THE "SCREWDRIVER EXPERT'S" GUIDE

TO PEAKING OUT & REPAIRING
CB RADIOS

By

Lou Franklin

THE "SCREWDRIVER EXPERT'S" GUIDE TO PEAKING OUT & REPAIRING CB RADIOS

by

Lou Franklin

Dedicated to the truckers of America, and particularly to that great bunch of drivers with whom I worked during all those late-night repair sessions at the Union 76 Truck Stop in Ontario, California. Keep on truckin' . . .

1981 EDITION

Address correspondence to:

C.B. CITY INTERNATIONAL
P.O. Box 31500
Phoenix, Arizona, 85046 U.S.A.

TABLE OF CONTENTS

AUTHOR'S NOTE
1981 Edition

Since this book was first written in the summer of 1977, just before the introduction of 40-channel CB radios in the U.S., many changes have occurred in the personal communications industry. Among these changes has been the rise of new manufacturers and the demise of others including some very old-line companies.

The greatest change has of course been in the use of PLL frequency control to get the 40 channels without using a lot of crystals. We've also seen some extremely advanced sets featuring microprocessors for scanning, monitoring, and storing information for the operator. The remaining technical changes are minor and relate mainly to FCC requirements for cleaner signals. In keeping with this new technology, a new section on PLL has been added to aid your repair and modification attempts.

I'd like to emphasize that any repair/tuning references you may see here regarding 23-channel CB radios *are still completely accurate* in dealing with the problems of 40-channel sets. Parts and adjustments for power and modulation still look the same, still work the same, and are still located in the same general areas of the radio. The only important difference between the old and new sets is the fact that there are no longer as many crystals used. This is both a blessing and a curse; good because there are now fewer crystals to fail, and bad because the radios are sometimes more difficult to modify for extra channels.

As far as antennas, they still tune and operate in exactly the same way, using well-established electronic principles. For example, nearly all base-loaded mobile antennas will show a "DC short" between the whip rod and vehicle body, as described on page 22. (The K-40 is a rare exception; it's grounded through a capacitor so it won't show such a short.)

You'll find many references to specific products and companies here. These are all known to me by personal experience, and they're good. Meanwhile dozens of new radios, antennas, and accessories constantly appear on the CB scene, all asking for a piece of your hard-earned paycheck. I hope the information in these pages will help you to get the most enjoyment from your CB radio and also teach you to be a wiser shopper. You'll recognize and ignore most of the technical doubletalk heard on the airwaves. Instead you'll probably consult a professional repairman, or check it out yourself in one of the better CB/Ham magazines and books. Also, keep in mind that many of the "new" CB products on the market today are simply copies of already successful ones. In fact many of the technical articles you see in magazines which describe "new" antennas, mikes, etc., are written by the companies themselves to plug their own products. Remember, these manufacturers spend lots of money in advertising, so magazine publishers feel obligated to return some of it to them in the form of technical "articles" and editorials. Be just a little cautious before you buy!

I have tried here to give non-technical people enough information to enjoy their CB radios to the fullest, and save some money in repair costs. Maybe even make a few bucks in CB servicing. From the many great (and unsolicited) comments I've received since this book first appeared, it's working.

So many people have written to me asking for more specific tuneup information and modification advice that I've added a whole new section to help in this area. It's impossible to cover in detail all the thousands of radios being used in a book like this, so what I've done is made a list of the power/modulation adjustments for many popular models, as well as added a section detailing PLL frequency programming and modification. Since there are only a handful of companies who actually manufacture the radio "guts" anyway, this was fairly easy. For example, Cobras and Presidents are the same, Sears and J.C. Penney are the same, Kraco and HyGain are the same, etc. Study the information in this guide carefully, and I know you'll be very pleased with your increased radio knowledge.

As an aid to my readers, or anybody else needing specific technical information, CB CITY now offers other unique products and publications. Available are such things as TUNEUP/MODIFICATION REPORTS for specific model radios, a very effective and inexpensive Speech Processor, VOX for SSBers, and our new PLL DATA BOOK. As technology and interests change, we'll continue to offer you new products and information that usually cannot be found elsewhere.

If you find the information in these pages helpful, or if you'd like our current catalog, please write us at the address indicated on the front page. Your comments and suggestions are always welcome. Meanwhile, good numbers to you, and happy CBing!

Lou Franklin
"Supersparks"
KZB4389/K6NH

Phoenix, Arizona
January, 1981

INTRODUCTION

My personal experience working on over 2000 CB radios has shown that about 75% of all CB radio problems are in the microphone or antenna system, *not* the CB itself. Of that remaining 25% of internal problems, about 20% can be repaired by you if you carefully study the material in this book.

That leaves us with only about 5% that will require professional expertise and special, expensive test equipment. Therefore, the odds are greatly in your favor that by attempting to diagnose and repair the radio yourself, you will save a lot of money, time, frustration, and perhaps even more important, *make* a lot of money by starting or improving your own CB radio repair business.

A few of the repairs to be described are, officially, illegal to perform without the proper commercial grade FCC license, or under the direct supervision of such a licensee. That's up to you. I'll provide the necessary information only. Some of you may have a license, but not know enough about these type radios. And some of you may be studying for your commercial license. Congratulations!

If you are very sharp and can absorb everything in this book, you could easily make a pile of money on the side. Many of you are probably already "operating" out of your garage, or maybe even a legitimate business front, but from what I've seen, you're making an incredible mess of it. Therefore, since you're going to tear into these radios anyway, whether you know what you're doing or not, my philosophy is simply to give you expert, professional guidance, so you'll at least have a fighting chance to make correct, reliable repairs.

To give you an idea of the potential profit in CB radio repair, here's how I started: While working *full-time* as an engineer at a commercial broadcast station, I "played around" with CB at a large local truck stop. I never seemed to have less than $100-$200 "walking around money" in my pocket as a result of my moonlighting! YOU can do it too, as long as you realize that the amount of money you make will greatly depend on how much effort you spend studying this material, and how much money you're willing to invest eventually in special test equipment to speed up your repairs. You may even decide to learn enough electronics to repair that elusive *other* 5%.

Many of you will be reading this material for different reasons. Perhaps all you want to do is repair your personal equipment or that of your friends. A few of you may be in the retail sales end of the CB and consumer electronics business, and want to improve your technical knowledge and that of your sales employees. And some of you may already be in the electronics trade, such as TV service, and want to expand into CB service. Since we are dealing with a very sophisticated, technical piece of equipment, many of you will be unsure of yourselves because after all, CB radio is electronics, and electronics is a very complicated field. To all of you I say, "Don't worry about it!" Technical discussions will be kept to an absolute bare minimum, with fancy words and explanations thrown in occasionally only to prove a point. Many of you will already be familiar with some of the radio theory involved. But the simple fact to keep in mind while reading this book is this: YOU DO NOT HAVE TO KNOW *HOW* SOMETHING WORKS TO BE ABLE TO FIX IT.

The CB radio world is crying for *good* repairmen and *knowledgeable* sales people. All those fancy $800 correspondence school courses teach you is electronic *theory;* but I have boiled down years of practical experience repairing (and selling) CB radios to the contents of this book. And in all modesty, I have yet to meet any "repairmen" as good as myself; I have the customers and reputation in this area to prove it. If you are good, and *honest,* you will be very successful. The uninformed CB public, which includes hard-core CBers and potential customers, are extremely impressed by CB technicians and salesmen who know what they're talking about, since so few actually do.

THE BASICS YOU'LL NEED

The most important requirement for any electronic trouble-shooting is the need for *logical* thought. Armed with the knowledge I'll provide, you must logically study the problem, weighing every possibility. After a little experience, you'll be amazed how quickly you can diagnose and go straight to the problem. You'll know the tell-tale signs to look for, just like a doctor.

Most CBers cannot accurately describe their problem. If you've ever asked for a "radio check", you know what I mean: you'll get a dozen totally different answers. So don't let them dump the radio on you and say, "It doesn't work." WHAT doesn't work? Doesn't receive, doesn't transmit, breaks up, dead on certain channels, or exactly what? CAUTION: Don't take their word for it even after they've described the problem. Check it out yourself. Many CBers have grossly inaccurate, pre-conceived ideas of what the problem is, because that's what their CB buddies told them. You will generally find that they know absolutely nothing about what they're saying, and the problem will end up having *nothing* to do with what *they* think it is.

TOOLS & EQUIPMENT

You will need a few simple hand tools and accessories. You probably already have some of these, especially if you're a veteran CBer or TV repairman. Otherwise, you may be able to borrow many of these items from another CBer or ham operator. But if you plan to start or improve your own business, or wish to expand a retail sales operation, you'll need them eventually anyway. And they're very cheap compared to what I have invested! Here they are:

1) Common hand tools: screwdrivers, needle-nose pliers, diagonal cutters, wire strippers, electrical tape, etc.

2) A SOLDERING IRON. Beg, borrow, or buy one, and learn how to use it; it's easy! You can buy a good Weller or Ungar 25 watt pencil-type iron, or even a fancy cordless re-chargeable, like the Wahl Iso-Tip, for $10-$20. These will be used for delicate printed circuit board type repairs. Occasionally, you may need more heat than the pencil type iron can provide, so a good soldering gun, like the Weller D-440 or D-550 is helpful. CAUTION: Never use a gun on a printed circuit board; you'll curl the copper foil right off! And use only radio type, rosin-core solder of the 60/40 blend.
3) De-soldering tools. These remove solder. You can get a simple squeeze bulb for $2, or get fancier and use Soder-Wick ($2 a roll) or a Sclda-Vac suction gun.
4) A "dummy load." Absolutely essential! A $2 item at Radio Shack or any CB-type electronics store. Examples are the Gold Line Electronics GLC-1057, GLC-1072, GC Electronics #18-707 or #18-704, or Amphenol 83-888. The most handy item you'll ever use. Get several. Details on their use later.
5) A volt-ohm-milliammeter, or VOM. A fancy name for an extremely versatile instrument. You can get one that does everything you'll need from Radio Shack for $10 (#22-027) or $18 (#22-201A). An absolute must for most of the repairs described. I'll explain how simple it is to use shortly.
6) An SWR meter. Do NOT waste your money on the combination wattmeter/SWR/modulation meter; they are NOT accurate for *anything* except SWR readings. A simple SWR meter, such as the Pace 5453 or equivalent, is excellent for our purposes.
7) A package of "clip leads". Little colored wires with alligator-type spring clips at both ends. About $2 for a package of them at any electronics store.
8) A 12 volt "power pack" or "converter". This is what's commonly used in the home to operate a mobile CB as a base. It converts the 110 volt house wiring to 12 volts DC to operate the radio. Buy a *regulated* power supply. Perhaps you can borrow one, but if you plan to be in business, you'll get awfully tired of trying to work on CBs that are laying on a car seat plugged into the lighter socket. Good ones are made by Radio Shack, NPC, Vista, and many others.
9) A 2nd CB radio or Walkie-Talkie of any type is extremely useful for the "peaking out" repairs and adjustments described later.

USING A SOLDERING IRON & VOLT-OHM-MILIAMMETER (VOM)

These will undoubtedly be the MOST important instruments you'll be using throughout this book, so you must practice and learn to use them *properly*.

Soldering:

It's incredible to me how many people cannot do something as simple as learning how to solder. This includes some very high-priced electrical engineers I've met!

Solder is not just a form of metal "glue" used in electronics; it becomes a very important and permanent part of the entire connection. Used incorrectly, it can be worse than no solder at all. When a joint to be soldered is heated up enough, the solder will easily flow all around it. A GOOD solder connection will always look shiny and bright. (The only exception is the original factory mass-produced printed circuit board, which may appear dull, but is actually a good connection.) A BAD solder connection looks dull, flaky, or crystalline. The average person usually fails to heat up the connection long enough for solder to flow in smoothly; he just dabs it on as soon as it appears to stick. Such a "cold" solder joint can easily act as a very high resistance to the flow of electricity; enough to prevent it from performing its particular function. Metals to be soldered must be clean; however, most of the things you'll be dealing with in this book will probably be sufficiently clean for a good solder connection. If you have any doubts at all, scrape all the metal involved very clean and re-heat it! Sometimes a tiny dab of solder "flux" helps; this is a special chemical available in any electronics store that cleans the metals enough for proper solder bonding.

It's very important when soldering that you do NOT move any of the wires involved until the solder sets; this will cause a cold connection. You'll occasionally have to hold wires steady with a needle-nose pliers until the solder sets. If all this talk of soldering seems overdone, it's because few people can do it right.

Using a VOM:

This is one of the handiest instruments you'll ever use for CB troubleshooting. The device actually measures voltage, resistance, and current, but for our purposes we won't be concerned with the technical meanings of these terms.

The MOST important use of your VOM will be for what are called "continuity" tests. This simply means testing an electrical circuit to see if there is a continuous connection from one end to the other. This is done by using the VOM on the *resistance* or *ohms* ranges. They will be clearly marked on the switch by such abbreviations as "RX1", "RX10", "RX1K", etc. Don't worry about what these things mean. We will be using the "RX1" or "resistance-times-one" switch position almost exclusively. What this means is that when you touch both of the meter's red and black test probes together, the meter will deflect all the way over and read "zero ohms." This is therefore a "continuous" circuit. So, *anytime* the ohmmeter reads "zero ohms", you have a complete circuit. Sometimes this is exactly what we want it to read; other times, it will mean we have a *short circuit*, which in that particular case is exactly what we *don't* want! Study the instructions that come with your ohmmeter; it's extremely easy to use. You MUST understand the use of "continuity" testing for many of the repairs we will be discussing.

