *CB Radio Antenna Guidebook*, published by Howard W. Sams & Co., Inc.

5

Station Installation



One of the primary considerations for a fixed-station installation is the location of the antenna—particularly if maximum range is desired. Thus, it would seem advisable to place the antenna as high as possible; however, a long cable run to the transceiver may result in too much signal loss. The transceiver should also be situated relatively close to the power source, but since antenna elevation is most important, it may be more practical to place the unit closer to the antenna and use an extension cord of suitable current-carrying capacity to supply the required source voltage.

FIXED STATION

Fig. 5-1 shows a typical Class-D fixed-station arrangement. Notice that the transceiver is as close as possible to the point where the antenna cable enters the room. After the antenna has been properly installed in an advantageous location, the coaxial transmission line should be routed directly to the transceiver. Usually it can be run under a window or through an access hole in the wall. Some type of vitreous or ceramic tubular feedthrough insulator should be used (Fig. 5-2) to protect the cable, and the excess space around the insulator should be filled with some type of sealer. Running the lead between the window and the sill is not too desirable as a permanent installation. If the transmission line is longer than necessary, it should be cut to length and the transceiver end terminated with the proper antenna connector (Fig. 5-3). Notice that the center conductor of the cable passes through the center terminal of the plug, and that the cable shield

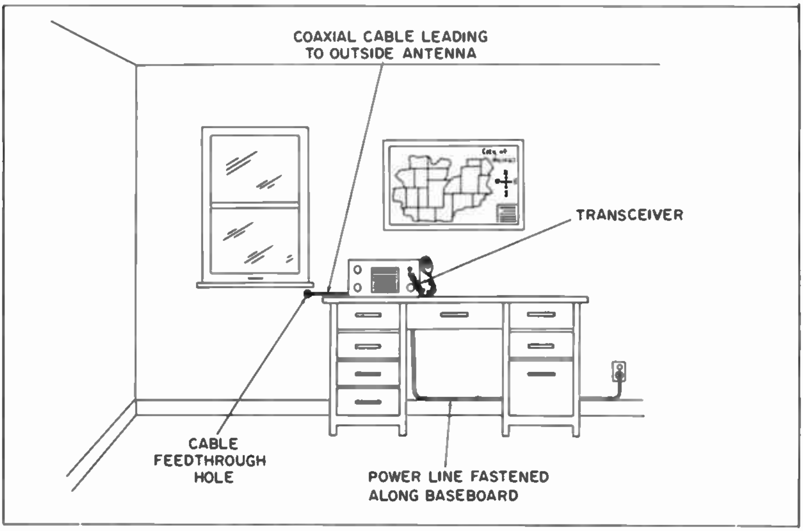


Fig. 5-1. A typical Class-D fixed-station installation.

connects to the outer housing. Care must be taken when soldering the cable and plug connections, since excessive heat will melt the polystyrene insulation between the center conductor and the shield. The power line, which may have to be extended to reach an outlet, should be routed along the baseboard and fastened about every 15 inches or so. The equipment itself can be placed

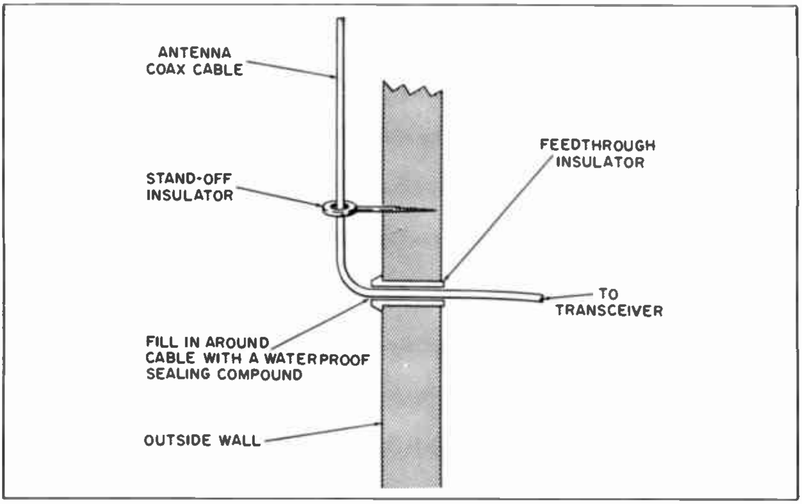


Fig. 5-2. Method of feeding the antenna cable through a wall.

on almost any level surface; however, it must be situated where it can receive adequate ventilation to prevent overheating.

Some transceivers also require a ground connection, which can be provided by driving a standard 5-foot copper ground rod into the earth and running a wire (not less than 14 gauge) between it and the proper terminal on the radio equipment. In some cases an existing water pipe or faucet can serve as the ground, with the wire firmly clamped to it. The antenna mast should also be grounded as protection against lightning.

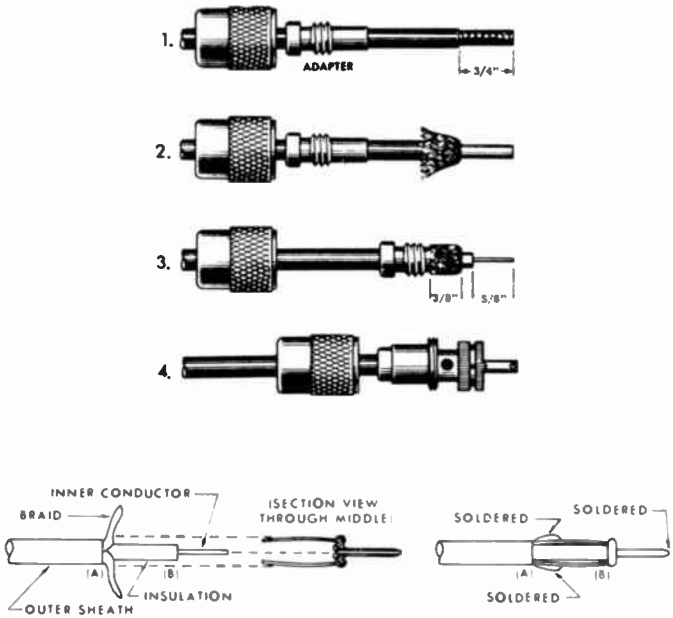


Fig. 5-3. Two methods of fastening the antenna connector to the cable.

After all the required connections have been made, refer to the procedure outlined by the manufacturer for the initial operation of the particular equipment being used. Generally, an antenna loading, or matching, adjustment of some type must be made prior to going on the air. Adjustments of this type are covered in Chapter 7.

Most CB equipment is of the transceiver type where the transmitter, receiver, and power supply are incorporated as a single unit. There are also base stations that consist of separate units which are interconnected to permit single-button operation. Practically all CB equipment (regardless of type) is designed to use the same antenna for both transmitting and receiving.

MOBILE INSTALLATIONS

Unlike the average fixed station, mobile installations will present individual problems because of the variety of vehicles in which the equipment may be installed. Although it is virtually impossible to give the exact procedure for each type of installation, an understanding of some of the major considerations will serve the purpose in most cases.

Installing CB equipment in an automobile or other vehicle is not difficult. Even a layman will have little trouble when guided by a few simple hints. Furthermore, only the basic complement of tools is needed—assorted screwdrivers (standard and Phillips head), socket wrenches, pliers, ¼-inch electric drill, a small soldering iron, and some rosin core solder. A tapered reamer can also be used to advantage for making oversized holes.

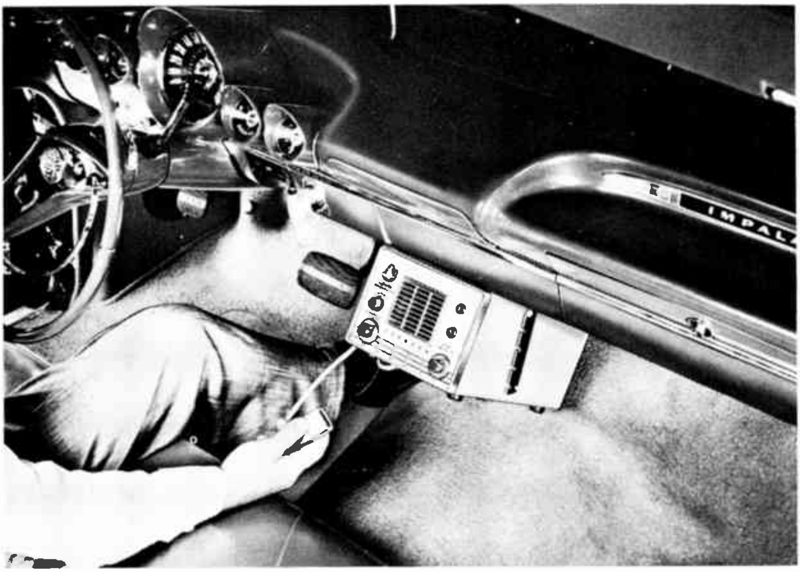
Mounting the Transceiver

A temporary short-range installation can be achieved by simply placing the transceiver and associated antenna in the front seat of the car and using the cigarette lighter outlet as the power source. However, this reduces seating space and provides no means for securing the equipment in place; also, the shielding effect of the metal car body reduces the communicating range. The range can be improved by fastening a small clamp-on type antenna to the drain trough above the car door, and routing the antenna lead-in through the window.

For more permanent installations, the transceiver is usually mounted under the dash, within easy reach of the driver, as shown in Fig. 5-4. This is not always practical, however, because of some factor in the automobile design. For example, the unit must not be mounted directly in the heater air stream, because temperature extremes will affect frequency stability, and excessive heat can damage components. (Remember, too, that crystal mikes can be damaged by temperatures above 120°F.)

The transceiver must also be mounted in such a way that it does not interfere with proper operation of the vehicle. If it were located beneath the dash but too near the steering column, it could interfere with brake-pedal travel or cause the driver discomfort when applying the brakes. Equally dangerous is a mounting too far to the right, requiring the driver to lean over to reach the set. Also, for safety's sake a microphone with a push-to-talk button should be employed, permitting one-hand operation while driving. These are only a few of the possibilities that should be considered before choosing the mounting location.

To complicate matters, you'll often find that the underside of the dash is either not level, or is cluttered with such things as



(Courtesy E. F. Johnson Co.)

Fig. 5-4. Typical Class-D automobile installation.

heater and air-conditioner controls, auxiliary switches, cigarette lighters, ash trays, and the like. In such cases, there are several alternatives: (1) choose another location for the transceiver; (2) relocate the interfering object(s); or (3) use mounting brackets that will extend below the interfering object.

Fig. 5-5 shows a set of brackets which can be adjusted to different widths; loosening the wing nut on either side permits the unit to be positioned at various angles. Fig. 5-6 shows how longer brackets permit the radio equipment to be mounted directly below an obstacle mounted under the dash, without interfering with the operation of either.

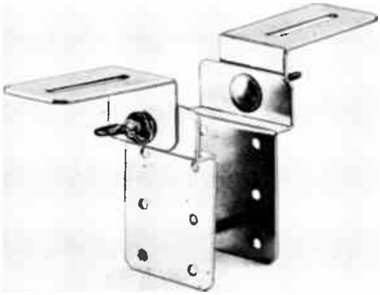


Fig. 5-5. One type of adjustable under-dash mounting brackets.

(Courtesy Utica Communications Corp.)

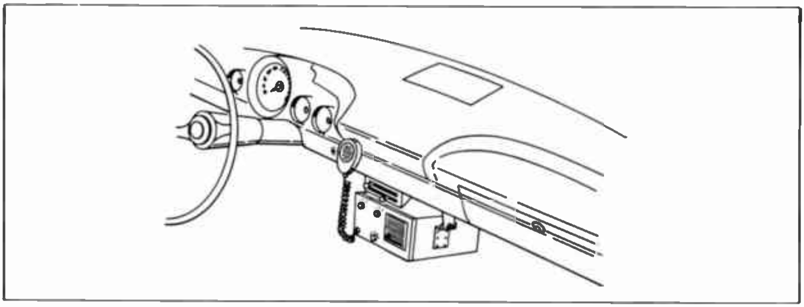


Fig. 5-6. Suitable brackets permit transceiver to be mounted below interfering objects.

If it's impractical to fit the transceiver under the dash, perhaps it can be mounted on the hump in the center of the front floorboard, as shown in Fig. 5-7. The microphone hanger can be fastened to the dash within easy reach of the operator. (Usually, the hanger on the transceiver can be removed and fastened to the dash with a couple of small sheet-metal screws.) Large self-tapping screws are generally used to fasten the transceiver to the floorboard, since the transmission located directly beneath makes use of bolts and nuts impractical.

Antenna Cable

After mounting the transceiver and antenna, the next step is to figure out how the antenna cable is to be routed and what length will be needed. (It's always better to have too much than not enough.) The cable route should be as short as possible, at the same time away from the engine, gauges, switches, relays, etc.—which all tend to induce noise. If a rear-bumper antenna mount is used, the cable can be run either through the inside of

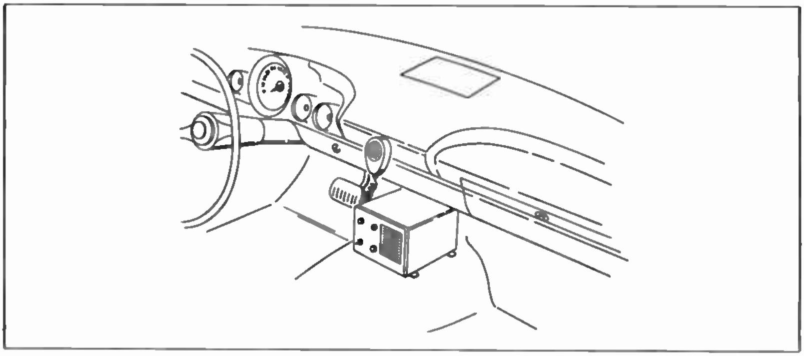


Fig. 5-7. A floor mounting can be used if no space is available under the dash.

the car as shown in Fig. 5-8, or along the underside. On an inside route, lay the cable along the edge of the floor, beneath the floor mat or carpeting. The rear-seat cushion will have to be removed, and perhaps a small hole will have to be drilled, in order to feed the line into the trunk area. Another hole may have to be drilled so that the line can pass from the trunk area to the antenna. Always check for existing openings before drilling a hole. If it does become necessary, fit the hole with a rubber grommet to prevent the cable from being damaged.

When the antenna cable is run along the underside of the car, it must be securely clamped along the frame and routed away from movable parts as well as the muffler or exhaust pipe. Suitable clips for fastening the cable to the car frame can be purchased at most automotive supply stores.

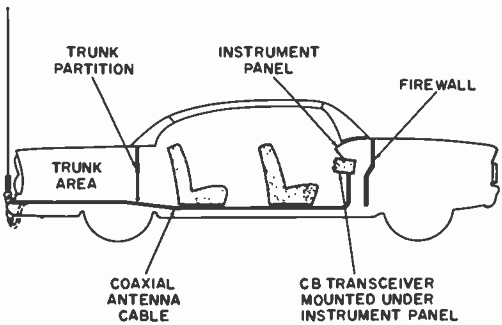


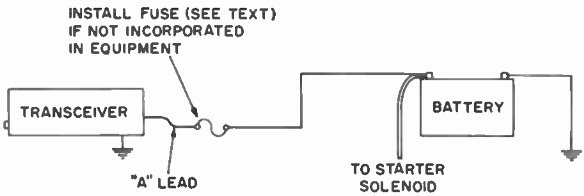
Fig. 5-8. One method of routing the antenna cable in an automobile installation.

Power Source

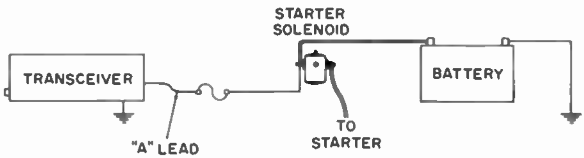
CB equipment can be connected to the automobile power source at several points, as shown in Fig. 5-9. Practically all commercial transceivers include a protective fuse of some type, either in series with the "A" lead, or in a holder on the equipment itself. Locate the fuse before installing the equipment so you'll know where it is, should trouble occur.

Keep the supply lead as short as possible. Wire has a certain amount of resistance which causes some of the source voltage to be dropped across it. Running an excessively long wire between the transceiver and voltage source increases the resistance and thereby reduces the voltage supplied to the transceiver. If an excessively long lead must be used and it results in too much voltage drop, use a conductor with a larger diameter.

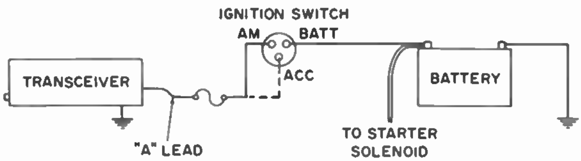
In Fig. 5-9A, the "A" lead is connected directly to the battery terminal. The DC path is completed from the battery through the metal framework of the car to the transceiver chassis.



(A) Battery.



(B) Starter solenoid.



(C) Ignition switch.

Fig. 5-9. Various points where a transceiver can be connected to the automobile source voltage.

The starter solenoid may be located closer to the radio equipment. If so, the "A" lead can be connected to its "hot" side, as shown in Fig. 5-9B. The solenoid can be located by tracing the battery cables; one (usually braided) will be connected to ground (the engine or frame), and the other will lead to the starter solenoid.

Fig. 5-9C shows how the radio equipment can be connected to the ignition switch, provided it does not require too much power. The "A" lead can be connected to either of two terminals in this instance. If you wish the transceiver to operate only when the ignition switch is on, connect it to the ammeter terminal (AM). The equipment can be used anytime (with the ignition switch on or off) if connected to the battery terminal. The former method can prevent a dead battery should the unit be unknowingly left on for any length of time.

Perhaps you have a transceiver that was originally purchased for 6-volt operation but is now to be installed in an automobile having a 12-volt electrical system. Previously we spoke of a voltage loss between the transceiver and the power source because of DC resistance in the wire. Now such a drop is desirable. The

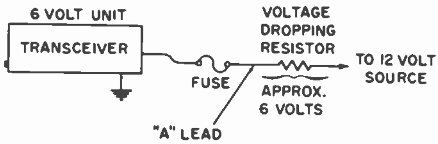


Fig. 5-10. Method of connecting a 6-volt transceiver to a 12-volt source.

same connections shown in Fig. 5-9 can be used, but an additional resistance is placed in series with the "A" lead, as shown in Fig. 5-10. The value of this resistor is chosen so that approximately 6 volts will be dropped across it, thereby providing only the required 6 volts at the transceiver. The value is not given here since it will vary with power consumption; however, it can easily be computed by Ohm's law. Also, the amount of power to be dissipated will determine its wattage.

This arrangement cannot be used with all equipment, because the amount of voltage dropped across the resistor depends on the current through it. Although some CB units use the same amount of current for both transmitting and receiving, most of them draw more current when transmitting. This, of course, means that a resistor chosen to drop 6 volts when receiving, will drop even more when transmitting. This will reduce the voltage at the transceiver to less than 6 volts, and transmitter power will be reduced accordingly. Consult the service literature for the power consumption of the equipment in question. If the difference between transmitter and receiver requirements is significant, this method should not be used.

Incidentally, when installing a CB unit designed to operate from various power sources, be sure to use the proper terminals or the correct power cord, whichever the case may be. In addition, battery polarity may make a difference—especially with transistorized equipment, which will not operate if connected in reverse (and may even become damaged).

In cases where polarity must be considered, it's important to know which terminal of the car's battery is connected to ground. Since the adoption of the 12-volt electrical system, almost all American cars use the negative-ground electrical system; however, prior to 1956, most used the positive-ground system.

A transceiver designed to be powered only from 110 volts AC can also be used in a mobile installation with the use of an inverter, which converts DC into household current (110 volts, 60 cycle). Fig. 5-11 shows one type of inverter, a portable unit that can be plugged into the receptacle of a standard cigarette lighter. The AC voltage is available from the outlet at the far right. The control just to the left is a four-point voltage regulator that per-

(Courtesy American Television and Radio Co.)

Fig. 5-11. The Model 12T-RME portable inverter.

mits the voltage to be adjusted for minimum and maximum loads, as well as for variations in the DC input voltage. This particular inverter operates from a 12-volt DC source and provides a 110-volt, 60-cycle output at 90 watts continuous and 125 watts intermittent. This is sufficient to operate the majority of Class-B and -D transceivers, which usually require no more than 60 to 70 watts. However, if more power is required, the universal inverter in Fig. 5-12 can be used. This one also operates from a 12-volt DC source, but provides 150 watts continuous and 175 watts intermittent—enough to operate a small portable TV in the car. Inverters can be obtained in models to operate from practically any

Fig. 5-12. The Model 12U-RHG universal inverter.

(Courtesy American Television and Radio Co.)

of the popular DC voltages, thereby making them adaptable to a variety of installations.

There are several possible locations for such a device when used in automobile installations. Here again, a lot depends on the type of car, size of unit, available space, etc. Smaller inverters can be set in the front seat or on the floorboard or, if adequate space is available, perhaps mounted under the dash beside the transceiver. If not, there is usually sufficient room in the trunk. Suitable mounting brackets to securely fasten the inverter under the dash or in the trunk are available as accessories for permanent installations. Also available is a small remote-control unit that fits under the dash for the trunk-mounted inverter, providing complete control from within the vehicle.

One of the most commonly asked questions concerning a two-way radio installation in an automobile is "Will it run the battery down?" It depends on the power consumption of the equipment and how much it is used while the engine is idling or turned off. The batteries employed in today's cars are designed to supply a great deal of power. Although late-model broadcast receivers generally draw less current than their older counterparts (which did not have low-current tubes and transistors), additional current is required for such things as power windows, seat, etc.

The average Class-B or -D Citizens-band transceiver should cause no undue strain on the present electrical system of the car, provided the latter is in good working condition and the radio equipment is used with discretion. Like any other electrical device, it would not be advisable to operate the equipment for prolonged periods when the engine is not running. Even running at a slow idle is equally as bad, since at this speed the engine is usually not turning the generator fast enough to restore the same amount of power being drawn from the battery.

If you have trouble keeping the battery charged, even under normal operation, it would be advisable to have the electrical system of the car checked, paying particular attention to the voltage-regulator setting. If most of your driving is confined to short runs in the city, for example, the voltage regulator can usually be adjusted to provide a higher charging rate. However, to prevent possible damage to the electrical system, there is a maximum setting which should not be exceeded.

If the present generator is not capable of safely providing enough current to keep the battery sufficiently charged, an oversized generator may be the answer. These are not too expensive and will fit most cars, although some space difficulty may be encountered in the compact models.

Another type of charging device, known as an alternator, can also be used where higher charging currents are needed. This is an AC generator which operates in conjunction with a rectifier to supply DC current to the battery. One of the nice features of the alternator is that it is capable of providing charging current even at idling speed. This is one of the reasons why it is commonly used on police cars and in other mobile applications where more than average battery power is required. Alternators are included in many of the late-model automobiles as standard equipment.

Not all mobile equipment is installed in cars. Boats, planes, and other types of vehicles employ Citizens band equipment, too; however, the same problems of space, power requirements, interference (to be discussed shortly), etc., must be considered.

Fig. 5-13. A Class-D marine installation.

(Courtesy Raytheon Co.)

