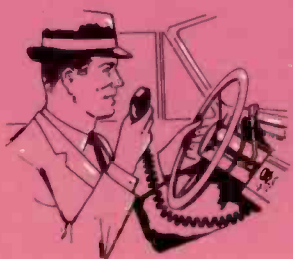
$1

SKILLFACT™ LIBRARY • 632

KNOW ABOUT Citizens Band Radio

A PRACTICAL GUIDE TO THE ESTABLISHMENT OF A CB SYSTEM:

- What CB radio is
- Licensing and eligibility
- Choosing your equipment
- Operation of the transceiver
- CB antennas
- Installation of equipment
- Operating hints
- Tests and repairs
- The FCC and you



KNOW ABOUT

Citizens Band Radio

by Len Buckwalter

EDITORS and ENGINEERS, LTD.
New Augusta, Indiana

FIRST EDITION

FIRST PRINTING — JANUARY, 1966

KNOW ABOUT
CITIZENS BAND RADIO

Library of Congress Catalog Card Number: 65-28881

PREFACE

Following approximately twenty years of steady development in the field of radiocommunications, the Federal Communications Commission, in 1958, allocated a communications band for general use by citizens of the United States. Called the Citizens Radio Service, this band of channels is provided for applications which do not fit into the established categories of municipal, emergency, and transportation services. The Citizens band is especially for "business and personal" communications.

To derive maximum benefit from the CB service, a user must understand the rules, regulations, procedures, and equipment operation. This book is written to supply such information. The applications of CB radio are discussed, and the restrictions imposed by the FCC are explained. This is a guide to the establishment of a CB system—from the initial idea to the completed and functioning installation.

By following the directions in this book and referring to the discussions, anyone should be able to set up an efficient CB communications system.

LEN BUCKWALTER

CONTENTS

CHAPTER 6

CHAPTER 7

CHAPTER 8

CHAPTER 9

CHAPTER 10

CHAPTER 1

WHAT IS CB RADIO?

Following twenty years of phenomenal growth in the field of radio communications the Federal Communications Commission (FCC) in September, 1958, allocated a 2-way radio service for use by the general public. The miracle of instant wireless communications, previously reserved for a select few, became available to virtually anyone who wanted to set up his own radiotelephone system. Compared with other radio services, licensing for the Citizens band is extremely simple—just fill out a form and mail it to the FCC secretary. There is no code test, and no technical skill or specialized knowledge of radio required.

The Citizens Radio Service fulfills several basic needs. It provides channels for persons who do not come under the traditional classifications of police, fire department, taxicab, or trucking company. In fact the prescribed use of Citizens Radio falls into two broad categories—business and personal communications. The low cost of equipment is another advantage. Purchasers of Citizens Radio gear will find that prices are a mere fraction of those commanded by commercial equipment. Substantial savings are also realized in the erection of an antenna and installation of equipment, since neither requires the services of an FCC-licensed technician.

To provide the maximum benefit to individuals, corporations, or other groups who desire to use Citizens Radio, the FCC has imposed certain limitations. By definition, the service is for "short-distance" communication. Under actual operating conditions, this means coverage from one to approximately 20 miles, depending on a variety of factors. Transmitter power is restricted to five watts and antenna height is regulated. The curbs on Citizens Radio are designed to prevent chaos in a medium which is intended to yield maximum benefit for the greatest number of users.

CLASS-D BAND

The origin of Citizens Radio actually dates back to 1947. In keeping with the concept of providing radio channels for the public-at-large, the FCC assigned a band of frequencies in a region known as *uhf* (ultrahigh frequency). Although the new band, extending from 460 to 470 megacycles, generated widespread interest, it suffered from several severe drawbacks. Equipment for UHF is costly and demands careful maintenance. Several manufacturers made ingenious attempts to reduce costs by new design techniques, but they never could truly alleviate the major shortcoming of the band—limited range.

Frequencies in the 460-megacycle portion of the radio spectrum begin to take on the characteristics of light waves. These frequencies are easily reflected or absorbed by trees, buildings, and other obstacles in their path. Also long cables between radio and antenna, quickly dissipate a large portion of the transmitting power. The bands are often erratic and unpredictable. There have been incidents where two persons, in plain view of each other, were unable to communicate over a distance of several hundred yards. These high frequencies are successfully used in commercial installations where elaborate antenna arrays and high power are feasible, but this is of course impractical in terms of true, low-cost Citizens Radio Service.

11-Meters

The FCC's September, 1958, ruling created the long-awaited Class-D band. The 11-meter (27-megacycle) amateur-radio band was segmented into 22 channels for Class-D Citizens Radio Service and later a 23rd was added. The ruling brought overwhelming public approval. Within two years over 100,000 persons filed applications and were licensed for the new band. The number of manufacturers producing popular-priced Citizens Radio sets spiraled from one to over 30. The reasons behind the acceptance of the Class-D band are simple—low cost and good operating range.

Kits

Another welcome aspect of the new service is the FCC's approval of kit-built equipment. For the first time outside the field of amateur radio, a nontechnical person can build his own 2-way radiotelephone without special skills or equipment. The kit manufacturers met the brisk demand by marketing a variety of Citizens Radio kits in several price ranges. The savings afforded are comparable to those which made the "do-it-yourself" hi-fi kit so popular.

The content of this book emphasizes the Class-D band. As a medium of 2-way communications, it offers a multitude of advantages over the older Class-A and -B, (uhf) channels. The remaining group of frequencies, under the heading of Class-C, are reserved for radio-control systems (e.g. model airplanes and garage-door openers).

APPLICATIONS OF CB RADIO

Within the limits of business or personal communications, the uses of Citizens Radio can be varied widely. An installation in your car provides continuous voice contact with a set located in your home. Communications between two cars or two homes is practical, and instal-

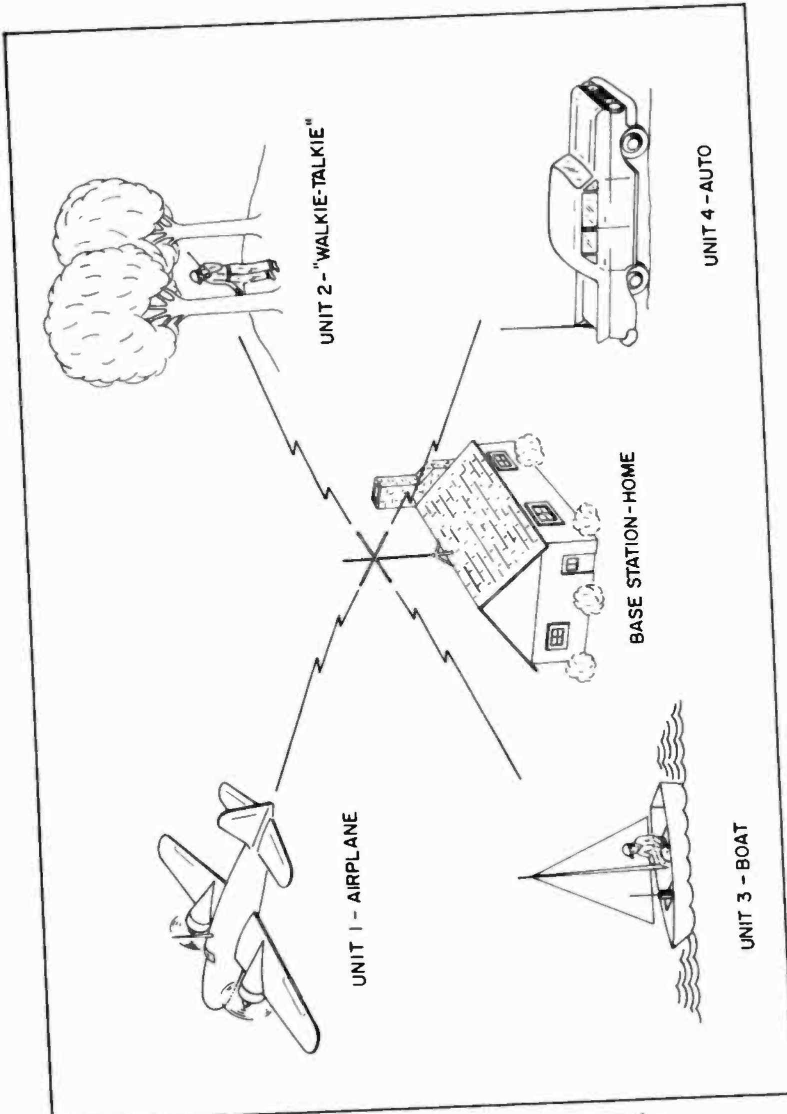


Fig. 1-1. A base station and four remote units.

Fig. 1-2. CB "handie-talkie" provides three-mile range.

lations can be made in a business office, factory or other key locations. Each station in the "network" (Fig. 1-1) is linked to the others within the communicating range.

Business Uses

Business uses of Citizens Radio can result in more profitable operation. The efficient dispatching of trucks en route can more than make up the cost of the equipment and its servicing within a short time. Businessmen, professional people, and salesmen can be in constant contact with their offices—quickly informed of important messages. Wireless communication proves indispensable to the large-scale operations often encountered in farming, construction projects, and plant security (Fig. 1-2).

Fig. 1-3. Stranded motorist can summon assistance on CB radio.

Personal Uses

Personal uses are similarly varied. Tied up in traffic, automobile trouble (Fig. 1-3), staying late at the office, last-minute change in social plans? Contact the home station while driving along the highway. Campers and sportsmen have found numerous uses for communication between widely separated points. Boating enthusiasts will find Citizens Radio a boon, and possibly a lifesaver, in their activities. The simplicity and low cost of installation enables the smaller boats to approximate the same electronic safety equipment enjoyed by larger crafts.

Restrictions

Although the restrictions on the use of the band are reasonable, it should be remembered that it is set up on a "party-line" basis. You will, on occasion, have to wait until another station has completed its transmission and the channel is clear. Keeping transmission time down to the shortest possible length (as indicated by FCC law), is essential to keeping the Citizens band an efficient medium.

This band is certainly no place for the type of activity reserved for amateur radio where lengthy discussions of equipment, antennas, etc. are commonplace and legal. *Contacting another station merely to see how far your signal "gets out" is a practice which is strictly illegal.* Since the initial rulings on Citizens Radio were published the FCC has followed up with several amendments to curb some of the abuses of the band. Many of them apparently were due to misunderstanding of the role of Citizens Radio. The service is not an end in itself (i.e. a hobby or form of recreation), but rather a medium for the brief exchange of definite messages. Part 95 of the Rules and Regulations of the Federal Communications Commission should be studied thoroughly before attempting any operation of CB equipment.

CHAPTER 2

LICENSING AND ELIGIBILITY

Any U.S. citizen over the age of 18 may file for a Citizens Radio license. Actually, the minimum age limit is not quite that restrictive. The license is for the station equipment only; there is no need for an operator's ticket. Thus, a person under 18 may use a Citizens Radio system, if the licensee assumes responsibility for the proper operation. The responsibility applies to anyone you authorize to participate in your private communications setup. A single station license covers all units under your control.

Provisions for licensing partnerships, corporations, and state and local governments also appear in the regulations. The notable exceptions in the case of group licensing occur where any officer of a corporation is an alien or if the corporation is controlled by a foreign government.

The eligibility requirements for Citizens Radio are intended to give the largest possible group access to the benefits of 2-way radio. But, this does not imply that anyone may indiscriminately use the band to expedite an illegal business. A Citizens Radio station may not be operated for any purpose contrary to federal, state, or local law.

Since there are no examinations required for the license, all paper work may be completed at home and the filing done through the mail. The license fee is $8.00 and the license is good for 5 years. The only other cost involved is for a copy or copies of the regulations.

FCC RULES AND REGULATIONS

The first step toward obtaining a license is to secure a current copy of Part 95 of the FCC Rules and Regulations. According to Federal Communications Commission ruling this must be in your possession when you sign the application form.

The laws of telecommunications are grouped into ten volumes which cover all the services under FCC jurisdiction. Part 95, dealing with Citizens Radio, appears in Volume VI which also includes parts on Amateur and Disaster Communications, and costs $1.25. This one-time charge entitles the buyer to receive all future amendments to Volume VI for an indefinite period. On receipt of an amendment, the obsolete page is removed and the new one is inserted (Fig. 2-1), thus, continuity is not disturbed.

Volume VI is available by writing to:

Superintendent of Documents
U.S. Government Printing Office
Washington, D. C. 20402

Enclose $1.25, in check or money order, and allow about two weeks for delivery.

(Part 95 covers not only the legal aspect of Citizens Radio, but constitutes a sort of "handbook" of operating procedures, frequency allocations, and a wealth of other essential information.)

HOW TO FILL OUT AND FILE APPLICATIONS

The application form for the Citizens Radio license is secured from your local FCC field office. (Select the nearest one from the list given in the appendix.) Request by telephone or letter, FCC Form #505, Application for Class B, C, or D Station License in the Citizens Radio Service.

The application, Form #505, consists of three major sections: (1) an instruction sheet, (2) a work sheet, and

(3) the license form itself. In an effort to reduce the number of improperly completed applications, (which can cause weeks of delay), the instruction sheet is quite detailed. It explains each entry to be made on the work sheet, a duplicate of the license form (except for the

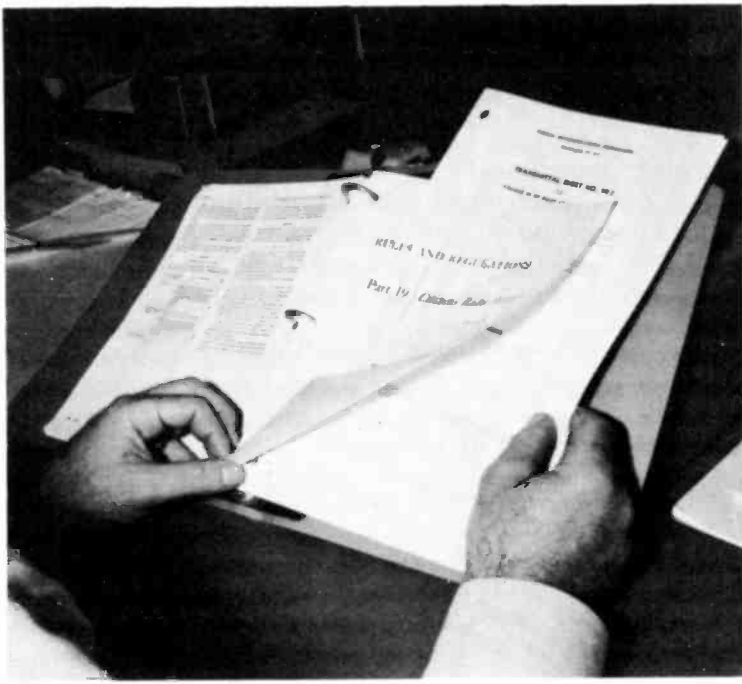


Fig. 2-1. Part 95 of FCC rules and Regulations.

words "Work Sheet" printed across its face). After you fill out and carefully check the work sheet transfer the information to the license form.

Tear off the instruction and work sheets and proceed to Item 1 (Fig. 2-2). The name to whom the license is to be issued is listed here. If you are in a partnership which has a business name or a corporation, list the business name under Item 1. If the partnership does not have a business name list one partner's name under Item 1, the other partners' names are then listed under Item 2.

Item 3 is self explanatory. Give your correct mailing address. Check the appropriate box under Item 4. If for a trust or a joint venture, check the box marked "Other" and specify the classification in the space provided. This should be further explained in the "Remarks" space (on the reverse side of the application). Put an "X" in the box preceding the words "Class D" in Item 5.

Items 6 and 7 are self explanatory. Check the appropriate boxes. If you check "yes" under Item 7, the reason you are requesting an additional license should be explained in the space for remarks on the reverse side of the application. For example, describe the area of operation, and state whether or not the license is to be for the same radio system or group of transmitters.

The total number of transmitters you expect to have in operation at any one time during the next 5 years should be listed under Item 8. If you expect to add to your system later, list the proposed stations now. Otherwise a new application will have to be filed before the new stations can be put into operation.