Notes:

1) *Never* use a VOM in any "ohms" switch position when there is any voltage turned on. (Such as your CB) You will permanetly zap the meter.
2) Before making any continuity test, touch the red and black test probes together to make sure the meter does in fact deflect all the way over; it *is* possible that a test lead has a broken connection, or you forgot to turn the function switch to ohms! Remember, any test you are trying to make is only as accurate as the test equipment you are using.
3) It does not matter which of the red and black test probes you touch to which circuit point when making continuity tests.
4) The red and black leads will only make a difference when measuring *voltages;* if you reverse the leads, the meter will try to deflect backwards. This is probably the only time you will have to worry about positive (red) and negative (black.) Using your VOM as a *voltmeter* on the "DC" ranges will only be needed to check out "hot" leads in mobile installations.
5) You will not be using the VOM at all in the *current* (milliammeter) ranges, so don't even worry about it.
6) For a brief demonstration of continuity checking, see Figure 1.

For the purposes of saving space, we will be using the following abbreviations throughout this book:

TX - means transmit or transmitter
RX - means receive or receiver

MICROPHONE PROBLEMS— ONE OF THE BIGGEST CB HEADACHES (And the EASIEST to fix!)

Typical mike problems:

1) Throws "dead carrier" but no modulation;
2) Breaks up on TX;
3) Squeals on TX;
4) Won't TX at all;
5) No RX, or breaks up during RX;
6) Tried to wire a power mike yourself, and got it wrong;
7) Tried to plug a mike a from a *different* CB into your radio.

Generally, almost all mike problems are the result of a broken wire in the plug (unless it doesn't use a plug, as on some Johnsons, Couriers, etc.) or a broken wire in the mike cord within about 3" of where it enters the mike. Other causes, but not nearly as common, are bad power mike batteries or bad connections to those batteries, broken wires on the push-to-talk switch, dirt on that switch, or in very rare cases, a defective mike element itself.

Now that you have an idea of what to expect, you must first ask yourself, "Is it in the mike, or in the radio?" The MOST COMMON complaint among CBers is that "I can't seem to get out, but can hear other people very well." This *in almost every case* turns out to be a problem with the mike or the antenna, so both these areas will be discussed in great detail.

HOW TO DECIDE WHETHER IT'S THE MIKE OR THE RADIO

METHOD #1: Use the modulation light/dummy load described in the introduction. (And later in the Antenna Section) This is the EASIEST way. Key the mike. The light should light brightly, indicating that the TX is in fact working, even if it has no modulation. When you talk or whistle, the light will normally get even brighter on AM. If it doesn't change, you have a "dead carrier," which is almost always a mike problem. (In some very rare cases described later, the light will get *dimmer* when talking; this is a TX problem.)

METHOD #2: If you have no modulation light or dummy load, just observe the S/RF meter on the CB; it should move towards the far end when keyed, indicating a good carrier. Then, talking or whistling should make the meter jump up a bit higher in almost all CB radios, indicating the presence of modulation. On an AM/SSB rig, you can double-check on USB or LSB; the meter will move only when you talk, if the mike is OK.

If your tests show no modulation but a good carrier, try wiggling the mike connector and/or mike cord at the neck of the mike while talking. If the meter starts jumping around or the light changes, you've found the problem. Broken wires in the neck of the mike cord are actually *more* common than broken wires in the connector itself. The solution here is to open the mike, cut off about 3" of the bad cord from inside the mike, and carefully re-solder and tape all wires, color for color. (You do NOT have to cut the wires off the switch itself; you may forget which wire went where.) The problem is usually in the sharp-toothed metal strain-relief clamp used in most mikes; eventually after enough tugging on the mike, the sharp teeth cut through one of the wires.

If your CB has no meter at all (Cobra 19, Realistic Mini-23, etc.) and you have no modulation light bulb, you'll either have to use a second CB set to listen, or have a friend listen while you wiggle the ends of the cord. If an external SWR meter is available, you can use this in the "FOR" position to determine carrier output. In this case, modulation will often make the SWR meter flicker *backwards* when you talk; this Is OK.

In some cases, in *electonically*-switched CBs (see Mike Wiring section) a broken wire anywhere in the mike cord can prevent the receiver from working as well. You will see your "poundage" meter jumping around, indicating that the radio itself *is* working, but you won't hear anything.

In those few radios that are directly wired without a plug, the problem logically HAS to be either in the cord or the mike itself, or internally in the radio, which is the *least* likely. Open the mike and inspect the wires, the switch, and the mike element itself. You may just have a broken wire, or dirt on the push-to-talk switch. Shoot some WD-40, alcohol, or other cleaner in the switch while you work it a few times. Check all soldered connections to the switch, the mike element, and between various colored wires. See Figure 2.

Power mikes suffer the same connector and cord problems as regular mikes. But we also have these possibilities:

1) Weak or dead battery, or broken wire inside the snap-on connector of mikes that use standard 9-volt transistor batteries. When the voltage you measure with your VOM drops about ½ to 1 volt from its rated voltage, time to replace it. (By the way, those strange little 7-volt batteries, such as the Radio Shack 23-601, or Eveready E-175, can often be found in photographic equipment shops if you're having trouble getting one.)
2) Sometimes the little metal spring clip battery holder, such as used on Turner, GC, etc., is too loose to make a good contact. Just use a fine screwdriver or needle-nose pliers to bend the ends slightly tighter towards each other.
3) Battery reversed. The solution is obvious. The "plus" and "minus" ends are always marked on both battery and clip holder.

PROBLEM—SQUEALS ON TRANSMIT

A very common problem. *If* the mike is correctly wired and there are no broken wires in the plug or cord, the squeal is being caused by "RF feedback," a fancy name with a very simple solution. Usually, the stock mike works fine, but the squeal starts when you try to wire up a power mike. THERE IS NOTHING WRONG WITH THE POWER MIKE, even though the original mike worked fine. "RF feedback" means simply that, due to poor filtering in the CB, or high antenna SWR, some of your TX energy is getting back into the audio or modulation section of the CB, creating a self-perpetuating feedback exactly like a PA system that is turned up too high with the mike too close to the speaker. The cure is cheap and simple.

HOW TO CURE THE SQUEAL

1) Open the mike and determine which colored wire is the actual "audio" or mike line. (See section on Mike Wiring to determine this.)
2) After finding the audio line, cut it at a convenient spot and insert a 4700 ohm, ½ watt or (preferably) ¼ watt "resistor" (yellow-violet-red) *in series* with the audio line. See Figure 2.
3) For extra filtering protection, also connect a .001 mf or .01mf *ceramic disc capacitor* from *either* side of your resistor/audio line connections to the bare twisted shield braid of the mike cable. Refer again to Figure 2. The value of these parts is not critical; just get the physically smallest ones you can find, such as a ¼ watt resistor and a 50 volt "cap". These will easily fit inside the mike.
3) *Solder and tape* all your connections. (Please, no Scotch tape!) These parts together cost about 50¢ and will prevent any RF energy in the TX section from trying to get into the mike. This works 99% of the time.

OTHER MIKE PROBLEMS

In some rare cases, the mike "element" itself is defective. This is the little round job with the 2 wires coming from it and a very thin "diaphragm" facing towards the outside of the mike. See Figure 2. The only way to confirm this is with an ohmmeter, as follows:

1) Unplug mike from radio. If the mike doesn't use a connector, or is a *power* mike, you will have to unsolder either of the 2 wires on the element for an accurate test.
2) Use your ohmmeter on *anything but* the RX1 scale, such as RX100 or RX1K. Touch the 2 test probes to the 2 mike element connection points. The meter should deflect and show a *definite* resistance on some scale. If you get no deflection on any scale, the mike element is "open" internally and is defective. Unfortunately, these elements come in so many shapes and sizes you'll probably never find an exact replacement, so you'll have to replace the entire mike.

Special Note:
If you just got a bargain used mike from somebody, do NOT plug it into your CB unless it came from the exact same make and model as your CB. You may zap your radio for an expensive repair! Even though the connector is the same, it is rarely *wired* the same. Mike wiring varies tremendously between brands and even between different models of the same brand. For example, a COBRA mike will not necessarily work directly on a ROYCE radio except under the luckiest coincidence. Check the wiring first, as described next.

HOW TO WIRE ANY REGULAR OR POWER MIKE TO (ALMOST) ANY CB

There are 3 steps in trying to wire a new mike to your CB:
1) Determine which pin on the radio's mike socket performs which function (TX, RX, audio) on the CB itself;
2) Determine which *color* wire on the new mike performs the same function; (Figure 4 shows color codes of many popular brands.)
3) Be able to *neatly* solder and insulate those wires on the corresponding pins of the new plug.

Before you even start, you must know if the CB uses *relay* or *electronic* switching between TX and RX. This is easy to figure out. While listening to a signal, unplug the mike. If you can still hear something, it's *relay*-switched. If the speaker goes dead but the S/RF meter still shows a signal there, you have *electronic* or "diode" switching. If your CB only has a 3-pin mike socket (Pearce-Simpson, some Robyns, etc.) this is a dead giveaway that the CB is relay-switched; electronic switching requires at least 4 wires.

Since diodes are cheaper than relays, most CBs use them. Some old 23-channel AM, all old 23-channel SSB, and the first generation 40-channel SSB (Cobra 138/139XLR, etc.) used relays. Nowadays all rigs use electronic TX/RX switching to save production costs. Generally, relay switching was easier to wire because you need only 3 connections: Mike audio, ground, and TX keyline which when grounded energizes the relay. Electronic switching uses four wires: A common ground, mike audio, TX keyline which when grounded switches to TX mode, and RX speaker line which during TX opens up the speaker to prevent feedback squeal.

OK, you know it will require either 3 or 4 wires in almost every case. These 3 or 4 connections are *regardless* of how many pins there are on the CB socket. In other words, if your CB has one of those female 5 or 6-pin "DIN" type sockets, it will (normally) only use 3 or 4 of the pins. Manufacturers tend to use the cheapest parts they can find. If they got a good deal on a million DIN sockets, they'll build radios with them, instead of the more common and superior 4-pin male socket with threaded coupling nut.

First you must figure out which pin on the CB mike socket does what. This will require either an antenna or dummy load, a "clip-lead" or piece of bare wire, and possibly an ohmmeter. (This wiring discussion assumes you have no schematic for the radio, or no information for the mike. Figure 4 gives mike color codes for most popular brands.)

Method #1: With use of an ohmmeter

1) Use the RX1 resistance range, and attach one test lead to the *black* power wire coming from the CB or slide mount, or the "minus" pin on the DC socket of a base station radio. *REMEMBER:* Radio OFF for this first test! If wiring a base station and the DC power socket is not stamped with "plus" and "minus" symbols, you'll have to remove the cover; the inside of the DC socket will normally have a red and black wire attached to the "plus" and "minus".
2) While still leaving one ohmmeter lead on the black or "minus" wire or pin, touch the other ohmmeter test probe to all the mike socket pins until you find one (or sometimes 2) pin(s) that make the meter deflect all the way over, showing a DC "short" or continuity between the black power lead and the mike socket pin. (On the DIN type socket, you'll probably have to jam a wire into the socket hole; the test probe won't fit.) Once you've found which pin this is, you have the ground or "common" connection. Immediately draw a sketch of the socket, using its notch as a reference point. Mark the common lead(s) you just found. Figure 3 shows numbering systems of all the common CB mike sockets.

Note: While probing around the mike socket pins of an *electronically*-switched radio with an ohmmeter, you may hit one pin that causes a tiny crackling noise in the CB speaker. (It will show a few ohms resistance.) This is a dead giveaway for the *receive* line. Mark it on your sketch. You can also confirm the RX line in Step #4.

3) Remove your ohmmeter and turn on the CB. Now attach a clip-lead or piece of bare wire to the common pin you just found, and start touching the other end of the wire or clip-lead to the other pins *briefly* while observing what happens.
4) In an *electronically*-switched radio, you will observe the following:
   Touching one pin will make the receiver operate. Write it down. Touching another pin will key the transmitter, as indicated by the S/RF meter jumping over, the TX light coming on if it has one, the dummy load/light bulb coming on brightly, or hearing a "dead carrier" on another CB set tuned to the same channel. This is the *transmit* line. Write it down. If you get any kind of weird squeal or buzzing sound, release the wires; you have either found the audio (mike) line, or shorted the mike line to the speaker (RX) line.
   Assuming you found the "common," RX, and TX, the only thing left on the typical 4-pin socket MUST be the audio or mike line, so you're done. On a 5 or 6-pin DIN socket, finding the mike line will be slightly harder; you'll have to first find the TX line, as before, and while leaving the CB transmitter keyed, listen on another CB tuned to the same channel while you touch the remaining socket pins (or bare wires jammed in them) with your fingers until you find one pin that causes a definite weak hum in the other set. That is the mike or audio line.
5) In a *relay*-switched CB, jumpering the common with the correct pin will key the TX; you can then use the hum/fingers method to find the mike line.