Fig. 5-13 shows a Class-D transceiver being used in a marine installation. Such units can be mounted in the open as shown here, or they can be enclosed in a ventilated compartment. It is best to mount the transceiver in a location that will be convenient to the operator, yet afford some protection against moisture. As mentioned previously, special rust-resistant antennas are generally used in marine installations.

NOISE AND INTERFERENCE SUPPRESSION

The majority of pulse-type noises disrupt the amplitude rather than the frequency of radio signals; thus they have their greatest effect on AM communications. FM (frequency modulation) is relatively unaffected by most types of noise because of the action of the limiters. Noise-limiter circuits (discussed in Chapter 3) are employed in the most Citizens band equipment; however, additional steps may have to be taken to suppress noise, especially in mobile installations. Don't forget, the noise level is one of the limiting factors in communicating range.

Noise Sources

Noise falls into one of the two categories—natural or man made. Lightning caused by atmospheric disturbances is one example of natural noise. Some of the sources of man-made noise primarily affecting fixed-station installations include electric mixers, hair dryers, fans, drills, fluorescent lights, and medical equipment, to name just a few. In vehicular installations (cars, boats, airplanes, etc.) the electrical and ignition systems are the chief sources of noise. Basically there are three ways in which noise can enter a transceiver: (1) through the antenna; (2) through the power source; (3) from radiation pickup by the internal circuit. Some types of noise can be overcome or minimized; others cannot.

Generator Noise

In vehicular installations generator noise is one of the most common types and is especially troublesome at high frequencies.

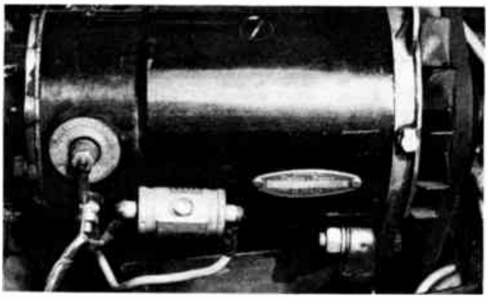


Fig. 5-14. A noninductive capacitor installed on a generator.

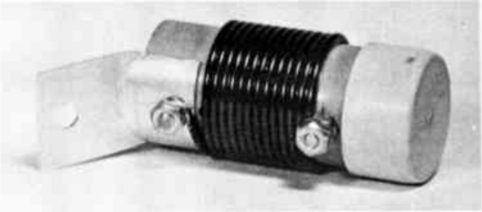
It can be recognized by a whine that varies in pitch with the speed of the engine. This noise is caused by arcing between the generator brushes and commutator. A bypass capacitor will usually minimize or completely eliminate this trouble. A standard capacitor (0.5 mfd) may already be connected to the armature terminal of the generator. However, this capacitor, because of its construction, has a certain amount of inductance which reduces its efficiency at higher frequencies. Therefore, a noninductive coaxial feedthrough type capacitor should be connected in series with the wire going to the armature terminal of the generator as shown in Fig. 5-14. The case must be properly grounded to the generator; it may be necessary to scrape or sand the surface under the mounting screw to provide a good ground contact. The capacitor must not be placed in the field lead, since the generator could be damaged if the capacitor should short. If the noise is still severe after this capacitor is installed, the trouble may be due to worn brushes or a dirty or worn commutator. If this is the case, the generator will have to be overhauled.

A device designed especially to suppress generator noise in the 14- to 30-mc range is shown in Fig. 5-15. Electrically it comprises a high-Q parallel-tuned circuit. With the unit connected in series with the armature lead to the generator, the capacitor is tuned for maximum noise reduction at the frequency used.

Ignition Interference

The ignition system is another common source of noise. It produces a popping sound which is especially noticeable when the engine is running slow. It also increases with engine speed, but is easily distinguished from generator whine. Ignition noise is caused by high-voltage discharges at desired and undesired points in the system—for example, between high tension wires, from the wiring to some point on the engine, down the outside of a greasy spark plug, or across the gap of a poor connection.

Fig. 5-15. A tuned generator noise suppressor.



(Courtesy Globe Electronics)

Ignition noise may not be due to defects in the system. A certain amount is produced during normal operation. This noise can often be reduced or eliminated by using resistor-type spark plugs or radio-resistance high-tension wire to interconnect the coil, distributor, and spark plugs. Do not, however, use both radio-resistance wire and resistor spark plugs, as the efficiency of the ignition system will be impaired.

Ignition noise can be reduced still further by installing a 10,000-ohm suppressor in series with the center wire (high tension lead) of the distributor. Many commercial suppressors are available for this purpose.

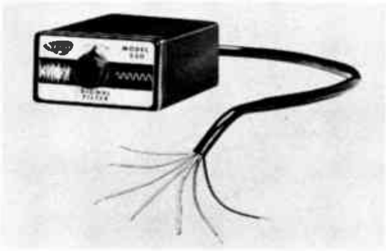
Other Interference

Another type of noise is produced by the voltage regulator. This "hash" type interference occurs as the relay points open and close. It can usually be eliminated by installing noninductive bypass capacitors in series with the battery and armature leads of the voltage regulator.

Other sources of noise are the gas gauge (both the sending unit at the tank as well as the gauge on the panel), the turn-signal flasher, and the brake-light switch. Noise produced by these sources can be eliminated in most cases by connecting a non-inductive bypass capacitor in series with the "hot" lead to each unit, in the same manner as described previously. Some manufacturers produce complete automotive noise suppression kits. These usually include all appropriate suppression devices and wiring plus installation instructions.

Static electricity creates still another type of noise. It too is recognized by a popping sound from the speaker, but unlike ignition interference this noise will generally continue as long as the vehicle is in motion and even with the engine turned off. In fact, this is one way of identifying it.

Whenever metal joints in an automobile body become loose, there is a chance that a static electric charge will build up between them. When this charge reaches a certain value it will discharge as a spark to adjacent metal structures, thereby causing a popping sound to be heard from the receiver. The best way to prevent or eliminate static interference is by bonding together any metal structures that are now loose or could become loose. A bonding strap may have to be used to bond the instrument panel to the frame or the hood and trunk lid to the body or frame; and in some cases the fenders may even have to be bonded to the frame before the trouble can be eliminated.

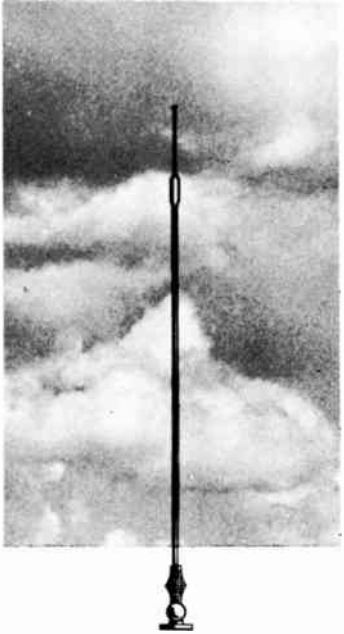


(Courtesy SECO Electronics, Inc.)

Fig. 5-16. The SECO Model 530 "Signal Filter," used to eliminate ignition interference, hash, and background noise.

Stations operating at fixed locations such as a home or office are also troubled by noise, but not to so great an extent as in automotive installations. Noise is often picked up through the AC power line and transferred into the transceiver circuits. A line filter connected in series with the power cord will generally correct this situation.

A number of commercial devices designed to suppress radiated man-made noise and interference are currently available for use with CB equipment. Fig. 5-16 shows one example. These devices can be used for either mobile or fixed station installations.



6

Maintenance And Repairs

Citizens band units, like any other man-made equipment, occasionally require the services of a skilled technician. Many repairs will be routine, involving nothing more than replacing a tube, vibrator, or similar component; others will be more complex, calling for the troubleshooting techniques of a specialist.

According to the FCC regulations, not just anyone can service two-way radio equipment. Any transmitter tests or adjustments which may affect the legality of operation must be made by or under the immediate supervision of a person holding either a first- or second-class commercial radio license appropriate for the type of emission being used. Changing adjustments, disturbing the chassis wiring, or replacing critical components may cause off-frequency operation, introduce spurious radiation, or increase the power input beyond the legal limit. Obviously, before an unlicensed person can perform any type of tests, repairs, or adjustments, he must first know what changes can affect proper operation. This is one place where the old saying, "a little knowledge can be a dangerous thing," holds true.

Notice that the regulations state "by or under the immediate supervision of a properly licensed person." This means that such tests and adjustments can be made by anyone, as long as he is supervised by a person with the proper license. The licensed person is held responsible for the proper functioning of the station equipment after such tests, repairs, or adjustments have been completed.

Certain exceptions to the rule make it possible for an unlicensed person to construct, install, and service certain commerciallymanufactured Class-C and -D equipment. For example, no commercial radiotelephone license is required to construct a kit or to install and maintain other commercial equipment in which the frequency-determining elements of the transmitter (including the crystal) and all other components in the crystal-oscillator circuit have been preassembled, pretuned, and sealed at the factory. Replacement or adjustment of any components which might cause off-frequency operation cannot be made without first breaking the seal (see paragraph D, Section 95.97, of the FCC regulations in the Appendix). If a technician intends to service CB equipment, he should plan on getting a commercial license as soon as possible.

TEST EQUIPMENT

Many shops already have most of the test equipment needed to service CB equipment, and will thus need only a few additional items. A good VOM with a sensitivity of at least 20,000 ohms per volt is already included on most shop benches. A VTVM can also be helpful.

Although most tubes will be checked by substitution, a general-purpose tube tester can be used to confirm leakage, shorts, low emission, and other types of tube defects, some of which are not always readily apparent.

When circuit alignment becomes necessary, as it will in any radio equipment of this type, a stable signal generator (preferably crystal calibrated) is required. It should be able to cover all RF and IF ranges from 150 kc to 30 mc, be capable of delivering a signal of less than 1 microvolt, and have provision for signal modulation. The signal generator can also be used to locate defective stages. An additional generator may have to be acquired if Class-A and -B equipment is to be serviced; however, the majority of business will consist of Class-D equipment.

Some type of DC power supply will be needed at the bench when equipment is brought into the shop for repair. The DC source can be a fully charged storage battery capable of delivering sufficient current, or a battery eliminator. A power supply that delivers fixed DC voltages (both 6 and 12 volts), or a filtered variable DC supply such as that used to service transistorized equipment, can be employed. The latter is more desirable since it will deliver either 6 or 12 volts, and can be varied both above and below these amounts to simulate actual DC voltage variations encountered during normal operation. A DC power supply of this type is shown in Fig. 6-1.

In addition to the basic test equipment just mentioned, a couple of other instruments not usually included in the average service shop will also be needed. One of these is an RF power meter for checking the transmitter output signal. The second, and one of the most important as far as legal operation is concerned, is the frequency meter. It, of course, is needed to check the operating frequency of the transmitter, which should be a routine part of every service job. Several instruments are suitable for this purpose, one of the most popular being the heterodyne frequency meter.

Fig. 6-1. A variable 6/12 volt filtered DC power supply.

(Courtesy EICO Electronic Instrument Co., Inc.)

(Courtesy Globe Electronics.)

Fig. 6-2. The Globe "Signal Optimizer".

(Courtesy Allied Radio Corp.)

Fig. 6-3. The Knight-Kit "Ten-2" portable CB checker.

A number of test instruments designed primarily for checking the operation of Class-D Citizens band equipment are available. Among other things these instruments check modulation, RF power output, antenna efficiency, field strength, etc. There are also several all-purpose CB testers like the ones in Figs. 6-2 and 6-3. Among other functions, the test set in Fig. 6-2 can be used as an RF wattmeter, SWR bridge, modulation monitor, field strength meter, and crystal checker. The unit in Fig. 6-3 serves as a signal monitor, crystal-controlled signal generator, and audio oscillator. In addition, measurement of SWR, RF power output, modulation percentage, field strength, and crystal activity can be made with it. Other test equipment for checking the operation of CB radio equipment is described in Chapter 7.

SERVICING HINTS

When a piece of equipment becomes defective, check the service manual first for possible causes. Not only can this save time, but it will often prevent additional troubles caused by promiscuously probing and testing in an attempt to locate the trouble.

Lead Dress and Component Placement

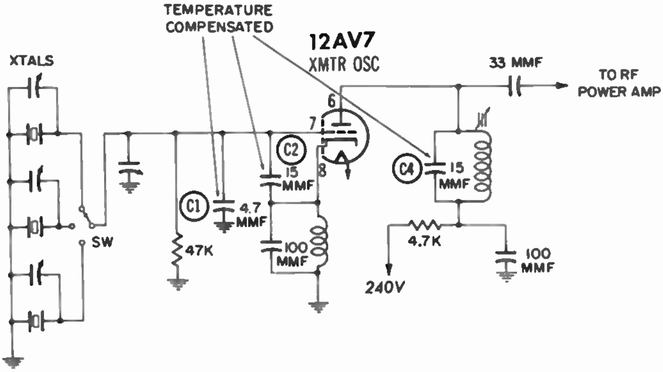
Improper lead dress, especially in the RF and IF stages, can cause unstable operation and/or result in spurious oscillations. When a component is to be replaced, the new part should be located and wired exactly like the original. Replacement components should always be of the same value and rating; also, it isn't wise to try to improve on the original design.

Temperature-Compensated Components

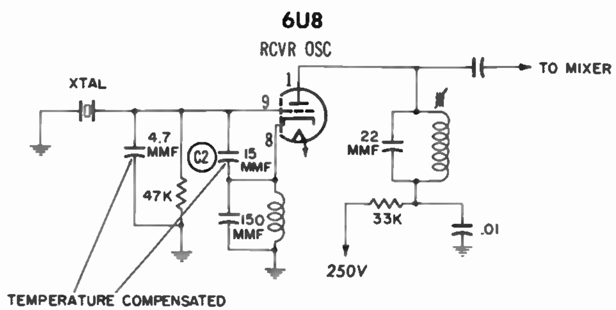
Components used in critical circuits, such as the oscillator, may be temperature-compensated. Replacement with a standard type can cause improper operation. The value of a negative temperature-coefficient capacitor varies inversely with temperature. In other words, as the ambient temperature increases, the capacitance decreases, and vice versa; thus, the circuit in which it is used will be relatively unaffected by heat. Fig. 6-4 shows the location of temperature-compensated capacitors in a typical transmitter oscillator circuit (Fig. 6-4A) and a receiver oscillator circuit (Fig. 6-4B). Circuits are not all alike; however, this will give you a general idea of where this type of component is used. It shouldn't be difficult to determine if a defective capacitor is temperature-compensated or not. One with a negative-temperature coefficient, for example, is designated by the letter *N* followed by several numbers, such as N150. If not stamped on the capacitor, it will most likely be indicated in the parts list.

Printed-Circuit Boards

A number of CB transceivers use printed circuitry. Fig. 6-5 shows an example of a printed board, which is usually made of a phenolic material. The wiring pattern, which is a flat metal foil conductor, is imprinted or etched on the board, and is sometimes covered with an epoxy resin coating to prevent dust and moisture from affecting operation. The circuit components, which may be



(A) Transmitter oscillator.



(B) Receiver oscillator.

Fig. 6-4. Location of temperature-compensated capacitors in two typical RF-oscillator circuits.

located on either side of the board, are connected to the printed wiring through holes in the board. This method of construction eliminates the old-style array of wires and provides a somewhat more compact assembly. However, special care must be exercised when servicing equipment of this type, since these boards can be easily damaged. Occasionally one of the conductors will break due to physical strain, rough handling during servicing, etc. Often this will be nothing more than a hairline break, although it can be sufficient to disable the entire transceiver. If a break should occur, try to locate it without removing the circuit board from the chassis. Sometimes it can be spotted by placing a light on the underside (opposite the wiring side) of the board. Although this board is flexible, avoid bending it in order to prevent damaging the printed wiring.

When checking a printed-circuit board, it's best to use a test prod with a sharp point to pierce the epoxy resin coating over the printed wiring. Tests should be made at soldered junctions rather than by punching holes at just any point along the delicate conductors. (Such holes represent potential breaking points.) In a conventionally-wired circuit, it's common practice to unsolder one lead of a component before testing it. With printed-circuit boards, however, special soldering techniques must be used to prevent damaging the board. Therefore, check carefully and be reasonably certain a part is defective before unsoldering it. Then use a low-wattage iron or gun, since the bond between the printed wiring and the board can be broken by excessive heat. Also, using too much solder on a connection can result in a short between conductors.

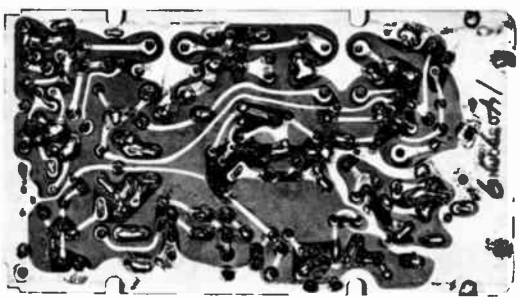


Fig. 6-5. A typical printed-circuit board.

Transistors

Transistors, like printed circuits, also require special considerations when being tested and replaced. Basically there are three types of transistors: (1) the small low-power type for RF and IF circuits; (2) the medium-power audio transistor; and (3) the high-power transistor used in audio-output stages and power supplies. Some of the most frequent defects in these units are leakage, shorts, and open elements. In some circuits, like the one in Fig. 6-6, the emitter resistor (R1) is fusible and will occasionally open, "killing" circuit operation. When replacing a fusible resistor, make sure the replacement has the same characteristics as the original.

The schematic symbol in Fig. 6-6 is commonly used to represent the transistor. Fig. 6-7 shows several methods of identifying the transistor terminals. The leads in Fig. 6-7A are unevenly spaced, and the collector lead is isolated from the other two. In Fig. 6-7B the leads are evenly spaced, but the collector is marked with a bright red or orange dot. The two terminals of the power transistor in Fig. 6-7C are marked "E" and "B." The only remaining connection is the collector—in this instance, the transistor case itself.

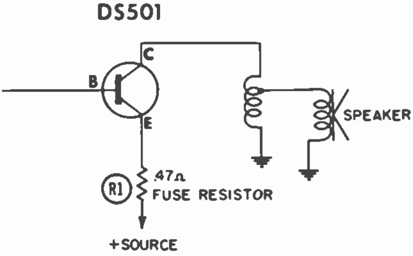
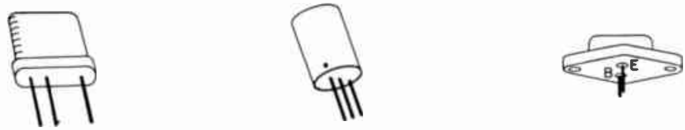


Fig. 6-6. A fuse resistor in the emitter lead protects the transistor in case of overload.

It's not absolutely necessary to acquire a transistor tester just for CB servicing. If one is already on hand—fine! For the most part, though, a VOM will suffice. Several tests can be made with an ohmmeter. Those discussed are performed with the transistor out of the circuit. Fig. 6-8 shows how the front-to-back resistance ratio can be checked. For a low-power transistor, the ohmmeter is set on the R × 100 scale and the test leads are applied to the base and emitter (Fig. 6-8A). The reading is noted, then the leads



(A) Uneven spacing.

(B) Even spacing; colored dot indicates collector.

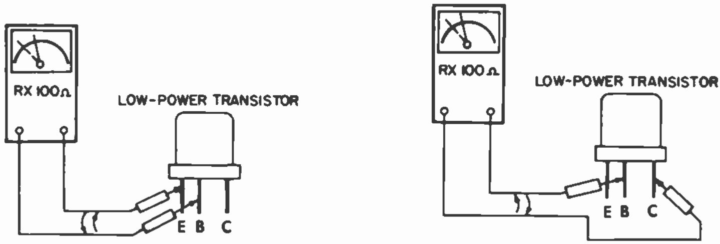
(C) Pins marked.

Fig. 6-7. Methods of identifying transistor leads.

are reversed. The same measurements are made between the base and collector terminals, as shown in Fig. 6-8B. In either case, a very high reading will be obtained in the reverse direction. In fact, the needle may not even move from the peg. In the forward direction, however, the reading will usually be less than 1,000 ohms for the low-power type. Failure to obtain a reading in either direction indicates an open element. An extremely low reading in both directions signifies leakage or a short between the transistor elements.

Power transistors can be checked in the same manner, except that the ohmmeter must be set at the R × 10 range. The high-resistance reading of power transistors should be 5,000 ohms or higher, while the forward reading will be approximately 100 ohms and may be even less.

Considerable heat is generated within a power transistor and must be dissipated to prevent it from being damaged. Some type of heat sink is used for this purpose. It may be an insulated portion of the transceiver chassis, or a separate device. When replacing a power transistor, make sure it is mounted firmly on its heat sink to provide maximum transfer of heat. Make it a point to always check these mountings when a piece of equipment using power transistors is serviced.



(A) Between emitter and base. (B) Between collector and base.

Fig. 6-8. Checking the front-to-back resistance ratio of a transistor.

Small, low-power transistors generate very little heat. In fact, they are usually cool to the touch. Excessive heat at the leads when soldering one into a circuit, however, can easily cause damage. Therefore, always grasp the lead being soldered with a pair of long-nose pliers, between the transistor and the soldering iron. The pliers will act as a heat sink and prevent possible damage. Plug-in transistors should be removed from their sockets before heat is applied to the socket terminals. Always use a low-wattage soldering iron in transistor circuits.

Another reminder concerning repairs in transistorized equipment—make sure the internal ohmmeter voltage supplied to the test leads is not above the rated value of the transistors and other components. Also, you should avoid indiscriminately grounding various terminals throughout the circuit, and be certain of your test points.

LOCALIZING DEFECTS

Before a defective transceiver is removed from a permanent installation, a check of all logical trouble possibilities may save lots of time. A disconnected power cord, a blown fuse, or possibly even a defective power cord or power receptacle could be the reason. Some units are equipped with a pilot light that indicates when power is applied. This can be helpful in determining if supply voltage is present.

In vehicular installations, make certain the battery voltage is up to par and the fuse (located either in the *A* lead or in the transceiver) is not defective. Don't just look at it. Visual inspection of fuses is often deceptive, since a hairline break in the element may not be detected with the naked eye. Fuses should be checked with an ohmmeter, or replaced. If a replacement fuse does not blow, chances are the transceiver is not at fault. A hairline break is not always a sign of trouble in the radio equipment. Often it is caused by vibration or by supply-voltage surges. Repeated fuse failures of this type, not traceable to the CB equipment itself, may be due to trouble in the car's electrical system, possibly a misadjusted voltage regulator. This is further evidenced by frequent burnout of not only the tube filaments but also various lights throughout the vehicle.

If the fuse is found to be good but the equipment still does not receive power, check the "A" lead and the connection to the voltage source. Also check the equipment for proper ground.

A transceiver could be receiving power, but still not transmit or receive signals. The first points to check in such instances are the antenna connectors, the antenna itself, and the transmission line. You'll find cases where the antenna cable has been pinched under the edge of the rear seat, or there is low source voltage due to a cable half-eaten away by battery acid. You'll also come across antenna and "A" leads that have literally been sawed in two by windshield-wiper mechanisms, and loose connections and poor grounds of all kinds.