Items 9 through 17 require simple "yes" or "no" answers. Note that a "no" answer for items 10(c), 11, or 12 will cause the application to be returned, since such operation is contrary to FCC regulations. If the station is to be operated at the same location as the mailing address, write "same" under Item 18. If not, describe the location where the station will be operated.

Two additional groups of questions are included on the reverse side of the application. Item 19 applies only to corporations and Item 20 to associations.

A space for your signature is also included on the reverse side of the application. In signing the application, you certify that: (1) you have (or have ordered) a current copy of Part 95 of the FCC Rules and Regulations, (2) that you waive any claim to any particular frequency,

FCC FORM 505
JANUARY 1964

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

FORM APPROVED
BUDGET BUREAU NO. 52–R123.10

APPLICATION FOR CLASS B, C, OR D STATION LICENSE IN THE

CITIZENS RADIO SERVICE

DO NOT WRITE IN THIS BLOCK

1. Application for Class A station license must be filed on FCC FORM 400.
2. Complete on typewriter or print clearly.
3. Be sure application is signed and dated. *Mail* application to Federal Communications Commission, Gettysburg, Pa., 17325.
4. Enclose appropriate fee with application, if required. DO NOT SUBMIT CASH. Make check or money order payable to Federal Communications Commission. (See Part 95, Volume VI of FCC rules to determine whether a fee is required with this application.)

1 NAME OF APPLICANT

BUSINESS NAME (OR LAST NAME, IF AN INDIVIDUAL)

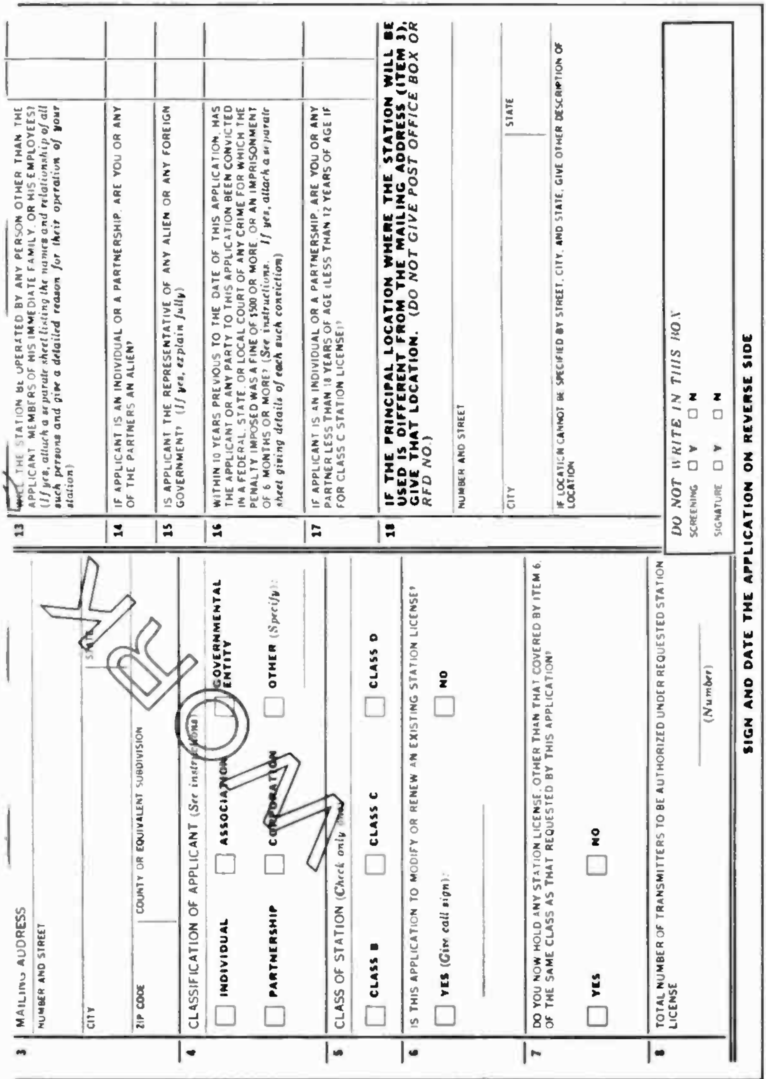
FIRST NAME (IF AN INDIVIDUAL) | MIDDLE INITIAL

2 IF AN INDIVIDUAL OPERATING UNDER A TRADE NAME, GIVE INDIVIDUAL NAME; OR IF PARTNERSHIP, LIST NAMES OF PARTNERS (*Do not repeat any name used in item 1*)

LAST NAMES	FIRST NAMES	MIDDLE INITIAL

		YES	NO
9	DOES EACH TRANSMITTER TO BE OPERATED APPEAR ON THE COMMISSION'S "RADIO EQUIPMENT LIST, PART C," OR, IF FOR CLASS C OR CLASS D STATIONS, IS IT CRYSTAL-CONTROLLED? (*If no, attach detailed description: see subpart C of Part 95*)		
10	A. WILL APPLICANT OWN ALL THE RADIO EQUIPMENT? (*If no, answer B and C below*)		
	B NAME OF OWNER		
	C IS THE APPLICANT A PARTY TO A WRITTEN LEASE OR OTHER AGREEMENT UNDER WHICH THE OWNERSHIP OR CONTROL WILL BE EXERCISED IN THE SAME MANNER AS IF THE EQUIPMENT WERE OWNED BY THE APPLICANT?		
11	HAS APPLICANT READ AND UNDERSTOOD THE PROVISIONS OF PART 95, SUBPART D, DEALING WITH PERMISSIBLE COMMUNICATIONS FOR WHICH THIS CLASS OF STATION MAY BE USED?		
12	WILL THE USE OF THE STATION CONFORM IN ALL RESPECTS WITH THE PERMISSIBLE COMMUNICATIONS AS SET FORTH IN PART 95, SUBPART D?		

Fig. 2-2. License



3 MAILING ADDRESS
NUMBER AND STREET
CITY | STATE
ZIP CODE | COUNTY OR EQUIVALENT SUBDIVISION

4 CLASSIFICATION OF APPLICANT (*See instructions*)
☐ INDIVIDUAL ☐ ASSOCIATION ☐ GOVERNMENTAL ENTITY
☐ PARTNERSHIP ☐ CORPORATION ☐ OTHER (*Specify*):

5 CLASS OF STATION (*Check only one*)
☐ CLASS B ☐ CLASS C ☐ CLASS D

6 IS THIS APPLICATION TO MODIFY OR RENEW AN EXISTING STATION LICENSE?
☐ YES (*Give call sign*): ☐ NO

7 DO YOU NOW HOLD ANY STATION LICENSE, OTHER THAN THAT COVERED BY ITEM 6, OF THE SAME CLASS AS THAT REQUESTED BY THIS APPLICATION?
☐ YES ☐ NO

8 TOTAL NUMBER OF TRANSMITTERS TO BE AUTHORIZED UNDER REQUESTED STATION LICENSE
(*Number*)

13 WILL THE STATION BE OPERATED BY ANY PERSON OTHER THAN THE APPLICANT, MEMBERS OF HIS IMMEDIATE FAMILY, OR HIS EMPLOYEES? (*If yes, attach a separate sheet listing the names and relationship of all such persons and give a detailed reason for their operation of your station*)

14 IF APPLICANT IS AN INDIVIDUAL OR A PARTNERSHIP, ARE YOU OR ANY OF THE PARTNERS AN ALIEN?

15 IS APPLICANT THE REPRESENTATIVE OF ANY ALIEN OR ANY FOREIGN GOVERNMENT? (*If yes, explain fully*)

16 WITHIN 10 YEARS PREVIOUS TO THE DATE OF THIS APPLICATION, HAS THE APPLICANT OR ANY PARTY TO THIS APPLICATION BEEN CONVICTED IN A FEDERAL, STATE, OR LOCAL COURT OF ANY CRIME FOR WHICH THE PENALTY IMPOSED WAS A FINE OF $500 OR MORE, OR AN IMPRISONMENT OF 6 MONTHS OR MORE? (*See instructions. If yes, attach a separate sheet giving details of each such conviction*)

17 IF APPLICANT IS AN INDIVIDUAL OR A PARTNERSHIP, ARE YOU OR ANY PARTNER LESS THAN 18 YEARS OF AGE (LESS THAN 12 YEARS OF AGE IF FOR CLASS C STATION LICENSE)?

18 **IF THE PRINCIPAL LOCATION WHERE THE STATION WILL BE USED IS DIFFERENT FROM THE MAILING ADDRESS (ITEM 3), GIVE THAT LOCATION.** (***DO NOT GIVE POST OFFICE BOX OR RFD NO.***)
NUMBER AND STREET
CITY | STATE
IF LOCATION CANNOT BE SPECIFIED BY STREET, CITY, AND STATE, GIVE OTHER DESCRIPTION OF LOCATION

DO NOT WRITE IN THIS BOX
SCREENING ☐ Y ☐ N
SIGNATURE ☐ Y ☐ N

SIGN AND DATE THE APPLICATION ON REVERSE SIDE

Courtesy Federal Communications Commission

application form.

(3) that you accept full responsibility for the operation of the station, (4) that the station will be operated in accordance with all applicable laws and the current FCC rules, (5) that the station will not be used for any purpose contrary to law, (6) that you will have unlimited access to the equipment and will prevent its use by unauthorized persons, and (7) that all statements are true, complete, and correct to the best of your knowledge. Notarization of the application is not necessary. However, any willful false statements are punishable by fine and imprisonment.

After you sign the application, keep the work and instruction sheets and mail the license form with your check or money order for $8.00 to:

Secretary
Federal Communications Commission
334 York Street
Gettysburg, Pennsylvania 17325

The processing, assignment of call letters, and delivery of your license will take from three to eight weeks. *Do not* attempt to operate your equipment until the actual license is received—such operation is strictly illegal. Do not attempt to speed up your license by writing to the FCC and inquiring about your application. This will usually slow it up instead, because your application will have to be removed from the regular flow channel for checking. Thousands of applications are received each month; each is processed as soon as modern data-processing equipment can handle it, so just be patient.

CHAPTER 3

CHOOSING YOUR EQUIPMENT

The prospective buyer of Citizens Radio equipment is confronted with an array of models produced by dozens of manufacturers. The products of individual companies are varied to suit the needs of diverse applications, but regardless of shape or style, each unit sold for Class-D Citizens Radio has to conform to FCC specifications. This is assured by a rule that states the manufacturer must certify to the purchaser, in writing, that the unit is designed and furnished in accordance with these regulations. Watch for this in advertising literature and instruction manuals.

LEGAL REQUIREMENTS

The buyer should be wary of equipment offered on the surplus market and labelled for Citizens band use. True, the frequency coverage often falls within the 27-megacycle region, but it takes a skilled technician to perform the necessary modifications. This expense often offsets the initial low cost. Another limitation on the conversion of this type gear is the commercial radiotelephone license required to perform certain changes and adjustments.

The safest course for the person with a limited electronics background is to select equipment from one of the reputable companies engaged in the manufacture of Citizens Radio equipment.

Foremost among the FCC specifications covering Class-D sets are crystal control, frequency tolerance, and transmitter power. The licensee is not *required* to understand these terms, but a basic understanding will promote intelligent selection and operation of a station.

Citizens Radio equipment offered in kit form (Fig. 3-1) must conform to the same regulations as the factory-

Courtesy Allied Radio Corp.

Fig. 3-1. Knight C-22, a unit which is available in kit form.

assembled units. To insure against off-frequency operation, the kit manufacturer must include in his kit a prewired and pretuned crystal oscillator. This "packaged" circuit contains the critical frequency-determining section of the transmitter. Fortunately, this represents only about one fifth of the kit's components and thus leaves most of the construction in the hands of the builder. This arrangement permits the benefits of the do-it-yourself kit, while eliminating the need for expensive test equipment and the services of an FCC-licensed technician.

Most of the FCC regulations apply to the transmitting section of a Citizens' Radio station, with little mention of the receiver, because of the possible interference to stations which operate on the same or adjacent channels. Off-frequency operation or distorted signals, which spill over into nearby channels, seriously affect the intelligibility of transmissions. Also, the power limitation of five watts keeps the range of a station on a local basis. Operators, far removed from each other, should be able to simultaneously transmit on the same channel. The technical restrictions on equipment ensure *clean signals*—an important factor in the crowded radio spectrum.

SPECIFICATIONS

Most Citizens Radio sets are *transceivers*—a combination of transmitter and receiver. The transceiver design offers the twin advantages of compactness and economy. Duplication of circuits is avoided by making certain sections of the unit serve alternately in the send and in the receive positions. An audio amplifier, for example, boosts the signals for the speaker when the set is on receive, and amplifies the microphone signals when the switch is thrown to send. The need for two power supplies is avoided in a similar manner.

In certain modes of operation, it is valuable to have a piece of equipment capable of receiving only. For example, when a transceiver is located in a garage and used for truck dispatching, a receiver which will pick up both sides of the conversation is often placed in a nearby office for monitoring purposes. There are two units which can supply the receive function: a short-wave receiver or a converter. Most short-wave sets have a frequency coverage extending to 30 megacycles, and thus will receive the Citizens band. On older sets, look for a dial calibration which reads "Amateur" or "11 Meters." This slot, in the vicinity of 27 megacycles, is the site of the Class-D Citizens band.

Converters

The converter is an add-on device. It is used to extend the coverage of a standard broadcast radio to include the Citizens band. Converters are useful in mobile applications for monitoring purposes or where a separate transmitter is purchased. The relatively low cost is the principle advantage of this kind of unit which utilizes all the circuits of the broadcast receiver.

Converters are available in tunable and fixed-tuned types—simple construction and ease of tuning have made the fixed-tuned version the more popular of the two. After installation, the broadcast tuning dial is used to select stations. To restore reception on the standard broadcast band, the converter is unplugged, or disconnected through a suitable switching arrangement. The receiver can then be used in the normal manner.

Most Citizens band equipment is of the transceiver type—a complete package with most of the technical problems already solved by the manufacturer. Choosing an appropriate model is a matter of matching the unit's features to the intended application. It would be impractical for a mid-western farmer, who requires communication between a tractor and the farmhouse, to buy a feature-laden unit in the $200-plus category. For very short range, in a relatively interference-free area, one of the simpler sets would be adequate.

Receivers

Transceivers are generally classified according to their special features.

Selectivity—The superheterodyne receiver (Fig. 3-2) is not afflicted with selectivity problems to the extent that the older superregenerative set was, and it can accommodate a host of special features. Evaluating a *superhet* is mostly a process of counting and comparing specifications. Since each feature will add to the over-all cost, each one should be judged in terms of the intended use of the station.

Is the receiver equipped with an r-f (radio-frequency) amplifier? This stage contributes much to sensitivity and selectivity. Selectivity normally increases with the number of receiver stages. Although r-f stages rarely exceed one in number, the i-f (intermediate-frequency) section may contain two or more.

The most complex sets employ a system known as *dual conversion,* wherein two i-f sections sharpen the receiver's *response,* making it immune to a type of superhet fault known as images. These are false signals that can interfere with your channel, although they are produced by stations on other frequencies (not necessarily in the

Courtesy Lafayette Radio Electronics Corp.

Fig. 3-2. Lafayette HE-20b, a typical superheterodyne transceiver.

Citizens band). When incorporated into a particular model, basic circuit refinements are usually well-advertised by the manufacturer.

Noise Limiting—Mobile transceivers should have some form of noise-limiting device since pulses of energy generated by auto or boat ignition systems can seriously interfere with reception. There are several measures for eliminating noise at the source—spark plugs, generator, and voltage regulators—but they are ineffective against noise emanating from vehicles other than your own. The measure of a good noise limiter is how effectively it reduces noise without producing excessive distortion or reduction of the audio.

Squelch—Another valuable feature in the receiver of Citizens Radio sets is *squelch*. This circuit will mute the speaker until a signal is received. A squelch (Fig. 3-3) is especially convenient when the receiver is left on for long

Courtesy International Crystal Mfg. Co. Inc.

Fig. 3-3. International Crystal KB-1, one of the many CB kits that include a squelch circuit.

periods of time in anticipation of a message. The constant background noise and assorted static crashes in the speaker can disrupt the quiet atmosphere of an office or prove distracting while driving. With the squelch switched on, the speaker comes to life only through the action of a received signal. The simple squelch system is not selective; other stations operating on the channel can

Courtesy EICO Electronic Instrument Co. Inc.