Older, relay-switched rigs often used a small shielded cable at the mike socket containing the mike line/ground. The newest generation (Cobra 140/142GTL, etc.) now use electronic switching almost exclusively, and generally have 5 or 6-pin mike sockets where more than one pin may be grounded. Some (President AR-144, etc.) get away with 4-pin sockets but are still electronic, even for SSB. (Diodes are cheap!) In any case, only 4 wires are needed.

Method #2: Without use of an ohmmeter

Without a VOM, you'll have to use trial-and-error wire jumpering. For electronic switching, this is exactly the same as described above without the benefit of already knowing the "common" connection.

Start jumpering any 2 mike socket pins together and observe what happens. Suppose it keys the TX. Draw another sketch, marking both those pins that made it key the TX. (Refer again to Figure 3) Keep jumpering around until you hear a normal receive signal or noise level. Note *those* pin numbers. You will discover that one of the pins is common to *both* RX and TX. For example, if pins 2 and 3 cause TX, and pins 2 and 4 cause RX, then obviously pin #2 is common to both functions. Therefore, #3 is the TX line, and #4 is the RX line. Which leaves only the one remaining pin, #1, that must be the mike line. (By the way, this just happens to be the pin numbering for all COBRA radios.) The word "common" means the same thing as "ground" or shield wire.

Relay-switched radios will be slightly more complicated, unless you have an older type that uses only a 3-pin mike socket. With the set turned on, attach a clip-lead to the *black* power wire. (On old tube-type sets, clip one end of the lead to any part of the metal chassis.) Now start touching the other end of the clip-lead to the mike socket pins until it keys the TX. Write it down. Then use the hum/fingers method or look inside the radio to find the shielded audio cable, as before. And by the way, if you are looking inside the radio, you can just as easily find the common or ground by noting which socket pin the *shield* of that audio cable attaches to. On a 4, 5, or 6-pin socket that is relay-switched, those remaining pins are either unconnected, or possibly also grounded, which is another way of saying that *more* than one combination will key the TX.

Occasionally, you need all 4 pins of the mike socket to properly wire a relay-switched CB. (Eg., SBE "Cortez.") In such rare cases, there will be voltage to ground on two pins instead of just one; touching either of those pins to common will make the lights go out or blow the fuse. In this case, you need a separate set of mike switch contacts to wire it right; most power mikes can be arranged this way. (Refer again to Figure 4.)

Now that you know which mike pin on the CB does what, you must match those pins to the corresponding colored wires on the new mike. Figure 4 shows the color codes for most popular brands of power mikes and regular replacement mikes. If the mike you want to wire is not included, you will have to figure out the color code yourself, which is very easy to do using an ohmmeter. (On a power mike, the battery *must* be installed before the tests.)

The typical power mike will have 3, 4, or 5 colored wires and a shield braid. If one of the colored wires is obviously covered by the shielded braid, that is the mike or audio line. Otherwise, if you cut off about an additional inch or so from the main cord cover, you will most likely see one wire that is wrapped with the shielded wire. Now for some typical examples:

Case #1—3 colors and shield
Touch one lead of the ohmmeter (RX1 scale) to the shield braid and the other test probe to one color at a time. One color should show a "short;" i.e., zero ohms which opens up *when keyed*. This is the *RX* line. Write it down. Another color should show a dead short (zero ohms or continuity) when you key the mike, and open when the mike button is *released*. This is the *TX* line. The remaining color is obviously the mike or audio line. If you couldn't seem to find the TX or RX line this way, the mike is wired *internally* for relay switching; it will short 2 of the 3 colored wires on TX, rather than 1 color and the shield braid.

The mike or "audio" line can be found as follows:

1) On a straight dynamic *non*-power mike, it will normally show a DC resistance of roughly 300-1000 ohms when you key it. (You will have to use a scale *larger* than RX1, such as RX10, RX100, etc.) You may also get this reading even when the mike is *un*-keyed; i.e., all the time. This is definitely the mike line, as the TX and RX lines will show DC resistance of zero ohms.
2) On a power mike with the battery installed, the reading may vary anywhere from a few ohms to several thousand ohms, depending on the setting of the mike gain control. Many times you will note the ohmmeter "kick up," then slowly settle to a definite reading, as the capacitors in the mike amplifier charge up. (This "kick" is *only* when keyed.)

Note: Many power mikes will show a mike line reading of a few ohms *all the time* until you key it. This indicates a "normally-closed" audio line, a very *undesirable* feature. (The mike line will show a meter jump when you key it.) A normally-closed audio line can be a real problem to wire to many CBs. It's usually done because the manufacturer was too cheap to use a switch with enough contacts on it to begin with. Ideally, the mike line should make a complete circuit *only* when you key it. All Turner mobile mikes work this way.

If you found the mike line OK, but could not get an indication of TX and RX continuity between the shield and one particular color, you have a mike which is wired *internally* for *relay* switching. A quick ohmmeter check after you find the mike line will reveal that you do get a complete circuit (continuity) between the 2 remaining colored wires, rather than one color and the shield. On many mobile and almost all base power mikes, there will be a miniature slide switch *inside* the mike or base plate marked "E" and "R." Just put it in the "E" for "Electronic" position, and it will then show TX and RX continuity between shield and colored wires. Do this *even if* your CB uses relay switching. You can wire 99% of all CBs that use relay switching in the "Electronic" position, BUT THE REVERSE IS NOT TRUE; a mike internally wired for relay switching must be modified to use it on electronically-switched CB radios.

Note: Turner mobile mikes do not have the internal switch, although some of their base mikes do. If the Turner mike starts with the letter "J," such as "JM+2, JM+3, etc., you're all set up for electronic switching. If it doesn't have the "J", you must make an internal wiring change on the switch. In other words, a Turner M+2 will connect the red and black wires when keyed; the white is the mike line. But the JM+2 connects red and shield for RX, and black and shield for TX. White is still the mike line. See the difference? Figure 5 shows how to convert Turner mike switches very simply.

Generally speaking, it is much better to buy a mike wired for *electronic* switching, because it can be easily re-wired to another CB later, and all you need to do is strip either of the switching wires and twist it together with the shield as *one wire.* The remaining color then becomes the TX line for relay-switched radios. You have reduced the 4 wires down to 3 and saved the hassle of having to open up the mike and re-wire the switch itself.

Case #2: 4 or 5 colors and shield
Here's a case where the manufacturer actually gave you enough wires to make all necessary switching functions. Usually, one or two of these wires will end up being unused and can be cut off when you solder on the plug. Let's say the mike has the following wires in the cord:

1) red
2) yellow
3) blue
4) green
5) shield braid.

Step #1: Identify the mike or audio line. This will have the shield wrapped around it. If it doesn't, cut back another inch or so of covering; you'll find it. If you don't, use the previously-described ohmmeter method, looking for the wire that shows a "kick" or a definite resistance reading between it and the shield when keyed.

Step #2: It's very unlikely you'll find any continuity between shield and the remaining colored wires. (Except the mike line.) So, when using your ohmmeter, touch the remaining 3 colors with *both* test probes. You should discover that 2 of the 3 colors will short (show continuity) when keyed, and 2 of the 3 will short *un*-keyed. Therefore, 1 of those 3 colors is common to the other 2 colors, in exactly the same way we found the common on the mike socket itself.

Step #3: Strip back that common color and twist it together with the shield, making a single wire. Then solder them together. You will now have one color left for RX, and one color for TX, when tested for continuity with the shield. You have thus reduced those 5 wires down to the 4 you need for electronic switching, or the 3 you need for relay switching. (In this case, also cut off the unnecessary 4th RX wire.)

To repeat as a practical example:
Assume from the above you discovered that *yellow* is the mike line, leaving red, blue, green, and shield. You then discover that *red* and *blue* make continuity when keyed, while *green* and *blue* break continuity when keyed. Therefore, blue is common to both red and green. You would then strip and twist the blue to the shield as one wire, leaving you with red as TX, and green as RX. (With relay switching, you could also cut off the green wire.)

Special Note:
As previously mentioned, many power mikes and regular mikes come with a normally-closed or shorted mike line. This can make it difficult or even impossible to wire to certain CB radios. This would show up as a loud buzz, squeal, or the receiver going dead the instant you plug the mike into it. The reason is that there are not enough switch contacts to perform all the necessary functions, which are:

1) connect RX or TX at the proper time;
2) connect audio line; (ideally *only* when keyed)
3) connect the power mike battery only on TX so battery won't drain except when actually being used.

In many cases, installation of a resistor of about 4700 ohms or more in series with the mike line will cure the problem. This you would wire exactly the same way as the RF feedback squeal filter already described. You may have to experiment to find the proper value resistor. You will probably notice a slight decrease in receiver volume if it becomes necessary to resort to this method. Use the *smallest value* resistor that will prevent the RX from going dead or squealing. The mike should then work normally, and you probably won't even notice the volume decrease. (Refer back to Figure 2 for wiring the resistor.)

If you experience this problem when trying to wire certain brands of mikes, it IS possible the mike cannot be wired to that particular CB. For example, the Astatic D-104 "Lollipop" mike with the TUG-8 base stand uses a double-pole, double-throw T/R switch. If you had this wiring problem with such a mike, you could not wire the CB to it; you would have to buy the TUG-9 D-104, which uses a *triple*-pole, double-throw T/R switch. (And is also more expensive.) This problem is very rare though, and happens in maybe 5% of all mike wiring/CB combinations.

A WORD ABOUT BUYING *ANY* POWER MIKES

Generally speaking, cheap bargain-brand power mikes, or even major brands that use straight preamplifiers *without* compression, are practically worthless and will do you no good at all. Only a "compression" type amplified mike has a little usefulness in the average CB radio installation. However, the "noise-cancelling" types are very useful to truckers and other CB users in noisy surroundings. In all the newer 40-channel sets which must meet tougher FCC specs, power mikes of any type will rarely increase your actual "talk-power" much; the new sets have sophisticated internal limiters so that *no matter how much modulation you try to cram through the radio,* the limiter will prevent any overmodulation. You get what you pay for in this life, and that includes electronics. So I offer you these tips on buying power mikes:

1) Don't waste money trying to put a power mike on any Johnson CB; they already have a very effective speech compression circuit built in which increases talk-power noticeably. Also, some Johnsons use a

ceramic rather than the more common dynamic mike element. Which means a power mike may not work right at all, and may even sound worse.

2) The better brands of 40-channel sets have sophisticated speech "processing" circuits built into them, so power mikes won't make any difference here.

3) If you must have a power mike, spend the extra money and insist on one that has built-in speech compression. This increases talk-power about 3 db., which is *just* noticeable under weak-signal conditions. Good examples are the Turner JM+3, +3B, +3 Base, and the Mura PRM series.

4) The well-known D-104 "Lollipop," while an excellent mike, is *not* a compression mike; it is a pre-amplified mike only. It has a normally-shorted mike line, making it difficult to wire to some CBs, and can also overdrive some radios so that it requires an internal modification. (The D-104 instructions show you how to do this.) But unless you happen to like the looks of the "Lollipop" and its higher price, the Turner +3 Base, a compression mike, will run circles around it anyday, especially on sideband.

5) Cheap, non-compression power mikes do have their usefulness in certain CBs that have weak modulation to begin with. Otherwise, they are a total waste of money. For example, a standard Turner +2 pre-amplified, *non*-compression mike would be practically no use to you at all on a Cobra 29; Cobras have more than enough modulation power anyway. You can increase modulation in other ways. (By the way, the "DYNAMIKE" control on the Cobra is *not* a power mike control; it's just something for you to play with.)

6) If the set has weak modulation, you can probably crank it up without any power mike and get the same results. Most 23-channel CBs, and all 40-channel sets, have internal modulation adjustments which are factory set. You can disable them, or turn them up higher. These controls are labelled "MIKE GAIN," "MOD," "AMC," or "ALC" on the schematic, and are of the mini-pot variety shown in Figure 19. ("ALC" is a term generally used only in regard to sideband sections of an AM/SSB radio, although a few AM-only sets also use this term.) You can disable these controls and circuits by clipping them off or de-soldering them from the printed circuit board, or if you have the schematic and parts layout, you can often just remove the limiter diode or transistor completely. For example, on the Cobra 85 Base, removal of the limiter transistor, marked "Q-17" on the board, (a 2SA562 transistor) will make the modulation jump sky-high! On the Cobra 138/139XLR sideband rigs, the ALC adjustment is marked "CT-7" near the rear of the board; this is a ceramic trimmer capacitor with a screwdriver slot. You can turn this while whistling into the mike on SSB and watch the power output shoot way up. See Appendix C for modulation controls of 40-channel rigs.

Please Note: Doing any of these things is FCC illegal, may even sound *worse,* and is guaranteed to cause overmodulation, splatter, and channel bleedover. Maybe even a few enemies. That's up to you . . .