Only after all possibilities of this type have been checked, should the transceiver be removed from its mounting. Even then, it's best to try to repair it on the spot, where its antenna and source voltage are available. In this way, repairs and adjustments can be checked under actual working conditions. Some repairs, of course, are impractical to handle in the field, in which case the unit should obviously be taken into the shop.

Adjustments of some type will be a part of practically every service job, and a check of the operating frequency should be a matter of routine. This chapter, however, is concerned only with physical defects; servicing adjustments are discussed in the next chapter and therefore will not be covered here.

Isolating the Trouble to a Section

After removing the equipment to be serviced, you'll have to determine which section is defective—the transmitter, receiver, or power supply. It's unlikely that all three will become defective at one time, although a common receiver-transmitter stage may develop trouble and impair the operation of these two sections. Furthermore, since the power supply is common to all stages, a defect in it may affect the operation of all three sections of the transceiver.

Persistent fuse blowing is caused by excessive current being drawn by the equipment. This could mean trouble in either the power supply, transmitter, or receiver circuits. If a universal supply is employed and the unit operates normally on AC or DC, but not both, a power-supply defect is indicated. However, should the fuse blow on both types of operation, the trouble probably lies within the transmitter or receiver circuits.

Before checking the unit, disconnect the antenna (where applicable) and attach a dummy antenna in its place to prevent interfering with other stations while testing. Commercial dummy antennas (also called dummy loads) are available for this purpose, or a dummy antenna can be made by connecting a No. 47 pilot lamp across an extra antenna connector, as shown in Fig. 6-9. (This same method can also be used with other types of antenna connectors.)

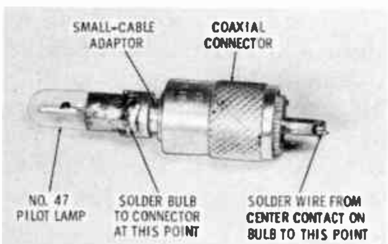


Fig. 6-9. A home-made dummy antenna made from a PL259 connector and a No. 47 pilot lamp.

Check to see if the tubes light. If so, depress the Transmit button and notice whether the pilot lamp used as the dummy load lights. It should if the transmitter is radiating RF energy. If not, determine whether the receiver is working by turning the volume control fully clockwise and rotating the squelch control (if one is used) to maximum in both directions. A rushing sound should be heard from the speaker. Negative results on both tests indicate possible trouble in the power supply. This can be confirmed by a voltage measurement in the power supply. Suspect an open circuit, possibly the power switch, or an open choke coil or B+ resistor. A short in the power supply would normally cause repeated fuse blowout.

In a case where the receiver alone is working, a simple test with an additional receiver will often prove helpful in determining the condition of the transmitter. To perform this test, temporarily disconnect the dummy load and connect a regular antenna in its place (one should always be available at the bench). Tune or switch the extra receiver to the frequency of the transmitter in question, and turn the squelch to the Off position. The usual background noise will now be heard. Now momentarily depress the Transmit button on the defective unit and speak into the microphone. If the background noise is silenced on the test receiver but no voice is heard from the speaker, the RF carrier is being produced and radiated, but there is no audio modulation of the signal.

The transmitters used in CB transceivers are relatively simple and should not be too difficult to troubleshoot. By using a little common sense, you can often save much time in a case like this. For example, here we have a receiver that works properly, which means the audio-amplifier and output stages (which usually act as the speech amplifier and modulator when transmitting) are working all right. The fact that RF energy is being radiated is reason enough to assume that the transmitter oscillator (and RF power-amplifier stage if used) are functioning—at least to some degree. Because of the continuous flexing of the microphone cord, one of the inner conductors will occasionally break. This, of course, eliminates the audio from the carrier, and could easily be the case here. To check, hold the Transmit button down and speak into the microphone while twisting and bending the cable. This should cause the voice to be heard intermittently at the receiver. A different broken connector in this same cable could have prevented the relay change-over system from operating, allowing the receiver to continue operating when the mike button is depressed. Other causes for loss of audio modulation are defective components between the mike input and modulator stage (coupling capacitors, resistors, microphone preamp stage, etc.), or the microphone itself could be defective.

Assuming the trouble occurs during the DC operation, connect the unit to a variable DC power supply having appropriate meters to read voltage and current. Switch it to the proper voltage range and turn the transceiver on. Notice the amount of current drain. If it's excessive, reduce the input power to a safe level. (Check the service literature to determine what the normal amount should be.) With the power off, disconnect one lead to the buffer capacitor(s) located across the secondary of the power transformer, and momentarily apply power again. If current drain is reduced appreciably, adjust the power-supply control until the rated voltage is applied and note the current reading. If normal, turn off the equipment and replace the defective buffer capacitor. (Make sure the replacement is of the correct value and voltage rating.) If two are used it would be wise to replace them both. Do not operate the equipment for any length of time with the buffer (s) disconnected. Other than tubes, a defective buffer capacitor is one of the most common vibrator power-supply troubles, second only to the vibrator itself.

If the buffer (s) are checked and found to be good, remove the vibrator and replace it with one known to be good. Turn on the power supply and again check the current drain. If it returns to normal, the original vibrator is defective. (The reason for checking the buffer capacitor first is that a new vibrator may otherwise be damaged.)

Occasionally you'll find that both the vibrator and buffer are bad. It's a good habit to always replace the buffer (s) when a new vibrator is installed. In fact, many manufacturers won't guarantee their vibrators unless the buffer is checked first.

The majority of equipment malfunctions will be due to tube defects. Open filaments can often be spotted by a quick visual inspection. Other tube defects can be readily located by direct substitution (the preferred method) and can usually be confirmed by a tube tester. Unlike most electronic equipment, many CB units will not work efficiently if one or more tubes fall even slightly on the weak side. Therefore, it will often be necessary to replace a tube that would ordinarily give much longer service in other types of equipment.

Incidentally, it should be pointed out that in some of the super-regenerative Class-B equipment, replacing a tube in a critical circuit can throw the frequency off far enough to require adjustment before the unit will operate properly.

Finding the Defective Stage and Component

After determining which section is defective, standard techniques can be applied to further localize the trouble. In the receiver section, for example, a signal generator can be used to inject a modulated signal at the grid and plate of each stage, working backward from the audio output to the antenna as shown in Fig. 6-10. First disconnect the antenna. Then, with the transceiver turned on, inject a signal at the grid of the output tube. If this stage is operating normally, a tone will be heard from the speaker. Next, apply the generator signal to the plate of the audio amplifier. The tone should become increasingly louder as each additional stage adds amplification. When you get to the input of the detector, switch the generator to the IF frequency, and to the RF frequency when you reach the grid of the converter. When you get ahead of the inoperative stage, the signal will no longer be heard. If you received a normal response at the input of the audio detector, but heard nothing at the grid of the second IF stage, the trouble lies somewhere between the grid of the

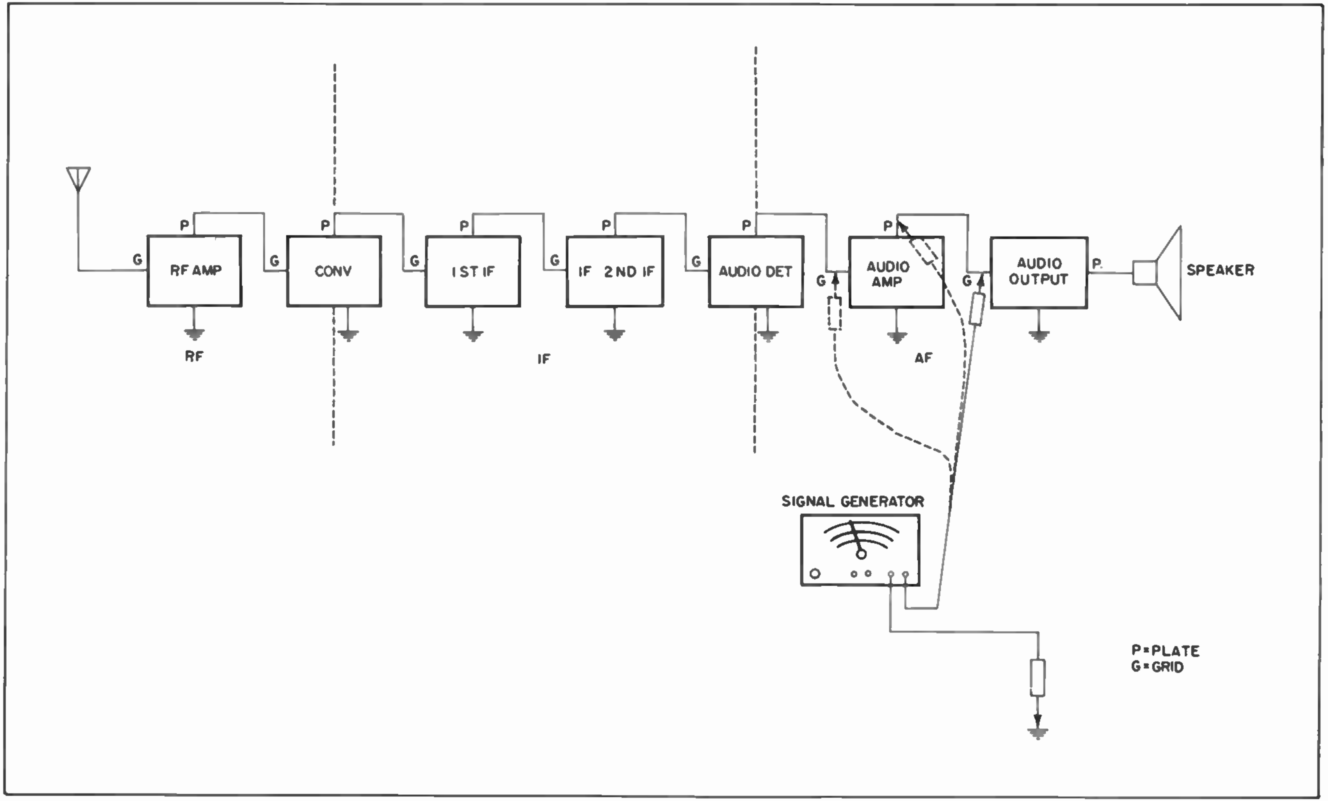


Fig. 6-10. Method of localizing a defective stage by signal injection.

second IF and the audio detector. With the aid of a schematic and a VOM, a few voltage and resistance measurements should reveal the defective component with little trouble.

A weak stage can also be located by this same method; however, when the defective stage is passed, the only indication will be a less-than-normal increase in gain. The converter stage normally produces little if any stage gain, so bear this in mind when you evaluate your findings.

The transmitter in the average Class-D transceiver usually consists of no more than three or four stages, two of which are part of the receiver circuit. This leaves only one or two more stages—namely the transmitter oscillator and the RF power output. Occasionally, the RF power-output stage is not used; on the other hand, an additional audio stage serving as a microphone preamp may be. There should be no trouble determining which stage of the transmitter is defective by using the process of elimination. Here again, the defective component in the suspected stage can be isolated by the use of standard voltage and resistance measurements.

Make a visual examination of the components in the defective stage. Often a charred or cracked resistor, or a blackened wire or burned spot on the chassis, will immediately indicate the faulty part. However, don't just replace a burned component; check further to determine why it burned. Your sense of smell can be of help, since most parts give off a rather unpleasant odor when they become overheated. Moreover, placing the tip of your finger on the body of a large wirewound resistor, which ordinarily should get very warm, will sometimes reveal an open resistor. Listening will often pay off as well. When the transceiver is turned on, listen for the buzz of the vibrator (in DC sets). If a jar is required to shock the vibrator into operation, the contacts are probably sticking and it should be replaced. Likewise, one that has a rough or erratic tone which changes pitch intermittently should also be replaced.

PREVENTIVE MAINTENANCE

Preventive maintenance can keep equipment from breaking down at inopportune times. By pulling the chassis out of the cabinet at least every six months and performing a few simple operations, you may save yourself or your customer future trouble.

To check the unit over completely, it must be fully accessible as shown in Fig. 6-11. Check all tubes and replace any that are weak, leaky, or shorted. Check the vibrator and make certain all crystals are plugged in tightly. Then check the relay contacts

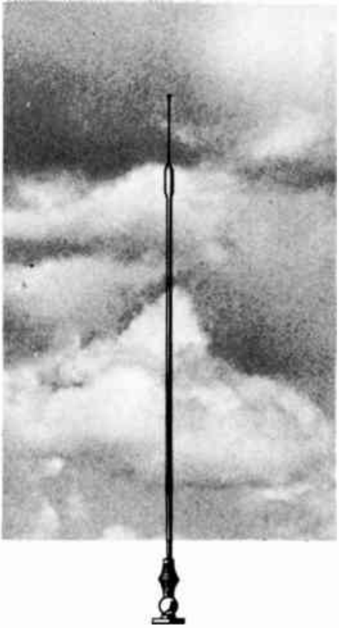
(Courtesy E. F. Johnson Co.)

Fig. 6-11. Transceiver chassis removed for servicing.

for wear. Clean them with carbon tet or other grease-dissolving solvent, and wipe them dry with a soft cloth. Rub a clean strip of paper between the contacts to burnish them. (Never use sandpaper, emery cloth, or other abrasive.) Brush all dirt and dust from the chassis. Finally, the transmitter output stage should be peaked for maximum efficiency. Any tests made with the dummy antenna disconnected should be kept as brief as possible.

7

Servicing Adjustments and Measurements



One of the most important parts of any service job is a check of the equipment's performance and adjustment of any circuit components for maximum efficiency. This is particularly true in low-powered CB equipment, where all of the available transmitter power and receiver sensitivity are needed.

A 5-watt plate input power to the final transmitter stage will generally produce an output of somewhere between 2 to 3.5 watts. A Class-D transceiver capable of delivering 3.5 watts of output power is operating at 70% efficiency, which is considered very good for this type of equipment. This output is determined primarily by the efficiency of the final stage and is affected to a large degree by associated circuit adjustments.

Periodic adjustments and frequency checks are therefore vital to proper operation, and should be made at least every six months during normal usage, every three months in commercial applications, and any other times deemed necessary or when repairs are made. No service job is complete without checking the transmitter frequency and the input and output power of the final stage, as well as making the necessary adjustments to provide a maximum transfer of power between the transmitter and the antenna, and a check of receiver operation. Some of these tests may have to be performed before or during a service job, but they should definitely be repeated as a final step after all repairs are completed. A simple thing like replacing a defective tube in the transmitter oscillator or RF power-output stage is sufficient reason for making frequency adjustments.

CHECKING TRANSMITTER OPERATION

Only persons who hold a first- or second-class radiotelephone license are permitted to make tests and adjustments that affect transmitter power and frequency. Before making any adjustments on the transmitter, remove the antenna lead and attach a dummy load in its place. A No. 47 pilot lamp, connected as shown in Chapter 6, is suitable for indicating that the transmitter is radiating energy and that modulation is taking place. However, a better impedance match will be obtained by connecting two 100-ohm, 2-watt resistors in parallel in place of the lamp. More effective dummy loads than either of these can also be purchased. Any adjustments or tests made without such a device should be kept as brief as possible. A simple field-strength meter (Fig. 7-1) is helpful in determining whether a transmitter is "putting out." It also provides an indication of carrier presence and field strength.

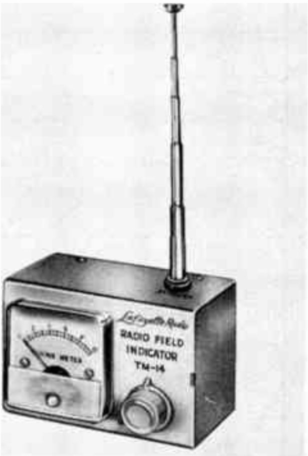


Fig. 7-1. Lafayette Model TM-14 field-strength indicator.

(Courtesy Lafayette Radio Electronics)

Operating Frequency

The most important, and surely the most frequent, measurement involves checking the transmitter frequency. Several instruments are available for this purpose; the accuracy of the type chosen will depend on the class of CB gear to be checked. The most critical, of course, are Class-A units which, except for mobile stations operating with an input power of 3 watts or less, are allowed a frequency tolerance of only .001 per cent. This calls for an extremely accurate frequency meter—one with an even closer tolerance. Class-C and -D stations, with a .005 per cent tolerance, are somewhat less critical; and Class-B stations are permitted variations of 0.3 and 0.5 per cent, depending on the plate power input. A frequency meter used to check Class-D equipment should be accurate within at least .0025 per cent.

One instrument commonly used for this purpose is the heterodyne frequency meter. With this device, a signal from a built-in tunable oscillator is heterodyned with the transmitter signal to obtain the measurement. Another commonly used meter indicates the difference between the frequency of the transmitter and a crystal-controlled reference frquency within the instrument.

A tolerance of .005 per cent means that a Class-D station operating on a frequency of 27.005 mc cannot deviate more than ±1,350 cycles per second. In other words, if the frequency checks between 27.00365 and 27.00635, it's within the legal limit.

Before checking the transmitter frequency, turn on both the transceiver and the frequency meter and allow them to reach operating temperature. (This will insure a more accurate reading.) If a heterodyne frequency meter is to be used, make sure it is properly calibrated and set up for the test as described in the instruction book. Then depress the mike button and adjust the dial of the meter to produce a zero beat with the transmitter signal. The transmitter frequency is then determined from the setting of the meter dial or from the calibration chart. Meter accuracy must also be taken into account when evaluating the reading. The meter itself should be accurate to a much higher degree than the tolerance of the frequency to be measured. Always let the transmitter operate a minute or two while measuring the frequency. Some crystal-oscillator circuits have been known to perform satisfactorily at first, only to jump off frequency after a minute or so of operation.

Fig. 7-2. The SECO Model 500A crystal test set.

(Courtesy SECO Electronics, Inc.)

Just because a crystal is guaranteed to be accurate within a specified tolerance does not mean it cannot operate off-frequency. Some crystals are designed to be used in a particular circuit, and will operate off frequency if placed in another. Likewise, an improperly adjusted circuit can cause the same trouble. The crystal may also have been tampered with; if so, it should be replaced. Crystals are assembled, sealed, and tested at the factory, and no attempt should be made to open them. If the operation of any crystal is questionable, replace it. Fig. 7-2 shows a test set that is designed especially for checking crystals of the fundamental and overtone types. In addition, it can serve as an RF voltmeter or wattmeter when used in conjunction with an accessory RF probe.

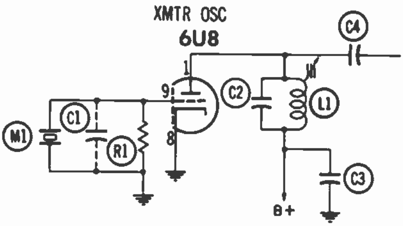


Fig. 7-3. Crystal-oscillator circuit.

Many crystals are designed to operate at their specified frequency when working into a capacitive load. The amount of this load has been standardized at 32 mmf, which may be a physical capacitor acting in combination with stray capacitance and the input capacitance of the oscillator tube, or it may consist of the latter combination alone. Fig. 7-3 shows a basic crystal-oscillator circuit that operates on the third mechanical overtone principle. The parallel-resonant circuit at the plate is tuned to the desired frequency. An overtone crystal designed to operate at anti-resonance into an unloaded grid circuit is used here. Capacitor C1, shown by the dotted lines, represents the stray circuit and the grid-to-cathode capacitance. Replacing this crystal with one of a different type could easily cause off-frequency operation. In circuits where a fixed capacitor is used across the crystal, you'll generally find it's less than 32 mmf. The value of this capacitor, however, in conjunction with stray and tube input capacitances, should add up to the needed 32-mmf load.

The oscillator circuit will usually have an adjustable trimmer capacitor across the crystal to provide a means of varying the capacitive load and subsequent frequency of the oscillator stage. In multichannel oscillators (containing more than one crystal), a trimmer may be placed across each crystal or a single trimmer may be used for all crystals. The operating frequency must be checked on each channel used. The frequency adjustment for the crystal (s) installed in the equipment is made at the factory; however, if additional crystals (even of the proper type) are added or one is replaced, the operating frequency of each channel should be rechecked.

In a fixed-tuned single-channel unit, all adjustments are made at only one frequency. In multichannel equipment, however, these adjustments are usually a compromise between the various channel frequencies; thus you'll generally find that all channels will not produce the same output. This compromise is best reached after checking and adjusting the operating frequency of the transmitter, by making the rest of the adjustments on a center channel frequency. In other words, if Class-D Channels 1, 2, and 3 are used, the transmitter adjustments should be made with the selector in the Channel-2 position.

To further guarantee legal operation, check the frequency while varying the source voltage both above and below the rated value. The frequency of a unit designed to operate at 115 volts should remain within legal limits at voltages ranging from 100 to 130 volts. Battery-operated sets should be checked from 5 to 7.5 volts for a 6-volt unit, and from 10 to 14 volts for 12-volt sets.

Power Input

Another important factor to consider when checking the transmitter is the amount of plate input power to the final stage. This stage may be the RF power amplifier, or the transmitter oscillator itself in equipment where the former circuit is not used. Naturally, full use should be made of the permitted 5 watts' input; however, this amount cannot be exceeded. Plate power input is computed by multiplying the plate voltage by the plate current. To obtain these figures, measure the DC plate voltage with a VOM. Then connect a milliammeter in *series* with the plate lead, and note the amount of current. Let's assume the plate voltage is 250 volts and the current is 20 milliamperes (or .02 ampere). Input power would then be exactly 5 watts—the legal limit.

Usually, transceivers rated at 5 watts will actually measure somewhere between 4 and 5. Less than 4 watts indicates something may be wrong. Other than misadjustment or improper impedance matching at the output, the most common causes are low source voltage or weak tubes. In this type of equipment, the tubes must operate at or near peak efficiency to obtain the rated output, and thus require replacement fairly often.

Modulation and RF Output

After installing a CB station, one of your first procedures involves checking to see that maximum power is being delivered to the antenna. A dummy load, consisting of a No. 47 pilot lamp connected across the antenna terminals, can be used to indicate the presence of RF energy. Speaking into the microphone will cause the brightness of the lamp to vary in accordance with the voice level if the transmitter carrier is being modulated.

Although power output can be indicated by a pilot light, an RF wattmeter with a 50-ohm impedance is more desirable. Two types of RF wattmeters are commonly used for this purpose. One not only measures the amount of RF power, but acts as the dummy load as well. Hence, it is referred to as a termination-type meter. The other type is connected between the transmitter and the dummy load (or the antenna) to indicate the amount of power being delivered.

(Courtesy SECO Electronics, Inc.)

Fig. 7-4. SECO Model 510B CB transmitter tester.

(Courtesy SECO Electronics, Inc.)

Fig. 7-5. SECO Model 520A antenna tester.

Fig. 7-4 shows a CB transmitter tester that can be used to measure either relative RF power output or modulation percentage. As an RF wattmeter it functions as one of the terminating-type instruments; the RF energy is dissipated in a six-watt 50-ohm resistive load. Modulation percentage is read directly from the lower scale on the meter, and either positive or negative peaks can be measured.

The antenna tester shown in Fig. 7-5 is another useful instrument. It has a meter with scales calibrated to read relative forward and reflected power in watts, SWR, and antenna system efficiency. This tester is connected in series with the coaxial line between the transmitter output and the antenna.