Fig. 3-4. EICO 772 multichannel transceiver available in kit or factory-wired form.

also disable it and become audible. The selective call system, where the squelch is overcome only by your remote stations, is quite costly at present, but is a convenient feature. In this system, the squelch on your receiver can only be triggered by a tone transmitted by your other units. It eliminates a lot of inconvenience in that other stations on the same frequency will not be heard. Your receiver will be silent until it is activated by one of your own units.

Transceiver Tuning

One of the important questions in the choice of Citizens Radio equipment deals with multichannel operations. In multichannel units a front-panel switch (Fig. 3-4) permits the choice of several transmitting frequencies. The immediate advantage is that communications can be shifted to a clear channel in the event of interference. Another benefit is that transmissions may be addressed to one group of remote units while excluding others (for example: trucks on one channel, passenger cars on another).

The system used for receiver tuning is closely coupled with the multichannel operation of the transmitter. The simpler units have continuous tuning over the complete Citizens band. If the transmitter is of a single-channel design, the receiver tuning dial is left on the same channel with only occasional need for retuning. But, where multichannel operation is used, the continuously tuned receiver can present a problem. The operator must tune his receiver to other channels with precision or the transmission will be missed. The tuning error is worsened by the dial calibration employed on most Citizens Radio sets: channel numbers which appear on the panel are only rough indications of frequency. Drifting due to heating and mechanical "play" often causes the receiver to be far off frequency.

The more expensive transceivers utilize a crystal-controlled receiver (often in addition to the continuously tuned dial). The operator manipulates a channel selector which clicks precisely into place, the receiver is electronically locked on the channel by receiving crystals. The transmit channel ganged to the same switch, simultaneously shifts into place. This system has been traditionally used in commercial communications equipment where continuous tuning would be slow and inaccurate; in other words, highly inefficient.

Compared with receivers, transmitter sections offer few special features except for multichannel operation. The input power to the final radio-frequency stage of the transmitter must not exceed five watts and the crystal frequency *must* have a tolerance of $\pm .005\%$ or less to comply with FCC regulations.

Power Supply

After a transceiver is selected on the basis of features versus cost and application, the major consideration is the power supply. Virtually all Citizens Radios have provision for three types of primary power sources: 120-volt alternating current, 6-volt direct current, and 12-volt direct current. There are sets which offer one or any combination of these power supplies. If the transceiver has interchangeable power supplies, select the one which matches the power source: auto or boat storage battery, or the 120-volt a-c house current. The trend, however, is toward the combined supply: either 6-volt direct current and 120 alternating current, or 12-volt direct current

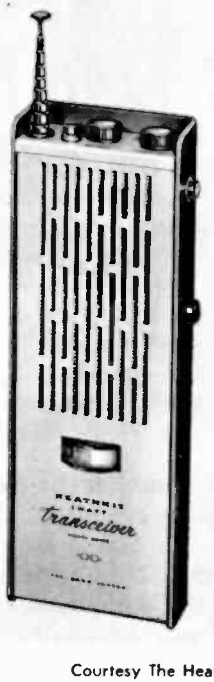


Fig. 3-5. The Heathkit 1-watt walkie-talkie.

Courtesy The Heath Co.

and 120-volt alternating current. Versatility is attained with the dual supply since the set may be quickly switched from mobile to fixed station operation. The changeover is usually effected by choice of the proper power cable.

CB RADIO KITS

The choice of between buying a kit (Fig. 3-5) or a unit assembled by a manufacturer is a highly individual one. With reasonably good workmanship, kit-built equipment

Courtesy Allied Radio Corp.

Fig. 3-6. A factory-assembled unit with many features not found in a kit.

should match the performance of a factory model of comparable circuitry. If you do not calculate your assembly time in terms of dollars, the kit affords a significant saving. This approach, too, can yield the sense of satisfaction which most people associate with the do-it-yourself project. After the unit has been in service some of the repairs and maintenance can be performed by the kit builder with knowledge acquired during assembly. According to FCC regulations, however, there are sections which may only be serviced by a licensed technician—primarily the frequency-determining circuits which are prewired at the factory.

The appeal of the factory-built unit (Fig. 3-6) also manifests itself in several ways. It is ideal for those who are not handy with a soldering iron or who are limited in the amount of free time. Time consideration begins to assume special importance where large numbers of units are required. Finally, there are certain features incorporated in commercial equipment which are unavailable in kit form.

CHAPTER 4

OPERATION OF THE TRANSCEIVER

The basic design of the transceiver varies little between models—usually the number of operating features and the mounting style. Thus it is possible to explain the operation of transceivers with a fundamental block diagram.

Although the circuit configuration presented here is greatly simplified it can be of assistance in keeping a transceiver in peak operating condition. It is also helpful for isolating trouble. Fig. 4-1 is a block diagram of a typical transceiver. Each of the boxes represents one or more vacuum-tube stages and often, a single box will mean a multiunit tube where a single glass envelope encloses the elements of more than one tube. The block diagram serves as a kind of road map which traces the route of the signal as it is processed. While the transceiver is in the receive mode, the signal path is from antenna to speaker. In the send, or transmit, mode the signal originates in the microphone and ultimately radiates from the antenna.

TYPICAL TRANSCEIVER UNIT

Referring to Fig. 4-1, note that the circuit is marked off into four major sections—receiver, audio, transmitter, and power supply—each enclosed by dotted lines. In order to direct the signal to the proper section, switches (marked SW-A through SW-D) are shown at various points throughout the diagram. This actually represents one switch with four sections, and appears on the front panel of the transceiver as a single lever or button: press to talk or send-receive. When this switch is thrown from

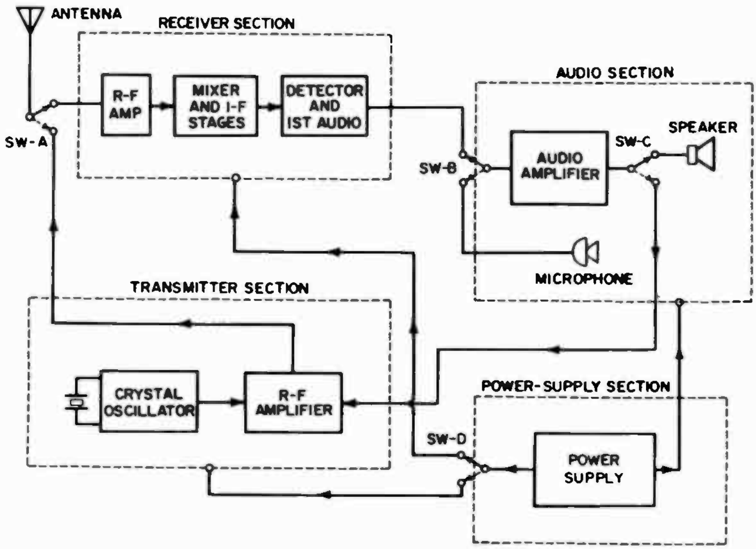


Fig. 4-1. Block diagram of a typical transceiver.

receive to send, all of its sections change over simultaneously, and the signals will be routed correctly. The power-supply and audio sections will then serve alternately for the receiver and transmitter. The transceiver cannot transmit and receive at the same time as a consequence of this. Each party must wait until the other transmission is completed before he can respond. This limitation becomes insignificant when the simplicity of the circuit is considered; there is no need for dual (or large) power supplies or two audio sections.

Receive Mode

Fig. 4-1 shows the transceiver in its receive position. The antenna, at the upper left of the drawing, is placed to intercept the radio waves originating from the transmitting station. Signals of all frequencies travel down the antenna and are diverted to the receiver. Signals reach this point through SW-A, the first section of the send-receive switch. If the switch were in its alternate position, (transmit), the antenna would be connected to the transmitter.

Audio—The audio section of the receiver is shown as a separate unit since it is common to both the receive and transmitter sections. Note that SW-B, the second section of the send-receive switch, transfers receiver output to the audio amplifier (not to the microphone). At this point in the circuit (the output of the receiving section) audio signals are very low in level and must pass through two stages of audio amplification before they are at sufficient power to drive the speaker to adequate listening levels.

Power Supply—The Power supply, through SW-D, energizes the receiver when the set is in the receive mode. The audio portion of the circuit, however, is always powered, since it is used in both transmit and receive positions—only the signal connections to the audio amplifier are switched.

Transmit Mode

During transmitter operation the switch is in the send position, as shown by the dotted arrows on the four switch sections. The crystal, which determines the transceiver's transmission channel, (at the lower left of Fig. 4-1) is a tiny piece of quartz, ground and lapped to extremely close tolerances and mounted in a plug-in container. For multichannel receivers, more than one crystal is employed with appropriate channel switch. The crystal, working in conjunction with a tube, generates electrical vibrations to precisely control the frequency of the transmitter. The *overtone* crystal was developed because a crystal cut specifically for the 27-megacycle band is very fragile and therefore unable to pass sufficient current. If a crystal is cut to vibrate at a specified frequency, it will be found to produce overtones, or harmonics (vibrations, which are multiples of its fundamental frequency). Through special techniques, a crystal can be manufactured to favor its third harmonic—the most popular type in Citizens Radio equipment. Therefore the fundamental of a 27-megacycle, third-overtone crystal will be 9 megacycles. To avoid confusion, manufacturers mark their crystals with the Citizens band or actual operating frequency. The crystal oscillator contains the frequency-determining elements of the transmitter, which should be adjusted or repaired only by a licensed technician.

R-F Amplifier—Second in the transmitter line-up is the r-f amplifier. Its purpose is to raise the low output of the crystal oscillator to the five-watt limit (in most cases) permitted by FCC law.

Modulation—The modulation for the transmitter originates at the microphone. The voice sets up trains of air movement which strike the diaphragm of the microphone. This mechanical action is converted into audio voltage and applied to the audio amplifier; and as in the receive function, the low-level audio is raised in strength (but here, until it reaches approximately 2½ watts). Since the send-receive switch is now in transmit position, the audio goes to the transmitter rather than to the speaker. The modulation process of impressing the voice signal onto the r-f carrier occurs at the output of the transmitter's r-f amplifier. As in the conventional a-m system, the strength (amplitude) of the radio-frequency carrier is varied according to the applied audio signal. When the audio amplifier section functions in this manner, it is called an *amplitude modulator*.

Radiation—The modulated radio frequency is passed to the antenna through the SW-A section of the send-receive switch and transmission occurs as the carrier currents leave the antenna in the form of electromagnetic radiation. These radio waves bridge the gap between two transceivers at the speed of light (i.e. 186,000 miles per second).

TYPICAL SUPERHETERODYNE RECEIVER

For the sake of clarity, the block diagram of the superhet transceiver in Fig. 4-1 shows the receiver as only three units. Actually, these three sections contain several subsections (Fig. 4-2).

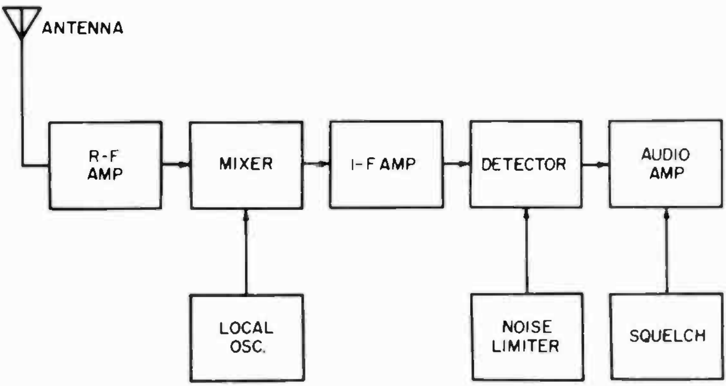


Fig. 4-2. Block diagram of a superheterodyne receiver.

Signal Path

It is immediately apparent that the superhet receiver is more complex than the transmitter. There are several more stages—the mixer, local oscillator, i-f amplifier, noise limiter, and squelch accessories.

The signal path through the block diagram commences at the antenna. The r-f amplifier tunes to and amplifies radio signals in the 27-megacycle band. The next stage in the signal path is the mixer, where a radical change in frequency occurs. The local oscillator is connected to the mixer and generates a radio frequency which heterodynes with the incoming signal in the mixer stage. The result of this combination of two different frequencies is called the intermediate frequency (i-f).

The reasons for altering the incoming frequency with the local oscillator are twofold: one, the selectivity of an amplifier is more favorable at lower frequencies; also, the i-f amplifier can be designed to operate more efficiently on a single frequency.

Assume that an intermediate frequency of 1750 kilocycles (1.75 megacycles) is arbitrarily selected. When the set is tuned to 27.065 megacycles (channel 9), the local oscillator will produce 25.315 megacycles. When the two signals—local oscillator and received signal from the antenna—combine, or heterodyne, in the mixer, the result is a difference of 1750 kilocycles. Other mixing products are present in the mixer output, but the i-f amplifier is fixed-tuned and only accepts 1750 kilocycles. The voice modulation on the radio-frequency carrier remains unaffected by the mixing process.

If the tuning dial is moved to another channel, the local oscillator will similarly shift and generate a frequency which is always 1750 kilocycles below the channel frequency. The net result is that all incoming channels will be converted to the intermediate frequency whose low numerical value provides sharp selectivity. Also, the i-f stage operates best on its nominal 1750 kilocycles with no need for the compromise incident to tunable amplifiers. The ultimate in superhets uses the double conversion system, in which the intermediate frequency is converted to a lower value for a second time.

Crystal control of the local oscillator is a means for providing rapid, precise tuning of the receiver. In this modification, the variable tuning dial gives way to a switch and one or more crystals. When the switch is clicked onto a channel, the crystal generates the exact local-oscillator frequency for that channel. In some transceivers a selector switch gives the operator the choice of either continuous tuning or crystal-controlled reception, thus adding to the versatility of the set and equipping it for any mode of operation.

The output of the i-f amplifier is applied to the detector for removal of the voice modulation from the carrier wave (now on 1750 kilocycles). At this point in the circuit, the noise limiter functions to clip the sharp pulses of interference which often mar reception. The squelch performs its job by cutting off the operation of the first audio amplifier unless a signal is being received. Output of the audio amplifier then proceeds to the balance of the audio amplification section and speaker.

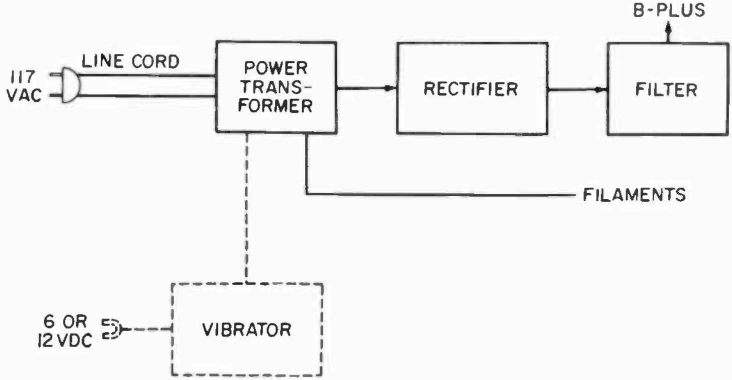


Fig. 4-3. Block diagram of a power supply.

POWER SUPPLIES

The primary source of electricity determines the type of power supply used to energize the transceiver. For home use, the supply is usually of the transformer-operated type. Tracing the pathways shown in Fig. 4-3, the line cord is plugged into the 120-volt a-c source; the transformer then provides two levels of output voltage: approximately 300 volts and 6.3 volts of alternating current. The higher voltage proceeds to the rectifier where it is changed to pulsating direct current, and on to the filter where it is smoothed out to pure direct current. At the output, the pure direct current is termed the B+ voltage and is used to power the plate elements of the various tubes in the transceiver. The lower 6.3-volt output, which does not have to be rectified and filtered, heats the tube filaments, lights the pilot lamps and energizes the relays (if any are used). Most transceivers have built-in power supplies for operation from the 120-volt a-c line.