Because the physical location of these adjustments and parts can be almost anywhere, it's impossible to describe them in any greater detail here. If you're really interested, get a SAMS FOTOFACTS or factory service manual to find the part. But there are MUCH better ways to increase range and talk-power that are completely legal. See #8.

7) Combination SWR/Power/Modulation meters commonly sold in CB stores are a complete waste of money, as they are grossly inaccurate for any measurements except SWR. It is impossible to measure modulation percentage on an inexpensive instrument of this type; the mechanical meter needle cannot possibly follow the instantaneous *electronic* changes during modulation. The ONLY way to measure modulation accurately is with a very expensive instrument called an "oscilloscope." Mine cost $1000. Used. So if you decide to tinker with modulation controls and limiters, better let a pro check it out afterwards.

8) If you really want to increase range and talk-power, forget about power mikes completely. Forget all about internal adjustments. Buy yourself a speech clipper/processor. This is a tiny, powerful little module that cuts through the interference with real "talk power" and easily wires between the mike and CB. The beauty of speech processing is that once you set its output level at 100%, you will *never* overmodulate, but the *average* modulation will stay near 100% all the time! If you've ever wondered why all those Top 40 Rock 'n Roll radio stations always seem to sound so LOUD, it's because they use external sound processors that work on similar principles. Hams have been using speech processing for years, so wake up, CBers! They haven't been able to cram all the necessary parts for a really good speech processor into an area the size of a CB mike yet. A very effective and inexpensive Speech Processor• is available from CB CITY in either kit or assembled form. Write us for details.

THE NEXT BIGGEST PROBLEM AREA, *ANTENNAS*

In discussing mobile CB antenna problems, let's start right off with the mobile slide mounts commonly used by CBers, and sold by fast-talking CB salesmen. I'm referring to the type that contains a built-in coax splice; i.e., a male and female coax connector on the appropriate halves of the mount. This is the type of mount where nothing, not even the coax connector, must be disconnected to remove the radio from the vehicle. DON'T USE THEM! Or perhaps I should say, don't use *that part* of the mount. Regardless of manufacturers' and salesmens' claims, these slide mounts *can* cause you to lose transmitter power, perhaps as much as ½ watt, *can* upset SWR, *can* radiate and cause TVI/RFI, and most important, *can add* two additional antenna connections to possibly go bad and cause eventual antenna problems. This rule applies even to those slide mounts that use silver-plated contacts for the coax splice. In technical terms, opening up a continuous run of coax cable to splice across a slide mount creates an "impedance bump" where the coax is no longer "50 ohms impedance" at that point. If you're already using such a mount, ignore or cut off that part of it, and connect your antenna *directly* to the back of the set; you need all the power you can get! The only exception would be a customized installation where it's impossible to reach the back of the set, or else you are so incredibly lazy that you refuse to fiddle with anything while sliding the CB in and out. You have been warned . . .

CB ANTENNAS AND THE MYSTERY OF SWR REVEALED

What is an antenna, anyway?
Very simply stated, an "antenna" is anything which is capable of sending out or picking up radio signals. Your body could be an antenna. (I have the burns to prove it!) A *tree* could be used as an antenna. (Believe it or not, I have seen military experiments where a tree was actually "loaded up" with several hundred watts of transmitter power!) And of course, a piece of wire is an antenna. The difference in materials used is simply a matter of *efficiency*. The more efficient the antenna, the farther you will get out.

As you can see from Figure 6, there are 3 links in the chain between your CB radio and the CB radio at the receiving end. Assuming the radio is working properly and the coax cable has good connections at both ends, the *weakest link* in the chain is the antenna.

Coax Cable: A Critical Link
There are basically two kinds used for CB communications:

1) RG 58/U or 58/U Foam. The "thin" stuff.
2) RG 8/U or 8/U Foam. The "thick" stuff.

The numbers are actually military designations and are meaningless for our purposes. Coax cables consist of a solid or stranded inner wire, some insulation around that inner wire called a "dielectric," which is typically polyethylene or plastic foam, and a braided shield tightly woven around the dielectric, all covered by a tough vinyl coating. These cables are designated "50 ohm impedance." Don't sweat the fancy language. Just be sure you are using one or the other. Here are the basic differences:

RG 58/U:
1) used exclusively for mobile installations;
2) higher power loss/foot at CB frequencies than the "thick" stuff;
3) maximum power about 400 watts at 27 MHz. CB frequencies;
4) cheaper than the "thick" stuff.

RG 8/U:
1) used mostly for base station antennas;
2) lower power losses/foot than the "thin" stuff;
3) good for about 1200 watts at CB frequencies;
4) about double the price/foot as the "thin" stuff.

The foam dielectric versions of both cables have *slightly* lower losses/foot than the standard coax, and both are slightly more expensive.

Now, FORGET all that stuff about power losses and don't waste money on the "thick" stuff, RG 8/U, unless you need more than about 30 feet, as in a very high base antenna installation. The difference in losses between the two types in such short lengths *is impossible to notice* at the receiving end of the signal. You'll learn why later.

If the base antenna requires over about 50 feet of cable, then your best bet is RG 8/U foam dielectric. The best coax is made by Amphenol, Columbia, and Belden. Typical examples, Belden 8240 or 8259 for RG 58/U, and 8214 or 9208 for RG 8/U. These can usually be bought in various lengths with factory assembled connectors on the ends. An excellent idea, because very few amateurs can correctly install the standard PL-259 connector.

Caution:
DO NOT skimp in the coax department. Do not buy any other brands. You get what you pay for sooner or later. You can always tell the cheap stuff because the outer braid is not *tightly* woven around the dielectric, causing higher losses, and possibly even TVI and RFI. If you can see the dielectric through the woven outer braid, you got the junk stuff. (See Figure 7A.) Keep every link in the signal chain as strong as possible!

If you bought a typical packaged mobile antenna, just use the coax that comes with it; the better brands will use good cable anyway, even though it may have their own name printed on it.

Note: There is a 3rd type of coax used exclusively for co-phase harnesses and cerain special marine and base antennas. This is RG 59/U, which is "75 ohm impedance." You will know it because it is slightly thicker than RG 58/U, but nowhere near as thick as RG 8/U. NEVER use this for any single CB antenna. And while we're on the subject, if you are using co-phased duals on a mobile and have had one of the two antennas broken or stolen, do NOT continue transmitting on the remaining antenna with that co-phase harness. It will create a very high SWR and may even damage your CB. (Truckers notoriously suffer from this problem.) You will either have to replace the missing antenna or stinger tip and re-match the whole system, or else replace the harness with *any convenient length* of RG 58/U to the good antenna and use it alone, after re-matching it.

Splicing Coax Cables

If the coax turns out to be too short to reach where you want it, NEVER attempt to splice another piece onto it by simply connecting center wire to center wire and shield braid to shield braid. YOU CANNOT SPLICE COAX CABLE THIS WAY, EVER! This is because the "impedance" at the splice point will no longer be "50 ohms." Technically, this impedance is determined by the size and spacing of the center wire and shield, AND the type of dielectric material between them. You cannot hope to duplicate the precision of the cable manufacturer.

By trying to splice coax crudely, you will create an "impedance bump" exactly like that mentioned in the case of the slide mount. This will upset the antenna system, cause faulty SWR readings, and reduce power output and antenna efficiency, with possible damage to the CB transmitter itself.

There is one and only one way to correctly splice coax cables: You must use 2 male coax plugs, PL-259 type, at each end to be joined, and a double female connector, usually called a "barrel" connector, to join them. (Amphenol PL-258, Radio Shack 278-1369, GC Electronics #18-410.) By the time you read this, there will be some new solderless *female* ends available from Gold Line and Amphenol, (Amphenol 83-58FCJ) thus saving you the cost and trouble of one connector. By splicing coax cable with the proper connectors, you will maintain that very critical "50 ohm impedance" throughout the line. (Refer to Figure 7.)

S.W.R.—NO BIG DEAL AT ALL!

By now you have no doubt heard all kinds of garbage about "SWR" and don't know who or what to believe. This is unquestionably the *least* understood area in the entire CB radio world. This is partly due to the rash of articles about SWR published in various electronics magazines which are poorly researched and written by people who simply DO NOT KNOW WHAT THEY ARE TALKING ABOUT. So they help perpetuate the same old myths. But the most blame must be placed on CBers themselves, who just blindly go along with everything their buddies tell them without stopping to check it out for themselves. So the myths spread anyway. Therefore, I must insist that you forget everything, ABSOLUTELY EVERYTHING, that has been passed on to you about SWR, and trust *me*. Later I'll refer you to books and people who DO know what they're talking about.

"SWR" is an abbreviation for a fancy technical term, *S*tanding *W*ave *R*atio. This is simply a statement of antenna efficiency. Remember anything, even a tree, can be an antenna. But the *more efficient* the antenna, the *lower* the SWR. The other *very important* point to understand is that the SWR number that we read on a meter is derived from a very complex mathematical formula that changes logarithmically, NOT linearly. In plain English, that means, for example, a 3:1 SWR is *not* 3 times as bad as a 1:1 SWR. Or a 2:1 SWR is *not* twice as bad as a 1:1 SWR. (In fact, it is about 90% as good as 1:1.) The only problem with high SWR (over about 3:1) is that its effects on CB communications efficiency are compounded by other factors, which you'll see later.

In very simple terms, SWR is simply the comparison of how much CB transmitter power is getting out into the air, where you want it, to how much is "reflected" back down the coax into the CB, where it doesn't belong. That's why your SWR meter is marked "FOR," meaning "forward power," and "REF," meaning "reflected power." You may occasionally see something about "VSWR," meaning "voltage standing wave ratio." This is *really* what your meter is measuring; i.e., forward and reflected *voltage*.

The term "SWR" is expressed as a number compared to the number 1, such as 3:1, 1.4:1, etc. Often we just drop the "1" at the end, and say simply, the SWR is "3", or "1.4", etc. Theoretically, SWR could go anywhere from 1 to infinity. *Theoretically.* An SWR of 1 would indicate the *most* efficient transfer from CB to air; an infinite SWR, the *worst* case. In real antennas neither extreme actually occurs. And typical low-priced SWR meters are NOT accurate at the low end, so if your meter says 1:1, it's probably more like 1.3:1. *But that difference cannot be detected at the other end.* So it's fruitless to attempt to reduce an SWR of 1.5 even lower.

Now back to this efficiency thing. Here are some common SWR readings and related efficiencies:

1:1 100% efficient. (A perfect antenna. Never really achieved.)
1.5:1 96% efficient.
2:1 89% efficient.
3:1 75% efficient.

I didn't pull these numbers out of a hat; they can be proven mathematically, but you could care less about that! What it means is that, for example, if your CB transmitter puts out 4 watts into a perfect 1:1 antenna, with a 3:1 SWR antenna, you would have 75% of 4 watts, or 3 watts delivered to the antenna. (There will be a tiny bit more loss depending upon the length of the coax cable, which increases *rapidly* with very high SWR, so the total power losses are compounded.)

Now, HERE IS THE CLINCHER THAT NOBODY SEEMS TO UNDERSTAND:

It is IMPOSSIBLE for the human ear to detect the difference at the receiving end of a 4 watt signal vs. a 3 watt signal. In other words, if your buddy was receiving you "9 pounds" with a 1:1 SWR, an SWR of 3:1 might still indicate on his meter as *very close* to the same "9 pounds." In actual situations, other factors enter which can add to the signal loss enough to make a detectable difference.

This sounds hard to believe, and probably goes against everything you've ever heard from your CB pals, but it IS true. To put it another way: An SWR of 3:1 is NOT so terrible after all. (In some microwave installations, where antennas are *really* touchy, engineers are completely satisfied with a 5:1 SWR!) The reason for all this has to do with the way the human ear detects changes in volume or power. It is measured in "decibels," or "Db." You've probably heard all about THAT too by now! You'll understand it shortly.

I promised to demolish your most cherished "myths" about antennas and SWR, so here we go!

Myth #1: An SWR of 3:1 will blow out my radio. I must have a 1:1 SWR.

TOTALLY FALSE, in a well-designed radio. Many CBs have built-in protection against high SWR. In fact, I have *purposely* shorted the coax on a CB with the mike keyed; the "final" transistor didn't even get warm. I've been with truckers where we deliberately left the antenna disconnected, keying the mike with a rubber band while we went inside for coffee. We would come out 20 minutes later, and the rig would still be transmitting fine! This does NOT mean that you can get away with it, and I definitely don't encourage trying it. The specific circuit used and the internal construction of the transistor itself will determine the safety margin before it blows. (In fancy technical terms, many RF power transistors use a construction process called "emitter ballasting" inside them to protect from overheating.) Then again, I have seen "finals" blow right away with bad antennas. The problem with a 3:1 or higher SWR is that the inefficiency of the transmitter is compounded by other factors to be explained later.

Myth #2: Cutting coax will change the SWR.

FALSE, FALSE, TOTALLY FALSE! Get the picture?

There is *NOTHING* you can do at the CB end of the system which will change the SWR *at the antenna*. The problem can ONLY be corrected at the antenna itself. And if you heard somebody claim his SWR changed as he trimmed the coax, that was a *definite indication* of a problem at the antenna end. What actually happened was that due to a faulty antenna, the coax itself had become a part of the overall radiating system, so naturally cutting it affected the entire system. *Only the antenna* should affect the SWR reading.