Fig. 7-6 shows an in-line, or series-type, RF meter used to check transmitter output. It provides relative indications of forward and reflected RF power, and has a scale calibrated directly in

SWR (standing wave ratio). This type of meter must be terminated with either an antenna or dummy load of the proper impedance. SWR readings provide an indication of the degree of impedance mismatch between the transmission line and the antenna. Instruments such as these may be left in the line indefinitely because they introduce only a negligible amount of insertion loss.

To adjust the transmitter circuit in Fig. 7-7 for maximum efficiency, an RF indicating instrument of the proper impedance must be connected at the RF output (antenna) terminal. Since several crystals are used, the selector should be set for the

Fig. 7-6. The Cesco "Transicheck" used for indicating RF power and SWR (standing wave ratio).

(Courtesy Continental Electronics and Sound Co.)

frequency nearest the middle. With the Transmit button depressed, C3 and C4 are adjusted for maximum meter indication. Because of a slight interaction between these two adjustments, they must be reset several times, or until no further increase in output is obtained. Next, L3 is adjusted for maximum output and best modulation. Operation is then tested by speaking into the microphone and noting the amount of variation on the meter. Also, the Transmit button is actuated several times to make sure the oscillator responds immediately. Quality of modulation is checked with another receiver. If the audio quality is poor, it may be necessary to readjust L3.

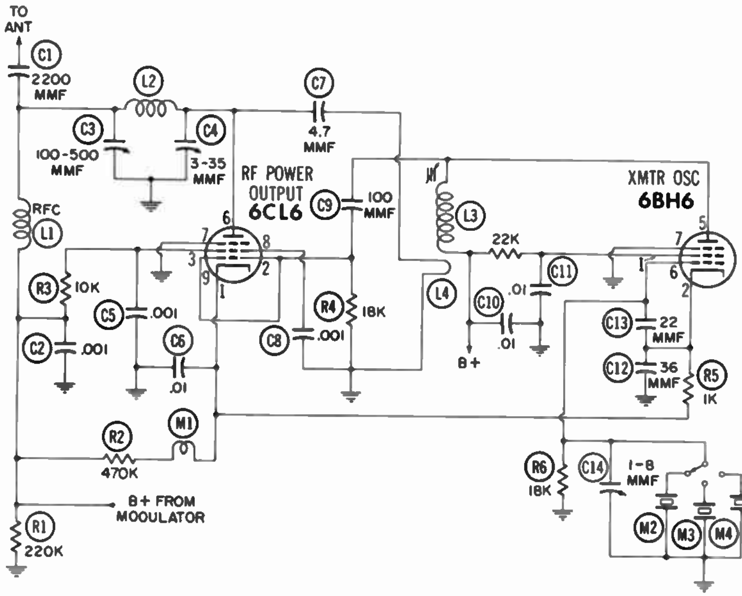


Fig. 7-7. RF section of a CB transmitter using a single trimmer capacitor for all three crystals.

All of the adjustments and procedures discussed here are generalized, since they will differ for various types of equipment. So, before attempting to adjust any transmitter, consult the service literature for the recommended procedure.

CHECKING RECEIVER OPERATION

One of the most important factors of receiver operation is sensitivity. No matter how efficiently the transmitter operates, the communication link is broken if the other party cannot be received.

Reduced sensitivity is a common trouble; however, it usually occurs at a gradual rate and often goes unnoticed. Two common causes are weak tubes and misaligned circuits. The latter may be brought about by an inexperienced person tampering with adjustments (as some will often do), or by vibration, excessive moisture, a gradual aging of components, and numerous other factors that make alignment necessary from time to time.

Receiver alignment will generally be no more difficult than for most standard AM broadcast receivers. Some of the simpler units will be even easier, and dual-conversion superhets will perhaps be a little more difficult because there are two IF frequencies to contend with.

8

Operating Procedure

The number of Citizens-band stations is increasing by the thousands each month. Such expansion can only mean that many of the CB channels will become quite crowded—especially those in the Class-D service. Thus, it is important that every operator become thoroughly familiar with the proper equipment usage—not only in accordance with FCC regulations, but also with courtesy and respect for others who must share the same channels. If each person would follow the correct procedures outlined within this chapter, much of the congestion caused by improper, lengthy, and unnecessary transmissions would be reduced to a minimum. This, of course, would benefit everyone.

HOW TO OPERATE CB EQUIPMENT

After receiving your station license, obtaining the desired CB equipment, and making the necessary installations, you are just about ready to begin operations. First of all, however, it is important that you have a basic understanding of how to operate the equipment.

One attractive feature of the Citizens-band transceiver is its simplicity of operation. Although there is a variety of Citizens-band equipment on the market, the number of basic operating controls varies only slightly from unit to unit. Some equipment, because of more elaborate circuits or special features, will have more controls than others. This does not mean the equipment with the most controls will permit longer-range communications, just as an automobile with accessories such as heater, windshield washer, and fog lights will not necessarily travel farther or faster than one without them.

Volume Control

The controls employed on the Class-D transceiver in Fig. 8-1 are typical of those found on the majority of transceivers in this class. The volume control is one of the basic controls used on all CB equipment. As the name implies, its purpose is to control the volume level—but only of the receiver output, not the output level of the transmitter as some would think. The RF power output of the transmitter is fixed; therefore, it is useless to turn the

(Courtesy Pearce-Simpson, Inc.)

Fig. 8-1. This Class-D transceiver, the Pearce-Simpson "Escort," has all of the desirable features including spot tuning and an S-meter.

volume control up when transmitting. On some equipment, the volume control may be a step-type arrangement —a rotary switch with three or more positions. The desired volume level is selected by switching to the position that most nearly meets the demand. This switch, however, cannot be set to obtain a level between these positions. The most popular control used in present-day CB equipment is the continuously-variable resistance type consisting simply of a potentiometer which adjusts the volume to any level within its range of rotation.

Power Switch

The on-off power switch on most CB equipment is mechanically affixed to the rear of the volume control and works in conjunction with it—just as on most radio or TV sets. Turning the control clockwise switches the unit on and increases the volume. Conversely, turning it counterclockwise reduces the volume and, at maximum rotation, actuates the switch that turns the unit off. Many CB units employ a pilot light to indicate when the equipment is on. Occasionally you may find a unit that has the power switch separate from the volume control. This will usually be a two-position toggle switch or one of the slide type.

Squelch Control

The squelch circuit is incorporated in practically all late-model Citizens-band equipment. This control adjusts a voltage that the incoming signal must overcome before the latter can be heard from the speaker. When the Squelch control is backed off, the speaker will reproduce the usual random background noise similar to that heard from the average broadcast receiver when tuned between two stations. When a signal of significant strength is received it will "override" much or all of this background noise. When the transmission ends, the background noise will again emanate from the speaker. By advancing the Squelch control to the point where the receiver is silenced, nothing will be heard from the speaker until a signal of sufficient strength is again received.

Any signal that lacks the strength to overcome the squelch will not be heard. This is just as well, since in most cases it would be unintelligible anyway. The further the Squelch control is advanced, the stronger the signal must be to reach the speaker.

As a general rule, the Squelch control should be adjusted to the point where the receiver is silenced and then just a bit further. In mobile CB operation, it will probably have to be adjusted slightly beyond this point; otherwise, noise pulses from power lines, neon lights, factory equipment, etc., may be of sufficient strength to "break" the squelch. As you become familiar with the equipment, you will be able to determine the proper setting with little difficulty.

Channel Selector

There are three basic types of CB equipment—fixed-tuned, tunable, and a combination of both. In all cases, the transmitter is fixed-tuned for immediate operation on one or more channels; however, the receiver may be fixed-tuned at one or more predetermined frequencies, or continuously tunable over a band of

(Courtesy Sonar Radio Corp.)

Fig. 8-2. The Sonar Model G is an 8-channel Class-D transceiver with a dual-conversion superhet receiver that can be crystal controlled or variably tuned. Other features include spot tuning and built-in S-meter.

frequencies. In some equipment the receiver is fixed-tuned for operation on several channels and also tunable across the entire band.

Fixed-Tuned—The frequency-selection control on the multichannel fixed-tuned transceiver is usually labeled "Channel." This control will probably be a rotary-type switch with letters or numbers designating the various positions. Some fixed-frequency equipment may have provision for only two channels, in which case a toggle, slide-type, or two-position rotary switch may be used. The single fixed-frequency unit, of course, will not have any frequency-switching control. The operating frequencies of the fixed-tuned multichannel units can be selected by turning the selector to the desired channel position. Furthermore, the frequency at any of the switch positions can be altered by changing the crystals within the equipment. Therefore, even a single-channel unit can be made to operate on other channels with little difficulty. For this reason, the selector positions are usually marked with arbitrarily selected letters or numbers rather than with the actual channels or frequencies. Some transceivers like the one in Fig. 8-2 have blank spaces provided next to each channel-selector position so that the user can indicate the corresponding frequency or channel number. The channel frequencies for the various positions depend on which crystals were provided by the manufacturer, and which crystals were added or changed after the unit was purchased.

Tunable—In this type of unit, the transmitter frequency is fixed but the receiver can be continuously tuned, usually over the entire band. This equipment, unlike the fixed-tuned, will have some type of dial indicating the relative setting for various frequencies (Fig. 8-3). The desired channel to be received is tuned in much the same manner as a regular broadcast receiver. This particular transceiver is actually one of the tunable/fixed-tuned types that can be operated either way.

(Courtesy GC Electronics Co.)

Fig. 8-3. The "Globe Master" 11-channel transceiver, featuring a crystal-controlled or variably-tuned dual-conversion receiver with squelch and noise limiter circuits plus spot tuning and a built-in S-meter.

Channel Selection

Several factors should be taken into consideration when selecting a CB channel for operation. As you know, Citizens-band frequencies are shared with other units in this service. Therefore, try to pick a channel that is not too crowded, and at the same time one that will afford the least interference. For example, the FCC does not guarantee Class-D operators any protection from interference due to the operation of industrial, scientific, and medical equipment most of which operates on the frequency of 27.120 mc. This frequency falls between Channels 13 and 14, so if you intend to use your equipment near hospitals or factories, it would be best to select a channel other than 13 or 14, and possibly not even 12 and 15 if the interference is too severe. The twenty-third channel used in Class-D operation is shared with Class C (for remote control of devices by radio) and other services, it may become quite congested and impractical to use in some localities.

The frequency chosen for operation will depend largely on the area where the equipment is to be used. A particular channel may be overcrowded in one area and practically unused in another. If in doubt as to which channels are best suited for your particular locality, ask some of the local CB operators.

In many areas certain channels have been set aside (by gentleman's agreement) as *calling* and *working* frequencies. The calling frequency is used solely for contacting other stations. After communication is established with the desired station, both then switch to one of the "working" channels to exchange messages. Marine stations, businesses, and other groups are likewise afforded a specific channel or channels in certain areas. The FCC regulations permit operation on channels 1 through 8 and 15 through 22 by CB stations operating under the same license. The other channels (9 through 14 and 23) may be used for communications between stations of the same or different licenses. In addition to the local calling and working frequencies, Channel 9 has arbitrarily been adopted as the national calling frequency.

Other Control Features

In addition to the basic controls previously mentioned, some transceivers have a switch that permits the automatic noise limiter, squelch, or AVC systems to be disabled. Other transceivers incorporate a signal spotting feature which enables the operator to accurately preset his receiver dial on the frequency in which he expects a reply. For example, if the operator of a transceiver having a tunable receiver wishes to call a station on 27.115 mc (Class-D Channel No. 13) and expects a reply on this same frequency, he merely has to set the transmit selector to the Channel 13 position and actuate the Spotting switch (this may either be a selector-type switch or a pushbutton). He may then "pinpoint" this frequency on the receiver by adjusting the tuning dial until a peak is indicated by the S-meter; other frequency spotting arrangements might require tuning for a zero beat. Without this feature inaccurate tuning could result in calls being missed. (Remember that by necessity a CB transceiver must tune quite "sharp" in order to separate stations.) To "spot" channels other than the one on which you wish to call, you merely set the transmit selector to the appropriate channel, "spot" it on the receiver dial, and then return the transmit selector to the desired operating channel before calling the other station.

Some transceivers also include a selective calling feature which accounts for at least one additional control, and there are several other controls or switches that will be found in some of the more sophisticated transceivers. It would not be practical, however, to go into a detailed discussion of these controls at this time since the primary concern here is with basic operating controls.

Operating the Microphone

There is a wide variety of microphones (discussed in Chapter 2) for use with Citizens-band equipment. Some employ push-to-talk buttons, and others depend instead on a pushbutton or switch (usually an automatic-return type) on the equipment itself.

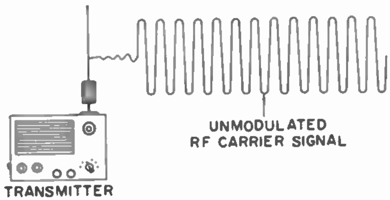
The push-to-talk button is pressed to activate the transmitter. At the same time the receiver is automatically "killed." Releasing it disables the transmitter and at the same time restores the receiver to normal operation. After depressing the push-to-talk switch, wait for an instant before speaking into the microphone. This allows the transmitter circuits to stabilize and thereby eliminates having to repeat the message because of a word missed at the beginning of the transmission. A simple practice such as this will help to alleviate much unnecessary traffic in the CB channels.

It was pointed out earlier that the power output of the transmitter is at a fixed level. This is the unmodulated RF carrier output in Fig. 8-4A. The voice spoken into the microphone produces an electrical equivalent of the sound waves (Fig. 8-4B). When fed into the transmitter, the voice signal is superimposed on the carrier signal as shown in Fig. 8-4C. This process is known as modulation.

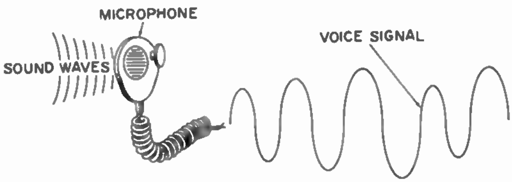
When the press-to-talk button is actuated, a signal is being transmitted even though no words are spoken into the microphone. An unmodulated carrier (Fig. 8-4A) is being radiated from the antenna. Not until you speak into the microphone, however, is it modulated.

To produce a good, clear signal at the receiver, the microphone must be held the proper distance from the mouth. Holding it too close will cause the voice to sound garbled or muffled, and too far away will produce a weak signal at the receiver. Best results will be obtained by holding it one to three inches from the mouth.

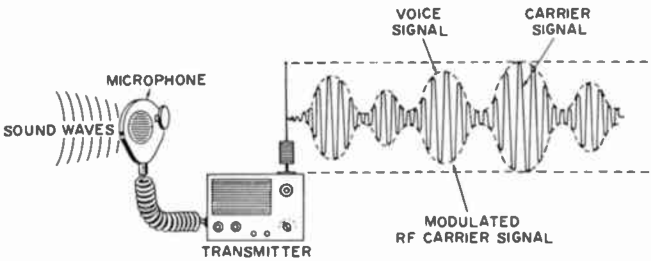
Occasionally, a whisp may be heard by the receiving station due to breath entering the microphone from close range. This situation



(A) The RF carrier.



(B) The audio signal.



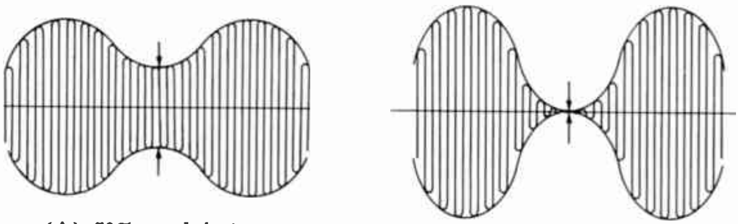
(C) The resultant modulated carrier.

Fig. 8-4. Producing an amplitude-modulated carrier.

can be relieved somewhat by holding the microphone farther away or by holding it at a 45-degree angle when speaking.

Even though the unmodulated RF carrier power of the transmitter is fixed, the level of the reproduced voice signal at the receiver will vary in accordance with the percentage of carrier modulation. The maximum modulation level allowed a CB station is 100 per cent. The percentage of modulation increases somewhat when one is speaking loudly into the microphone, and decreases when speaking softly. This does not mean, however, that you should yell into the microphone. True, the higher the percentage of modulation, the louder the received voice signal; nevertheless, there is a limit. Fig. 8-5 better illustrates the effect of modulation on the transmitter carrier. Fig. 3-5A shows an RF carrier modulated 50 per cent. This is the equivalent of speaking into the microphone in a moderate voice. Fig. 8-5B shows a carrier that has been modulated 100 per cent by a higher-level signal. Should the carrier be overmodulated (over 100 per cent), it would not only distort the voice signal, but also introduce harmonics which may extend outside the assigned frequency and interfere with other services.

Since higher-modulation percentages extend the transmitting range to some extent, it is desirable to operate close to the maximum limit. Most Citizens radio equipment is designed to operate near 100 per cent, but usually includes some type of self-limiting arrangement to prevent exceeding this amount.



(A) 50% modulation. (B) 100% modulation.

Fig. 8-5. Effect of modulation on the RF carrier.

STATION OPERATION

The FCC regulations discussed throughout this book were in effect at the time of publication; however, as the number of CB stations increases, revisions and extended control may become necessary. Indications at present point to an eventual strengthening of these regulations. Some of the changes proposed by the FCC will be discussed shortly.

The station licensee is solely responsible for the proper operation of his equipment. If he allows other persons to operate the station, he must assume full responsibility for their actions. Obtaining the license is relatively easy. However, you can lose your station authorization by operating contrary to FCC regulations. In fact, the FCC is currently imposing heavy fines on violators in addition to (or instead of) revoking the station license. To protect this privilege, you should become familiar with and operate according to the regulations governing proper operation. It is also necessary to review these regulations from time to time.

Permissible Communications

Citizens radio is intended to fulfill a definite need in connection with business or personal activities. It can be used for a personal convenience, such as establishing a means of communication between your automobile and home, or for practically any legitimate purpose. The applications are practically unlimited; however, transmitters should not be put on the air unless there is something that must be said. The CB channels are similar to a telephone party line and must be shared with other operators. Unnecessary transmissions serve only to cause congestion, thereby depriving others of needed channel space.

Many individuals are abusing the privilege granted them by operating their equipment in a manner contrary to good practice. Some are under the impression that Citizens radio can be used for experimentation or as a hobby, while others discuss sports, weather, or the mating habits of the South American tsetse fly. This is not the intended purpose of Citizens radio. Used properly, it can be a useful communications tool for everyone; abuse it and you may be denied its use.

A CB station may communicate with operators in any of the other CB classes except Class C. It, of course, is for control purposes only and may not employ radiotelephone emission. Perhaps you are wondering how communications are carried on between different classes, since they are separated by other bands. Actually you will be concerned with two types of operation—cross-channel and cross-band. Either is easily accomplished if you have the proper equipment. If the frequency of your transmitter and receiver can be changed separately, you can engage in cross-channel communications with other operators having similar equipment. For example, if the controls at one Class-D station are adjusted to transmit on Channel 10 and receive on Channel 14, communications can be established with another Class-D station which can transmit on Channel 14 and receive on Channel 10.

Cross-band transmission is practically the same, except for the receiver. Communication between Class-D and -A operators, for example, can be established if the Class-D operator has a Class-A receiver and the Class-A operator has a Class-D receiver. Inasmuch as each operator transmits only on the frequencies within the respective band for which he is licensed, no regulations are violated. The FCC is concerned only with transmitting frequencies.

Although channel and band jumping are permitted between CB stations, communications with operators of other services, including government and foreign stations, is prohibited. Some exceptions to this rule are made for operation during emergency situations (refer to Section 95.85 of the FCC rules and regulations in the Appendix).

In any case, transmissions should be made only when necessary, and even then should be limited to the minimum practical transmission time. A radiotelephone code used for some time by other services has been adopted by many CB operators because it greatly reduces the time required to transmit a message. (See Table 8-1.) The following sequence will demonstrate how effec-

Table 8-1. Radiotelephone Code.

Code No.	Meaning
10-1	Receiving poorly.
10-2	Receiving well.
10-3	Stand by.
10-4	O.K.
10-5	Relay message.
10-6	Busy at present.
10-7	Out of service.
10-8	In service.
10-9	Repeat.
10-10	Out of service—subject to call.
10-11	Transmitting too rapidly.
10-12	Officials or visitors present.
10-13	Advise weather and road conditions.
10-18	Complete assignment as quickly as possible.
10-19	Come to office.
10-20	Your location?
10-21	Call this station by phone.
10-22	Disregard.
10-30	Does not conform to rules and regulations.
10-33	Emergency traffic at this station.
10-36	Correct time?
10-42	Out of service at home.
10-45	Call ——————— by phone.
10-60	What is next message number?
10-64	Not clear.
10-71	Proceed with transmission in sequence.
10-84	What is your telephone number?
10-92	Your quality poor; transmitter apparently out of adjustment.
10-93	Frequencies to be checked.
10-94	Test intermittently with normal modulation for . . .
10-95	Test with no modulation.
10-99	Unable to receive your signals.

tively it simplifies messages and reduces the time required for transmission. First, here is how a typical message will sound without use of the code.

Station A: "This is KHA3653, unit 1 calling mobile unit 3. Over."
Station B: "This is mobile unit 3, KHA3653. Over."
Station A: "Come back to the office. Over."
Station B: "I can't right now, I'm busy checking a street-light installation. Over."
Station A: "Where are you now? Over."
Station B: "I'm at the corner of 10th and Main. Over."
Station A: "Get through with that job as soon as possible and then come to the office. OK? Over."
Station B: "All right, I am almost through here now. I'll be there shortly. This is KHA3653, mobile unit 3—over and out."
Station A: "This is KHA3653, unit 1—over and out."

This conversation is typical of thousands transmitted every day on the Citizens band. Now let's see how the same message would sound using the radiotelephone code in Table 8-1.

Station A: "This is KHA3653, unit 1, calling mobile unit 3. Over."
Station B: "This is mobile unit 3, KHA3653. Over."
Station A: "10-19."
Station B: "10-6."
Station A: "10-20."
Station B: "Corner of 10th and Main."
Station A: "10-18, 10-19, 10-4?"
Station B: "10-4. Mobile unit 3, KHA3653—over and out."
Station A: "KHA3653, unit 1—over and out."

Obviously the same basic information was transmitted with this method, but in much less time. It is desirable to use code to some extent, especially in a business that requires heavy traffic such as dispatching delivery trucks, taxis, etc.

Improper Operation

Improper station operation can be classified into one of two categories—accidental and willful. Possibly a third category could be added to include those who have not taken the time to learn the rules, or who have been misinformed somewhere along the line. In any event, there is an increasing number of violations occurring in all categories.

The FCC operates a number of monitoring stations twenty-four hours a day. These stations are manned by engineers who, with the help of the most modern and efficient radio receivers and tracking devices, scan the frequency spectrum for violations committed in any of the radio services. A recent FCC report indicates that a large number of violations are occurring in the Citizens Radio Service. These violations fall mainly into two large groups—off-frequency operation and the use of CB stations for communications contrary to Part 95 of the FCC rules and regulations.

Off-frequency operation can be the result of an inexperienced or unqualified person tampering with the transmitter, or the equipment may have become defective or is badly in need of frequency adjustment. How often the frequency of a transmitter should be checked will depend on a number of factors. Some units require daily frequency checks, whereas others may not require it for months. The best safeguard against off-frequency operation is periodic checks by a qualified person having the proper equipment and skill.