Where the primary power source is a storage battery (auto, boat, etc.) a vibrator may be added as shown in Fig. 4-3. Its purpose is to change the direct current from the battery to interrupted direct current; a type which the transformer can handle. The newer models almost invariably use solid-state power supplies in which the older vibrators and rectifier tubes are replaced by transistors and silicon diodes. These solid-state supplies are usually for 12-volt operation.

CHAPTER 5

CB ANTENNAS

A Citizens Radio antenna system assumes enormous importance—it is the primary, single element for determining range. The five-watt limitation on transceivers leaves little margin for power loss in the antenna installation. From the profusion of antennas on the market, it is possible to choose a model well suited to any particular application. A "multielement stacked array" can make a five-watt transceiver sound like 80 watts to a distant station—but is useless in certain modes of operation.

FCC regulations on antennas mostly concern height; the antenna must not extend more than twenty feet over a man-made or natural structure. One exception; if your antenna is mounted on the existing antenna tower of another station, your antenna should not exceed the height of that structure.

RANGE

As radio waves are emitted from an antenna, they are roughly analogous to an inflating balloon; they expand outward in all directions at once, becoming thinner with distance. If no obstacles are interposed between transmitting and receiving points, the range can be phenomenal. This was dramatized when an American space probe transmitted data from a point several million miles from earth with its tiny five-watt transmitter. Of course the techniques used in space-probe reception are quite sophisticated, but the comparison points up the potential of an unimpeded radio wave.

Height

Thus, the basic rule for achieving maximum operating range states: mount the antenna as high as possible. This affords the radiation an opportunity to clear nearby trees and building. In mobile applications height is impractical since the antenna is mounted on a vehicle. But, if the fixed-station antenna is high, and in the clear, the height deficiency of the mobile antenna can be offset to a significant degree; the fixed station will transmit stronger signals and receive weaker ones.

Antenna height also increases the distance to the horizon. The ability of a radio wave to follow the curvature of the earth depends on its frequency. At low frequencies the wave hugs the earth's surface, thus following the curve over the horizon. This is ground-wave transmission, which yields reliable coverage for standard broadcast stations and other low-frequency services. But Citizens Radio occupies the lower edge of the very-high frequency (VHF) band, which extends from 30 to 300 megacycles. Ground-wave propagation in this sector of the radio spectrum is considerably reduced, and gives way to the direct wave. The characteristics of direct-wave transmission are somewhat similar to light waves. Due to its inability to follow the earth's curvature, the direct wave shoots off into space, as illustrated in Fig. 5-1.

Note in the illustration how the direct wave travels from the fixed to the mobile station. The reflective properties of the hill indicate the importance of antenna height. Part of the wave from the fixed station clears the hill while the lower portion is reflected upward. The skywave, in the upper right of the drawing, is from a distant station and is reflected or refracted off the ionosphere.

The 27-megacycle band of Citizens Radio is subject to a third type of propagation—the *sky wave*. This is produced by the action of the ionosphere. When radio waves strike this electrical "mirror" high in the earth's atmosphere, they bend and return earthward. In an effect known as skip, waves can cover tremendous distances as they hop between the earth and the ionosphere.

Communication via sky waves is contrary to the purpose of Citizens Radio, which is defined as a short-range service. It is described here since it can be a source of interference. When conditions are favorable, stations located anywhere from several hundred to several thousand miles away will be heard as if they were originating locally. Fortunately, sky-wave propagation lasts for just a few hours per day, and only during certain seasons of the year.

Other Variables

The range of a particular Citizens Radio system cannot be predicted on a mileage chart. The variables of antenna type, height, and location and the terrain make this impossible. Certain general categories, however, can be stated. The shortest range is encountered in heavily populated urban areas, especially between two automobiles. Under rapidly changing conditions, results are erratic. Tests in a large city reveal that fairly consistent communication is possible within a radius of about one to three miles. This distance increases when one of the transmitting points is elevated above ground level. The

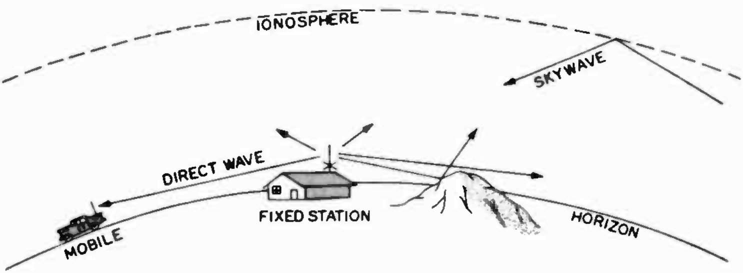


Fig. 5-1. Behavior of CB radio waves.

fixed station, for example, with an antenna located on top of a building, could double the mobile range. In one test, where an antenna was mounted on the roof of a 22-story building (over 200 feet high) the talking distance to a mobile station increased to ten miles.

Open terrain, with few hills, aids the transmission path. A five-mile average is usual under these conditions. Where signals are eclipsed by the shadow of a hill, it is often feasible to drive to the top of the hill and gain the necessary height. Range over open water is excellent—the average is ten miles. Salt water, which is favorable to the ground-wave component, imparts three times the signal distance of dry land.

Maximum range in Citizens Radio is rarely over twenty miles. This is attained through a combination of height and the high-gain antenna. As detailed under the section devoted to directional beams, this distance can be achieved under ideal conditions which primarily exist only between two fixed stations.

HALF-WAVE DIPOLE

A discussion of specific antenna types should start with the half-wave dipole (Fig. 5-2); it is simple in design and serves as the standard against which virtually all other antennas are measured. "Half-wave" refers to the physi-

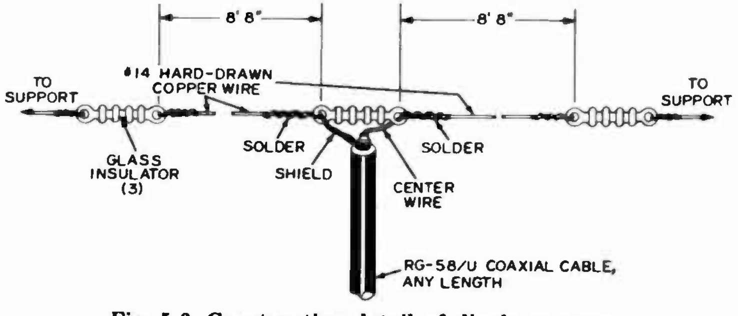


Fig. 5-2. Construction detail of dipole antenna.

cal length of the radio wave. Citizens Radio is assigned to the 11-meter band, which reveals that one wavelength is aproximately 35 feet long (after converting meters to feet). In actual practice the antenna is cut to a half-wave, or somewhat over 17 feet.

A consideration in the use of a dipole, or any antenna, is its radiation pattern. The dipole is basically bidirectional—maximum energy occurs broadside to the wire. If the antenna runs north-south, most of the energy will radiate in an east-west direction.

Polarization

As seen in Fig. 5-2, the dipole is mounted horizontally. This influences the antenna property known as polarization. If the dipole were mounted vertically, the radiated waves would change from horizontal to vertical polarization, and the result would be a shift in the radiation pattern to nondirectional. Instead of a "figure 8" distribution of energy, the pattern would look more like an expanding doughnut reaching out in every direction at once. Best efficiency takes place when both transmitting and receiving stations have antennas with similar polarization. Since the antennas on vehicles are almost always vertically mounted, the trend in Citizens Radio is to use vertical polarization for the fixed station. Cross polarization occurs where two stations use antennas which lie in different planes, the result frequently produces a reduction in signal strength.

GROUND PLANE

The ground plane (Fig. 5-3) is typical of the popular antennas. Its most significant feature is that its length is one half that of the half-wave dipole. Its principle dimension is somewhat over eight feet, which provides ease of mounting for both mobile and fixed station operation. As a vertically polarized antenna, the ground plane may be supported by a single mast.

The ground-plane aspect of the antenna provides the missing half of the radiating element when compared to the half-wave dipole. Ideally, the vertical element should sit just above the surface of the earth supported by an insulator as is done in standard broadcast stations. One or more towers, in excess of 100 feet high, comprise quarter-wave radiators which function in close proximity with

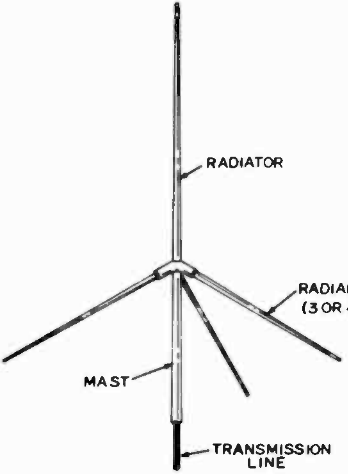


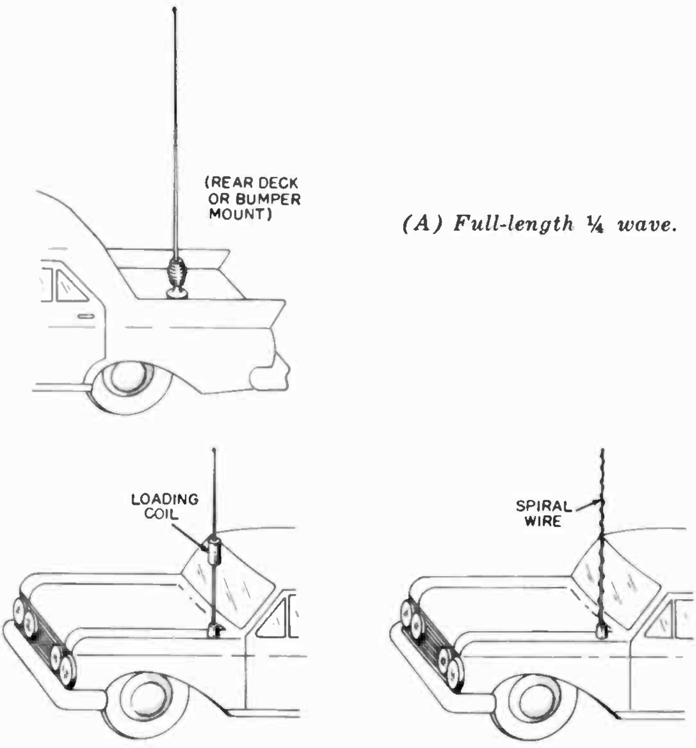
Fig. 5-3. Ground-plane antenna.

earth ground. But Citizens Radio on 27 megacycles utilizes direct rather than ground-wave propagation, and consequently requires height. The ground plane is a means of simulating ground at a point above the earth. Physically it appears as a group of radial elements which extend outward from the quarter-wave length vertical rod. Commercial versions of the ground plane have three or four elements which may mount anywhere from a right angle to a drooping 45° angle relative to the vertical rod. The radials make the ground-plane antenna physically independent of earth ground, while providing the necessary electrical effect.

WHIP ANTENNAS

As the most popular mobile antenna, the whip (Fig. 5-4) is actually a ground-plane variation. There is, however, no need for radial elements since the car body itself presents a large mass of metal just below the vertical rod.

The radiation pattern of the whip is essentially nondirectional. But, in actual installations, the pattern is subject to departures from a perfect circle. This stems



(A) Full-length ¼ wave.

(B) Center loaded. *(C) Continuously loaded.*

Fig. 5-4. Basic mobile whips.

from the fact that the distribution of metal below the whip is not equal in all directions. Various obstructions, too, will alter the pattern. The bumper-mounted whip, for example, is partially blocked by the car's trunk deck and rear fender.

LOADING COILS

Virtually all antennas may be physically shortened by a loading coil—inserted in series with the elements. The effect is to electrically lengthen an antenna which is physically cut to less than a quarter wave. This has given rise to a number of clip-on types which may be conveniently attached to the rain gutter of the car. The standard ground plane and whip are also available in shortened version with various types of loading.

The loaded antenna will always have less range than the full quarter-wave whip. Where short-range is adequate, however, the small size of these units is used to advantage for limited space applications and mounting versatility.

The continuously loaded whip combines the loading coil and radiating element in a single conductor. It is constructed of a spiral wire which extends from the bottom to the top of the whip rod and is usually encased in plastic for support and flexibility.

DIRECTIONAL BEAM

Among the antennas most efficient for communication between two fixed points is the directional beam (Fig. 5-5). With its array of elements most of the radiated energy can be concentrated into a narrow arc and aimed at the desired station. Multiplication of power occurs since most of the energy which would be wasted in undesired directions is channelled into a narrow beam.

The heart of the beam antenna is the half-wave dipole. Assuming that it is positioned in a north-south direction, it will radiate the conventional figure 8 pattern with lobes of energy propagated to the east and west. As the various elements are added, this pattern is modified. If a horizontal rod of proper length is placed several feet to the east of the dipole, it will act as a reflector and bounce the radio wave back toward the dipole. The result is a near doubling of power in the westerly direction. The pattern of this simple two-element beam is greatly sharpened by

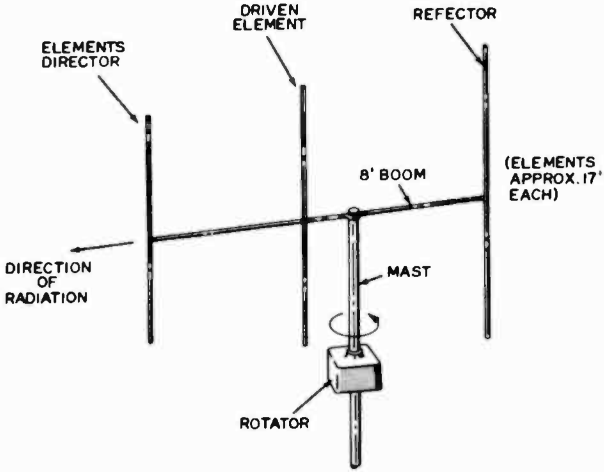


Fig. 5-5. Vertically polarized 3-element directional beam.

the addition of one or more directors on the opposite side of the dipole. These rods pick up energy from the dipole and reradiate it toward the west. Whereas several directors will narrow and reinforce the beam, only one reflector is used to return the arc of electromagnetic energy to the desired direction.

Stacking is a technique to further increase a beam's power gain. Two director-dipole–reflector combinations can be vertically stacked and tied together by a suitable matching device. The limit to the amount of stacking is mainly a physical one. A complex array soon becomes unmanageable and imposes a heavy load on the mounting mast and boom.

The fact that a five-watt signal can be reinforced is not a violation of the FCC law. The regulations limit only the input power to the final radio-frequency stage of the transmitter. As long as the antenna is not too high, its ability to impart signal gain is acceptable.

The directivity of the beam antenna renders it a poor choice for certain applications. When a fixed station is in contact with several mobiles, the vehicles will not always be in the beam's signal path. It is possible to orient the beam with a rotator, but this is a marginal procedure. An example of efficient use of a beam is between home and office, where the distance may not easily be covered by a ground plane antenna. Two beams oriented toward each other can supply maximum range and reliability of communication.

TRANSMISSION LINES

Unless the antenna simply plugs into the transceiver (for very short-range work) a transmission line is employed to carry radio-frequency power between transceiver and antenna. Only a cable which meets precise specifications will effectively conduct with minimum loss. The coaxial cable has been almost universally adopted for Citizens Radio equipment since it does not radiate along its length. It does, however, place the power in the antenna where it counts.

At the antenna jack of a typical transceiver the impedance is aproximately 52 ohms. This value indicates that a transmission line whose impedance is also 52 ohms can be connected to it. It follows that the other end of the line hooks into a 52-ohm antenna. Through observing and matching impedances, maximum transfer of energy will take place between these elements. Most CB antennas are pretuned at the factory and designed for 52-ohm input. An ideal coaxial cable is RG 58/U.

CHAPTER 6

INSTALLATION OF YOUR EQUIPMENT

A carefully planned installation pays big dividends in operating ease and efficiency. Mounting Citizens Radio equipment demands little in the way of special skills or tools—rarely more than a screwdriver, pliers, hand drill, and other inexpensive implements are required. The transceiver is typically a package with main components housed in a single cabinet. This arrangement lends itself to rapid installation and can conveniently be used on a semipermanent basis; i.e., one which is occasionally changed from mobile to fixed-station service.