To go a step further, if you had *two* SWR meters, one at the CB and one at the connection to the antenna, and the coax length was anything other than an odd multiple of a *half-*wavelength (½, 3/2, 5/2, etc.), you would observe two *different* SWR readings. "Now, wait a minute! What was that stuff about odd wavelengths? I thought he just said coax length doesn't matter!" That is correct; the coax length does not matter. BUT at certain specific coax lengths, you will get essentially accurate SWR readings at the *CB end* of the coax, where you might not otherwise.

A "half-wavelength" is the amount of physical space than *any* radio signal occupies during half the time of one "cycle." At CB frequencies, there are 27 *million* "cycles" per second! Without going into mathematical details, all you need to know is that a half-wavelength for your CB radio is about 17 feet long. So an *odd* multiple of this would be 1 × 17', 3 × 17', 5 × 17', etc. In other words, 17, 51, or 85 *feet*.

Now it just happens that the typical mobile CB antenna comes with about 17 feet of coax cable. This of course is a half-wavelength, and is coincidentally just about the right length to reach through the average car or truck from CB radio to antenna. This is a very lucky coincidence for you, because it means that the SWR you measure at the CB will be essentially the same as that at the antenna end. So if you had those two SWR meters, one at each end, they would indicate just about the same SWR.

Let's go one technical step further, then drop the whole subject of coax length. Remember, all we care about is the greatest *antenna efficiency,* and the antenna is our *weakest* link. If you ever delve further into electronics, you will learn that theoretically, when the output "impedance" of a radio transmtter is perfectly matched to the "characteristic impedance" of the coax cable, which in turn is perfectly matched to the "impedance" of the antenna, we will have the *greatest* efficiency, and maximum transfer of radio energy into the air where it belongs. This would give us that perfect SWR reading of 1:1. In other words, a perfect "match."

OK so far? Now, the "impedance" of *all* CB radios is "50 ohms" by design; we can't change that. And our coax cable is also "50 ohms" by design, so we can't change that either. That leaves us with the weakest link, the antenna itself, which could actually be any "impedance" from a few "ohms" to several thousand "ohms." (The factors that determine how many "ohms" an antenna might be are far too complex to explain here.) BUT, you are clever enough now to realize that if your CB antenna *could be* "50 ohms," then BINGO! You have that perfect 1:1 SWR. So once again: a "50 ohm" CB radio, connected to a "50 ohm" coax, connected to a "50 ohm" antenna, and you get that perfect match of 1:1. So what you are actually doing when you slide that antenna tip rod up and down is trying to *make* that antenna become "50 ohms impedance."

Back to that coax length: All you really need to know is that an *odd* multiple of a *half-*length will indicate approximately the same SWR at both ends of your system; i.e., whatever "impedance" exists at the antenna will show up at the CB, where it is transformed electronically into a specific SWR number. (An SWR meter simply compares 2 different "impedances" and displays them as a number.) Problem: If you end up with an odd multiple of a *quarter-wavelength,* such as 8½ feet, 3×8½ feet, 5×8½ feet, etc., you may NOT get an accurate reading at the CB end. Such a coax length inverts the antenna reading. For example, a "25 ohm" antenna might indicate something much *higher* than the "50 ohm" coax and CB, as shown on your SWR meter. And if the antenna were higher than 50 ohms, it would reflect a *lower*-than-50-ohm reading at the CB end where you placed the SWR meter. So that is why cutting coax will NOT really change the actual SWR that exists *at the antenna.* (Refer to Figure 8)

Looking at this coax length/SWR question another way, it simply means that what you see on the old SWR meter is NOT necessarily what you get! So, can you trust what the SWR meter says? The answer is YES, for the following antennas;

1) 102" steel or fiberglass whip, properly mounted and connected on a mobile;
2) a properly installed, *good* loaded mobile antenna at least 40" long, with the usual 17 feet of coax attached;
3) *any* omni-directional base station antenna, properly mounted and installed, regardless of whether it is a ¼ wave (9 feet), ½ wave (17 feet), or ⅝ wave. (22 feet long.) BEAMS of ANY type are NOT included here; they belong to a special category of antennas.

The reason that the above antennas *will* read SWR accurately is that they are already very close to "50 ohm impedance" by their very nature; i.e., they are "resonant". This is a fancy word meaning that their physical length is exactly the right amount for ¼, ½, or ⅝ of a radio wave to "fit" on the antenna.

Beam antennas are NOT "50 ohms" *until you make them* so by properly adjusting them. This usually involves sliding a special "gamma rod" in and out until you get the lowest SWR reading. But you do not have to run out and cut you base station coax to exactly 51 feet, 85 feet, etc., for accurate readings. Just understand that such lengths give the least accurate readings *at the CB end* of the line. Anybody who's been into CB long enough to use a beam should realize that the ONLY proper way to adjust SWR on a beam is with the meter *at the antenna end*. This usually requires 2 or 3 people yelling back and forth between the roof or tower and the CB set while the adjustments are made. And since base station antennas come with the standard coax socket on them, it is very easy to hook up the meter there through a short coax patch cord while watching the readings change.

Enough about SWR theory. So what does it all mean in REAL installations? Well, a high SWR, say 3:1 or greater, will have the following effects:

1) The antenna is inefficient, so you are losing valuable TX power that is *not* getting into the air where it should be;
2) In solid-state (transistorized) CB radios, a high SWR can prevent the "final" transistor from delivering its full rated output power. When transistor output stages "see" a high antenna SWR, they have a sort of built-in self-defense mechanism that lowers transmitter power output. In other words, a CB that will deliver 4 watts into an antenna with an SWR of, for example, 1.5:1 may only put out 2 watts transmitter power into an antenna with an SWR of 3:1. So you are actually compounding the problem of inefficiency, and losing even *more* transmitter power that isn't getting out into the air. Tube-type radios, at least of the 5 watt variety, do not have this peculiar problem; tubes are much tougher than transistors.
3) You also will not be able to trust SWR readings *anywhere* except at the antenna itself, *regardless* of coax length. High SWR can cause coax to start acting very funny, due to all sorts of complex RF voltages and currents flowing through it. This results in EVEN MORE lost transmitter power. (As a matter of fact, in very high-power transmitters of say, several thousand watts, a high SWR will actually cause you to be able to feel "hot spots" every quarter-wavelength along the coax cable. That's when things *really* start smoking!) If all this is starting to sound very complicated, IT IS! You won't learn it in a day.

Just two final notes regarding coax length rules:

1) Dual co-phased mobile antennas using the special RG59/U MUST NOT BE CUT. (There are better ways. Details later.)
2) Magnetic mobile antennas using the usual 17 feet of coax cable operate on a special "ungrounded" principle; do NOT cut the coax of any magnetic antenna.

Myth #3; Dual Antennas are better than a single Antenna. Let's face it people, the antenna companies are getting *twice* as rich, *twice* as fast, selling this idea to the public. Dual antennas are DIFFERENT; they are DEFINITELY not better. They are also much trickier to match up.

It can be proven theoretically that two phased ¼ wave vertical antennas, *spaced ½ wavelength apart*, will show a gain of "3 db." in certain directions and under perfect conditions. Now first of all, "3 db." is *barely noticeable* at the receiving end; the difference between say, "8 pounds" and "9 pounds" on your radio meter. (Actually *less*, since industry standard is normally 6 db. per "S" unit.) And a half-wavelength at CB frequencies, as you now know, is almost 18 feet. I haven't seen many cars or trucks 18 feet wide lately, have you? AND, as the spacing between the antennas decreases, so does the gain. By the time you get to the average car, the gain is down to zero, and all you have is a distorted directional pattern. See Figure 9.

The reason most 18-wheelers and large motor-homes use "duals" is exactly *because* of this distorted, elongated directional pattern. Truckers are only interested in talking to other truckers in front of them and behind them, so duals are good for that purpose. You, however, stick them on your car or pickup and may want to talk to people driving on other roads *parallel* to your road. In that case, those people are in your "null" or weak side, so you will get out to them even *worse* than with a single antenna. And on very small compact cars, we get just the *opposite* effect: stronger signal sideways, weaker signal up and down the road! So to sum it all up, forget about co-phased duals unless you're a trucker.

A FEW MORE ANTENNA BASICS

The physical location of mobile CB antennas on the vehicle is the prime factor in determining SWR and directional characteristics. Referring to Figure 9, you can see that the strongest signal goes in the direction of the greatest mass of metal on the vehicle. However, for all practical purposes, a good single antenna properly installed and matched anywhere on the vehicle will get out well enough in all directions.

Exception to Mounting Location Rule:

A 102" whip mounted on the *bumper* of a van. Don't do it! It will be impossible to achieve a low SWR, because about 4 feet of that 9 foot whip is right next to the metal van body. This will seriously detune the antenna, resulting in extremely poor efficiency and possible damage to the radio from high SWR. And that tennis ball won't do a thing for you either. See Figure 10.

To use a 102" steel or fiberglass whip on a van, you must either mount it in the center of the roof (a real monstrosity) or way up high on one side near the roof. This will require a swivel ball mount, which in turn will require one giant 1½" center hole plus the 3 mounting bolt holes, and all on a single wall section of the van body. If you're not prepared to drill all those holes in a fancy customized van, forget the 102" whip and use a different antenna. I suggest on a van using something like the Antenna Specialists "Big Momma" base-loaded whip, the M-510, or the American Antenna K-40. Roof mounted, they're tops for vans!

BASE ANTENNA EFFICIENCIES

Refer back to Figure 9. This shows the basic differences in efficiencies between ¼, ½, and ⅝ wave-length base antennas of the omni-directional type. You will notice that the difference is in what is termed the "angle of radiation." The lower the angle, the greater the range and efficiency. What you want from such a base antenna is the *lowest* possible angle between the earth and the main concentration of radio energy, called the "lobe." When this lobe is lower to the ground, the signal travels much farther because it sees a farther horizon. Therefore, a ¼-wave base antenna is nowhere near as efficient as a ⅝-wave antenna, which is the ideal non-beam type base station antenna. But be VERY cautious about manufacturers' claims of "db. gain" figures. More on that later.

MOBILE ANTENNA EFFICIENCIES

Basic mobile CB antennas include the following general groups:

1) Full length ¼-wave steel or fiberglass 102" whips;
2) Electronically shortened: base or center-loaded (standard or oversize coil), and continuously or top-loaded fiberglass whips;
3) Specialized antennas: magnetics, gutter clips, AM/FM/CB "disguise" types (and their motorized, disappearing versions), AM/FM/CB couplers for use with existing car antennas, and the Intenna.

All mobile and almost all base antennas are designed on the half-wavelength or "dipole" principle. The antenna proper is ¼ wave, and the metal vehicle body (or radials on a base) form the other ¼ wave, better known as the "ground plane." So, ¼ plus ¼ equals ½. Simple addition.

Note: When discussing mobile antenna efficiency, we will be emphasizing *transmitting* range, since this is the most critical factor. Naturally, antennas affect receiver performance also, *but not nearly as much.* This is something most CBers just don't understand. Modern CB receivers are so incredibly sensitive that you will almost always be able to *hear* farther than you can *transmit.* (Unless you're using an illegal linear amplifier.) You could use practically anything from a wet noodle on up for receiving, but *transmitting* antennas are very critical. This is one reason it's ridiculous to waste money on so-called "receiver pre-amps" that boost receiver sensitivity even more. What good will it do to hear even MORE noise and weak stations? THEY will never hear YOU.

In *decreasing* order of efficiency and range, here's how mobile antennas perform:

1) **102" Whip.** The best. The greatest range. The most expensive. The most obnoxious-looking. No difference between steel or fiberglass except price. Remember when choosing one of these, the steel whip will be flexible enough to bend over and hold down with a gutter clip. It also flops around a lot more at freeway speeds. On the other hand, fiberglass will ride stiffer and remain more vertical, but trying to hold one down with a gutter clip will probably split the fiberglass; you'll have to leave it up all the time.

While we're on the subject, have you ever noticed that fiberglass whips are *shorter* than steel whips? They're 96", to be exact. Reason: The fiberglass whip is essentially a copper wire embedded in fiberglass; in other words, a "copper whip." Your CB radio is generating radio waves at the rate of 27 *million* times per second. But even at this incredible speed, it still takes a definite amount of time for the radio wave to travel from one end of the whip to the other end. Since copper is a much better conductor of electricity than steel, the same wave shoots through the copper much faster. So in other words, the fiberglass-copper whip doesn't have to be as long for ¼ wave of the CB signal to "fit" on the whip. Technically, this is called "propagation delay." But both types perform equally well.

Important: You do not have to match a full-size whip of this type. You just mount it and forget it. The SWR will always be under 1.5:1, unless you put it on the bumper of a van or possibly the bumper of a large station wagon. If the SWR is *much* higher than this, you have either mounted the swivel ball *directly* to the vehicle body (a dead short), or you have a shock spring that is broken or corroded internally. *TO REPEAT:* There is *no* tuning or matching of the full-size whip. It is totally foolproof when installed and maintained properly.