Another common mistaken belief is that Citizens radio can be used in the same manner as ham radio. This has been especially noticeable in the Class-D service. Perhaps the reason is that Class-D frequencies occupy a space formerly allocated to the 11-meter amateur band. Some who desired to become a ham operator, but for some reason could not make the grade, have resorted to Citizens radio, feeling that it can be used in the same manner. Occasionally an amateur-radio operator, who feels the loss of the 11-meter band unjust, has entered the CB ranks for the purpose of continuing ham-style operation in this band. Fortunately, such cases are in the minority.

Such practices as calling *CQ* (any station answer) to establish contacts with unknown operators is contrary to proper operating practices. This would be permissible only in an emergency where it was imperative that a unit within the area be contacted. In general operation, however, all calls should be directed to the specific station or stations controlled by the license. Contacts with those outside this network should be made only by prearrangement or in an emergency. This is done to discourage activities such as DXing (attempting to communicate with other stations solely for the purpose of achieving maximum distance), seeing how many contacts can be made with other stations, or to just plain reduce the temptation for casual visiting and "rag chewing" on the air. Another improper operating practice that has become quite a problem is excessive on-the-air testing. It should be kept to a minimum because it only adds to the channel congestion.

Citizens-band equipment cannot be used for any purpose contrary to federal, state, and local laws. The meaning of this should be apparent—obviously you cannot use CB equipment to aid in a break-in, bank robbery, or any other crime. Moreover, you cannot use Citizens-band equipment for conveying any type of program material (music, broadcasting, etc.) either directly or indirectly (see Article 95.83(a) of the FCC rules in the Appendix). Also, while it is permissible for the licensee to allow other persons to use the equipment, he cannot charge a fee for this service except in the cases outlined in 95.87.

The licensee, unless possessing a valid first- or second-class Commercial Radiotelephone Operator's License, is not permitted to make any adjustments, repairs, or modifications that could cause improper transmission of RF energy. The foregoing can be performed only under direct supervision of a person holding such a license. Occasionally, an individual will attempt a modification to "soup up" the transmitter. This can lead to nothing but trouble. Furthermore, any proposed changes that affect the terms of the current license require prior approval from the FCC.

Other on-the-air practices that are strictly forbidden include the use of false call letters, and any type of profane, indecent, or obscene language. The FCC monitoring stations are very effective in tracking down persons operating equipment contrary to any of the rules and regulations governing this service, and a violation may result in a written citation. A reply to this citation must be made in the manner prescribed in Article 95.113 of the FCC regulations. A continuance of such operation can result in a fine and/or revocation of the station license and loss of all operating privileges.

Operating Requirements

Citizens radio equipment operated at a fixed location must have a current license permanently posted at the key point of control for such operation. Furthermore, a photocopy of this license must be posted at all other fixed locations from which the station is controlled (see Article 95.101 of the FCC regulations in the Appendix).

The serial number on each citizens radio station license serves as the call letters for the station. The complete assigned call letters of the CB station must be given (in English) at the beginning and end of all communications. Only standard nationally or internationally recognized phonetic alphabets can be used in place of the letters in the call sign.

All communications or signals must be restricted to the minimum practical transmission time. In any case, the transmission between different stations can not exceed 5 minutes during normal operation. At the conclusion of the 5 minute period or at the termination of an exchange lasting for a shorter period, 5 minutes of silence must be observed before any further transmissions can be made. All channels concerned must then be monitored before communications are resumed. Stations used only for radio control (Class C) need not identify their transmissions unless specifically requested by the FCC.

Should normal communications be inadequate or be disrupted during an earthquake, hurricane, flood, or similar disaster, CB equipment in any class can be operated on an emergency basis in compliance with the provisions stated in Article 95.85 governing permissible communications. However, as soon as possible after such emergency operation begins, a notice must be sent to either the FCC in Washington, D.C., or to the Engineer-in-Charge of the nearest field office, stating how the equipment is being used and what type of emergency exists. As soon as normal communicating facilities are restored, such operation must be discontinued and the FCC notified that special operations have ceased. Discontinuance of special operations may be ordered by the FCC at any time.

NEW REGULATIONS

In policing the Citizens bands (particularly the Class-D service) the FCC monitoring stations are uncovering violations by the thousands. This, of course, has resulted in increased regulation of this service and stricter enforcement of the Part 95 of the *FCC Rules and Regulations.* These regulations are altered and amended from time to time as the need arises and it appears that this need is becoming much more frequent. One approach to the increasing number of violations is to impose heavy fines on violators, and this has been done in a number of instances. The most drastic step, however, lies in the recent set of rules adopted by the commission. They limit not only the amount of RF power applied to the antenna terminals, but also the communicating range of CB stations. It is now illegal to communicate with another station more than 150 miles away even though conditions permit. Another rule (see 95.83) prohibits on-the-air discussion of many subjects. The recent regulations also limit communications between Class-D stations of different licenses to Channels 9, 10, 11, 12, 13, 14, and 23.

These new rules, which are included in the appendix of this book add many restrictions to citizens band operation. They are not designed to limit the usefulness of CB radio, but instead are intended to discourage improper operation and make CB radio serve the purpose for which it is intended—that of providing short-distance personal and business radiocommunications.

APPENDIX I

FCC Rules and Regulations

In filing an application for a Citizens-band station license (Form 505), you must certify that you have a current copy of the FCC *Rules and Regulations*, Part 95. For your convenience, Part 95 has been included in this Appendix. Although the Rules and Regulations reproduced here are current and include all changes scheduled to take effect January 3, 1966, they are subject to amendment and thus may or may not fulfill the requirements of FCC Form 505 at a later date.

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SUBPART A—GENERAL

§ 95.1 Basis and Purpose.

The rules and regulations set forth in this part are issued pursuant to the provisions of Title III of the Communications Act of 1934, as amended, which vests authority in the Federal Communications Commission to regulate radio transmissions and to issue licenses for radio stations. These rules are designed to provide for private short-distance radiocommunications service for the business or personal activities of licensees, for radio signalling, for the control of remote objects or devices by means of radio; all to the extent that these uses are not specifically prohibited in this part. They also provide for procedures whereby manufacturers of radio equipment to be used or operated in the Citizens Radio Service may obtain type acceptance and/or type approval of such equipment as may be appropriate.

§ 95.3 Definitions.

For the purpose of this part, the following definitions shall be applicable. For other definitions, refer to Part 2 of this chapter.

(a) Definitions of services.

Citizens Radio Service. A radio communications service of fixed, land, and mobile stations intended for short-distance personal or business radiocommunication, radio signalling, and control of remote objects or devices by radio; all to the extent that these uses are not specifically prohibited in this part.

Fixed service. A service of radiocommunication between specified fixed points.

Mobile service. A service of radiocommunication between mobile and land stations or between mobile stations.

(b) Definitions of stations.

Base station. A land station in the land mobile service carrying on a service with land mobile stations.

Class A station. A station in the Citizens Radio Service licensed to be operated on an assigned frequency in the 460-470 Mc band and with input power of 60 watts or less.

Class B station. A station in the Citizens Radio Service licensed to be operated on an authorized frequency in the 460-470 Mc band and with input power of 5 watts or less.

Class C station. A station in the Citizens Radio Service licensed to be operated on an authorized frequency in the 26.96-27.23 Mc band, or on the frequency 27.255 Mc, for the control of remote objects or devices by radio, or for the rémote acutation of devices which are used solely as a means of attracting attention.

Class D station. A station in the Citizens Radio Service licensed to be operated on an authorized frequency in the 26.96-27.23 Mc band, or on the frequency 27.255 Mc, with input power of 5 watts or less, and for radiotelephony only.

Fixed station. A station in the fixed service.

Land station. A station in the mobile service not intended for operation while in motion. (Of the various types of land stations, only the base station is pertinent to this part.)

Mobile station. A station in the mobile service intended to be used while in motion or during halts at unspecified points. (For the purposes of this part, the term includes hand-carried and pack-carried units.)

(c) Miscellaneous definitions.

Antenna structure. The term "antenna structure" includes the radiating system, its supporting structures, and any surmounting appurtenances.

Assigned frequency. The frequency appearing on a station authorization from which the carrier frequency may deviate by an amount not to exceed that permitted by the frequency tolerance.

Authorized bandwidth. The maximum width of the band of frequencies, as specified in the authorization, to be occupied by an emission.

Bandwidth occupied by an emission. The band of frequencies comprising 99 percent of the total radiated power extended to include any discrete frequency on which the power is at least 0.25% of the total radiated power.

Control point. A control point is an operating position which is under the control and supervision of the licensee, at which a person immediately responsible for the proper operation of the transmitter is stationed, and at which adequate means are available to aurally monitor all transmissions and to render the transmitter inoperative.

Dispatch point. A dispatch point is any position from which messages may be transmitted under the supervision of the person at a control point.

Harmful interference. Any emission, radiation or any induction which endangers the functioning of a radionavigation service or other safety service, seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with applicable laws, treaties, and regulations.

Landing area. A landing area means any locality, either of land or water, including airports and intermediate landing fields, which is used or approved for use for the landing and take-off of aircraft, whether or not facilities are provided for the shelter, servicing, or repair of aircraft, or for receiving or discharging passengers or cargo.

Man-made stucture. Any construction other than a tower, mast or pole.

Person. The term "person" includes an individual, partnership, association, joint-stock company, trust or corporation.

Remote control. The term "remote control" when applied to the use or operation of a citizens radio station means control of the transmitting equipment of that station from any place other than the location of the transmitting equipment, except that direct mechanical control or direct electrical control by wired connections of transmitting equipment from some other point on the same premises, craft or vehicle shall not be considered to be remote control.

Station authorization. Any construction permit, license, or special temporary authorization issued by the Commission.

§ 95.5 Policy Governing the Assignment of Frequencies.

(a) The frequencies which may be assigned to Class A stations in the Citizens Radio Service, and the frequencies which are available for use by Class B, Class C, or Class D stations, are listed in Subpart C of this part. Each frequency available for assignment to, or use by, stations in this service is available on a shared basis only, and will not be assigned for the exclusive use of any one applicant; however, the use of a particular frequency may be restricted to (or in) one or more specified geographical areas.

(b) In no case will more than one frequency be assigned to Class A stations for the use of a single applicant in any given area until it has been demonstrated conclusively to the Commission that the assignment of an additional frequency is essential to the operation proposed.

(c) All applicants and licensees in this service shall cooperate in the selection and use of the frequencies assigned or authorized, in order to minimize interference and thereby obtain the most effective use of the authorized facilities.

§ 95.6 Types of Operation Authorized.

(a) Class A stations may be authoried as mobile stations, as base stations, as fixed stations, or as base or fixed stations to be operated at unspecified or temporary locations.

(b) Class B, Class C, and Class D stations are authorized as mobile stations only; however, they may be operated at fixed locations in accordance with other provisions of this part.

§ 95.7 General Citizenship Restrictions.

A station license may not be granted to or held by:

(a) Any alien or the representative of any alien;

(b) Any foreign government or the representative thereof;

(c) Any corporation organized under the laws of any foreign government;

(d) Any corporation of which any officer or director is an alien;

(e) Any corporation of which more than one-fifth of the capital stock is owned of record or voted by: Aliens or their representatives; a foreign government or representative thereof; or any corporation organized under the laws of a foreign country;

(f) Any corporation directly or indirectly controlled by any other corporation of which any officer or more than one-fourth of the directors are aliens, if the Commission finds that the public interest will be served by the refusal or revocation of such license; or

(g) Any corporation directly or indirectly controlled by any other corporation of which more than one-fourth of the capital stock is owned of record or voted by: Aliens or their representatives; a foreign government or representatives thereof; or any corporation organized under the laws of a foreign government, if the Commission finds that the public interest will be served by the refusal or revocation of such license.

SUBPART B—APPLICATIONS AND LICENSES

§ 95.11 Station Authorization Required.

No radio station shall be operated in the Citizens Radio Service except under and in accordance with an authorization granted by the Federal Communications Commission.

§ 95.13 Eligibility for Station License.

(a) Subject to the general restrictions of § 95.7, any person, other than an unincorporated association in the case of a Class D station, is eligible to hold authorization to operate a station in the

Citizens Radio Service: *Provided*, That if an applicant for a Class A, Class B, or Class D station authorization is an individual or partnership, such individual or each partner is eighteen or more years of age; or if the applicant for a Class C station authorization is an individual or partnership, such individual or each partner is twelve or more years of age.

NOTE: While the basis of eligibility in this service includes any state, territorial, or local governmental entity, or any agency operating by the authority of such governmental entity, including any duly authorized state, territorial, or local civil defense agency, it should be noted that the frequencies available to stations in this service are shared without distinction between all licensees and that no protection is afforded to the communications of any station in this service from interference which may be caused by the authorized operation of other licensed stations.

(b) Notwithstanding the provisions of paragraph (a) of this section, an unincorporated association may be authorized to operate a Class D station in this service upon a showing satisfactory to the Commission that the proposed radio operations are not feasible, or may not be as efficient or economical, when conducted under station licenses issued to the individual members. A station license shall not be issued to an unincorporated association solely to avoid the operating restrictions on communications between stations licensed to different persons, contained elsewhere in this part. Unincorporated associations which hold Class D station licenses in this service as of November 1, 1964, must make the showing required by this paragraph upon application for renewal and/or modification of license. An unincorporated association, when licensed under the provisions of this paragraph, may upon specific prior approval of the Commission provide radiocommunications for its members.

(c) No person shall hold more than one Class B, one Class C, and one Class D station license.

§ 95.15 Filing of Applications.

(a) To assure that necessary information is supplied in a consistent manner by all persons, standard forms are prescribed for use in connection with the majority of applications and reports submitted for Commission consideration. Standard numbered forms applicable to the Citizens Radio Service are discussed in § 95.19 and may be obtained from the Washington, D.C. 20554, office of the Commission, or from any of its engineering field offices.

(b) All formal applications for Class B, Class C, or Class D station authorizations shall be submitted to the Commission's office at 334 York Street, Gettysburg, Pennsylvania 17325. Applications for Class A station authorizations, requests for special temporary authority or other special requests, and correspondence relating to an application for any class citizens radio station authorization shall be submitted to the Commission's office at Washington, D.C. 20554, and should be directed to the attention of the Secretary. Applications involving Class C or Class D station equipment which is neither type approved nor crystal controlled, whether of commercial or home construction, shall be accompanied by supplemental data describing in detail the design and construction of the transmitter and methods employed in testing it to determine compliance with the technical requirements set forth in Subpart C of this part.

(c) Unless otherwise specified, an application shall be filed at least sixty days prior to the date on which it is desired that Commission action thereon be completed. In any case where the applicant has made timely and sufficient application for renewal of license, in accordance with the Commission's rules, no license with reference to any activity of a continuing nature shall expire until such application shall have been finally determined.

(d) Failure on the part of the applicant to provide all the information required by the application form, or to supply the necessary exhibits or supplementary statements may constitute a defect in the application.

§ 95.17 Who May Sign Applications.

(a) Except as provided in paragraph (b) of this section, applications, amendments thereto, and related statements of fact required by the Commission shall be personally signed by the applicant, if the applicant is an individual; by one of the partners, if the applicant is a partnership; by an officer, if the applicant is a corporation; or by a member who is an officer, if the applicant is an unincorporated association. Applications, amendments, and related statements of fact filed on behalf of eligible government entities, such as states and territories of the United States and political subdivisions thereof, the District of Columbia, and units of local government, including incorporated municipalities, shall be signed by such duly elected or appointed officials as may be competent to do so under the laws of the applicable jurisdiction.

(b) Applications, amendments thereto, and related statements of fact required by the Commission may be signed by the applicant's attorney in case of the applicant's physical disability or of his absence from the United States. The attorney shall in that event separately set forth the reason why the application is not signed by the applicant. In addition, if any matter is stated on the basis of the attorney's belief only (rather than his knowledge), he shall separately set forth his reasons for believing that such statements are true.

(c) Only the original of applications, amendments, or related statements of fact need be signed; copies may be conformed.

(d) Applications, amendments, and related statements of fact need not be signed under oath. Willful false statements made therein, however, are punishable by fine and imprisonment, U.S. Code, Title 18, section 1001, and by appropriate administrative sanctions, including revocation of station license pursuant to section 312(a)(1) of the Communications Act of 1934, as amended.

§ 95.19 Standard Forms To Be Used.

(a) *FCC Form 505, Application for Class B, C, or D Station License in the Citizens Radio Service.* This form shall be used when:

(1) Application is made for a new Class B, Class C, Class D station authorization for any required number of transmitters to be operated as a group in a single radiocommunication system in a particular area. A separate application shall be submitted for each proposed class of station.

(2) Application is made for modification of any existing Class B, Class C, or Class D station authorization in those cases where prior Commission approval of certain changes is required (see § 95.35).

(3) Application is made for renewal of an existing Class B, Class C, or Class D station authorization, or for reinstatement of such an expired authorization.

(4) Application is made for consent to transfer of control of a corporation holding a Class B, Class C, or Class D station authorization.

(b) *FCC Form 400, Application for Radio Station Authorization in the Safety and Special Radio Services.* This form shall be used when:

(1) Application is made for a new Class A base station or fixed station authorization. Separate applications shall be submitted for each proposed base or fixed station at different fixed locations; however, all equipment intended to be operated at a single fixed location is considered to be one station which may, if necessary, be classed as both a base station and a fixed station.

(2) Application is made for a new Class A station authorization for any required number of mobile units (including hand-carried and pack-carried units) to be operated as a group in a single radiocommunication system in a particular area. An application for Class A mobile station authorization may be combined with the application for a single Class A base station authorization when such mobile units are to be operated with that base station only.

(3) Application is made for station license of any Class A base station or fixed station upon completion of construction or installation in accordance with the terms and conditions set forth in any construction permit required to be issued for that station, or application for extension of time within which to construct such a station.

(4) Application is made for modification of any existing Class A station authorization in those cases where prior Commission approval of certain changes is required (see §95.35).

(5) Application is made for renewal of an existing Class A station authorization, or for reinstatement of such an expired authorization.

(6) Application is made for consent to transfer control of a corporation holding a Class A station authorization.

(7) Application is made for an authorization for a new Class A base or fixed station to be operated at unspecified or temporary locations. When one or more individual transmitters are each intended to be operated as a base station or as a fixed station at unspecified or temporary locations for indeterminate periods, such transmitters may be considered to comprise a single station intended to be operated at temporary locations. The application shall specify the general geographic area within which the operation will be confined. Sufficient data must be submitted to show the need for the proposed area of operation.

§ 95.25. Amendment or Dismissal of Application.

(a) Any application may be amended upon request of the applicant as a matter of right prior to the time the application is granted or designated for hearing. Each amendment to an application shall be signed and submitted in the same manner and with the same number of copies as required for the original application.

(b) Any application may, upon written request signed by the applicant or his attorney, be dismissed without prejudice as a matter of right prior to the time the application is granted or designated for hearing.

§ 95.27 Transfer of License Prohibited.

A station authorization in the Citizens Radio Service may not be transferred or assigned. In lieu of such transfer or assignment, an application for new station authorization shall be filed in each case, and the previous authorization shall be forwarded to the Commission for cancellation.

§ 95.29 **Defective Applications.**

(a) If an applicant is requested by the Commission to file any documents or information not included in the prescribed application form, a failure to comply with such request will constitute a defect in the application.

(b) When an application is considered to be incomplete or defective, such application will be returned to the applicant, unless the Commission many otherwise direct. The reason for return of the applications will be indicated, and if appropriate, necessary additions or corrections will be suggested.

§ 95.31 **Partial Grant.**

Where the Commission, without a hearing, grants an application in part, or with any privileges, terms, or conditions other than those requested, the action of the Commission shall be considered as a grant of such application unless the applicant shall, within 30 days from the date on which such grant is made, or from its effective date if a later date is specified, file with the Commission a written rejection of the grant as made. Upon receipt of such rejection, the Commission will vacate its original action upon the application and, if appropriate, set the application for hearing.

§ 95.33 **License Period.**

Unless otherwise stated in the authorization, licenses for all stations in the Citizens Radio Service will normally be issued for a term of five years from the date of original issuance, renewal, or modification.

§ 95.35 **Changes in Authorized Stations.**

Authority for certain changes in authorized stations must be obtained from the Commission before the changes are made, while other changes do not require prior Commission approval. The following paragraphs of this section describe the conditions under which prior Commission approval is or is not necessary.

(a) Proposed changes which will result in operation inconsistent with any of the terms of the current authorization require that an application for modification of license be submitted to the Commission. Application for modification shall be submitted in the same manner as an application for a new station license, and the licensee shall forward his existing authorization to the Commission for cancellation immediately upon receipt of the superseding authorization. Any of the following changes to the authorized stations may be made only upon approval by the Commission:

(1) Increase the overall number of transmitters authorized.

(2) Change the presently authorized location of a Class A fixed or base station or control point.

(3) Move, change the height of, or erect a Class A station antenna structure of the type which requires prior approval from the Commission as set forth in § 95.37.

(4) Make any change in the type of emission or any increase in bandwidth of emission or power of a Class A station.

(5) Addition or deletion of control point(s) for an authorized transmitter of a Class A station.

(6) Change or increase the area of operation of a Class A mobile station or a Class A base or fixed station authorized to be operated at temporary locations.

(7) Change the operating frequency of a Class A station.

(b) The operation of any station in this service shall be discontinued upon a change in the permanent mailing address of the station licensee unless, within 30 days before or after such change and prior to commencement of operation, notice of such change has been furnished the engineer(s) in charge of the radio district(s) in which both the former and the new permanent mailing addresses are located and an application for modification of the station license has been filed with the Commission. Upon compliance with these conditions the station may be operated until a final determination has been made by the Commission with respect to such application for modification. These provisions do not authorize a change in the location of a Class A base or fixed station, or the control point of a Class A station, without prior approval of the Commission.

(c) Proposed changes which will not depart from any of the terms of the outstanding authorization for the station involved may be made without prior Commission approval. Included in such changes is the substitution of various makes of transmitting equipment at any station, provided that the particular equipment to be installed is included in the Commission's "Radio Equipment List, Part C" and listed as acceptable for use under the technical standards governing such use under this part or, in the case of a Class C or Class D station using crystal control, the substitute equipment is crystal controlled; and further provided the substitute equipment employs the same type of emission and does not exceed the frequency tolerance and power limitations prescribed for the particular class of station involved.

§ 95.37 Limitation on Antenna Structures.

(a) No new antenna or antenna structures shall be erected for use by any Class A station licensed or proposed to be licensed in this service, and no change shall be made in any existing antenna or antenna structures for use or intended to be used by any Class A station licensed or proposed to be licensed in this service so as to increase its overall height above ground level, without prior approval from the Commission in any case when either:

(1) The antenna structures proposed to be erected will exceed an overall height of 170 feet above ground level, except where the antenna is mounted on top of an existing man-made structure, other than an antenna structure, and does not increase the overall height of such man-made structure by more than 20 feet; or

(2) The antenna structures proposed to be erected will exceed an overall height of one foot above the established airport (landing area) elevation for each 200 feet of distance or fraction thereof from the nearest boundary of such landing area except where the antenna does not exceed 20 feet above the ground or where the antenna is mounted on top of an existing man-made structure, other than an antenna structure, or natural formation and does not increase the overall height of such man-made structure or natural formation by more than 20 feet. Application for Commission approval, if required, shall be submitted on FCC Form 400.