FIXED STATION

The simplest installation is a fixed station which requires less than a mile range. This is often encountered in farm applications and certain industrial uses where the units serve as a "wireless intercom" between nearby vehicles and buildings. Some transceivers will accommodate a short whip mounted directly on the cabinet. The unit can be placed on a desk, table, or shelf; and simply plugged into a wall receptacle. No special power lines are required—the power drain of the transceiver averages less than that of a television set or hi-fi system. Place the unit where air circulation is abundant, being especially sure to avoid blocking the ventilation holes.

Location

Within the limits of a mile, the transceiver should operate satisfactorily inside a wooden frame building on the first floor level. The radio energy will penetrate wood, plaster, and other nonmetallic materials with little attenuation. Metal surfaces, however, are opaque to radio waves and act as effective reflectors. If the building is not of "bird cage" construction, a considerable amount of energy will find its way out. Location of the CB transceiver in a steel constructed building often results in blind spots in the radiation pattern as signals reflect in an unpredictable manner. Various spots in the room should be tested before a more complex type of antenna installation is attempted. If the transceiver is on a desk which cannot be moved, a short whip antenna can be tried. The antenna should be placed at least several feet from any large metallic object, which includes window screens, filing cabinets, etc. A further improvement is possible with a window-mounted antenna—its level of performance is somewhere between the indoor and roof antenna. There is a possibility, however, that signal strength will be reduced if the antenna is located on the opposite side of the building from the receiving station.

Installation of an antenna in an attic should not be overlooked. This location yields the multiple benefits of simple installation, protection from the elements, and ease of maintenance. In its sheltered location, the life of the attic-mounted antenna is practically indefinite. The height advantage over the whip fastened to the transceiver cabinet makes it a good choice for moderate-range applications; assuming of course, that the roofing material is nonmetallic.

Outdoor Antennas

The high outdoor antenna will, in most cases, be mandatory for the fixed station. As the control unit of the network, it should be able to contact the most distant mobile unit in the service area. The coaxial cable which carries power to the antenna influences the location of the transceiver in the room; the cable should be as short as possible. Thought should be given to the routing of the cable as it runs from the window to the roof; the shorter the span of cable, the lower the corresponding power drop. The method of feeding the cable to the outside will depend on the individual installation. The easiest system is to run the cable through an open window, but this, of course, presents problems and potential damage to the cable. Where feasible drill a hole in the base of the window frame and feed the cable through. The hole should be caulked to prevent the entry of moisture. An alternative is to chisel out a channel in the window sill to a depth which permits the window to fully close without striking the cable. Unlike the twinlead used for television transmission line, the coaxial cable does not suffer losses when positioned close to a metal surface. But the television-type standoff is useful to support the cable run from the window to the roof. It is made with a small insulated hole to accommodate the cable and comes with either a screw-base (for fastening to wood), or nail-base (for hammering into concrete or the space between bricks).

Much of the hardware for installation of television antennas will serve admirably for Citizens Radio use. Antenna mast sections are sold in five- and ten-foot lengths. Brackets are available in wall, chimney, pipe, eave, and roof-peak mounts. Where masts rise higher than ten feet, guy wire should be used. The rotators for television antennas are usable with a directional beam of the light 3-element type.

The first step in selecting an antenna site on a roof is locating the spot which offers best mechanical support and maximum height. Although a chimney often fills the height requirement, it should not be used if large volumes of smoke and soot continuously issue forth. This may form conductive deposits and lower the efficiency of the insulated antenna elements. If a fixed directional beam is to be installed, the heading of the other station should be considered. Choose the mast location which best enables the signal to clear large obstacles.

When faced with the dilemma of height versus transmission line length, height should win out in most cases. In a 100-foot run of RG 58/U coaxial cable, close to half the transmitter power is lost in the cable. Thus, if another ten or twenty feet of line allows the antenna to be positioned at a higher point, it should be mounted there without question. The obstacles which the signal would encounter at a lower position often cause more power attenuation than a moderate increase in the length of the transmission line.

One of the troublesome points in an antenna system is where the transmission line connects to the antenna terminals. An effective means is the use of a coaxial connector which provides the line with a friction and screw fastening to the antenna. This forms a strong, watertight joint. Many commercial antennas are equipped with this feature. But where screw terminals are provided for fastening the shield and center conductor of the cable to the antenna, extreme care should be used to prevent poor contact. Both conductors of the cable, shield and center, should terminate in lugs. There are lugs which provide mechanical support by crimping to the conductor's insulation and effect a good electrical connection after being soldered. Once the lugs are installed on the ends of the cable, they are slipped under the screws and washers of the antenna terminals and tightened. All strain is removed from this point by running the cable through a standoff clipped to the mast. An added measure to preserve the efficiency of the antenna is to wrap the terminals completely with black plastic tape. This reduces corrosion and the leakage effects of material which may deposit between the terminals.

Sensible precautions can protect you against the major hazards of antenna installation—falling from a height and electric shock. Unfortunately, a good antenna site is often located near power lines. While manipulating the elements of an antenna, it is possible to brush against these lines and come in direct electrical contact with voltages in excess of house current. *It is wise to be extremely wary and perform as much antenna assembly on the ground as possible.*

MOBILE

The power requirements of a Citizens Radio transceiver are comparable to a standard tube-type auto radio. This eliminates many of the special considerations needed with high-power sets. The conventional electrical system in modern cars is adequate without special generators, alternators, or high amperage batteries. Installation problems center on transceiver and antenna location and interference from ignition noise. Many transceivers have built-in power supplies for operation from 6- to 12-volt sources. Otherwise, an external chassis with the proper power plug is available. The cable to the outboard power supply is several feet long, which permits mounting at a point independent from the transceiver.

Mounting

The favorite spot for a transceiver in automobiles is under the dashboard, approximately a foot to the right of the steering column. This permits access to all operating controls, yet presents little interference to driver and passengers. While determining the precise mounting position of the transceiver, hold it in place by hand. It is not a good idea to locate it directly in the path of the hot air stream from a duct of the car heater.

Most manufacturers provide mobile mounting brackets for their transceivers. Make a visual check under the dashboard for predrilled holes which match those of the brackets. Some auto makers provide knockout holes under the dash. If these do not match the bracket holes, new ones must be drilled. The metal here is usually thin enough to permit the job to be done by a hand drill. Before applying the drill, be certain that no damage will be done to wires that run behind the dashboard; push them aside while drilling.

If brackets are not supplied for the transceiver, they may be made from angle iron, L-brackets (sold in hardware stores) or a sheet metal strap. Fasten them to the sides of the transceiver cabinet with sheet metal screws, or nuts and bolts, being careful not to disturb any of the components inside the unit. Wing nuts or thumb screws are convenient where the transceiver is frequently removed from its mount.

If, for some reason, underdash mounting is not desirable, a second choice is under the front seat. Some autos have sufficient room here for a complete transceiver, but several disadvantages must be considered. Sound from the speaker is reduced, which affects intelligibility, especially when the car is traveling at high speeds. The operating controls are not readily accessible and a transceiver which has a push-to-talk button on the microphone must be used. Also, if the On-Off switch is not accessible, another must be installed in the power line.

Unlike other communication equipment, current Citizens Radio sets do not lend themselves to a mounting within the car's trunk. This placement requires a small control unit under the dash which enables all transceiver functions to be performed remotely.

Power Lines

After the transceiver is in place, two lines from the power plug are connected. Most power supplies will work equally well with positively or negatively grounded auto batteries. But this should be checked in the instruction manual—especially if the supply uses transistors. All 12-volt car batteries are negatively grounded. The 6-volt type can be checked by looking for the plus and minus marking stamped on the battery terminals. The ground lead is usually a heavy braided wire connected directly to the car chassis or frame. The ungrounded lead goes to a terminal protruding out of a small metal can which houses the starter solenoid.

The ground lead (Fig. 6-1) from the transceiver, often color-coded black, is fastened to the frame of the car as close to the set as possible. (If no ground lead is supplied make one from braided wire.) Actually, the set should ground through its mounting brackets, but the ground wire will assure a dependable connection and reduce the possibility of intermittent noise pickup. To establish a low-resistance electrical path, be sure to scrape away any paint or corrosion where the ground wire connects to the frame of the car.

Fig. 6-1. Ground lead connected to transceiver.

The *hot* lead, usually red, can be slipped under the same terminal used for the car radio. This is often the accessory terminal behind the ignition lock and automatically cuts the power when the ignition key is removed. In semipermanent installations, a plug is inserted into the cigarette lighter receptacle for power pickup. The cigarette lighter in most autos continues to supply power even though the ignition key is removed, so special care should be taken to avoid leaving the transceiver on accientally, or the battery will run down in a few hours.

Whip Antennas

The ideal place for a whip antenna is on the rear left trunk deck. Maximum mobile range is attainable with an 8½-foot rod and base spring at this location. Mounting holes are drilled and the coaxial cable routed underneath the floor mats from the trunk to the transceiver. Standard lengths of coaxial cable are available for this use, but one can be made from RG 58/U with connectors to match the transceiver jack and the antenna base. An antenna clip may be fastened to the appropriate point on the car's rain gutter (just above the side windows) to hold down the whip when it is not in use.

One drawback of the full-length whip is the holes which must be drilled into the body of the car; these could affect the car's resale value. There are several ways to avoid this; the bumper mount, for example, is simply fastened to the rear bumper and is easily removed. This, however, will reduce the range somewhat, due to the lower antenna position and the shielding of the trunk in the forward direction. A trick used by hams is to mount the whip adjacent to a tail light. When the time arrives to sell the car, a back-up light is installed in the hole.

Another whip location is in the space provided for the original car radio antenna. There are loaded whips designed for Citizens band which substitute for the broadcast whip. These units will serve for both the transceiver and the car radio. Particularly suited for this location is the continuously loaded whip, which extends to approximately four feet.

NOISE SUPPRESSION

The automobile ignition system is a prolific generator of radio noise on the Citizens band. This interference can hamper communications considerably. The major source of noise originates in high-voltage impulses which fire the spark plugs. The generator and voltage regulator also contribute to this hash. The most effective countermeasure is the noise limiter, a feature found in many superhet transceivers; but noise suppression at the source will compensate for the noise limiter's deficiencies, the reduction of speaker volume, and a decrease in intelligibility of the received signal.

Tracking down noise should be a step-by-step process, since the interference may arise from a single cause or a combination of effects. Before proceeding with the tests outlined here, check the transceiver's ground connection. With the car engine running and the transceiver turned on, determine the effects of shifting the ground wire from one point on the car frame to another. Secure it to the ground area which produces the quietest reception, but try to keep the wire short. Also, check for any noise suppression measures which the car manufacturer has already installed.

These tests are listed in order of importance, ranging from the most common noise sources to the rarest ones. Switch on the transceiver, set its tuning dial somewhere in the middle of the band, and idle the car engine. It is not necessary to receive a station during these steps. Turn up the volume control so the effects of the noise can be easily discerned. Ignore the normal background hiss.

Distributor

During the first check quickly depress the gas pedal. Listen for a train of sharp "popping" sounds which increase in speed as the engine revs up. This is produced by the spark plugs or distributor and can be reduced by suppressors (Fig. 6-2). These devices, available in auto supply stores, simply snap into place. The cable to each plug is removed and the suppressor pushed on to the top of the

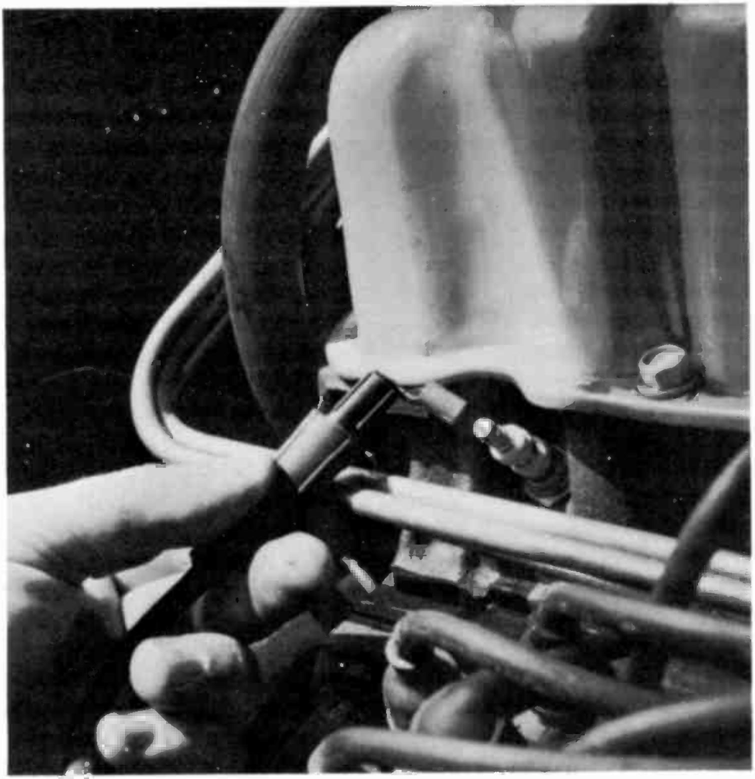


Fig. 6-2. Spark-plug suppressor clipped between plug and cable.

plug. Each cable is then connected to the top of its suppressor. For the distributor, a single suppressor (Fig. 6-3) is plugged into the center hole after the cable is removed. If your car is due for new spark plugs, the resistor type may be installed—the suppressor is built into the body of the plug.

Generator

The second test determines the noise effects of the generator. Race the engine and listen for a howl or whining sound (almost musical) which lowers in pitch as the engine slows. Generator noise is produced by brush sparking and may be cured by installing a bypass capacitor

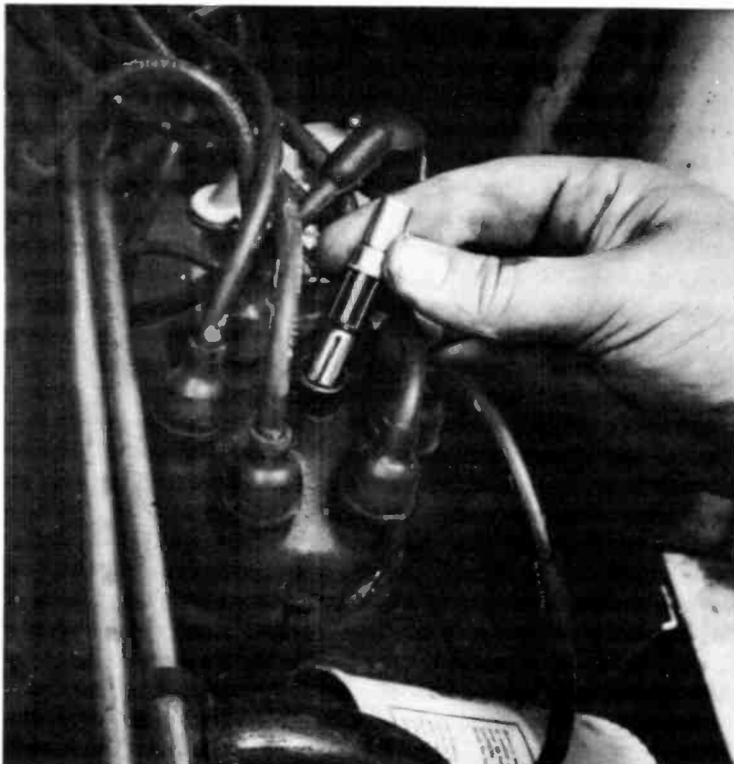


Fig. 6-3. Installation of distributor suppressor.