2) Base, Center, & Top-Loaded Antennas

None of these are as efficient as the full-size whip, but a well-designed one represents a reasonable compromise between efficiency, cost, and looks. Those mysterious loading coils, regardless of what section of the antenna they are on, are necessary to make the antenna work right. They are there to electrically fool the CB radio and coax into thinking it "sees" a *real* ¼-wave whip. Therefore, the quality, precision, and consistency with which those coils are made will determine how much transmitter power is wasted in the coil, and thus how far you will get out. As we will see shortly, the overall length of the rod itself will also affect the range. Never forget one basic principle of mobile CB antennas: You get what you pay for!

Everybody knows you don't get something for nothing. By using any antenna that is electronically shortened or "loaded," what you get in reduced space and cost you *lose* in transmitting range. That loading coil radiates almost *none* of the CB radio energy. For all practical purposes, the only part that radiates the signal is the *straight* part. Therefore, the longer the overall length moves towards our ideal 102", the better it gets out. In other words, a 3' loaded antenna is not as good as a 6' loaded antenna. (But not necessarily half as good.) Deciding what type to use depends upon why you use CB radio; a fanatical "rachet-jaw" and "skip talker" will want the greatest possible range regardless of how big the antenna, while the person who only uses CB for road information and emergencies will find that a properly-working 3' antenna will perform just fine.

A Brief But Necessary Technical Word About Loaded Antennas

Whenever an antenna emits a radio signal, that antenna contains a combination of "radio frequency" ("RF") voltage and current at every point on the antenna. There are points of high and low RF voltage, and points of high and low RF current. These points never occur at the same physical place: where voltage is maximum, current is minimum, and vice-versa. Generally, the area of high RF *current* is where the strongest signal radiates. This high RF current point on a loaded antenna is at the loading coil. In other words, with a base-loaded whip, the strongest signal comes from the base; with center-loading, it comes from the center, etc.

If you were to mount two identical loaded antennas such as a base-loaded and a center-loaded at the same spot on your car (trunk lid, etc.) and these two antennas were otherwise exactly the same overall length, the center-loaded antenna would radiate its signal AT A HIGHER ELEVATION than the base-loaded one. In other words, it would see a farther horizon and greater range, just as you would see farther from the top of an office building than from the ground floor. Therefore, *all other factors being equal,* the center or top-loaded would give greater range than the base-loaded antenna.

But here's the catch: For complex technical reasons, base-loaded CB mobile antennas cannot be made shorter than about 40" overall length. (Coil, whip, and spring.) But *center*-loaded antennas can be made very short, as short as about 18" at CB frequencies. Such antennas are GROSSLY inefficient, impossible to match on more than a few consecutive channels at a time, and will probably get out about as far as your next-door neighbor in populated areas. DON'T BUY THEM, EVER. They don't work. They may even damage the "final" from high SWR. Included in this category are some real junky center-loaded magnetic types, about 2 feet long and usually of the off-brand discount-store variety. In fact, these magnetics are even *worse;* they don't even have a metal-to-metal contact with the vehicle body, which probably doubles their inefficiency.

As a general rule, an efficient CB antenna should be at least 40" long. Most standard trunk lid mount antennas fall into this category. A really top-notch center-loaded antenna is the Hustler HQ-27, which is 55" long, has standard ⅜" × 24 threads, and comes in a variety of mounts. Base-loaded antennas run around 40" in 23-channel versions, and about 3" longer in 40-channel types. And fiberglass rods of the ⅜" × 24 thread type can be bought in 3, 4, 5, or 6 foot lengths.

One final word on loading coils: You've probably seen CB antennas with really big coils on them, often called "beer-cans," because that's just about how wide they are. These oversize coil types are even *more* efficient than the standard antennas, due to lower power losses in the coils. They're also more expensive. Typical good ones are the Antenna Specialists (A/S) "Big Mommas." The M-510 is a base load for trunk or roof, and the MR-415 is the centerload version. Also excellent is the K-40.

Warning: Certain fiberglass sticks claim to be ⅝-wave, ¾-wave, etc. Such claims are ridiculous and NOT to be believed. There is NO WAY you can load a 4' or 6' stick to the equivalent of 22' (⅝ wave) with any efficiency that promises to have more "gain" than an ordinary 4' or 6' ¼-wave mobile antenna. And ¾-wave is *exactly* the same as ¼-wave: just an odd multiple with a bigger-sounding number!

If anybody makes such a claim, he's lying through his teeth. One of my distributors recently showed me a phony fiberglass whip of this type which actually had a *fake* loading coil on it to make it appear special. To look at it from the outside you would see the thick fiberglass rod, covered with the usual heavy vinyl, and the outline of the "coils" underneath. After cutting off the vinyl covering, we discovered that the "coils" were just a wrap of wire that WERE NOT EVEN CONNECTED TO ANYTHING! Just keep in mind that *everybody* is trying to cash in on the CB craze, and the crooks don't care how they do it. (If *I* really wanted to be dishonest and take advantage of you, I could take some ordinary fuses, re-package them and call them "power fuses," and sell them like hot cakes! So don't let these guys make out AT YOUR EXPENSE.) If you insist on name brands in the antenna department, such as A/S, Turner, Hustler, K-40, etc., you'll never go wrong.

There is one good exception to the greater-than-¼-wave rule: The Antenna Specialists MR-306, which is a super, no-ground-plane antenna for any *non*-metallic installation, such as fiberglass motor homes, snowmobiles, bicycles and motorcycles, and especially you Corvette owners. It also makes a very good base station antenna for small spaces, apartments, etc. I sell them to boat owners around here because they are fiberglass construction, but cheaper than a marine-type CB antenna. The MR-306 is a no-ground-plane antenna because it is a ½-wavelength but is still only about 40" overall length. This is accomplished basically by using a loaded ¼-wave stick AND a base loading coil to create the effect of the other ¼ wavelength. Also very good, and operating on the same principle, are the HyGain 488 and Shakespeare 4050 "Little Giant." Of course these antennas are not nearly as effective as a true 18 foot long ½-wave antenna, but they work quite well in limited spaces or where metal ground planes are not available.

This brings up another very important point: Do NOT attempt to use any other mobile antenna as a *base* station antenna. Unless you're prepared to mount it on a 9 foot sheet of metal to form the necessary ground plane, it will NOT match up, and may damage the CB from very high SWR.

Summary of rules for loaded mobile antennas:

1) Never buy any type mobile antenna shorter than about 40" total length;
2) With fiberglass whips, insist on the "tuneable tip" variety, such as the Turner FG46T. Remember, each installation and each vehicle is slightly different. Regardless of what the manufacturer claims, I have yet to see any "pre-tuned" fiberglass loaded stick that would match lower than a 2:1 SWR. Once it's installed, you're stuck with whatever SWR results. So always use a loaded antenna that has some *physical* means of adjusting it.

3) Specialized Antennas

Because of the enormous CB radio (and antenna) theft problem, many people want to hide that CB antenna with the big sign on it that says, "Steal Me!" A dead giveaway that there is a mobile CB somewhere nearby. Even if you spin off the typical base-loaded type, a sharp-eyed thief will still see the trunk lid mount left on the car. There are several good mounts of the flip-flop type that let you completely hide the whole antenna in the trunk. These are fine to use. Nowadays we're also seeing a lot more of the removeable magnetics, gutter clips, AM/FM/CB "disguise" antennas (and couplers), and the clever new "Intenna" (a new application of an old idea.) All these types compromise some efficiency and range, but the better ones work surprisingly well.

A) Magnetics:

The name brands over 40" or more work very well. Some will even stick on at over 100 MPH, and are often used by the "Smokies." These are all base-loaded. There are also a few junk brands which are center-loaded and about 2 feet long. These DO NOT work. I recommend the A/S M511, MT178, Turner SK900, SK910, HyGain 822, or K-40 Magna-mount. The 40-channel versions of all these are "broad-banded" and besides covering all 40 channels with very low SWR, they can usually be moved around anywhere on the roof or trunk lid with very little change in SWR. Remember though, since no magnetic antenna has a direct metal-to-metal contact with the vehicle to form the ground plane, they will be less efficient than the same size version of the trunk lid, gutter clip, or mirror mount. In technical terms, they are only "capacitively-coupled" to the vehicle body. However this disadvantage is often balanced by the fact that they can be placed right in the middle of the roof, giving higher elevation and a good omni-directional signal pattern. Other disadvantages: Having to bring the coax in through the window or door is unsightly, may cut or mash it, and being ungrounded, is sometimes more prone to ignition noise pickup.

Note: This antenna is one of those special cases where you cannot cut the coax.

B) Gutter Clips:

These generally work very well, if you stick to the 40" minimum rule and MAKE SURE there is a good metal ground. A very good antenna of this type is the A/S MS-131. There are a few of the 18" center-loaded types around; do NOT waste money on these. They NEVER work, regardless of brand.

Make sure when installing a gutter clip antenna that you scrape a bit of paint from the inside of the gutter to insure a good ground connection. The spring-clip types usually have tiny sharp points that dig into the gutter paint, but often this isn't enough. A very good installation, such as on a VW van with a plastic bubble top, is to use a permanent gutter mount that is held down by two separate metal plates that clamp together with screws, such as the Hustler GCM-1. This has standard ⅜" × 24 threads for any type antenna. I generally install a Hustler HQ-27 center-load on this mount; it uses ⅜" × 24 threads. You can also if you wish install a quick-disconnect such as the Van Ordt AQD-1040 between mount and antenna. (The quick-disconnect is a special 2-piece job having ⅜" × 24 threads at both ends and a spring-loaded bayonet lock; you just push down and twist slightly to remove. An excellent idea for any type installation.) Remember when using a gutter mount, the antenna will be slightly directional towards the opposite side of the vehicle. And since the coax must enter through a door or window, be VERY careful not to mash or cut it.

C) AM/FM/CB Disguise Antennas:
These are getting very popular. Typical good ones are the A/S MS-264 and the Antenna Inc. #11004. You *must* have an SWR meter for proper adjustment; claims that they are "factory pre-tuned" are not accurate enough for proper operation. Just remember that since the loading coil for the special coupler of these antennas is located *inside* the car, you won't even get the benefit of the small amount of signal radiation from the coil; the car body will shield it from getting outside. So once again, only the length of the straight part, the rod itself, will determine range and efficiency.

If you already have a car with a rod-type AM/FM antenna (*not* the windshield type), you can save about $15 by just buying the special AM/FM/CB coupler itself. And you save having to drill another hole. Good couplers to use are the A/S MR-133 or the Hustler ZM-60-R. If your regular antenna is a fixed length, just install the coupler according to directions and use an SWR meter for proper matching. If you have the telescoping type car antenna, you'll have to make a choice: Extending the whip to its maximum length will get out best, but you many not like the looks or trying to park in low garages, etc. Once you match it, *it must stay that length* without re-matching. You will either have to match it at a shorter length, be satisfied with less performance, and find a way to mark the exact spot (tape, paint, filing a notch) in case you want to raise it again sometime, or match it at the full length and drive around that way until you must lower it for garages. A fully-extended telescoping car antenna using these couplers will work just about the same as the disguise type. NOTE: Never cut any of the special cables that come with these antennas or couplers.

Motorized Versions of the Above:
These are very expensive and generally work just about the same as the ordinary combo types because they still use the same AM/FM/CB coupling device in the car. There are a few motorized types that use a center-loading coil and are designed for CB use only. Since the coil is outside the car, there will be a slight improvement, range-wise, over the others.

Any telescoping antenna, motorized or otherwise, must rely on *pressure* between sections to make the electrical connections. In salt-air environments, or anywhere with extremes of weather, corrosion between sections will eventually get to it and lower efficiency. This also applies to *any* CB antenna with a lot of mechanical connections between spring, whip adapter, coil, swivel ball, etc. Any of these connections can be an eventual trouble spot after the weather works on it.

To summarize these special antennas, any of them *when properly installed and matched* will work satisfactorily for the average guy who wants to hide the fact that he has a CB radio. Just be realistic and don't expect 20 mile contacts in crowded cities!

MOBILE ANTENNA GIMMICKS—SAVE YOUR MONEY.

There's an incredible amount of junk on the CB market today. Everybody wants to make a fast buck off your ignorance of the *true* facts. Well-established name brand companies rarely resort to this, although even they are guilty of stretching the truth just a little. (See section on "Db.")

There are gadgets on the market which promise the user outrageous power gains. These take the form of clamp-on loops, wing-shaped antennas, etc. They will do NOTHING for you except make your wallet a bit thinner.

I have challenged several of the manufacturers and distributors of these gimmicks to provide me with detailed technical proof of their claims. This would consist of "field intensity" measurements made under identical conditions with and without the accessory. So far they have ignored all my letters. I wonder why . . .

Technically all these loops and wings create what is called a "capacity hat." This has the effect of electrically shortening the antenna, so that a short loaded antenna will have about the same efficiency as a *slightly* longer one. In other words, *maybe* a 3' whip with a "loop" on it will work exactly the same as a 4' or 5' whip alone. BIG DEAL. The 4' or 5' whip would be cheaper to start with.