(b) [Reserved]

(c) A Class B, Class C or Class D station operated at a fixed location shall employ a transmitting antenna which complies with at least one of the following:

(1) The antenna and its supporting structure does not exceed 20 feet in height above ground level; or

(2) The antenna and its supporting structure does not exceed by more than 20 feet the height of any natural formation, tree or man-made structure on which it is mounted; or

(3) The antenna is mounted on the transmitting antenna structure of another authorized radio station and does not exceed the height of the antenna supporting structure of the other station; or

(4) The antenna is mounted on and does not exceed the height of an antenna structure otherwise used solely for receiving purposes, which structure itself complies with subparagraph (1) or (2) of this paragraph.

NOTE: A man-made structure is any construction other than a tower, mast or pole.

SUBPART C—TECHNICAL REGULATIONS

§ 95.41 Frequencies Available.

(a) The following frequencies are available for assignment to

Class A base, mobile, or fixed stations, on a shared basis with other stations in the Citizens Radio Service:

Mc	*Mc*	*Mc*	*Mc*
462.55	463.15	465.30	465.90
462.60	463.20	465.35	465.95
462.65	464.75	465.40	466.00
462.70	464.80	465.45	466.05
462.75	464.85	465.50	466.10
462.80	464.90	465.55	466.15
462.85	464.95	465.60	466.20
462.90	465.05	465.65	466.25
462.95	465.10	465.70	466.30
463.00	465.15	465.75	466.35
463.05	465.20	465.80	466.40
463.10	465.25	465.85	466.45

(b) The frequency 465.00 Mc is available for use by Class B mobile stations under the conditions specified in §§ 95.45, 95.47, and 95.49 on a shared basis with other stations in the Citizens Radio Service. In addition, a Class B mobile station employing equipment which has been type accepted for use by Class A citizens radio stations, is authorized to be operated on any of the frequencies listed in paragraph (a) of this section.

(c) The following frequencies are available for use by Class C mobile stations when employing amplitude tone modulation or on-off keying of the unmodulated carrier for the control of remote objects or devices by radio, or for the remote actuation of devices which are used solely as a means of attracting attention, on a shared basis with other stations in the Citizens Radio Service, subject to no protection from interference due to the operation of industrial, scientific, or medical devices within the 26.96-27.28 Mc band.

Mc	*Mc*	*Mc*
26.995	27.095	27.195
27.045	27.145	[1] 27.255

[1] The frequency 27.255 Mc is shared with stations in other services.

(d) The frequencies listed in the following tables are available for use by Class D mobile stations employing radiotelephony only, on a shared basis with other stations in the Citizens Radio Service, and subject to no protection from interference due to the operation of industrial, scientific, or medical devices within the 26.96-27.28 Mc band.

(1) The following frequencies, commonly known as channels 1 through 23, may be used for communications between units of the same station:

Mc	*Mc*	*Mc*	*Mc*
26.965	27.035	27.115	27.185
26.975	27.055	27.125	27.205
26.985	27.065	27.135	27.215
27.005	27.075	27.155	27.225
27.015	27.085	27.165	27.255 [1]
27.025	27.105	27.175	

[1] The frequency 27.255 Mc is also shared with stations in other services.

(2) Only the following frequencies may be used for communication between units of different stations:

Mc	*Channel*
27.065	9
27.075	10
27.085	11
27.105	12
27.115	13
27.125	14
27.255	23

(e) Upon specific request accompanying application for renewal of station authorization, a Class A station in this service, which prior to March 31, 1965 operated on a frequency in the 460-461 Mc band, may be assigned that frequency for continued use until not later than March 31, 1966, subject to all other provisions of this part.

§ 95.43 Station Power.

Neither the average power input to the plate or collector circuit or circuits which contribute radio frequency energy to the radiating system nor the average radio frequency power supplied to the radiating system of a station operating in this service shall exceed the following maximum values:

Class of station	*Power input (average watts)* [2]	*Power output (average watts)* [3]
A	60	48
B	5	4
C [1]	5	4
D	5	4

[1] An average power input of not more than 30 watts and an average output power of not more than 24 watts is permitted Class C stations on the frequency 27.255 Mc only.

[2] For the purpose of this section, power measurement shall be made dur-

§ 95.45 Frequency Tolerance.

The carrier frequency of a station in this service shall be maintained within the following percentage of the authorized frequency:

Class of station	Maximum authorized power input	Frequency tolerance	
		Fixed and base	Mobile
		Percent	*Percent*
A	3 watts or less	.001	.005
A	over 3 watts	.001	.001
B	3 watts or less	———	.5
B	over 3 watts	———	.3
C	5 watts or less [1]	———	.005
C	over 5 watts (27.255 Mc only)	———	.005
D	5 watts or less	———	.005

[1] Class C stations of 3 watts or less power input which are used solely for the remote control of objects or devices by radio (other than devices used solely as a means of attracting attention) are permitted a frequency tolerance of 0.01%.

§ 95.47 Types of Emission.

(a) Except as provided in paragraph (e) of this section, Class A stations in this service will normally be authorized to transmit radiotelephony only. However, the use of tone signals or signalling devices solely to actuate receiver circuits, such as tone operated squelch or selective calling circuits, the primary function of which is to establish or establish and maintain voice communications, is permitted. The use of tone signals solely to attract attention is prohibited.

(b) Class B stations in this service are authorized to use amplitude or frequency modulation, or on-off unmodulated carrier, and may be used for radiotelephony, to control remote objects or devices by means of radio, or to remotely actuate devices which are used as a means of attracting attention.

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ing maximum peaks of modulation using meters having a full scale accuracy of 2 percent or better and having a maximum time constant of not more than 0.25 of a second. Where the average unmodulated carrier power is increased by modulation applied to the circuit or circuits which contribute radio frequency energy to the radiating system, the sum of the unmodulated carrier power input and the average power output of the modulator shall not exceed the values specified in this table by more than 25 percent.

[3] Power output shall be measured at the transmitter.

(c) Class C stations in this service are authorized to use amplitude tone modulation or on-off unmodulated carrier only, for the control of remote objects or devices by radio or for the remote actuation of devices which are used solely as a means of attracting attention. The transmission of any form of telegraphy, telephony or record communications by a Class C station is prohibited. Telemetering, except for the transmission of simple, short duration signals indicating the presence or absence of a condition or the occurrence of an event, is also prohibited.

(d) Class D stations in this service are authorized to use amplitude voice modulation, including single side band and/or reduced or suppressed carrier, for radiotelephone communications only. However, the use of tone signals or signalling devices solely to actuate receiver circuits, such as tone operated squelch or selective calling circuits, the primary function of which is to establish or establish and maintain voice communications, is permitted. The use of tone signals solely to attract attention or for the control of remote objects or devices is prohibited.

(e) Other types of emission not described in paragraph (a) of this section may be authorized for Class A citizens radio stations upon a showing of need therefor. An application requesting such authorization shall fully describe the emission desired, shall indicate the bandwidth required for satisfactory communication, and shall state the purpose for which such emission is required. For information regarding the classification of emissions and the calculation of bandwidth, reference should be made to Part 2 of this chapter.

§ 95.49 Emission Limitations.

(a) Each authorization issued to a Class A citizens radio station will show, as a prefix to the classification of the authorized emission, a figure specifying the maximum bandwidth to be occupied by the emission.

(b) All operation of a Class B citizens radio station (including tolerance and bandwidth occupied by the emission) shall be confined to the frequency band 462.525-467.475 Mc.

(c) Except in the case of Class B citizens radio stations operating only on the frequency 465.00 Mc (see § 95.41(b)), the maximum authorized bandwidth of the emission of any station employing amplitude modulation (Type A2 or A3 emission) shall be 8 kilocycles, and the maximum authorized bandwidth of the emission of any station employing frequency or phase modulation (Type F2 or F3 emission) shall be 40 kilocycles. The use of Type F2 or F3 emission in the frequency band 26.96-27.28 Mc is not authorized.

(d) The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 decibels;

(2) On any frequency removed from the assigned frequency to more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 decibels;

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth, at least the amounts indicated in the following table:

Maximum authorized power input to the final radio frequency stage:	*Attenuation* (*db*)
Over 3 watts	50
3 watts or less	40 [1]

[1] In the case of Class B stations having a maximum power input to the final radio frequency stage of 3 watts or less, any emission appearing on any frequency that falls within a band allocated to industrial, scientific, and medical equipment under the provisions of Part 2 of this chapter shall be attenuated at least 30 db.

(e) When an unauthorized emission results in harmful interference, the Commission may, in its discretion, require appropriate technical changes in equipment to alleviate the interference.

§ 95.51 Modulation Limitations.

(a) When the radio frequency carrier of a station in this service is amplitude modulated, such modulation shall not exceed 100 percent on positive or negative peaks.

(b) Except in the case of Class B citizens radio stations operating only on the frequency 465.00 Mc (see § 95.41(b)), the frequency deviation of any frequency modulated transmitter operated in this service shall not exceed ±15 kc and the simultaneous amplitude modulation and frequency or phase modulation of a transmitter is not authorized.

§ 95.53 Compliance with Technical Requirements.

(a) Upon receipt of notification from the Commission of a deviation from the technical requirements of the rules in this part, the radiations of the transmitter involved shall be suspended immediately, except for necessary tests and adjustments, and shall not be resumed until such deviation has been corrected.

(b) When any citizens radio station licensee receives a notice of violation indicating that the station has been operated contrary to any of the provisions contained in Subpart C of this part, or where it otherwise appears that operation of a station in this service may not be in accordance with applicable technical standards, the Commission may require the licensee to conduct such tests as may be necessary to determine whether the equipment is capable of meeting these standards and to make such adjustments as may be necessary to assure compliance therewith. A licensee who is notified that he is required to conduct such tests and/or make adjustments must, within the time limit specified in the notice, report to the Commission the results thereof.

(c) All tests and adjustments which may be required in accordance with paragraph (b) of this section shall be made by, or under the immediate supervision of, a person holding a first- or second-class commercial operator license, either radiotelephone or radiotelegraph as may be appropriate for the type of emission employed. In each case, the report which is submitted to the Commission shall be signed by the licensed commercial operator. Such report shall describe the results of the tests and adjustments, the test equipment and procedures used, and shall state the type, class, and serial number of the operator's license. A copy of this report shall also be kept with the station records.

§ 95.55 Acceptability of Transmitters for Licensing.

(a) From time to time the Commission will publish a list of equipment entitled "Radio Equipment List, Part C." Copies of this list are available for inspection at the Commission's offices in Washington, D.C., and at each of its field offices. Equipment once placed on that list will continue to be included on the list until it is removed therefrom by Commission action in accordance with the provisions of Part 2 of this chapter.

(b) Except for crystal-controlled transmitters used at Class C and Class D stations, each transmitter utilized by a station authorized for operation under this part must be a type which is included on the Commission's current "Radio Equipment List, Part C" and designated for use in this service.

§ 95.57 Type-Acceptance of Equipment.

(a) Any manufacturer of a transmitter to be built for use at Class A stations in this service, or any manufacturer of a crystal-controlled transmitter to be built for use at a Class C or Class D station in this service, may request "type-acceptance" for such transmitter following the type-acceptance procedures set forth in Part 2 of this chapter.

(b) Type acceptance for an individual transmitter may also be requested by an applicant for a station authorization by following the type acceptance procedures set forth in Part 2 of this chapter. Such transmitters, if accepted, will not normally be included on the Commission's "Radio Equipment List, Part C," but will be individually enumerated on the station authorization.

(c) Additional rules with respect to type acceptance are set forth in Part 2 of this chapter. These rules include information with respect to withdrawal of type acceptance, modification of type-accepted equipment, and limitations on the findings upon which type acceptance is based.

§ 95.59 Submission of Class B and Non-crystal Controlled Class C or Class D Station Equipment for Type Approval.

(a) Manufacturers of equipment capable of being used or operated in this service may submit units of such equipment to the Commission for type approval, upon grant of request therefor made in writing by the manufacturer to the Secretary of the Commission. Such a request normally will not be granted unless at least 100 units of the model to be submitted are scheduled for manufacture. When advised by the Commission, the applicant must send a typical production model or prototype of the particular equipment complete with tubes and power supply to the Commission's laboratory at Laurel, Maryland, for tests. All instructions which are intended to be supplied to the purchaser of the equipment shall be included. Transportation of the equipment and associated documents to and from the laboratory shall be at no cost to the Government.

(b) Prior to approval or rejection of the equipment the results of these tests will be made known only to the responsible Government officials and to the Commission. An official report of the tests will be made available only to the manufacturer involved; however, the Commission will publish from time to time lists of approved equipment.

(c) The prescribed tests may be conducted by the Federal Communications Commission or by any other cooperating Government department. In addition, field tests, as deemed necessary or desirable by the Commission, may be carried out by authorized Government personnel to determine the reliability of the equipment under operating conditions comparable to those expected to be encountered in actual service.

(d) Type-approval is not required for Class C or Class D station equipment employing crystal control; however, the manufacturer of a crystal-controlled transmitter to be built for use at a Class C or Class D station may request "type-acceptance" for such transmitter in accordance with the provisions of § 95.57. The licensee of a Class C or Class D station utilizing crystal-controlled equipment may be required to certify that the frequency stability of the transmitter is within the tolerance specified elsewhere in this part.

§ 95.61 Type Approval of Receiver-Transmitter Combinations.

Type approval will not be issued for transmitting equipment for operation under this part when such equipment is enclosed in the same cabinet, is constructed on the same chassis in whole or in part, or is identified with a common type or model number with a radio receiver, unless such receiver has been certificated to the Commission as complying with the requirements of Part 15 of this chapter.

§ 95.63 Minimum Equipment Specifications.

Equipment submitted for type approval in this service shall be capable of meeting the technical specifications contained in this part for Class B, Class C, or Class D stations, and, in addition, shall comply with the following:

(a) Any basic instructions concerning the proper adjustment, use, or operation of the equipment that may be necessary shall be attached to the equipment in a suitable manner and in such positions as to be easily read by the operator.

(b) A durable nameplate shall be mounted on each transmitter showing the name of the manufacturer, the type or model designation, and providing suitable space for permanently displaying the transmitter serial number, FCC type approval number, and the class of station for which approved.

(c) The transmitter shall be designed, constructed, and adjusted by the manufacturer to operate on a frequency or frequencies available to the class of station for which type approval is sought. In designing the equipment, every reasonable precaution shall be taken to protect the user from high voltage shock and radio frequency burns. Connections to batteries (if used) shall be made in such a manner as to permit replacement by the user without causing improper operation of the transmitter. Generally accepted modern engineering principles shall be utilized in the generation of radio frequency currents so as to guard against unnecessary interference to other services. In cases of harmful interference arising from the design, construction, or operation of the equipment, the Commission may require appropriate technical changes in equipment to alleviate interference.

(d) Controls which may effect changes in the carrier frequency of the transmitter shall not be accessible from the exterior of any unit unless such accessibility is specifically approved by the Commission.

§ 95.65 Test Procedure.

Type approval tests to determine whether radio equipment meets the technical specifications contained in this part will be conducted under the following conditions:

(a) Gradual ambient temperature variations from 0° to 125° F.

(b) Relative ambient humidity from 20 to 95 percent. This test will normally consist of subjecting the equipment for at least three consecutive periods of 24 hours each, to a relative ambient humidity of 20, 60, and 95 percent, respectively, at a temperature of approximately 80° F.

(c) Movement of transmitter or objects in the immediate vicinity thereof.

(d) Power supply voltage variations normally to be encountered under actual operating conditions.

(e) Additional tests as may be prescribed, if considered necessary or desirable.

§ 95.67 Certificate of Type Approval.

A certificate or notice of type approval, when issued to the manufacturer of equipment intended to be used or operated in the Citizens Radio Service, constitutes a recognition that on the basis of the test made, the particular type of equipment appears to have the capability of functioning in accordance with the technical specifications and regulations contained in this part: *Provided*, That all such additional equipment of the same type is properly constructed, maintained, and operated: *And provided further*, That no change whatsoever is made in the design or construction of such equipment except upon specific approval by the Commission.

§ 95.69 Acceptance of Composite Equipment.

(a) Class B and non-crystal controlled Class C or Class D station equipment constructed by a manufacturer in lots of less than 100 units will not, in the usual case, be tested by the Commission for the purpose of granting type approval. Except as provided in paragraph (b) of this section, an applicant in this service who proposes to use or operate composite or other equipment which has not been type approved shall supply complete information showing that the equipment fully complies with appropriate station requirements using supplementary sheets which shall accompany the standard application form. The Commission may, at its discretion, require that such equipment or a prototype thereof be made available to its laboratory at Laurel, Maryland, for testing in accordance with the procedures described elsewhere in this part, as applicable to equipment to be manufactured in lots of more than 100 units. In addition, field tests as deemed necessary or desirable may be carried out by authorized Government personnel to determine the reliability of the equipment under operating conditions comparable to those encountered in actual service.

(b) In the case of Class C or Class D equipment employing crystal control, supplemental technical information is not required to accompany the standard application form: *Provided, however*, That it is clearly indicated that the equipment employs crystal control: *And provided further*, That the Commission may require the applicant to certify that the frequency stability of the crystal-controlled transmitter is within the tolerance specified elsewhere in this part.

SUBPART D—STATION OPERATING REQUIREMENTS

§ 95.83 Prohibited Uses.

(a) A Citizens radio station shall not be used:

(1) For engaging in radio communications as a hobby or diversion, i.e., operating the radio station as an activity in and of itself.

Note: The following are typical, but not all inclusive, examples of the types of communications evidencing a use of Citizens radio as a hobby or diversion which are prohibited under this rule:

"You want to give me your handle and I'll ship you out a card the first thing in the morning;" or "Give me your 10-20 so I can ship you some wallpaper." (Communications to other licensees for the purpose of exchanging so-called "QSL" cards.)

"I'm just checking to see who is on the air."

"Just calling to see if you can hear me. I'm at Main and Broadway."

"Just heard your call sign and thought I'd like to get acquainted;" or "Just passing through and heard your call sign so I thought I'd give you a shout."

"Just sitting here copying the mail and thought I'd give you a call to see how you were doing." (Referring to an intent to communicate based solely on hearing another person engaged in the use of his radio.)

"My 10-20 is Main and Broad Streets. Thought I'd call so I can see how well this new rig is getting out."

"Got a new mike on this rig and thought I'd give you a call to find out how my modulation is."

"Just thought I would give you a shout and let you know I am still around. Thanks for coming back."

"Clear with Venezuela. Just thought I'd let you know I was copying you up here."

"Thought I'd give you a shout and see if you knew where the unmodulated carrier was coming from."

"Just thought I'd give you a call to find out how the skip is coming in over at your location."

"Go ahead breaker. What kind of a rig are you using? Come back with your 10-20."

(2) For any purpose, or in connection with any activity, which is contrary to Federal, State, or local law.

(3) For the transmission of communications containing obscene, indecent, or profane words, language, or meaning.

(4) To carry communications for hire, whether the remuneration or benefit received is direct or indirect.

(5) To communicate with stations authorized or operated under the provisions of other parts of this chapter, with unlicensed stations, or with United States government or foreign stations, except for communications pursuant to §§ 95.85(b) and 95.121.

(6) For any communication not directed to specific stations or persons, except for: (i) Emergency and civil defense communications as provided in §§ 95.85(b) and 95.121, respectively, (ii) test transmissions pursuant to § 95.93, and (iii) communications from a mobile unit to other units or stations for the sole purpose of requesting routing directions, assistance to disabled vehicles or vessels, information concerning the availability of food or lodging, or any other assistance necessary to a licensee in transit.

(7) To convey program material for retransmission, live or delayed, on a broadcast facility.

NOTE: A Class A, Class B or Class D station may be used in connection with the administrative, engineering, or maintenance activities of a broadcasting station; a Class A, Class B or Class C station may be used for control functions by radio which do not involve the transmission of program material; and a Class A, Class B or Class D station may be used in the gathering of news items or preparation of programs: *Provided*, That the actual or recorded transmissions of the Citizens radio station are not broadcast at any time in whole or in part.

(8) To interfere maliciously with the communications of another station.

(9) For the direct transmission of any material to the public through public address systems or similar means.

(10) To transmit superfluous communications, i.e., any transmissions which are not necessary to communications which are permissible.

(11) For the transmission of music, whistling, sound effects, or any material for amusement or entertainment purposes, or solely to attract attention.

(12) To transmit the word "MAY-DAY" or other international distress signals, except when a ship, aircraft, or other vehicle is threatened by grave and imminent danger and requests immediate assistance.

(13) For transmitting communications to stations of other licensees which relate to the technical performance, capabilities, or testing of any transmitter or other radio equipment, including transmissions concerning the signal strength or frequency stability of a transmitter, except as necessary to establish or maintain the specific communication.

(14) For relaying messages or transmitting communications for a person other than the licensee or members of his immediate family, except: (i) Communications transmitted pursuant to

§§ 95.85(b), 95.87(b)(7), and 95.121; and, (ii) upon specific prior Commission approval, communications between citizens radio stations at fixed locations where public telephone service is not provided.

(15) For advertising or soliciting the sale of any goods or services.

(16) For transmitting messages in other than plain language. Abbreviations, including nationally or internationally recognized operating signals, may be used only if a list of all such abbreviations and their meaning is kept in the station records and made available to any Commission representative on demand.

(b) A Class D station may not be used to communicate with, or attempt to communicate with, any unit of the same or another station over a distance of more than 150 miles.

(c) A licensee of a Citizens radio station who is engaged in the business of selling Citizens radio transmitting equipment shall not allow a customer to operate under his station license. In addition, all communications by the licensee for the purpose of demonstrating such equipment shall consist only of brief messages address to other units of the same station.

§ 95.85 Emergency Use.

(a) All Citizens radio stations shall give priority to the emergency communications of other stations which involve the immediate safety of life of individuals or the immediate protection of property.

(b) Any station in this service may be utilized during an emergency involving the immediate safety of life or the immediate protection of property for the transmission of emergency communications. When so used, certain provisions in this part concerning use of frequencies (§ 95.41(d)); prohibited uses (§ 95.-83(a) (5) and (6)); operation by or on behalf of persons other than the licensee (§ 95.87); and duration of transmissions (§ 95.91 (a) and (b)) shall not apply. However, any emergency use which necessitates taking advantage of these exceptions to usual requirements shall be subject to the following conditions:

(1) As soon as possible after the beginning of such emergency use, notice shall be sent to the Commission in Washington, D.C., and to the engineer in charge of the radio district in which the station is located, stating the nature of the emergency and the use to which the station is being put.

(2) The emergency use of the station shall be discontinued as soon as possible, and the Commission in Washington, D.C., and the engineer in charge shall be notified immediately when such special use of the station is terminated. If the emergency use is

of less than 24-hour duration, a single notice containing all of the required information will serve to comply with the notice requirements of this paragraph.

(3) The Commission may at any time order discontinuance of such special use of the authorized facilities.

§ 95.87 Operation by, or on Behalf of, Persons Other Than the Licensee.