(Fig. 6-4) on the generator armature terminal, (usually marked *A* or *ARM*). The bypass already installed at this terminal is designed for noise reduction in the broadcast band and does a poor job on the 27-megacycle band. The special coaxial capacitor should replace it. These units

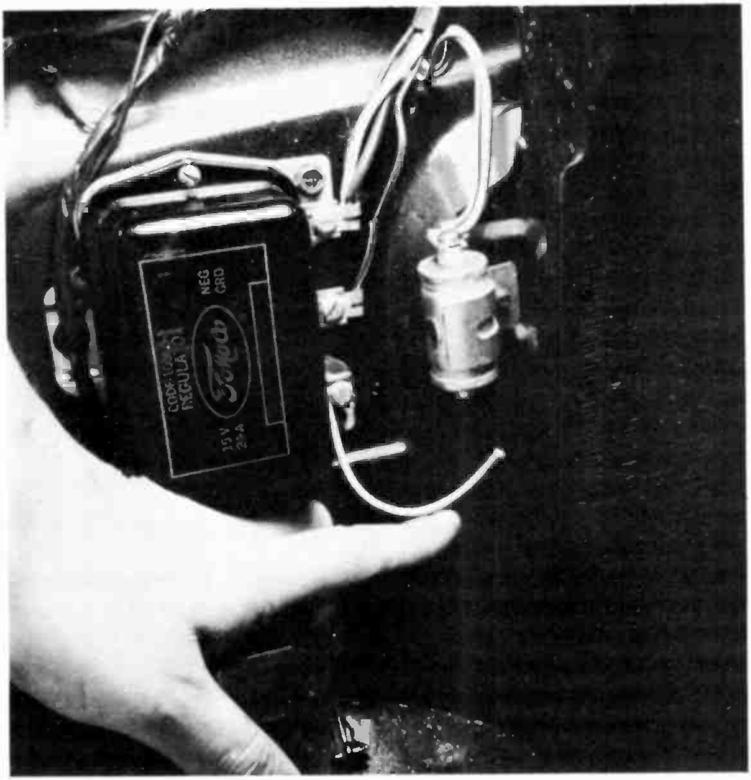


Fig. 6-4. Generator bypass capacitor.

are available from the large electronic supply houses. The wire connections to this capacitor should be kept as short as possible; its mounting lip requires firm ground contact with the frame of the generator. Use a piece of sandpaper to clean away any grease or corrosion at the mounting point to avoid poor contact.

Sparking at the voltage regulator contacts is heard as a crackling sound which might vary with engine speed. The remedy is a bypass capacitor on the voltage regulator terminal marked *B* (for Battery) and *A*. Since damage to the generator is likely, if the capacitor shorts, a bypass should not be installed on the *F* (field) terminal of either the generator or regulator.

Wheels

A less common noise source is the front wheel axle. As the wheels rotate, a static charge is built up between the

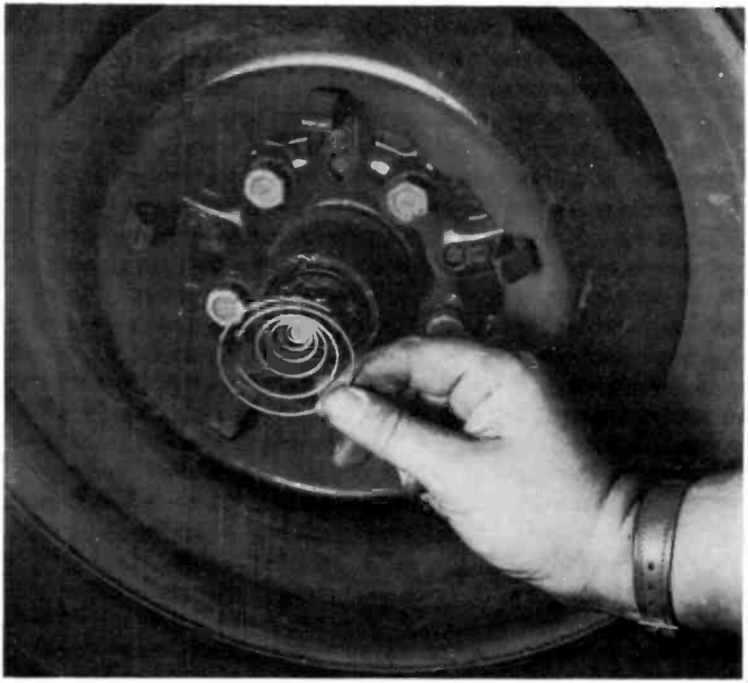


Fig. 6-5. Static collector springs installed on front wheel.

axle and wheel bearing, since they are insulated by a thin film of grease. The bouncing of the wheel causes contact between the two surfaces and the static charge is intermittently dissipated. This might produce noise when the car is driven over approximately 20 miles per hour. Static collector springs (Fig. 6-5) positioned under the

Fig. 6-6. Special tool and packets of antistatic powder.

axle dust cap counter this action by establishing a constant electrical path between the axle and the bearing. These devices are often stocked by the auto dealer for your make of car.

A static charge, similar to axle noise, can be generated by the inner tube and tire. The cure is the injection of antistatic powder (Fig. 6-6) into each of the tube valves.

A small kit complete with special tool and packets of powder, is available from electronic dealers.

Driving at various speeds over a bumpy road reveals poor grounds between certain areas of the car. The noise is intermittently keyed to the jarring of the road bumps. The technique of bonding is used to minimize this by providing low-resistance grounds between the motor block and the car chassis, the firewall and the motor block, and the muffler-tailpipe assembly and the car frame. Run a short length of heavy grounding strap between these parts, and be sure to keep the connections clean.

CHAPTER 7

TUNING UP

The low power of Citizens Radio necessitates careful tune-up; the receiver section should operate at peak sensitivity, and the transmitter must couple maximum energy into the antenna. Many of the tuning procedures can be done with very simple equipment, while others may be performed *only* by an FCC-licensed technician. The various adjustment screws and slugs used in the equipment are notoriously fragile—they are easily broken when tuned with an ordinary screwdriver. Damage can be avoided by using the alignment tool (Fig. 7-1) designed expressly for the job (available at electronic distributors). Many of these tools are made of nonmetallic material to prevent undue effects on the circuit while alignment is being done.

RECEIVER

Adjustment of the receiver requires no commercial license. Specific alignment procedures are usually covered in the manual which accompanies the kit- or factory-assembled sets.

Simple Alignment

The simplest alignment utilizes an off-the-air signal which can be provided by another transceiver in your vicinity. Avoid locating the sending unit too close to the set being aligned. This could lead to tune-up on false responses, which occur if one or more stages in the receiver section overload—a ¼-mile or more separation should prevent this. Listen for two distinct sounds in the speaker during alignment process; the voice, and the noise

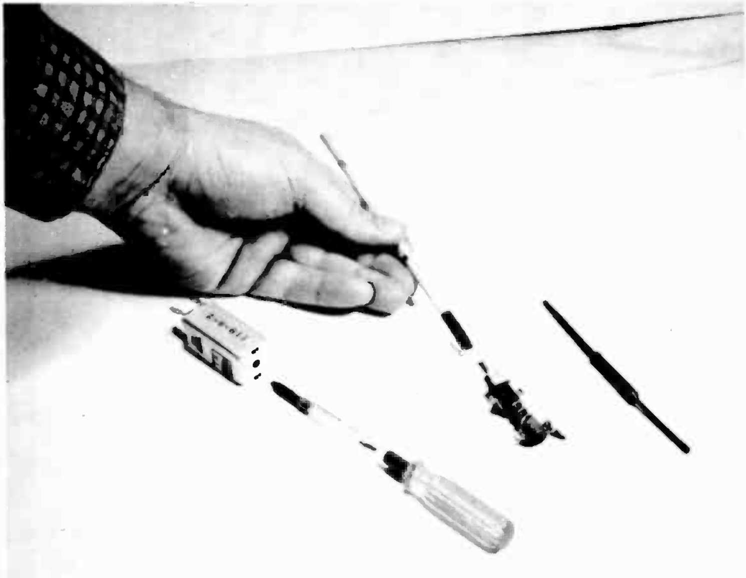


Fig. 7-1. Alignment tools for CB equipment.

behind it. The most accurate indication that a particular stage is being peaked is the reduction in the amount of noise, rather than an increase in voice volume. Avoid adjusting any trimmer or transformer slug more than a few turns. These components are prealigned at the factory and only need "touching up" to compensate for the slight variations between transceivers. Excessive rotation of these adjustments usually indicates that something else is at fault; a wiring error or damaged component.

Certain adjustments will be more critical than others. Where tuning is extremely broad, try to set the adjustment to the center of its sensitivity range. Reducing the amount of received signal is helpful for perceiving the best setting.

Kits

If the wiring of a kit is not carefully done, especially around the i-f transformers, there is a possibility that some tube stages will go into oscillation during alignment. This produces a "mushy" or distorted quality to the sound in the speaker—often sharply reducing intelligibility. The remedy, after rechecking the wiring, is to back off slightly on the adjustment until normal reception is restored. Be sure that oscillation does not occur over any part of the receiver's tuning range.

Instrument Alignment

Maximum receiver sensitivity is attained by alignment with a signal generator and a voltmeter. If this test equipment is available, the step-by-step instructions in the manual can be followed. The major precaution is to feed as little signal as possible into the receiver during the tune-up to prevent overloads. The basic procedure is to apply a 27-megacycle signal into the receiver and note the negative d-c voltage produced by the automatic volume control (avc) circuit. Starting at the last tunable stage in the set (the transformer before the detector) each adjustment is peaked for maximum reading on the meter. Any stage which breaks into oscillation will cause the needle to deflect rapidly up the scale.

TRANSMITTER

The transmit section of the transceiver has fewer tune-up stages than the receiver. But here is where FCC law must be observed. The reason for this is that improper alignment can result in off-frequency operation, interference to other stations and radio services, and excessive distortion on your signals. Actually, a "clean" signal is to your advantage; it often goes hand in hand with maximum power output.

For tune-up purposes, the transmitter can be considered in two major sections: frequency-determining circuit and output. The first section may be adjusted only by a first or second class radio telephone technician. These circuit elements include the crystal and the associated components which comprise the crystal oscillator. In consideration for the popularity of the kit transceiver, the FCC has waived the commercial license requirement—*if* the kit manufacturer provides a crystal oscillator which meets certain specifications. Most notable is that the crystal oscillator must be supplied from the factory as a preassembled, pretuned unit. Any adjustments which would cause improper operation cannot be made without breaking the seal of this subassembly. The manufacturer must certify that the kit is designed and furnished in accordance with applicable FCC specifications.

Dummy Load

The final checkout on a completed kit should be done with a dummy load (Fig. 7-2). This consists of a #47 pilot lamp soldered to an appropriate connector and plugged into the set's antenna output jack. Tuning can be done with the dummy load without radiating signals; output power is consumed in the form of heat and light and adjustments are made while observing the relative brightness of the pilot lamp. If the transceiver is tuned for maximum output with the dummy load, this does not necessarily mean that once it is removed, and the antenna substituted, maximum power will be absorbed by the antenna. The lamp is a valuable check on transmitter performance, but it is not the proper load which the antenna presents. It is therefore recommended that a final tune-up be accomplished with an indicator of radiated waves. With the dummy load connected, voice modulation may be checked—speaking into the mike should cause the bulb to increase in brightness with each syllable.

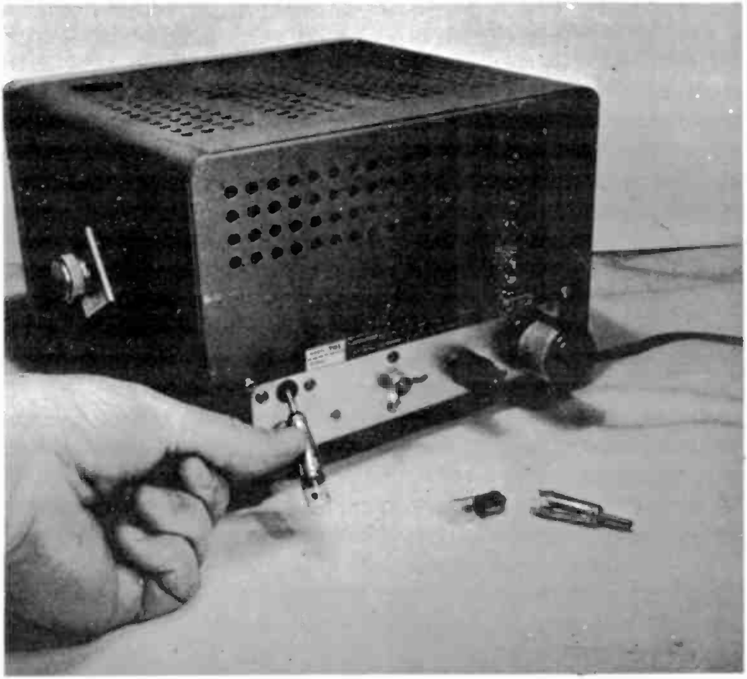


Fig. 7-2. Dummy load made from #47 pilot lamp and antenna plug.

Most transceivers have a small neon bulb mounted to their front panel marked "Power Output" or some similar designation. This bulb should not be the only indicator used for tune-up purposes, since it often ignites with no antenna connected. If, however, this lamp does not go on when the transmit switch is thrown, it is a good indication of either very poor tune-up or that the crystal has failed to oscillate.

Input-Power Measurement

The transmitter output should be tuned to the antenna with a multimeter (volt-ohm-milliammeter) (Fig. 7-3) and some type of output indicator which reads the relative strength of the radio wave emanating from the antenna. The multimeter enables a simple calculation of whether transmitter power *input* is within the 5-watt maximum. Transceivers are sometimes fitted with a meter jack. First, measure the final r-f–amplifier plate voltage at the point indicated in the instruction manual. Next, connect a milliammeter into the circuit and take a current reading. These two values are multiplied, and the result is the power input in watts. While making this calculation, it is important to change milliamperes to amperes; e.g., if the plate voltage is 250 volts direct current and the plate current is 18 milliamperes, the input power is 4.5 watts. In working this out, the 18 milliamperes, was

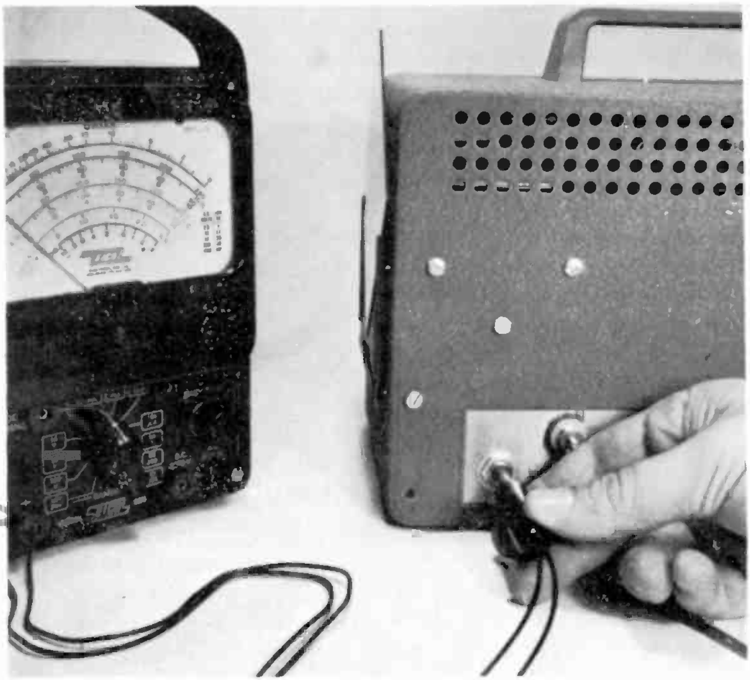


Fig. 7-3. Measuring power input with a multimeter.

changed to amperes by moving the decimal three places to the left. Thus:

$$250 \times .018 = 4.5 \text{ watts}$$

Output-Power Measurement

It is valuable to have some form of output indicator for adjusting transmitting output in conjunction with the check just described. It is impractical to measure antenna radiation directly in watts since meters of this type are costly. But, a number of relatively inexpensive devices (Fig. 7-4) permit accurate tune-up. First, the adjustments are made to peak up the output indicator, then a

Fig. 7-4. Antenna output meter.

check on the input power is made by the multimeter method. Indicating devices for the Citizens band include simple field-strength meters, a microammeter with a 1N34 diode across its terminals, or even a fluorescent tube held close to the antenna. If possible, final tuning should be done with the transceiver in its mounted position (Fig. 7-5).

Fig. 7-5. Tuning transmitter of a mounted unit.