Another interesting money-waster is a little light bulb that attaches to the tip of your antenna (the high "RF voltage" point) and promises to glow when you key up. Sure it lights up, but if you know anything about the laws of physics, you'll realize that the energy it takes to light up that bulb is being drained from your radiated CB signal, leaving you *less energy* to get into the air where you really need it. At only 4 watts, you need all the help you can get; you DON'T need power wasters.

BASE STATION ANTENNAS and THE MYSTERIOUS "Db."

Base antennas are covered in great detail in many excellent books, such as those listed in the references. No need to repeat what other good authors have already said, except as relates to efficiency and repairs.

Generally, base station CB antennas are totally foolproof when assembled carefully according to instructions. That's because they are physically large enough to be the correct electrical wavelength without the use of energy-wasting loading coils. However, there are several omni-directional base antennas that use loading coils *in the radials* to shorten them, even though the vertical radiator is the right length. They are *still* cheating; any coil-shortened radials will reduce efficiency almost as badly as a shortened radiator itself. In this case, the inefficiency is in the *ground plane* section, which is just as necessary for proper operation as the vertical part! Avoid using these types. The best omni-directional antenna is the "5/8-wave" type with full-size radials, such as the A/S M-400 "STARDUSTER." Refer back to Figure 9 for efficiencies of different base antennas.

It is very easy to find out if an omni-directional base antenna is working properly without even using an SWR meter. After installing, simply touch the red and black test probes of your ohmmeter (R×1 scale) across the coax connector at the CB end. It should show a DC "open," i.e., no reading at all. AND you should hear a BIG increase in noise level the minute you plug it into the CB. The only factors which would worsen the SWR are bad or corroded coax connections, guy wires touching the radials, guy wires which turn out to be "resonant" at CB frequencies (all guy wires should be broken up into 6 or 12 foot lengths with porcelain insulators), or the antenna being very close to other metal objects such as TV antennas, power lines, etc.

> EXCEPTION TO DC "OPEN" RULE: The Shakespeare Big Stick II and several marine type antennas will show a DC "short" (zero ohms) between center pin and outer shell of the coax connector. These antennas use a special matching "stub," a short piece of coax connected across the main coax cable.

Beam antennas are another story entirely. They use an adjustable "gamma" rod or something similar to match SWR.

One VERY important idea left to explain regarding beam antennas, power mikes, and other accessories is the use of the term "Db." or "decibel." Almost as mis-understood as SWR! It all has to do with how the human ear detects changes in volume or power levels. It is mathematically complex, so all you need to do is study the following chart:

Db. Gain	Power Factor to Multiply By	
0 Db.	TIMES	1.0
1 Db.	TIMES	1.2
2 Db.	TIMES	1.6
3 Db.	TIMES	2.0
(point where most people *just* notice a difference		
4 Db.	TIMES	2.5
5 Db.	TIMES	3.0
6 Db.	TIMES	4.0
7 Db.	TIMES	5.0
8 Db.	TIMES	6.3
9 Db.	TIMES	8.0
10 Db.	TIMES	10.0
11 Db.	TIMES	12.6
12 Db.	TIMES	15.8
13 Db.	TIMES	20.0
14 Db.	TIMES	25.1
15 Db.	TIMES	31.6
16 Db.	TIMES	40.0
17 Db.	TIMES	50.2
18 Db.	TIMES	63.2
19 Db.	TIMES	80.0
20 Db.	TIMES	100.4

As an example, a "3 Db." gain is the same as a doubling (times 2.0) of your *effective* power at the receiving end. This is about the minimum difference the average person can definitely notice. To put it another way, a 4 watt CB transmitter using an antenna with 3 Db. gain (power times 2) would sound the same at the receiving end as an 8 watt CB using a "zero gain" antenna.

Now, here's the catch:
This effect is true *regardless* of the original power that you doubled, tripled, etc. Doubling your transmitter power from 4 watts to 8 watts would produce a 3 Db. gain at the other end. Doubling your power from one MILLION watts to two MILLION watts would STILL only produce a 3 Db. gain! "But how can that be?", you think; you have added an extra one MILLION watts! Sorry, but that's the way our ears work.

AND THAT'S EXACTLY WHY HAM OPERATORS AND OTHER KNOWLEDGEABLE PEOPLE HAVE KNOWN FOR YEARS THAT HIGH-GAIN BEAM ANTENNAS AND SPEECH PROCESSORS WILL ALWAYS GET OUT *BETTER* THAN THE TYPICAL LINEAR AMPLIFIER. And, the effective power resulting from *these* accessories is completely legal and will get you more watts per dollar in terms of communicating long distances. And maybe even help keep peace with your neighbors.

This discussion of "Db." as relates to antennas is presented to you for only one reason:

Be VERY careful when reading advertising claims of beams offering "so many Db." gain, etc. These claims are absolutely meaningless unless the manufacturer specifies exactly *what* they are referencing their antenna *to*.

There are two industry comparison standards used by antenna designers:

1) The "isotropic" radiator;
2) The "reference" dipole.

Now an "isotropic radiator" is a fancy name for a theoretically perfect antenna which does *not* exist; its only usefulness is for engineers to simplify certain mathematical antenna calculations. On the other hand, a "reference dipole" is a real antenna that DOES exist, but even it is designed, built, and located under ideal conditions on a special antenna test range.

THERE IS A DIFFERENCE OF 2.15 Db. IN FAVOR OF THE ISOTROPIC RADIATOR. In other words, a beam antenna or an omni-directional antenna which advertises a gain of, for example, "7 Db. over isotropic" has a REAL gain of only 7 *minus* 2.15, or 4.85 Db. gain over a reference dipole. And even *this* figure is under ideal mounting conditions that rarely exist in actual CB installations. Which means probably even slightly *less* real gain in your particular installation.

The whole point is that antenna ads in CB magazines almost always use the *higher*, "isotropic" gain figure without bothering to tell you all this. They figure you are dumb enough to be impressed by the *bigger* numbers. DON'T BE! (Antenna ads in ham magazines always specify their source of reference; they know they can't fool hams with phony figures.)

Well you learned how to repair mikes right away, but we haven't said a thing about repairing antennas yet; just a lot of theory. The reason antennas are getting so much attention in this book is because they are the *least* understood part of the entire CB world, and the part about which the most misinformation still exists. That's because VERY few people really know anything about antennas.

I designed and built my first ham beam antenna when I was 12 years old. In those days, I was able to communicate *all over the world* with my homebrew, 50 watt transmitter, and getting "10 pound" reports too! I tell you all this not so much to impress you, but to make you aware that some of us know what we're talking about, and some of us are just in this business to make a quick buck off the typical CBer's ignorance of the true facts. I've been explaining antennas in great detail so that you would get an idea of what you'll be up against in trying to repair them. And in getting other people to pay YOU for that knowledge. If you have absorbed most of what was discussed so far, you are light-years ahead of all your CB buddies, and well on your way to becoming a true CB expert. You're getting twenty years of hard experience boiled down and served up to you on a silver platter. So let's get down to the nitty-gritty!

ANTENNA MATCHING BASICS

It is extremely important to realize that when you match an antenna, what you are actually matching, in effect, is the antenna to the *specific vehicle and location* on that vehicle, NOT to the radio. Remember, all CB radios and coax cables are "50 ohm impedance" by design and cannot be changed; all you're doing is attempting to make the actual antenna "look like" the same impedance to the other links in the signal chain. I am often asked, "If I replace my Brand X CB radio with a Brand Y, must I rematch for lowest SWR?" The answer of course, is NO. Assuming nothing else has changed, the SWR will appear exactly the same between any brands of radios.

ANTENNA "MATCHERS" OR "MATCHBOXES"

There are several antenna "matchers" on the market, and you must know exactly what these devices can and cannot do before you decide whether or not to buy one. Refer to Figure 11. This shows the proper *placement* of the matcher within the overall transmitting system. (On a base, you may also be using an optional low-pass TVI filter, shown by dotted lines.)

You MUST install the SWR meter, (filter), and matcher in the order shown, or you will get false SWR readings. If the CB has a built-in SWR meter, install all the other accessories in the order shown. If you accidentally reverse the matcher and SWR meter, you will never get correct readings. Just remember that the SWR meter is always the *first* accessory attached to the CB antenna socket. It then shows the total effect of all the other accessories in the coax line.

OK, you have a matchbox. Just what does it do? Very simply stated: If the antenna SWR is unusually high, say 3:1, the effect of the reflected radio transmitter energy will confuse the output stage of the CB. It will not see the 50 ohm impedance it *must have* to transfer all its energy to the coax, which in turn transfers the energy to the antenna and out into the air where you want it. (Those 3 links in the chain again!) Since you already know from studying MYTH #2, in many solid-state CB transmitters the final output stage will be unable to deliver its maximum rated output power into a bad antenna. The ONLY thing a matcher of any type does is to help make sure that the maximum transmitter power is at least transferred to the *coax;* what happens at the actual antenna is an entirely different story. This brings up again one of the MOST IMPORTANT FACTS YOU MUST UNDERSTAND ABOUT ANTENNAS:

> There is NOTHING, absolutely NOTHING, that you can do at the *CB end* of the system to lower the SWR at the *antenna* end. In fact, if you had two SWR meters, one at the CB and one at the antenna (and the coax was the proper odd multiple of a half-wavelength so that *its* effect was minimum), the SWR at the antenna would STILL be high, even though the matcher showed that you lowered it by adjusting its controls. You have only managed to fool the CB into thinking SWR is now low; a bad antenna will still have a bad SWR. The only way to lower high *antenna* SWR is to properly adjust the whip, the "gamma rod" on a base station beam, repair bad coax or ground connections, etc.

Also remember that a properly-installed omni-directional base antenna or a 102" whip does NOT have to be matched at all; it is the correct electrical wavelength to begin with.

In deciding to use a matcher or any other in-line accessories like TVI filters, switches, etc., you must consider one final factor called "insertion loss." Remember you never get something for nothing, electronics included. Insertion loss is measured in Db. (That word again!) In good matchers the loss is only a fraction of a Db., which is not enough to worry about. But with all the junk on the CB market, you could end up *losing* more of your precious 4 watts by inserting a matcher than you would gain in antenna efficiency. For example, if the SWR was 2:1 (89% efficient), using a matcher to lower it to 1:1 would be a complete waste of money; anything gained by the lower SWR would be *lost* by inserting the crummy thing in the coax line. And the guy at the receiving end would never notice the difference. So as a general rule, I recommend the following:

1) Don't bother with a matchbox for an SWR of less than 3:1. Nobody will ever hear the difference.
2) Use a matcher only *as a last resort,* such as a base antenna where the matching adjustments are too hard to reach, or in a mobile when nothing else we'll describe works, or you can't relocate or buy another antenna. A high SWR indicates an *antenna* problem; that's where to look for solutions.

HOW TO MATCH MOBILE ANTENNAS

Basic matching of mobile CB antennas involves sliding the whip rod up and down while observing the SWR meter, until you get the lowest SWR that is approximately the same at both ends of the band. (Channels 1 and 40.) This is indicated by the lowest reading on the "REF" switch position on most SWR meters, *after* you have set it to the full-scale "Set" or "Cal" mark in the "FOR" position.

All you need to do is switch back and forth between the end channels and observe the difference. Here are the basic rules of the game:

1) If the SWR is *higher* on channel 40 than on channel 1, the rod needs to be *shortened.* If the reverse is true, the rod needs *lengthening.* If you use the recommended 40" minimum length antenna, start with the rod dropped all the way down into its holder; i.e., the shortest length. In about 75% of all good antennas this will either be very close to the SWR minimum, or you will need to shorten it even more by cutting.
2) If after dropping the rod all the way down into its holder, the SWR still indicates higher on Channel 40 than on Channel 1, the rod must be even *shorter.* On a typical trunk lid mount, this will be the case a good 50% of the time. Cut off ½" at a time for steel rods, and ¼" at a time for graphite or fiberglass rods of the *base*-loaded type. I usually use a vise and hacksaw on steel rods, and file the burrs off the cut end.
Caution: NEVER cut the metal *bottom* piece (coil end) of a graphite or fiberglass whip. You will permanently break the electrical connection and it cannot be repaired. On these rods you want to do your cutting at the *top* end. Just remove the little plastic or rubber tip from the top and use a large diagonal cutter to snip off ¼" at a time. The fiberglass will start to split, but don't worry about it. When you get the SWR where you want it, just carefully file a small taper on the end and replace the tip, making sure all the split fiberglass hairs fit into the tip. Remember, this antenna is nothing more than a piece of copper wire embedded in fiberglass or graphite for support.
3) If lengthening is indicated (higher SWR on Ch. 1 than 40), just start sliding the rod out longer until you equalize SWR at both channel ends of the CB band.
4) In some very rare cases of cheap antennas or unusual mounting locations, the SWR meter may indicate lengthening *more* than the rod will physically slide out. In such cases you'll either have to settle for whatever SWR you get, or else try to buy a rod a couple inches longer and start experimenting. Better yet, buy a good A/S, Hustler, Turner or K-40, and you'll never have this problem.
5) If you are using a continuous or top-loaded fiberglass stick of the ⅜" × 24 thread variety *without* a tuneable tip (the type you were warned NOT to get), you may be able to adjust it, but ONLY in the case where *shortening* is indicated. (Channel 40 higher than Ch. 1) This is *very* touchy. Remove the plastic tip, and if necessary, cut away a bit of the vinyl outer covering until you can see the copper wire. Then, *very carefully* start pulling out and snipping off ¼" of the wire at a time until SWR is the same at both channel ends, and replace the tip. If lengthening is indicated, forget it. You can't do it. That's why you should always insist on the type that has an actual tuning tip.