(a) Transmitters authorized in this service must be under the control of the licensee at all times. A licensee shall not transfer, assign, or dispose of, in any manner, directly or indirectly, the operating authority under his station license, and shall be responsible for the proper operation of all units of the station.

(b) Citizens radio stations may be operated only by the following persons, except as provided in paragraph (c) of this section:

(1) The licensee;

(2) Members of the licensee's immediate family living in the same household;

(3) The partners, if the licensee is a partnership, provided the communications relate to the business of the partnership;

(4) The members, if the licensee is an unincorporated association, provided the communications relate to the business of the association;

(5) Employees of the licensee only while acting within the scope of their employment; and

(6) Any person under the control or supervision of the licensee when the station is used solely for the control of remote objects or devices, other than devices used only as a means of attracting attention;

(7) Other persons, upon specific prior approval of the Commission shown on or attached to the station license, under the following circumstances:

(i) Licensee is a corporation and proposes to provide private radiocommunication facilities for the transmission of messages or signals by or on behalf of its parent corporation, another subsidiary of the parent corporation, or its own subsidiary. Any remuneration or compensation received by the licensee for the use of the radiocommunication facilities shall be governed by a contract entered into by the parties concerned and the total of the compensation shall not exceed the cost of providing the facilities. Records which show the cost of service and its nonprofit or cost-sharing basis shall be maintained by the licensee.

(ii) Licensee proposes the shared or cooperative use of a Class A station with one or more other licensees in this service for the purpose of communicating on a regular basis with units of their respective Class A stations, or with units of other Class A stations if the communications transmitted are otherwise permissible. The use of these private radiocommunication facilities shall be conducted pursuant to a written contract which shall provide that contributions to capital and operating expense shall be made on a nonprofit, cost-sharing basis, the cost to be divided on an equitable basis among all parties to the argument. Records which show the cost of service and its nonprofit, cost-sharing basis shall be maintained by the licensee. In any case, however, licensee must show a separate and independent need for the particular units proposed to be shared to fulfill his own communications requirements.

(iii) Other cases where there is a need for other persons to operate a unit of licensee's radio station. Requests for authority may be made either at the time of the filing of the application for station license or thereafter by letter. In either case, the licensee must show the nature of the proposed use and that it relates to an activity of the licensee, how he proposes to maintain control over the transmitters at all times, and why it is not appropriate for such other person to obtain a station license in his own name. The authority, if granted, may be specific with respect to the names of the persons who are permitted to operate, or may authorize operation by unnamed persons for specific purposes. This authority may be revoked by the Commission, in its discretion, at any time.

(c) An individual who was formerly a citizens radio station licensee shall not be permitted to operate any citizens radio station of the same class licensed to another person until such time as he again has been issued a valid radio station license of that class, when his license has been:

(1) Revoked by the Commission.

(2) Surrendered for cancellation after the institution of revocation proceedings by the Commission.

(3) Surrendered for cancellation after a notice of apparent liability to forfeiture has been served by the Commission.

§ 95.89 Telephone Answering Services.

(a) Notwithstanding the provisions of § 95.87, a licensee may install a transmitting unit of his station on the premises of a telephone answering service. The same unit may not be operated under the authorization of more than one licensee. In all cases, the licensee must enter into a written agreement with the answering service. This agreement must be kept with the licensee's station records and must provide, as a minimum, that:

(1) The licensee will have control over the operation of the radio unit at all times;

(2) The licensee will have full and unrestricted access to the transmitter to enable him to carry out his responsibilities under his license;

(3) Both parties understand that the licensee is fully responsible for the proper operation of the citizens radio station; and

(4) The unit so furnished shall be used only for the transmission of communications to other units belonging to the licensee's station.

(b) A citizens radio station licensed to a telephone answering service shall not be used to relay messages or transmit signals to its customers.

§ 95.91 Duration of Transmissions.

(a) All communications or signals, regardless of their nature, shall be restricted to the minimum practicable transmission time. The radiation of energy shall be limited to transmissions modulated or keyed for actual permissible communications, tests, or control signals. Continuous or uninterrupted transmissions from a single station or between a number of communicating stations is prohibited, except for communications involving the immediate safety of life or property.

(b) Communications between or among Class D stations shall not exceed 5 consecutive minutes. At the conclusion of this 5-minute period, or upon termination of the exchange if less than 5 minutes, the station transmitting and the stations participating in the exchange shall remain silent for a period of at least 5 minutes and monitor the frequency or frequencies involved before any further transmissions are made. However, for the limited purpose of acknowledging receipt of a call, such a station or stations may answer a calling station and request that it stand by for the duration of the silent period. The time limitations contained in this paragraph may not be avoided by changing the operating frequency of the station and shall apply to all the transmissions of an operator who, under other provisions of this part, may operate a unit of more than one citizens radio station.

(c) The transmission of audible tone signals or a sequence of tone signals for the operation of the tone operated squelch or selective calling circuits in accordance with § 95.47 shall not exceed a total of 15 seconds duration. Continuous transmission of a subaudible tone for this purpose is permitted. For the purposes of this section, any tone or combination of tones having no frequency above 150 cycles per second shall be considered subaudible.

(d) The transmission of permissible control signals shall be limited to the minimum practicable time necessary to accomplish the desired control or actuation of remote objects or devices. The continuous radiation of energy for periods exceeding 3 minutes duration for the purpose of transmission of control signals shall be limited to control functions requiring at least one or more changes during each minute of such transmission. However, while it is actually being used to control model aircraft in flight by means of interrupted tone modulation of its carrier, a citizens radio station may transmit a continuous carrier without being simultaneously modulated if the presence or absence of the carrier also performs a control function. An exception to the limitations contained in this paragraph may be authorized upon a satisfactory showing that a continuous control signal is required to perform a control function which is necessary to insure the safety of life or property.

§ 95.93 Tests and Adjustments.

All tests or adjustments of citizens radio transmitting equipment involving an external connection to the radio frequency output circuit shall be made using a nonradiating dummy antenna. However, a brief test signal, either with or without modulation, as appropriate, may be transmitted when it is necessary to adjust a transmitter to an antenna for a new station installation or for an existing installation involving a change of antenna or change of transmitters, or when necessary for the detection, measurement, and suppression of harmonic or other spurious radiation. Test transmissions using a radiating antenna shall not exceed a total of 1 minute during any 5 minute period, shall not interfere with communications already in progress on the operating frequency, and shall be properly identified as required by § 95.95, but may otherwise be unmodulated as appropriate.

§ 95.95 Station Identification.

(a) The serial number on each citizens radio station license is the call sign assigned to such station. Except in the case of Class A stations having call signs in the international series, there shall be no continuity in the call sign assigned to a particular station, and a new call sign will be assigned on renewal or modification.

(b) Each transmission of the station call sign shall be made in the English language by each unit, shall be complete, and each letter and digit shall be separately and distinctly transmitted. Only standard phonetic alphabets, nationally or internationally recognized, may be used in lieu of pronunciation of letters for voice transmission of call signs. A unit designator or special identification may be used in addition to the station call sign but not as a substitute therefor.

(c) Except as provided in paragraph (d) of this section, all transmissions from any transmitting unit of a citizens radio station shall be identified by the call sign at the beginning and end of each transmission or series of transmissions with a unit of the same or other stations. Each required identification shall include the call sign of all stations involved. If the call sign of the station being called is not known, the name or trade name may be used, but when contact has been made the station shall thereafter be identified by the call sign. Where transmissions or exchanges of transmissions of greater length are permitted by this part, the identification shall also be transmitted at least every 15 minutes. Each transmission or exchange of transmissions conducted on different frequencies shall be fully and separately identified in accordance with the foregoing on each frequency used.

(d) Identification of the transmission of a citizens radio station used for the control of remote objects or for the remote actuation of attention attracting devices is not required except upon specific instruction from the Commission.

§ 95.97 Operator License Requirements.

(a) No operator license is required for the operation of a citizens radio station except that stations manually transmitting Morse Code shall be operated by the holders of a third or higher class radiotelegraph operator license.

(b) Except as provided in paragraph (c) of this section, all transmitter adjustments or tests while radiating energy during or coincident with the construction, installation, servicing, or maintenance of a radio station in this service, which may affect the proper operation of such stations, shall be made by or under the immediate supervision and responsibility of a person holding a first- or second-class commercial radio operator license, either radiotelephone or radiotelegraph, as may be appropriate for the type of emission employed, and such person shall be responsible for the proper functioning of the station equipment at the conclusion of such adjustments or tests. Further, in any case where a transmitter adjustment which may affect the proper operation of the transmitter has been made while not radiating energy by a person not the holder of the required commercial radio operator license or not under the supervision of such licensed operator, other than the factory assembling or repair of equipment, the transmitter shall be checked for compliance with the technical requirements of the rules by a commercial radio operator of the proper grade before it is placed on the air.

(c) Except as provided in § 95.53 and in paragraph (d) of this section, no commercial radio operator license is required to be held by the person performing transmitter adjustments or tests during or coincident with the construction, installation, servicing, or maintenance of Class C or Class D stations in this service:

Provided, That there is compliance with all of the following conditions:

(1) The transmitting equipment shall be crystal-controlled with a crystal capable of maintaining the station frequency within the prescribed tolerance;

(2) The transmitting equipment either shall have been factory assembled or shall have been provided in kit form by a manufacturer who provided all components together with full and detailed instructions for their assembly by non-factory personnel;

(3) The frequency determining elements of the transmitter, including the crystal(s) and all other components of the crystal oscillator circuit, shall have been preassembled by the manufacturer, pretuned to a specific available frequency, and sealed by the manufacturer so that replacement of any component or any adjustment which might cause off-frequency operation cannot be made without breaking such seal and thereby voiding the certification of the manufacturer required by this paragraph:

(4) The transmitting equipment shall have been so designated that none of the transmitter adjustments or tests normally performed during or coincident with the installation, servicing, or maintenance of the station, or during the normal rendition of the service of the station, or during the final assembly of kits or partially preassembled units, may reasonably be expected to result in off-frequency operation, excessive input power, overmodulation, or excessive harmonics or other spurious emissions; and

(5) The manufacturer of the transmitting equipment or of the kit from which the transmitting equipment is assembled shall have certified in writing to the purchaser of the equipment (and to the Commission upon request) that the equipment has been designed, manufactured, and furnished in accordance with the specifications contained in the foregoing subparagraphs of this paragraph. The manufacturer's certification concerning design and construction features of Class C or Class D station transmitting equipment, as required if the provisions of this paragraph are invoked, may be specific as to a particular unit of transmitting equipment or general as to a group or model of such equipment, and may be in any form adequate to assure the purchaser of the equipment or the Commission that the conditions described in this paragraph have been fulfilled.

(d) Any tests and adjustments necessary to correct any deviation of a transmitter of any Class of station in this service from the technical requirements of this rules in this part shall be made by, or under the immediate supervision of, a person holding a first- or second-class commercial operator license, either radiotelephone or radiotelegraph, as may be appropriate for the type of emission employed.

§ 95.101 Posting Station Licenses and Transmitter Identification Cards or Plates.

(a) The current authorization for each station (including units of a Class B, Class C or Class D station) operated at a fixed location shall be posted at a conspicuous place at the principal fixed location from which such station is controlled, and a photocopy of such authorization shall be posted at all other fixed locations from which the station is controlled. In addition, an executed Transmitter Identification Card (FCC Form 452-C) or a plate of metal or other durable substance, legibly indicating the call sign and the licensee's name and address, shall be affixed, readily visible for inspection, to each transmitter operated at a fixed location when such transmitter is not in view of, or is not readily accessible to, the operator of at least one of the locations at which the station authorization or a photocopy thereof is required to be posted.

(b) The current authorization for each station operated as a mobile station shall be retained as a permanent part of the station records, but need not be posted. In addition, an executed Transmitter Identification Card (FCC Form 452-C) or a plate of metal or other durable substance, legibly indicating the call sign and the licensee's name and address, shall be affixed, readily visible for inspection, to each of such transmitters: *Provided*, That, if the transmitter is not in view of the location from which it is controlled, or is not readily accessible for inspection, then such card or plate shall be affixed to the control equipment at the transmitter operating position or posted adjacent thereto.

§ 95.103 Inspection of Stations and Station Records.

All stations and records of stations in the Citizens Radio Service shall be made available for inspection upon the request of an authorized representative of the Commission made to the licensee or to his representative (see § 1.6 of this chapter). Unless otherwise stated in this part, all required station records shall be maintained for a period of at least 1 year.

§ 95.105 Current Copy of Rules Required.

Each licensee in this service shall maintain as a part of his station records a current copy of Part 95, Citizens Radio Service, of this chapter.

§ 95.107 Inspection and Maintenance of Tower Marking and Associated Control Equipment.

The licensee of any radio station which has an antenna structure required to be painted or illuminated pursuant to the provisions of section 303(q) of the Communications Act of 1934, as amended, and/or Part 17 of this chapter shall operate and maintain the tower marking and associated control equipment in accordance with the following paragraphs of this section.

(a) The tower lights shall be observed at least once each 24 hours, either visually or by observing an automatic and properly maintained indicator designed to register any failure of such lights, to insure that all such lights are functioning properly as required; or, alternatively, there shall be provided and properly maintained an automatic alarm system designed to detect any failure of the tower lights and to provide indication of such failure to the licensee.

(b) Any observed or otherwise known failure of a code or rotating beacon light or top light not corrected within 30 minutes, regardless of the cause of such failure, shall be reported immediately by telephone or telegraph to the nearest Air Traffic Communications Station or office of the Federal Aviation Agency. Further notification by telephone or telegraph shall be given immediately upon resumption of the required illumination.

(c) All automatic or mechanical control devices, indicators, and alarm systems associated with the tower lights shall be inspected at intervals not to exceed 3 months, to insure that such apparatus is functioning properly.

(d) All lighting shall be exhibited from sunset to sunrise unless otherwise specified in the instrument of station authorization.

(e) A sufficient supply of spare lamps shall be maintained for immediate replacement purposes at all times.

(f) All towers shall be cleaned or repainted as often as is necessary to maintain good visibility.

§ 95.111 Recording of Tower Light Inspections.

When a station in this service has an antenna structure which is required to be illuminated, appropriate entries shall be made in the station records, as follows:

(a) The time the tower lights are turned on and off each day, if manually controlled.

(b) The time the daily check of proper operation of the tower lights was made.

(c) In the event of any observed or otherwise known failure of a tower light:

(1) Nature of such failure.

(2) Date and time the failure was observed or otherwise noted.

(3) Date, time, and nature of the adjustments, repairs, or replacements made.

(4) Identification of the Air Traffic Communications Station (or office of the Federal Aviation Agency) notified of the failure

of any code or rotating beacon light not corrected within 30 minutes, and the date and time such notice was given.

(5) Date and time notice was given to the Air Traffic Communications Station (or office of the Federal Aviation Agency) that the required illumination was resumed.

(d) Upon completion of the 3-month periodic inspection required by § 95.107(c):

(1) The date of the inspection and the condition of all tower lights and associated tower lighting control devices, indicators, and alarms systems.

(2) Any adjustments, replacements, or repairs made to insure compliance with the lighting requirements and the date such adjustments, replacements, or repairs were made.

§ 95.113 Answers to Notices of Violations.

(a) Any licensee who appears to have violated any provision of the Communications Act or any provision of this chapter shall be served with a written notice calling the facts to his attention and requesting a statement concerning the matter. FCC Form 793 may be used for this purpose.

(b) Within 10 days from receipt of notice or such other period as may be specified, the licensee shall send a written answer, in duplicate, direct to the office of the Commission originating the notice. If an answer cannot be sent nor an acknowledgment made within such period by reason of illness or other unavoidable circumstances, acknowledgment and answer shall be made at the earliest practicable date with a satisfactory explanation of the delay.

(c) The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. In every instance the answer shall contain a statement of the action taken to correct the condition or omission complained of and to preclude its recurrence. If the notice relates to violations that may be due to the physical or electrical characteristics of transmitting apparatus, the licensee must comply with the provisions of § 95.53, and the answer to the notice shall state fully what steps, if any, have been taken to prevent future violations, and, if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and the promised date of delivery. If the installation of such apparatus requires a construction permit, the file number of the application shall be given, or if a file number has not been assigned by the Commission, such identification shall be given as will permit ready identification of the application. If the notice of violation relates to lack of attention to or improper operation of the transmitter, the name and license number of the operator in charge, if any, shall also be given.

§ 95.115 **False Signals.**

No person shall transmit false or deceptive communications by radio or identify the station he is operating by means of a call sign which has not been assigned to that station.

§ 95.117 **Station Location.**

(a) The specific location of each Class A base station and each Class A fixed station and the specific area of operation of each Class A mobile station shall be indicated in the application for license. An authorization may be granted for the operation of a Class A base station or fixed station in this service at unspecified temporary fixed locations within a specified general area of operation. However, when any unit or units of a base station or fixed station authorized to be operated at temporary locations actually remains or is intended to remain at the same location for a period of over a year, application for separate authorization specifying the fixed location shall be made as soon as possible but not later than 30 days after the expiration of the 1-year period.

(b) A Class A mobile station authorized in this service may be used or operated anywhere in the United States subject to the provisions of paragraph (d) of this section: *Provided*, That when the area of operation is changed for a period exceeding 7 days, the following procedure shall be observed:

(1) When the change of area of operation occurs inside the same Radio District, the Engineer in Charge of the Radio District involved and the Commission's office, Washington, D.C., 20554, shall be notified.

(2) When the station is moved from one Radio District to another, the Engineers in Charge of the two Radio Districts involved and the Commission's office, Washington, D.C., 20554, shall be notified.

(c) A Class B, Class C or Class D mobile station may be used or operated anywhere in the United States subject to the provisions of paragraph (d) of this section.

(d) A mobile station authorized in this service may be used or operated on any vessel, aircraft, or vehicle of the United States: *Provided*, That when such vessel, aircraft, or vehicle is outside the territorial limits of the United States, the station, its operation, and its operator shall be subject to the governing provisions of any treaty concerning telecommunications to which the United States is a party, and when within the territorial limits of any foreign country, the station shall be subject also to such laws and regulations of that country as may be applicable.

§ 95.119 **Control Points, Dispatch Points, and Remote Control.**

(a) A control point is an operating position which is under the control and supervision of the licensee, at which a person immediately responsible for the proper operation of the transmitter is stationed, and at which adequate means are available to aurally monitor all transmissions and to render the transmitter inoperative. Each Class A base or fixed station shall be provided with a control point, the location of which will be specified in the license. The location of the control point must be the same as the transmitting equipment unless the application includes a request for a different location. Exception to the requirement for a control point may be made by the Commission upon specific request and justification therefor in the case of certain unattended Class A stations employing special emissions pursuant to § 95.47(e). Authority for such exception must be shown on the license.

(b) A dispatch point is any position from which messages may be transmitted under the supervision of the person at a control point who is responsible for the proper operation of the transmitter. No authorization is required to install dispatch points.

(c) Remote control of a citizens radio station means the control of the transmitting equipment of that station from any place other than the location of the transmitting equipment, except that direct mechanical control or direct electrical control by wired connections of transmitting equipment from some other point on the same premises, craft or vehicle shall not be considered remote control. A Class A base or fixed station may be authorized to be used or operated by remote control from another fixed location or from mobile units: *Provided*, That adequate means are available to enable the person using or operating the station to render the transmitting equipment inoperative from each remote control position should improper operation occur.

(d) Operation of any Class B, Class C or Class D station by remote control is prohibited.

§ 95.121 Civil Defense Communications.

A licensee of a station authorized under this part may use the licensed radio facilities for the transmission of messages relating to civil defense activities in connection with official tests or drills conducted by, or actual emergencies proclaimed by, the civil defense agency having jurisdiction over the area in which the station is located: *Provided*, That:

(a) The operation of the radio station shall be on a voluntary basis.

(b) [Reserved]

(c) Such communications are conducted under the direction of civil defense authorities.

(d) As soon as possible after the beginning of such use, the licensee shall send notice to the Commission in Washington, D.C., and to the Engineer in Charge of the Radio District in which the station is located, stating the nature of the communications being transmitted and the duration of the special use of the station. In addition, the Engineer in Charge shall be notified as soon as possible of any change in the nature of or termination of such use.

(e) In the event such use is to be a series of pre-planned tests or drills of the same or similar nature which are scheduled in advance for specific times or at certain intervals of time, the licensee may send a single notice to the Commission in Washington, D.C., and to the Engineer in Charge of the Radio District in which the station is located, stating the nature of the communications to be transmitted, the duration of each such test, and the time scheduled for such use. Notice shall likewise be given in the event of any change in the nature of or termination of any such series of tests.

(f) The Commission may, at any time, order the discontinuance of such special use of the authorized facilities.

Fees for Filing Applications in the Safety and Special Radio Services

The following rules concerning fees and the fee schedule for filing applications in the Safety and Special Radio Services are extracted from Part 1 of the *FCC Rules and Regulations.*

SUBPART G—SCHEDULE OF FEES FOR APPLICATIONS FILED WITH THE COMMISSION

General Information

§ 1.1101 Authority.

Authority for this Subpart is contained in Title V of the Independent Offices Appropriation Act of 1952 (5 U.S.C. 140) which provides that any service rendered by a Federal agency to or for any person shall be performed on a self-sustaining basis to the fullest extent possible. Title V further provides that the head of each Federal agency is authorized by regulation to prescribe such fees as he shall determine to be fair and equitable.

§ 1.1103 Payment of fees.

(a) Each application, filed on or after January 1, 1964, for which a fee is prescribed in this subpart, must be accompanied by a remittance in the full amount of the fee. In no case will an application be accepted for filing or processed prior to payment of the full amount specified. Applications for which no remittance is received, or for which an insufficient amount is received, may be returned to the applicant.

(b) Fee payments accompanying applications received in the Commission's Offices in Washington, D.C., or in any of the Commission's field offices, should be in the form of a check or money order payable to the Federal Communications Commission. The Commission will not be responsible for cash sent through the mails. All fees collected will be paid into the United States Treasury as miscellaneous receipts in accordance with the provisions of Title V of the Independent Offices Appropriations Act of 1952 (5 U.S.C. 140).

(c) Receipts will be furnished upon request in the case of payments made in person, but no receipts will be issued for payments sent through the mails.

(d) Except as provided in §§ 1.1104 and 1.1105, all fees will be charged irrespective of the Commission's disposition of the application. Applications returned to applicants for additional information or corrections will not require an additional fee when resubmitted.

§ **1.1104 Return or refund of fees.**

(a) The full amount of any fee submitted will be returned or refunded, as appropriate, in the following instances:

(1) Where no fee is required for the application filed.

(2) Where the application is filed by an applicant who cannot fulfill a prescribed age requirement.

(3) Where the application is filed for renewal without reexamination of an amateur or commercial radio operator license after the grace period has expired.

(4) Where the applicant is precluded from obtaining a license by the provisions of section 303(1) or 310(a) of the Communications Act.

(5) Where circumstances beyond the control of the applicant, arising after the application is filed, would render a grant useless.

(b) Payments in excess of an applicable fee will be refunded only if the overpayment exceeds $2.