ANTENNA TUNING

Most antennas for Citizens Radio are not tunable and are supplied to match the output (52 ohms) of the transceiver. In some cases, antenna elements are equipped with sliding rods to match the 27-megacycle band. In these instances, the instruction manual supplied with the antenna has charts with recommended element lengths. Beam antennas, often equipped with sliding sections for optimum matching to the transmission line, are factory-pretuned. Similarly, the loading coils used with shortened antennas are cut to the necessary number of turns and encased in plastic. If a standard transmission line and antenna are used, there will be no need for impedance meters, standing-wave ratio indicators, antenna tuners, or other devices for antenna adjustment.

To comply with regulations concerning harmonic radiation, many transceivers incorporate a harmonic trap for suppression of the second harmonic on 54 megacycles. This is best adjusted with the transceiver close to a television set which is tuned to Channel 2. The appropriate trimmer is rotated until the least amount of interference appears on the television screen.

CHAPTER 8

OPERATING HINTS

Getting the message through on Citizens Radio with speed and efficiency depends, to a large degree, on operating technique. A single syllable can often replace an entire sentence; and this is certainly an asset during periods of intense interference or poor radio conditions. The jargon of Citizens Radio is universal—it serves the needs of all who participate on the band. Some aspects of it are official; station identification, for example, while others, like the "10" code, are informal. Each fulfills the requirements of brief, successful communication.

SELECTING A CHANNEL

The Citizens Radio licensee has operating privileges on all twenty-three frequencies assigned to the Class-D band. These channels are for use exclusively in this service, except for Channel 23, shared with Class-C (for radio control). Occupying 27.255 megacycles, Channel 23 is a potential source of interference—especially where it is used for the control of model airplanes, boats, or automatic garage doors. Actually, there are several other radio-control frequencies interspersed between the Class-D channels, but these should cause little interference unless the receiver has extremely poor selectivity.

The choice of a channel should be made before the transceiver is ordered. Most manufacturers, including the kit suppliers, offer the purchaser a choice of crystal frequencies. One common practice for the user is to equip all transceivers which operate in the same network with identical channels. This reduces the amount of receiver tuning and all units simultaneously hear all transmissions.

In multichannel transceivers, where a switch may select one of several frequencies, it is often mandatory to choose crystals which are not spaced more than two or three channels apart. Greater spacing would require retuning of the transmitter each time the crystal switch is thrown.

The choice of a particular channel must remain with the user of the equipment. There is no difference between the transmission characteristics of any of the 23 channels; they all provide the same operating range. If it is possible to monitor the traffic in your area for a day or two, determine which channels are crowded and try to avoid them when choosing your crystal.

There is a move to set aside certain channels for discrete purposes; a marine frequency, a national calling frequency, etc. These are unofficial at present but may be of special interest in your operation. If the FCC decides to make these allocations official, you will automatically receive notification via bulletin or amendment to Part 95.41 of the rules and regulations.

PROCEDURE

A prime operating requirement is station identification. This is the transmisison of the call letters which appear on the face of the Citizens Radio license. Each of the units covered by a single license is identified by the same call, but it is possible to distinguish between them by assigning a unit number to each transceiver. The base station might be 00W888, unit 1; the mobile units identified by 00W888, unit 2; 00W888, unit 3, etc.

The general rule is to give the station identification at the beginning and end of every transmission, as well as at least every fifteen minutes. During a rapid exchange of words between two units, this becomes awkward and the rules make allowance for it. In a series of transmissions, each less than three minutes long, the call signs need be transmitted only once every fifteen minutes. Assuming that total communication time runs under fifteen minutes, call signs need be given only at the open and close of the series. Here is an example of typical operating procedure:

Base Station:	"This is 00W888, unit 1, calling unit 2. Over."
Unit 2:	"Unit 1, this is 00W888, unit 2. Ocer."
Base Station:	"Did you complete the service call on Maple Street? Over."
Unit 2:	"Yes, just a few minor repairs. Shall I return to base? Over."
Base Station:	"No, proceed to warehouse for parts pickup. This is 00W888, unit 1, clear with unit 2."
Unit 2:	"This is 00W888, unit 2, clear with unit 1."

The use of call signs was limited in this example to the opening and closing transmissions. Call signs were not required within the body of the communication since no single transmission lasted more than three minutes, and total time did not exceed fifteen minutes.

In exchanging information on Citizens Radio, it must be remembered that only one person may talk at a time. There is no opportunity to break in and ask the other fellow to repeat something that has been missed until he says "Over." Keeping transmissions brief and uncomplicated assures intelligibility—especially where one station is in motion and may not be receiving each word clearly.

Time Limit

Within the FCC regulations there is a stated time limit on transmissions. Its purpose is to preserve the "party-line" status of Citizens Radio where many stations use the available channels on a shared basis. In effect, it says that the exchange of transmissions between two or more Class-D stations may *not* be longer than five minutes (Fig. 8-1). This shall be followed by a silent period of at

Fig. 8-1. Five-minute rule must be observed during CB operation.

least five minutes in order to provide other stations an opportunity to use the channel. Further transmissions may be made, if, after monitoring the channel for five minutes, it is found to be unoccupied. Of course this regulation does not apply when the communications are concerned with the immediate safety of life or the immediate protection of property. If you participate in an emergency use of Citizens Radio, the FCC in Washington and the

Engineer In Charge of your radio district must be notified after normal communications are restored.

"10" Code

Traffic can be speeded up considerably through the use of some form of spoken "abbreviation." Long in use by other radio services, the "10" code serves this need. Numbers take the place of complete ideas, phrases, or sentences and represent word groups which are used repeatedly in the course of daily operation. The consistent

Table 8-1. "10" Code

Code Number	Meaning	Code Number	Meaning
10-1	Receiving poorly.	10-18	Engineering test.
10-2	Receiving well.	10-20	What is your location?
10-3	Stop transmitting.	10-21	Call . . . . . station by phone.
10-4	O.K.	10-23	Stand by.
10-5	Relay message.	10-24	Trouble at station.
10-6	Busy.	10-25	Do you have contact with. .?
10-7	Out of service—leaving the air.	10-30	Does not conform with rules and regulations.
10-8	In service—subject to call.	10-33	Emergency traffic at this station.
10-9	Repeat, reception bad.	10-36	Correct time.
10-10	Transmission completed, subject to call.	10-65	Clear for message.
10-11	Talking too rapidly.	10-92	Your quality is poor.
10-12	Officials or visitors present.	10-99	Unable to receive your signals.
10-13	Advise weather and road conditions.		

use of the number 10 preceding other numbers immediately identifies the use of the code. Operating technique can be sharpened by memorizing and using the codes shown in Table 8-1.

CHAPTER 9

TESTS AND REPAIRS

Citizens Radio equipment, like most other electronic gear, is subject to both sudden and gradual deterioration in performance. In the suggestions outlined in this chapter, it is assumed that a kit-built set is correctly assembled, and that there are no wiring errors or poorly soldered joints. In certain instances, a miswired circuit may appear to function well, but may break down after a period of operation—consider any trouble soon after installation with this possibility in mind.

The danger from electrical shock while servicing a transceiver cannot be overemphasized. *Any voltage in excess of 20 volts should be treated as potentially lethal.* This is subject to many conditions such as: the type of circuit, skin resistance of the person, and body resistance to ground. An excellent way of reducing danger is to perform as many steps in the troubleshooting procedures with the power off—this does not mean just with the power switch flipped to the Off position; if the transceiver operates from house current, there is still one leg of the 120-volt line connected to a terminal on the switch. *Remove power completely by unplugging the cord from the wall outlet.* Next, hold a screwdriver by its insulated handle and touch the shank to the metal chassis. Then without removing the shank from the chassis, contact each of the lugs on the large filter capacitor with the screwdriver tip (Fig. 9-1) to drain off any residual charge.

Many tests may be performed with the power off; resistance measurements are the most important. Only if the resistance readings check with the schematic or resistance chart for your set should power be applied for voltage readings. To minimize the effects of accidental

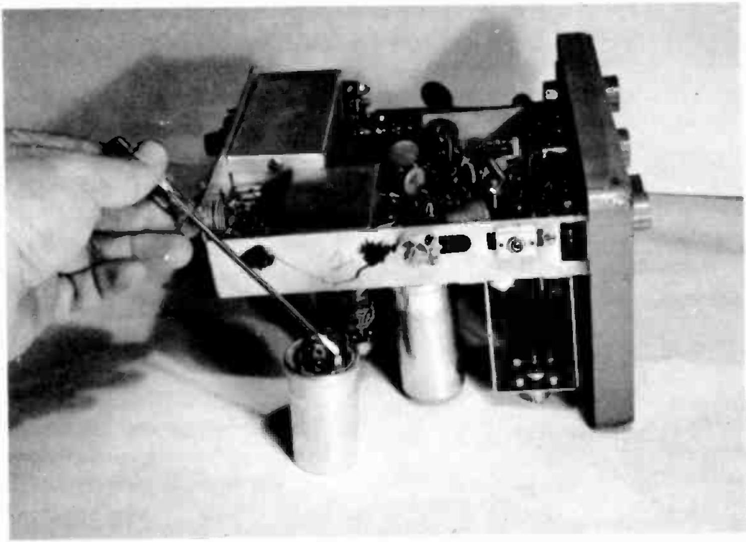


Fig. 9-1. Shorting filter capacitor to prevent shock.

contact with voltage keep one hand away from the chassis while testing. This eliminates at least one path through the body to ground.

TEST EQUIPMENT

For simple troubleshooting a multimeter which can measure voltage, current, and resistance is valuable. Its voltmeter section should have a sensitivity rated at 20,000 ohms per volt. Lower sensitivity will register voltages lower in value than those given in the instruction manual, and in certain circuits, it can actually short-out the voltage you are trying to measure. The VTVM (vacuum-tube voltmeter) affects the circuit least, but unfortunately most have no ammeter provision for measuring current. The ideal is the VOM (volt-ohm-milliammeter) which offers the advantage of complete portability; it does not need a power source and operates from a self-contained battery. This is handy for car or marine use where house current is not accessible.

As mentioned earlier, an output radiation indicator is desirable. It is a good idea to take output readings while the transceiver is operating properly; then, when trouble is suspected, take another reading and compare the two results. A simple assortment of tools—screwdrivers, nut-drivers (especially ¼-inch), and small wrenches round out the necessities for basic servicing.

LICENSE REQUIREMENTS FOR SERVICING

Repairs to the frequency-determining section of the transmitter may be made only by, or under the supervision of, persons who hold a First or Second Class Radiotelephone license. If the trouble exists in this circuit, the transceiver should be taken to a shop which employs such a licensee. These technicians are not difficult to locate; their license qualifies them to repair all manner of two-way radios—marine, aircraft, police, a-m, f-m, television, or similar transmitting equipment.

LOCALIZING TROUBLE

A frequent cause of faulty equipment can be traced to tubes. Power output falls as tubes lose their emission capability, develop shorted elements, and acquire gas or burned out filaments. A spare set of tubes should be kept, not only for replacement purposes, but also because they can be used in testing. Substitution is a widely used technique for pinpointing a suspicious tube, and the transceiver itself acts in place of a tube tester.

If tubes are tested on a checker, the mutual conductance type is best. It simulates an operating circuit, subjecting the tube to a more accurate test. On the other hand, the simpler emission tester may not always show

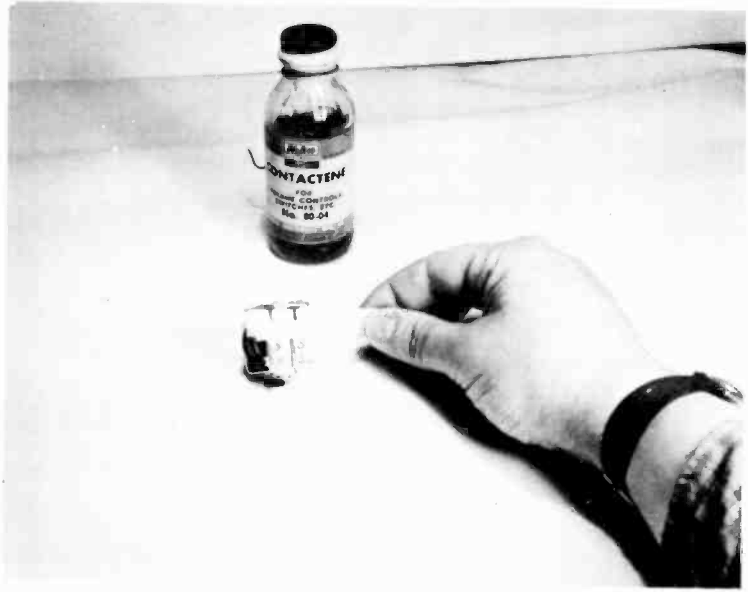


Fig. 9-2. Cleaning send-receive relay contacts.

negative indications for defective tubes used in high-frequency circuits (as found in a Class-D Citizens Radio).

Another troublesome area is the power supply. Its parts often operate at close to maximum ratings, and the heat they develop, especially when ventilation is inadequate, tends to shorten component life below that of other circuits.

An effective method for tracking down trouble is to review the symptoms and isolate the circuit or section in which they appear. This involves some detective work and a block-diagram conception of the transceiver. Once a particular section is singled out as the possible trouble source, the components are checked for their listed value. Narrowing down the circuit in this manner obviates a time consuming check of every part starting at the antenna jack and ending at the speaker.

Never overlook the possibility of difficulties arising from a mechanical source. It often appears where repeated flexing and manipulation occurs during normal operation, as in microphone cable or power leads. Wires can break or short-circuit without any visible indication when hidden by an insulating jacket. Switch contacts lose their springiness and function intermittently. Nuts and bolts loosen after months of operation as vibration takes its toll. Dirt and oxide coatings which form on contacts can be cleaned with a strip of paper, crocus cloth, or with cleaning solution.

Make every effort to diagnose the cause of improper operation while the transceiver is mounted in its normal operating position. Many units have been opened up on the service bench before the defect was found to be produced by something external to the chassis: antenna, power source, broken cable, or even an unplugged line cord!

If it is decided to remove the unit for closer inspection, the eye and ear can be relied on for initial tests. Careful visual examination reveals components blackened and charred from overload, shorts, and capacitors which have leaked their contents. The ear can perceive the quality and level of the sound issuing from the speaker and can help locate the arcing of voltage where parts are too close to each other or are partially shorted. Though most trouble is uncovered only by meter indication, these initial tests are worthwhile since they can be done rapidly without any test instruments.

Many cases of unsuccessful servicing can be traced to treating the symptom instead of the cause. A typical example is the replacement of a bad filter resistor in the power supply—only to find that the new one is destroyed within hours or days. Of course, any component may spontaneously fail because it has reached the end of its useful life. But, the question should always be asked: "Is the failure due to some other defective part?" Filter re-

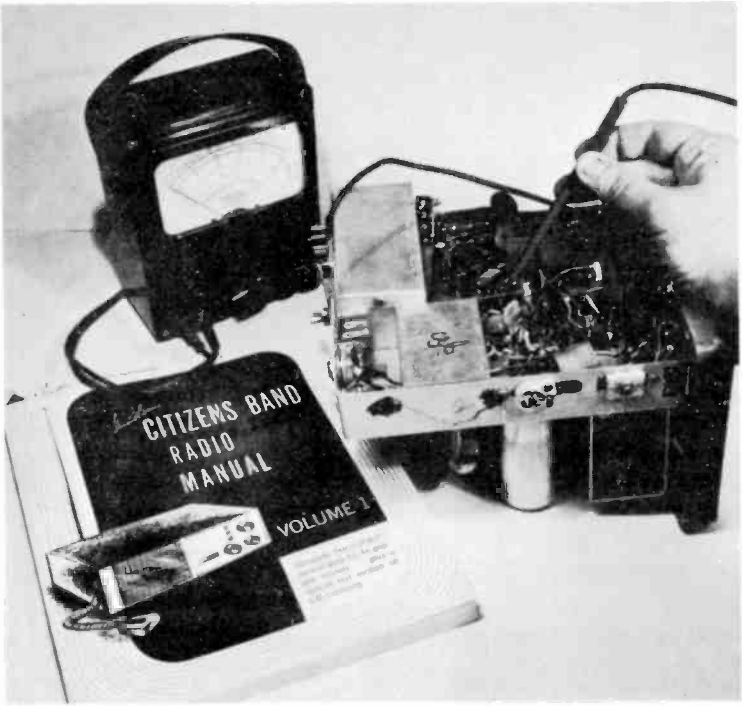


Fig. 9-3. Service literature plus voltage and current measurements will pinpoint most troubles.

sistors can be overloaded by a short in the filter capacitor which might not display any *visual* sign. Thus, component replacement should always be accompanied by a meter checkout (Fig. 9-3) of the associated circuitry.