§ **1.1105 General exceptions.**

(a) No fee is required for an application filed for the sole purpose of amending an authorization or pending application (if a fee is otherwise required) so as to comply with new or additional requirements of the Commission's rules or the rules of another Federal government agency affecting the authorization or pending application; however, if the applicant also requests an additional modification or the renewal of his authorization, the appropriate modification or renewal fee must accompany the application. Fee exemptions arising out of this general exception will be announced to the public in the orders amending the rules or in other appropriate Commission notices.

(b) No fee is required for an application filed by an alien pursuant to a reciprocal radio licensing agreement.

(c) No fee is required for any application or request for an STA or waiver.

§ **1.1115 Schedule of fees for Safety and Special Radio Services.**

(a) Except as provided in paragraph (b) of this section, all formal applications filed in the Safety and Special Radio Services shall be accompanied by the fees prescribed below:

Applications in the Amateur Radio Service:

For Initial License, including New Class of Operator License, and for Renewal of License .... $ 4

For Modification of License	2
Request for Special Call Sign Pursuant to § 97.51	20
Applications in the Citizens Radio Service:	
For Class A Station Authorization	10
For All Other Classes of Stations in the Citizens Radio Service	8
Applications for Radio Station Authorizations for Operational Fixed Radio Stations for which Frequencies above 952 Mc/s are requested:	
For construction permit	30
For modification of authorization	10
Applications for Common Carrier Public Coast Stations in the Maritime Radio Services:	
For construction permit	50
For modification of authorization	10
Applications for Renewal only for which FCC Form 405A is prescribed	4
All Other Applications Filed in the Safety and Special Radio Services	10

(b) Fees are not required in the following instances:

(1) Applications filed in the Police, Fire, Forestry-Conservation, Highway Maintenance, Local Government, and State Guard Radio Services.

(2) Applications filed by governmental entities in any of the Safety and Special Radio Services.

(3) Applications filed by the following in the Special Emergency Radio Service: Hospitals, Disaster Relief Organizations, Beach Patrols, and School Buses, and non-profit Ambulance Operators and Rescue Organizations.

(4) Applications filed in the Disaster Communications Services.

(5) Applications for ship inspections pursuant to the Great Lakes Agreement, the Safety of Life at Sea Convention, and Parts II and III, Title III, of the Communications Act of 1934, as amended.

(6) Applications for Novice Class license in the Amateur Radio Service, applications for amateur stations under military auspices, and applications filed in the Radio Amateur Civil Emergency Service (RACES).

(7) Operational Fixed Microwave Applications filed for Closed Circuit Educational Television Service.

(8) Applications for Civil Air Patrol Stations, Aeronautical Radionavigation Stations and for Aeronautical Search and Rescue Stations.

(9) Applications for license to cover construction permit.

APPENDIX II

FCC Field Offices and Districts

FCC Field Offices

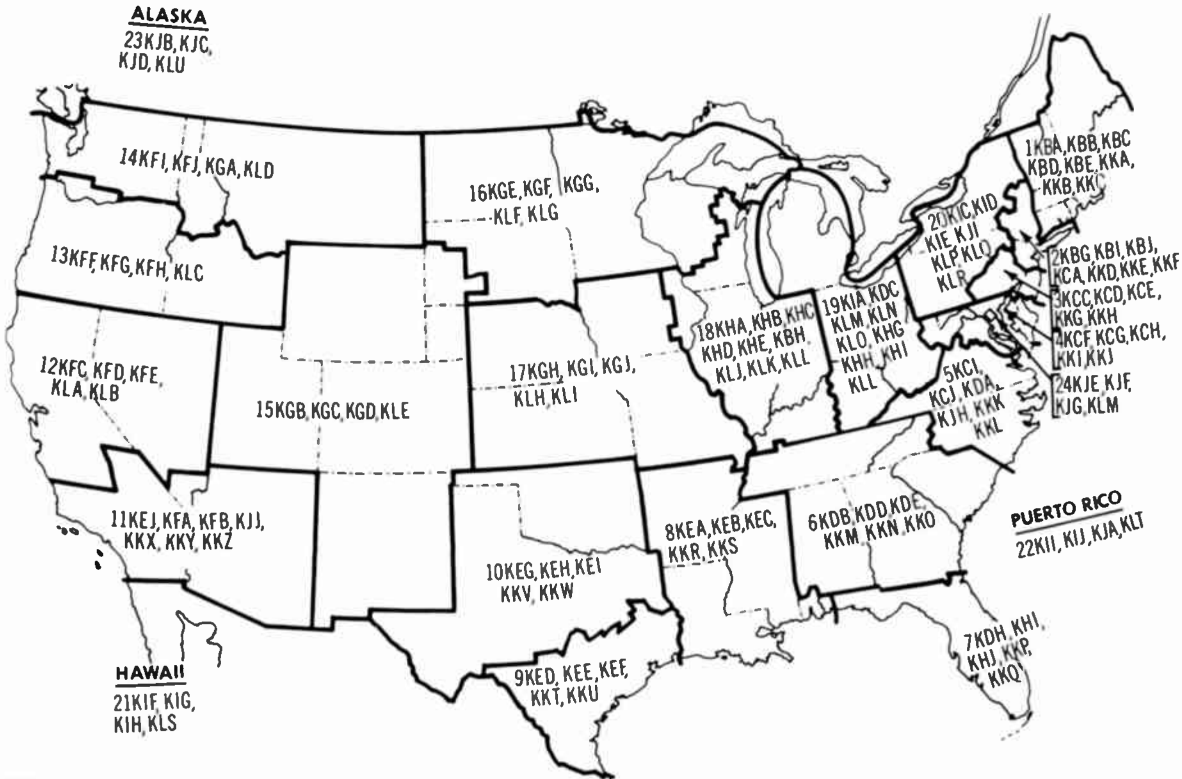
Address all communications to the Engineer-in-Charge. Street addresses can be found in local telephone directories under "United States Government."

Alabama, Mobile 36602
Alaska, Anchorage (Box 644) 99501
California, Los Angeles 90014
California, San Diego 92101
California, San Francisco 94126
Colorado, Denver 80202
D.C., Washington 20555
Florida, Miami (Box 150) 33101
Georgia, Atlanta 30303
Georgia, Savannah (Box 77) 31402
Hawaii, Honolulu (Box 1021) 96808
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
P. Rico, San Juan (Box 2987) 00903
Texas, Beaumont (Box 1527) 77704
Texas, Dallas 75202
Texas, Houston 77002
Virginia, Norfolk 23510
Washington, Seattle 98104

FCC Radio Districts

The United States is divided into 24 radio districts for purposes of license administration. The states included in each district are given below. The divisions are not by state lines; hence, a portion of a state may be in one district and the remainder in another. This is illustrated on the map on the following page.

District	*States*
1.	Connecticut, Maine, Vermont, New Hampshire, Rhode Island, Massachusetts.
2.	New York, New Jersey.
3.	Delaware, Pennsylvania, New Jersey, New York.
4.	West Virginia, Virginia, Maryland, Delaware .
5.	Virginia, North Carolina.
6.	South Carolina, North Carolina, Tennessee, Alabama, Georgia.
7.	Florida.
8.	Mississippi, Louisiana, Arkansas, Florida.
9.	Texas.
10.	Texas, Oklahoma.
11.	Nevada, Arizona, California.
12.	California, Nevada.
13.	Washington, Oregon, Idaho.
14.	Washington, Montana, Idaho.
15.	Utah, Colorado, New Mexico, Wyoming, South Dakota, Nebraska.
16.	Minnesota, Wisconsin, South Dakota, North Dakota.
17.	Nebraska, Kansas, Missouri, Iowa.
18.	Illinois, Wisconsin, Kentucky. Indiana, Iowa.
19.	Michigan, West Virginia, Ohio, Kentucky.
20.	New York, Pennsylvania, Maryland.
21.	Hawaii.
22.	Puerto Rico.
23.	Alaska.
24.	Washington, D.C.; Virginia; Maryland.


ALASKA
23KJB, KJC, KJD, KLU
14KFI, KFJ, KGA, KLD
16KGE, KGF, KGG, KLF, KLG
13KFF, KFG, KFH, KLC
12KFC, KFD, KFE, KLA, KLB
15KGB, KGC, KGD, KLE
17KGH, KGI, KGJ, KLH, KLI
11KEJ, KFA, KFB, KJJ, KKX, KKY, KKZ
10KEG, KEH, KEI KKV, KKW
9KED, KEE, KEF, KKT, KKU
8KEA, KEB, KEC, KKR, KKS
18KHA, KHB, KHC KHD, KHE, KBH KLJ, KLK, KLL
19KIA, KDC KLM, KLN KLO, KHG KHH, KHI KLL
20KIC, KID KIE, KJI KLP, KLQ KLR
1KBA, KBB, KBC KBD, KBE, KKA, KKB, KKC
2KBG, KBI, KBJ, KCA, KKD, KKE, KKF
3KCC, KCD, KCE, KKG, KKH
4KCF, KCG, KCH, KKI, KKJ
24KJE, KJF, KJG, KLM
5KCI, KCJ, KDA, KJH, KKK KKL
6KDB, KDD, KDE, KKM, KKN, KKO
7KDH, KHI, KHJ, KKP, KKQ
PUERTO RICO
22KII, KIJ, KJA, KLT
HAWAII
21KIF, KIG, KIH, KLS

APPENDIX III

Glossary

"A" Lead. The "hot," or supply, lead on DC radio equipment.
AC Generator. A mechanical or electric device that produces an AC voltage.
Adjacent-Channel Interference. Interference caused by equipment operating on one or both adjoining channels.
Alignment. The process of adjusting circuits to respond to desired frequencies.
Alternating Current (AC). A current that reverses its direction at regular intervals.
Alternator. A device that produces an alternating (AC) voltage.
Amateur. A person licensed to operate, install, build, and experiment with transmitters, receivers, and other types of electronic equipment as a hobby. Often referred to as a "ham."
Amateur Bands. Bands of frequencies allocated specifically for radio amateurs.
Ambient Temperature. The temperature of the air in the surrounding area.
Ammeter. A meter designed to measure electric current.
Ampere. The unit of electric current flow.
Amplification. The process of increasing voltage and/or current.
Amplifier. A device that produces greater voltage and/or current at its output than is applied to the input.
Amplitude Modulation. The process of varying the amplitude of an RF carrier in accordance with the intelligence signal.
Antenna Gain. The effectiveness of an antenna in a certain direction, compared with some standard antenna.
Atmospheric Interference. Interference caused by electrical disturbances in the atmosphere.
Audio Frequency. The frequency of a signal corresponding to sounds that can be heard by the human ear. The audio frequency extends from 20 to 20,000 cycles per second.
Automatic Volume Control (AVC). A system in which the gain of one or more receiver stages automatically increases to compensate for reductions in signal strength.
Autotransformer. A transformer having a single winding, a tapped portion acting as the primary.
B+. The positive terminal of a DC voltage source (battery, power supply, etc.).
B Supply. The plate-voltage source for a vacuum tube.
Background Noise. Random circuit or atmospheric noise heard in addition to the desired signal.
Bandwidth. The difference, in cycles, between the frequency limits of a band.
Beam Antenna. An antenna with a radiation or reception pattern confined to a somewhat narrow beam.
Beat Frequency. A third (difference) frequency produced when two different frequencies are combined.
Bias. A counteracting voltage used to control or limit the gain of an amplifier.
Bonding. Bringing two metal objects to the same electrical potential (usually ground) by connecting them together with a heavy metal conductor.
Capacitive Coupling. A method of coupling two circuits electrostatically in order to provide an AC path for desired signals while blocking DC.

Capacitor. Two conductors separated by an insulator (dielectric).
Carrier Frequency. The number of cycles per second of the unmodulated RF wave produced by a transmitter.
Carrier Wave. The unmodulated RF signal produced by a transmitter.
Cathode. The electron-emitting element of a tube or other radio component.
Channel. A band within which the assigned transmitter carrier frequency and its modulation must be confined during operation.
Channel Selector. A switch or dial used to select a desired channel.
Class-A Amplifier. An amplifier biased so that plate current flows at all times.
Class-C Amplifier. An amplifier biased so that plate current does not flow at zero input signal, and flows only during a portion of the cycle when a signal is present at the grid.
Coaxial Antenna. An antenna that is a quarter-wavelength extension of the center conductor of a coaxial cable. The outer conductor is connected to and covered with a quarter-wavelength sheath, or "skirt."
Coaxial Cable. A high-frequency transmission line consisting of an inner conductor and an outer shielding conductor. The two are separated by a dielectric material, and the entire assembly is covered with an insulating sheath.
Co-Channel Interference. Interference from an undesired signal having the same carrier frequency as the desired signal.
Collector. An electron-capturing electrode.
Communications Receiver. A receiver designed for reception of voice or code signals from stations operating in the communications services.
CONELRAD. Meaning CONtrol of ELectromagnetic RADiation. A system whereby stations were required to leave the air during an alert or enemy attack, to prevent their radio signals from being used as navigational aids by the enemy.
Continuity. The property of having a continuous DC electrical path.
Converter. A device for changing incoming radio signals to a frequency that can be readily handled by a receiver. Also a mechanical device for changing electrical energy from one form to another—such as AC to DC.
Cps. Abbreviation for *cycles per second.*
Crystal. A piezoelectric material, such as natural quartz, used as the frequency-determining element in some oscillator circuits.
Cycle. One complete round of a regularly recurring event. For example, an AC cycle consists of a movement from zero to maximum in one direction, beyond zero to maximum in the opposite direction, and then back to zero.
DC Resistance. The resistance (in ohms) a circuit or component offers to the flow of direct current.
Decibel (db). The amount the pressure of a sine-wave sound must be changed in order for such change to be barely noticeable by the average human ear.
Delayed AVC. An automatic volume-control circuit that permits maximum gain on weak signals by producing the AVC voltage for only those signals above a predetermined strength.
Detector. In a receiver, the stage where demodulation (detection) occurs.
Detune. To change the inductance and/or capacitance of a tuned circuit, causing it to be resonant at other than the desired frequency.
Dielectric. An insulating material between two conductors.
Diode. A device having two electrodes—a cathode for emitting electrons, and an anode for collecting them.
Dipole Antenna. A two-element antenna the length of which is usually no more than half the wavelength to which it is resonant.
Direct Current (DC). Current that travels in one direction only.
Directional Antenna. An antenna that radiates and receives signals better in some directions than in others.
Dress. The exact placement of leads and components to minimize or eliminate undesirable feedback and other troubles.
Dummy Antenna. A device used during transmitter tests and adjustments. It duplicates the electrical characteristics of the antenna, but greatly reduces or eliminates the radiation of radio waves.

Efficiency. The ratio of energy output to energy input, usually expressed as a percentage.

Electromagnetic Induction. The action by which a voltage is induced in a conductor when it is exposed to an electromagnetic wave.

Electromagnetic Wave. A wave consisting of electric and magnetic lines of force at right angles, such as the wave radiated from the transmitter antenna.

Emission. The radiation of a signal from the antenna into free space. Also, the giving off of electrons by an element.

Emission Types. A classification of the different types of radio transmission, modulation, and other supplementary characteristics, designated by symbols such as A1, A3, etc.

Emitter. An electron-emitting element.

Federal Communications Commission (FCC). The federal agency established to regulate the operation of all communications systems.

Feedback. The return of a small amount of energy from the output of a circuit to a previous point in the circuit. In-phase feedback causes regeneration; out of phase, degeneration.

Filter Capacitor. A capacitor used in conjunction with one or more components to remove AC.

Frequency. The number of complete cycles per second that occur, such as the AC cycles of a radio signal.

Frequency Conversion. The process of changing the frequency of a signal by combining it with another frequency of a different value.

Frequency Drift. A gradual change in frequency from a specified value. Prevalent in oscillator stages; usually caused by temperature changes within components.

Frequency Modulation (FM). The process of varying the transmitter carrier above and below its normal resting frequency in accordance with the voice signal.

Frequency Stability. The ability of an oscillator circuit or other AC-producing device to maintain a given frequency. Deviation limits from this frequency are usually given in percentage.

Frequency Tolerance. The maximum frequency variation permissible on either side of the carrier frequency.

Generator. A mechanical or electronic device capable of producing a voltage. For example, an automobile generator converts mechanical energy into electrical energy.

Grounded. Connection to earth, or to a conductor that simulates earth.

Ground-Plane Antenna. A type of vertical antenna with radials extending from the base, and having a low angle of radiation so practically all of the RF energy is confined to ground waves.

Ground Waves. Radio waves that travel principally along the earth's surface.

Half-Wave Antenna. An antenna with the main element(s) equal in physical length to one-half the wavelength of the received or transmitted frequency.

Harmonic. An integral multiple of any frequency. For example, the frequency of a second harmonic is twice that of its fundamental.

Heterodyne Frequency Meter. An instrument for determining the frequency of a transmitter or other signal-producing device.

Horizontally-Polarized Wave. An electromagnetic wave whose electric lines of force are parallel to the earth's surface.

Impedance. The total opposition offered to the flow of alternating current.

Impedance Match. The condition whereby the impedance of a circuit or component is equal to the impedance of its source.

Inductive Coupling. A method by which energy from a coil is induced into another coil.

Input Capacity. The sum of all direct capacitances at the input of a circuit.

Interference. Any noise or disturbance that affects the reception of radio signals.

Intermediate Frequency (IF). The difference frequency produced by mixing the incoming RF and the local-oscillator signals.

Intermediate-Frequency Amplifier. The amplifier that boosts the IF signal.

Inverter. A device that changes DC into AC.

Kennelly-Heaviside Layers. Layers of ionized gases between 50 and 400 miles above the earth. These layers tend to deflect the radio signals back to earth and thus make long-distance communications possible.
Kilocycle (kc). 1000 cycles per second.
Kilowatt (kw). 1000 watts.
Lead-in Insulator. A tube inserted through a hole drilled in a wall or window, through which the antenna lead-in wire is run.
Leakage. Undesirable current flow over or through an insulating material.
Line Drop. The amount of line voltage lost between the source and the equipment due to leakage, reactance, and DC resistance in the line.
Line Filter. A network connected between the voltage source and the radio equipment to remove unwanted noise signals.
Line Voltage. The AC voltage at the wall receptacle.
Load. A component or device placed into a circuit to absorb power so it can serve a useful purpose. Also, the amount of power taken from a circuit.
Loading Coil. A device used on an antenna to make it electrically longer than it is physically.
Matching. Connecting two circuits or components together so their impedances are equal.
Megacycle (mc). 1,000,000 cycles per second.
Milliampere. 1/1000th of an ampere.
Milliwatt. 1/1000th of a watt.
Mixer. The stage where two different signal frequencies are combined to form a third frequency.
Modulate. To vary the amplitude or frequency of a signal in accordance with another.
Modulator. The transmitter stage that delivers the modulating signal.
Neutralization. Any process that balances out or prevents an undesirable effect.
Noise Limiter. A network or circuit used to reduce or eliminate noise pulses.
Ohm's Law Formula. The formula that expresses the relationship between voltage, current, and resistance in a circuit—namely, $E = I \times R$.
Oscillator. A vacuum tube or transistor stage capable of generating an AC signal.
Output Stage. The final stage in the radio equipment.
Overtone. A harmonic of a fundamental frequency.
Parallel-Resonant Circuit. A tuned circuit whose inductance and capacitance are connected in parallel.
Piezoelectric. A term meaning "pressure electricity." Quartz, for example, will produce a small voltage when force is applied to it, or vice versa.
Pi-Network. A network consisting of three impedances connected to resemble the Greek letter π.
Plate. The electron-collecting electrode of a vacuum tube. Also called the anode.
Plate Current. The current which reaches the plate in a vacuum tube.
Plate Modulation. A process whereby the signal in the final RF transmitter stage is varied in step with a modulating signal injected into the plate circuit.
Plate Power Input. The plate voltage times plate current of the final RF transmitter stage, measured with no modulation present.
Potentiometer. A device having a circular resistance element with a rotating contact arm that can be set at any desired point along its surface.
Power Transformer. An iron-core transformer that usually has a number of secondaries to provide a variety of AC voltages.
Push-Pull Circuit. An amplifier circuit containing two tubes, each conducting during one-half of the cycle, so that their combined output is more than that of a single tube.
Quartz. A mineral having piezoelectric properties, commonly used as the frequency-determining element (crystal) in oscillator circuits.
Radiate. To emit energy, such as radio waves, into free space.
Radio Frequency (RF). The frequencies at which useful electromagnetic radiation can be obtained for communication purposes.
Radio-Frequency Amplifier. The stage that boosts RF frequencies.

Radio Spectrum. The area between the highest and lowest frequencies capable of producing usable radio waves.

Radio Wave Propagation. The diffusion of electromagnetic waves into space.

Rectifier. A device through which current can flow in one direction only.

Refracted Wave. A radio wave that has been bent from its original course.

Resistance. The opposition a device or material offers to the flow of direct current.

Resonance. The condition in which the inductance and capacitance values of a circuit are such that maximum response is obtained.

Selectivity. The ability of a receiver to select and reproduce signals from a desired station while rejecting signals from other stations on adjacent channels.

Sensitivity. The receiver's ability to reproduce weak signals so they can be heard with satisfactory volume.

Signal Generator. A test instrument capable of producing an RF signal of a known frequency.

Signal-to-Noise Ratio. The ratio of the intensity of a desired signal, to the intensity of existing noise signals.

Single-Ended Stage. A stage having only one tube, as opposed to a push-pull stage.

Sky Waves. Waves that travel into the upper atmosphere, and may or may not be reflected back to earth.

Squelch. A circuit that automatically mutes the receiver when no signal is being received, or when the signal is below a predetermined level.

Static. A cracking or popping type of interference caused when static electricity discharges.

Superheterodyne Receiver. A receiver in which the incoming carrier signal is mixed (heterodyned) with another signal to produce an intermediate-frequency carrier.

Superregenerative Detector. A detector circuit in which part of the output signal is fed back to the input and regenerated.

Suppressor. A device used primarily in vehicle installation to reduce noise-pulse interference.

Temperature Coefficient. The change in characteristics of a substance for each degree centigrade change in temperature.

Thermistor. A resistor whose value varies with temperature, used to compensate for the effects of temperature variations on circuit operation.

Transceiver. A transmitter and receiver mounted on a single chassis and having one or more stages common to both sections.

Transmission Line. Any conductor used to convey signal energy from one point to another.

Trimmer Capacitor. A small adjustable capacitor used principally in the tuning circuits of radio equipment.

Ultra-High Frequency (UHF). Any frequency within the 300- to 3000-megacycle range.

Universal Power Supply. A power supply designed to operate from one or more AC and/or DC voltages.

Vertical Antenna. A nondirectional antenna that operates from a perpendicular position.

Vertically-Polarized Wave. An electromagnetic wave whose electric lines of force are perpendicular to the earth's surface.

Vibrator. An electromagnetic device which, by means of vibrating contacts, chops up direct current in the primary circuit of a transformer to provide AC across the secondary.

Voice Coil. A coil, attached to the cone of a dynamic speaker, which moves as the audio signal passes through it.

Voltage Doubler. A rectifier circuit that doubles the voltage it receives.

Voltage Drop. The voltage developed across a component by the current flowing through it.

Wavelength. The distance a radio wave travels during one cycle.

Zero Beat. The condition in which a beat frequency cannot be produced because the two frequencies being combined are of the same value.

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