SYMPTOM AND CAUSE

The following symptoms fall into three major categories: afflictions of the receiver, of the transmitter, and of the two sections simultaneously. The service hints are general enough to apply to most transceiver circuitry, but always refer to your manual for specific values of voltage, resistance, or current. First, check for difficulties which affect the over-all operation of the transceiver.

Totally Inoperative

This points toward power source or power supply. Check the 120-volt a-c line, if the unit is line-operated, or 6- or 12-volt d-c supply, if the models use battery power. Is a fuse of correct rating inserted into the fuse receptacle (Fig. 9-4)? An ohms check (power to unit must be dis-

Fig. 9-4. Different fuses are often used for car and home operation.

connected) across terminals of the power switch should indicate zero ohms if the switch is on. Determine if power cables have continuity, and if all connectors are making firm contact.

Blown Fuses

Short circuits are often found in the power supply. Check the wiring for broken insulation. Run an ohms check on the windings of the power transformer. In a-c models the black transformer leads (primary) should read approximately five to thirty ohms, red leads (secondary) about 100 ohms, and green filament (secondary) about 1 ohm. A shorted B+ circuit should be checked at its origin—the cathode of the rectifier. The resistance to ground must exceed 15 or 20 thousand ohms. If lower, follow the B+ lead and find the branch which reads the lowest resistance. Disconnect it and check the value of the resistors, capacitors, and other components across the B+ lead, particularly those which go to ground. Shorts in the rectifier or filter capacitor are also likely to blow fuses.

In battery-operated power supplies, check for a stalled vibrator. If the vibrator is replaced (Fig. 9-5), the buffer capacitor (a unit of 1000-volt rating, or more, across the secondary of the power transformer) must be changed at the same time. It can be responsible for vibrator failure.

No Sound In Speaker

Turn volume up to full and place your ear about one inch from the speaker. If a soft hum is heard, this is a good indication that the power supply and speaker are functioning and the trouble could be in the audio amplifier. If tubes check OK, touch a screwdriver tip to the grid of the tube which feeds the audio output transformer. A definite "click" should be heard in the speaker if this stage is operating. Repeat this on the audio-driver tube preceding the output tube.

The absence of noise as the circuit is disturbed in this manner narrows the range of possible faulty stages. Resistance and voltage checks can also be made to isolate the specific defect.

Try the click test on each of the three lugs which protrude from the volume control (Fig. 9-6). The complete audio amplifier is probably functioning, if the disturbance

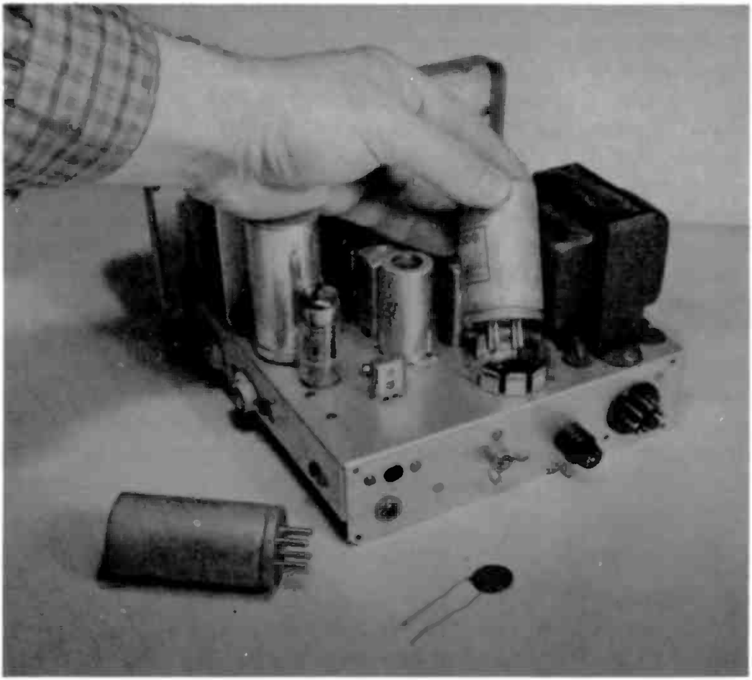


Fig. 9-5. Replace buffer capacitor when installing new vibrator.

is heard in the speaker when the screwdriver touches the control's center lug. This suggests that the trouble precedes the amplifier.

It should be remembered that the audio amplifier serves both transmit and receive sections in most Citizens Radios. If your transmitted signals are intelligible, the problem is in the receive section.

Poor Reception

With the audio amplifier functioning properly, poor reception can be traced to the antenna, send-receive switch or trouble in one of the receiver radio- or intermediate-frequency stages. The click test, which is primitive but

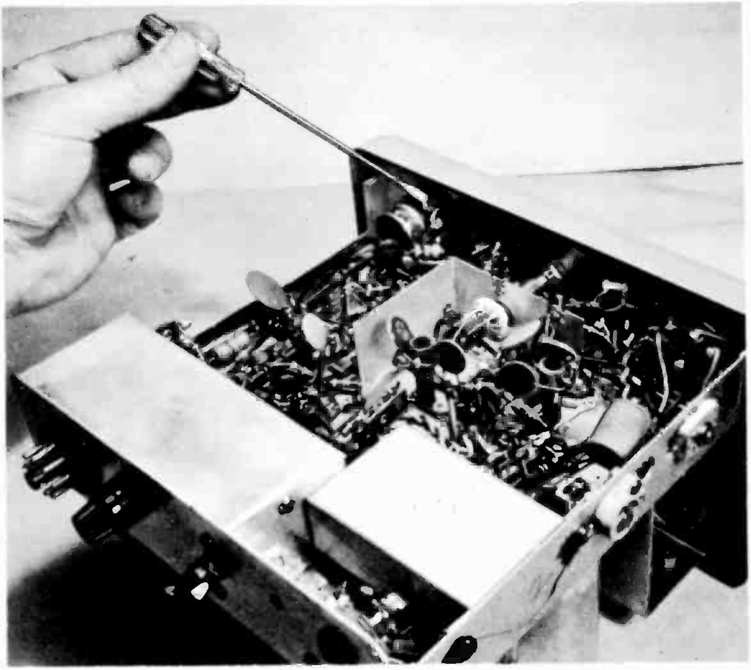


Fig. 9-6. Click test with screwdriver tip applied to control lugs.

useful, can be used to advantage, as in the audio section. Touch each tube grid in succession, working your way toward the front end or antenna-input stage of the receiver. (Note that the detector tube has no grid. Touch its plate).

If strong atmospheric noise is present in the speaker but no signals are coming through, the local oscillator is to be suspected; defective tube, resistor, capacitor, coil, or crystal if one is employed.

The transformer and coil adjustments rarely go out of alignment. However, if any of their associated components are replaced, a slight realignment might be necessary.

Low Transmitter Output

Correct tuning of the transmitter output is a critical point and should be checked. A fraction of a turn on any of its adjustments can cut power to unusable levels. Any time the antenna is changed, a new tune-up is in order. Check the antenna and its cables. These factors will affect the transmitter more adversely than the receiver.

Other causes of poor transmitter performance, aside from tubes, are commonly traceable to the frequency-determining section, namely the oscillator stage. Complaints of frequency drift or sluggish response when the send-receive switch is thrown to send can be produced by an aging crystal.

The flicker of the output indicator light on the front panel of many transceivers gives evidence of an oscillating crystal, and it also gives an approximate indication of modulation.

PREVENTING TROUBLE

A program of preventive maintenance will do much to forestall trouble. This is important if the Citizens Radio serves in business applications where equipment downtime can be expensive. There can be more serious implications, too; e.g., a small boat in rough waters with a dead transceiver. Periodic maintenance should include the following: a tube check, close visual inspection, and performance tests under identical conditions each time. Also lubricate all switches and sliding contacts with chemicals manufactured for the purpose. Blow out dust which collects inside the cabinet—especially between the moving plates of the tuning capacitor (Fig. 9-7). Dissolve any grease or sludge which deposits on or near components. Use crocus cloth on plugs and relay contacts to restore

Fig. 9-7. Rubber bulb is useful for blowing out dirt.

their original shiny surfaces. Tighten nuts and bolts, tubes in their sockets, and panel knobs. Replace burned-out pilot lamps. Wipe away soot or other formations on antenna terminals and elements.

CHAPTER 10

THE FCC AND YOU

To acquire a Citizens Radio license you must fulfill certain requirements of the law: citizenship, age, and an acceptable use of the band. And, as you operate, the responsibilities continue. The benefits which accrue from operating a two-way radio exist only as long as the rules are observed. Many of these rules appear in detail in Part 95 of the regulations—others are recommended to forestall further FCC restrictions.

PERMISSIBLE COMMUNICATIONS

The messages sent out over Citizens Radio are primarily for communication between units of the *same* station. Other stations may be contacted only for substantive messages relating to the personal or business activities of the individuals concerned. Within narrow limits, there are certain interpretations of these rulings. One example would be when you are driving in an unfamiliar part of the country looking for a motel. In this instance you may transmit an inquiry if you know the call signal of a specific motel. This is in sharp contrast to sending a *CQ*, or general call, to raise an unknown station for the sake of conversation or amusement. *DX*ing, (to see how far your signals reach) is also forbidden. To remain within the category of a short-range operator, transmissions must be *direct*, as opposed to sky-wave propagation which can travel many thousands of miles.

Transmitting music or charging a fee for your communication services is taboo. One-way transmission is allowed, if the messages are addressed to specific units. Hooking the output of the receiver into a public address system for broadcasting to the public is also forbidden.

STATION LICENSE REQUIREMENTS

Licenses are issued for a term of five years. Near the end of this period an FCC Form #505 (identical to the initial application) is filed for renewal. This extends the license for another five years. Unlike other radio call assignments, your Citizens Radio call letters will be different each five year period. This system was adopted to simplify FCC bookkeeping. Take this into consideration if you plan to have your call printed on stationery or other literature.

If modifications to the license are made, not only does the form #505 have to be submitted again, but in all probability the call letters also will change when the amended license returns to you. Anytime you vary the number of units in your network, change address or area of communications a new form is to be submitted for approval.

Licenses must be posted or readily visible for inspection. Many transceivers provide a transparent pocket on the side or bottom of the cabinet for this purpose (Fig. 10-1). Since a single license is issued for several units, transmitter identification cards (FCC Form #452-C) can be used for the additional sets. Some manufacturers provide these cards with their equipment. Each card should bear the call sign and licensee's name and address.

TYPICAL VIOLATIONS

While the Citizens band is intended for private communications, it is by no means a private system; anyone may listen, if he is within range of your signals. With

Fig. 10-1. Transmitter identification card must be attached to all units.

proper receiving equipment and a high-gain antenna, your signals can often be picked up many miles beyond your normal service area, and this is often done by FCC monitoring points (Fig. 10-2). The result is an issuance of citations to violators of the rules and regulations. These notices must be answered within 10 days of receipt with a written statement explaining the matter. It also must state the steps taken to prevent future violations of the type cited. Depending on the nature of the violation, three courses of action may follow—the notice goes into the FCC files for future reference, suspension of the license, or revocation of the license.

Two major categories appear to account for most citations: off-frequency operation and improper use of the band. The frequency of the transmitter should be periodically checked to discover circuit defects which might cause excessive deviation from the crystal's nominal frequency (Fig. 10-3). Faulty tune-up of the crystal oscillator can produce similar difficulty.

Fig. 10-2. FCC fixed monitoring stations are aided by mobile units. (Pictured here is Paul W. Gilligan, engineer at the Boston FCC field office.)

Improper Use

The large number of citations for improper use of Citizens Radio, according to one FCC bulletin, is partly due to misunderstanding regarding the band. Since the frequencies were formerly associated with amateur radio,

Fig. 10-3. Exchanging crystals between units of different manufacture might cause off-frequency operation.

some operators continue to use the band in a similar manner. The bulletin also states that many who could or would not obtain ham licenses seized on the Class-D service to carry out activities common to amateur radio. The *CQ*, "rag chew", and the fierce competition for *DX* which make ham radio a dynamic medium for the hobbyist or experimenter would soon disable the utility of the Citizens band. It is surprising that persons who wish to use two-way radio as a source of diversion and electronic interest do not secure the Novice Class amateur license. The examination is modest in its requirements and the frequency allocations are far more liberal than the 23 fixed channels of the Class-D band.

APPENDIX

FCC FIELD OFFICES

Mailing addresses for Commission Field Offices are listed below. Street addresses can be found in local directories under "United States Government." Address all communications to Engineer In Charge.

FIELD ENGINEERING OFFICES

Alabama, Mobile 36602
Alaska, Anchorage 99501
(P.O. Box 644)
California, Los Angeles 90014
California, San Diego 92101
California, San Francisco 94126
California, San Pedro 90731
Colorado, Denver 80202
District of Columbia,
Washington 20555
Florida, Miami 33101
(P.O. Box 150)
Florida, Tampa 33606
Georgia, Atlanta 30303
Georgia, Savannah 31402
(P.O. Box 77)
Hawaii, Honolulu 96808
Illinois, Chicago 60604
Louisiana, New Orleans 70130
Maryland, Baltimore 21202
Massachusetts, Boston 02109
Michigan, Detroit 48226
Minnesota, St. Paul 44102
Missouri, Kansas City 64106
New York, Buffalo 14203
New York, New York 10014
Oregon, Portland 97205
Pennsylvania,
Philadelphia 19106
Puerto Rico, San Juan 00903
(P.O. Box 2987)
Texas, Beaumont 77704
(P.O. Box 1527)
Texas, Dallas 75202
Texas, Houston, 77002
Virginia, Norfolk 23510
Washington, Seattle 98104

Own These Popular SKILLFACT™ Books

SKILLFACT Books offer the do-it-yourself and hobbyist reader an opportunity to build a most valuable low-cost library. Written by experts in their fields in language anyone can understand, these books clearly explain technical subjects, show you how to save money by doing-it-yourself, how to build practical projects, and how to select the best values in equipment.

- **601** care and REPAIR of your SMALL HOME APPLIANCES
- **602** Do your own ELECTRIC WIRING Modernizing and Repair
- **603** How to install your own AUTO TRANSISTOR IGNITION SYSTEM
- **604** Build useful ELECTRONIC ACCESSORIES FOR YOUR CAR
- **605** care and REPAIR of your LARGE HOME APPLIANCES
- **606** fascinating, easy-to-build ELECTRONIC GAMES
- **607** know about HI-FI AND STEREO
- **608** know about ELECTRONICS FOR BOATING
- **609** Getting the most from your TAPE RECORDER
- **610** know about ELECTRONIC ORGANS
- **611** know about GARAGE DOOR OPENERS
- **612** the FUN of HAM RADIO
- **613** care and REPAIR of your OUTBOARD MOTOR
- **614** Dictionary of ELECTRONIC TERMS
- **615** know about HOME INTERCOM SYSTEMS
- **616** know about MODEL RADIO CONTROL
- **617** Picture Guide to TV TUBE REPLACEMENT
- **618** the FUN of SHORT-WAVE RADIO LISTENING
- **619** easy-to-build TRANSISTOR PROJECTS
- **620** Getting the most from your HOME POWER TOOLS
- **621** Build useful ELECTRONIC GADGETS FOR YOUR HOME
- **622** AMATEUR PHOTOGRAPHY for the Beginner
- **623** Understanding the NEW MATH
- **624** Do your own MINOR HOME REPAIRS
- **625** let's cook . . . BARBECUE
- **626** fascinating EXPERIMENTS for young CHEMISTS
- **628** know about BIRDS AS PETS
- **630** know about COIN COLLECTING
- **631** know about GUNS
- **632** know about CITIZENS BAND RADIO

EDITORS and ENGINEERS, LTD.

New Augusta, Indiana