Exactly what do we mean by equalizing SWR at both ends of the CB band? Generally, anything under 2:1 is acceptable. On the junk types, you may never get it lower than 3:1 on *any* channel. If after all your matching attempts, you end up with, for example, 2.5 on Channel 1, and 1.3 on Channel 40, which indicates lengthening but the rod is already all the way out, leave it alone! Remember from our discussion of power and Db. that the guy at the other end will never hear the difference.

PROBLEMS TRYING TO MATCH MOBILE ANTENNAS

If none of the above techniques will lower the SWR to a reasonable value (under 2.5:1), you have some other problem in the antenna system. Before digging deeper into how to repair such problems, I'm going to throw in a few "cheap and dirty" tricks to get *rough* SWR readings without even using an SWR meter. For these tricks you MUST have a dummy load such as described in the introduction. A "dummy load" is nothing more than a resistor that looks to the transmitter like that mystical "50 ohm impedance", but simply absorbs the transmitter energy without radiating it into the air. This is absolutely the handiest and most necessary accessory you will ever be using for CB repair work. And all for about $3 at any CB/electronics store. There are two different types of dummy loads:

1) SPONGE TYPE—looks like an ordinary coax connector with a small colored plastic lump on the end;
2) COMBINATION DUMMY LOAD/MODULATION LIGHT—This is a coax connector with a special light bulb soldered to it. **REALLY** handy for peaking transmitters and checking **mike** problems. The more

transmitter power output, the brighter the bulb lights. In addition, it shows modulation, because it gets *brighter* when you talk into the mike.

Caution: Do NOT use the light bulb type on sideband; the higher power of sideband will probably burn it out. Use it only in the "AM" mode. Best to have at least one of each type of dummy load.

To use these tricks, you must understand how the S/RF metering circuits of a CB radio work. That S/RF meter simply picks off a small sample of the received or transmitted signal and makes the meter move over. How far over that meter deflects is purely *relative;* it doesn't have to go into the "red zone" on transmit. There are internal adjustments inside every CB that will make the meter read *anything* you want it to, from zero to pegged hard at the far end. This is true for both receive and transmit, AM and SSB. You can make good use of this fact to peak out the TX or RX, as we'll show later.

OK, let's now see the effect of a very high SWR on the meter circuit. Remember, SWR is simply a way to compare transmitter power flowing *out* of the CB to the power flowing or reflected *back into* the radio. Well, the ordinary S/RF meter on a typical CB set cannot tell *which power is which,* so it simply takes both those forward and reflected RF voltages, adds them together, and displays them as either the *sum* or *difference* of both factors. (Most CBs show the sum.) On the other hand, an SWR meter IS a specially-designed electronic circuit that CAN tell the difference between "coming" and "going" as it were.

Now for the trick:

1) Hook up a dummy load of either type and key the TX. The average CB meter will deflect about ⅔ to ¾ of full scale with normal TX power output. Therefore, seeing what the CB reads with a dummy load establishes a *reference* reading for your particular radio. A perfectly matched antenna would deflect the meter almost exactly as much as the dummy load.
2) Disconnect the dummy load and with *nothing* connected to the CB, key the mike *briefly* for a second or two. This will NOT damage the radio. Watch that meter; it will do one of two possible things:
   a) It will peg very hard at full scale. (This is most typical.)
   b) It will *barely* move the meter at all; i.e., 2 or 3 "pounds."

In technical terms, you have keyed into an "infinite VSWR" by disconnecting the antenna or dummy load. Under such conditions, forward and reflected voltages are equal, so the meter adds these components together electronically and shows the result as a sum or difference. You would also get the *same* meter effect by keying the TX into an antenna with a dead short, i.e., center and shield of coax shorted together.

THEREFORE, since you have established a reference meter reading by keying into a perfect dummy load antenna, you will get an *approximate* idea of SWR by seeing how much the S/RF meter varies from the reference when you connect up the actual antenna. If after connecting a new antenna, the meter either pegs very hard or barely moves, there is a very good chance you have either an open or shorted antenna. You'll soon learn how to confirm this problem with an ohmmeter.

If you happen to own a Royce, (some) Johnsons, or a few other brands which use a backlighted red TX meter light, you have another very handy SWR indicator. After establishing normal red brightness with a dummy load, you'll find that a very high SWR will make that red light even *brighter.* We'll skip the technical explanation on that one!

The ohmmeter and modulation light/dummy load are usually the only instruments I need in 95% of basic transmitter, mike, and antenna tests, even though I have thousands of dollars worth of precision test equipment. Once you get very familiar with how each of these devices works, a little experience will give you a sixth sense of what the problem is and how to track it down. But always remember: *Faulty* test equipment will give faulty readings. You can easily verify the ohmmeter is working by touching the leads together on any resistance range. And you can also check for a suspect burned out dummy light by touching the ohmmeter leads across the center pin and outer shell of its connector, looking for continuity.

Now we're ready to start tackling the trickiest CB repair problems, ANTENNAS.

I. PROBLEM: SWR is *around* 3:1 and nothing seems to change it. Very little or no difference in readings between Ch. 1 and Ch. 40.

Most Likely Causes:

1) Cheap, off-brand base, center, or top-loaded antenna, even if it meets the 40" minimum rule. That little coil is extremely CRITICAL. Due to poor quality control in manufacturing or poor design, it is quite possible that the antenna is actually tuned far out of the 27 MHz. CB band, or adjusted inside the coil to something other than the required "50 ohm impedance." Some of the junk on the market actually uses conductive *plastic* in their loading coils. By using any of the excellent major brands mentioned, this will never happen; you will always see a definite difference in SWR between end channels and can adjust the rod accordingly, even if both ends seem high to start with. REPEAT: Do NOT look for bargains in the antenna department. And if you're trying to repair one for a customer, he may end up having to buy another antenna.
2) Poor ground connection. Make sure those little Allen wrench set screws on a trunk lid mount break the paint. On gutter mounts, the mount usually has

sharp pointed corners to dig into the gutter paint when tightened, but often do not. You should always scrape a bit of paint off the inside of the gutter first.

3) Poor, corroded, or broken center coax wire on the center pin of a standard base-load mount. An awful lot of people assemble these wrong. Sometimes they just leave the bare copper center wire sticking straight up from the center pin. The wire MUST fold over into the tiny groove of the center pin. Ideally on a new installation, you should then solder the wire and center pin together. (See Figure 15 for detailed assembly instructions.) If the coil is removed enough times, often a tiny piece of the copper coax center wire will break off and lay down *inside* the mount where it can short out the center pin to the outer threaded base. Or the copper wire becomes corroded where it lays over the grooved center pin. Even if it looks OK, you should probably re-assemble the whole trunk lid mount, clean it up, and *solder* the copper wire to the center pin. At CB frequencies, the tiniest bit of corrosion, *even if you don't see it,* can show up as a high SWR that no amount of rod adjusting will change.
4) Use of a 102" whip on the *bumper* of a van. You were warned about this way back, so either move it, or be satisfied with lousy performance and maybe a blown final.
5) You are using the 102" whip, properly mounted this time. If SWR reads around 3:1, the problem is *inside* the shock spring. There is a heavy silver or copper-colored braid inside all good springs which is neccessary to *electrically* bond both ends of the spring. The braid is either corroded or completely broken. Flex the whip over and look inside the spring; you'll see the braid. If you see something inside that looks like another "spring" or "coil," throw the damn thing away and buy a good spring. The good shock spring will *always* have that heavy copper or silver braid inside. I guarantee the minute you replace that spring, the SWR will drop back down to its typical 1.5:1 (By the way, it's always a good idea to check the inside of the mini-springs on base-loaded antennas for corrosion or breakage; all these springs have a braid inside them too.)

II. Problem: Shorted Or Open Antenna

The MOST COMMON antenna problem of all. And the easiest to track down. You will know this one immediately because the SWR meter will appear to read *exactly* the same on the "REF" scale as on the "FOR" scale. In other words, after setting the calibration knob to full scale in the "FOR" position, it will also read *full scale* in the "REF" position. And you will not hear or be heard more than a block away. Check the S/RF meter on the CB, using the "cheap and dirty" method described earlier; this will also confirm an open or shorted antenna.

Note: On any type CB antenna that is NOT open or shorted, and even if it is terribly mismatched, you will still see a definite difference between "FOR" and "REF" readings, even if the "REF" goes way into the "red zone." You will also hear a definite increase in hiss noise or signals the instant you plug the coax connector in. It is only when "FOR" and "REF" read exactly alike and you can't hear a noticeable difference in receiver noise that you have a short or open.

If you don't hear *any* difference in hiss noise or signals as you plug or unplug the connector, you know there is a shorted or open antenna. With a short, you actually have NO antenna at all. With an open or discontinuous antenna, you may often notice you can hear signals OK *with only the center pin of the coax connector inserted;* as soon as you try to screw on the outer connector shell section, the signals disappear. The problem will always be either a broken center coax wire somewhere, or a broken shield braid somewhere along the coax between CB and antenna mount. (The broken center wire is the most common cause, with a broken shield inside a factory-crimped-on connector the next most likely cause.) What's happening in the case of an open antenna is that you are actually only using that piece of coax itself as the antenna, without the benefit of the real antenna.

To confirm either of these problems, *unplug* the coax connector from the CB or SWR meter, and proceed as follows:

A) Shorts:

1) If you're using a 102" whip, a shortened fiberglass whip of the 3/8" × 24 thread variety, or any *center-loaded* antenna, simply touch your ohmmeter test leads to the shell and center pin of the coax plug at the CB end of the cable. If the meter deflects at all (R×1 scale) you have a short. Carefully inspect the connections of the center and shield braid wires to the bumper hitch or swivel ball mount.
With bumper hitches, often the lug containing the center coax wire has bent up against the rest of the mount, shorting it to the vehicle body. Or one of the 2 large horizontal bolts that tighten the bumper hitch in the vertical position have come into contact with the large vertical bolt that passes through the 2 teflon collar washers. These washers hold the 3/8" × 24 threaded stud and are supposed to INSULATE the whip from the vehicle body. You may even occasionally get a customer that rigged his own "washers" so that the vertical bolt is actually not passing through the *exact center* of the hole meant for the collars; if that bolt has moved far enough to one side of the main hole, it may be touching the main vehicle body mount, shorting center wire to vehicle body. (See Figure 12.)
With swivel ball mounts, it's absolutely INCREDIBLE how many people install them wrong. You *must* drill or punch a hold at least 1¼" in addition to the 3 mounting bolt holes. Many people only drill out the

center hole large enough to pass the main threaded part of the ball. Thus the antenna is directly bolted to the vehicle body. which is a dead short. The entire whip, spring, and swivel ball are designed to be supported *completely* by the tough plastic mounting plate ONLY. (See Figure 13.)

If the swivel ball or bumper hitch is properly installed, and all connections look good, the problem must be a short in the coax itself, or the coax plug connector. Sometimes people run the cable *under* the vehicle, so that it gets mashed, burned, or stretched by some moving part. Or it gets cut on a sharp piece of metal, such as the carpet moulding step plate, or a metal piece under the back seat when the seat is replaced.

If you know the cable went all the way through the vehicle OK, the problem must then be in the coax plug connector. Unfortunately, you must cut off the plug to verify this. Try wiggling the plug hard first while you either listen, or transmit and observe the SWR meter. Often you will see a definite SWR change. If this doesn't work, you'll have to cut off the plug. After cutting it off, strip back some braid and the center wire and re-check with your ohmmeter. The meter should no longer move at all. (More on coax plugs later.)

2) On the typical base-loaded whip, you MUST REMOVE the coil/spring/rod assembly from its threaded mount before checking for shorts. (Almost all base-loading coils will show a "DC short" between the center "fingers" or whip rod and the outer threaded part of the coil. This is normal.)

After spinning off the antenna from the mount, check the still-disconnected CB end of the coax plug. If the ohmmeter still shows a short, it will be either in the cable, the coax plug, or the trunk mount itself. A very common problem with trunk mounts that do not come factory pre-assembled is that the installer did not route the cable properly in the mount; the coax MUST sit in the formed groove between the 2 Allen set screws. This hides the cable, making a neater installation, but *most important*, prevents the cable from being mashed when the trunk is closed. Many people just let the coax hang straight down from the cup of the mount. (See Figure 14 for proper installation.)

If the antenna is removed a lot, a piece of the copper center coax wire may break off and fall down *inside* the mount, shorting its center pin to the outer threaded shell. A quick look down inside the mount will confirm this.

The best way to prevent any of these very common problems is to use the type of antenna where the trunk mount/coax is factory pre-assembled. Good examples are the A/S MR-276, Hustler XBLT-4 or HQ-27M, or the Turner SK-210 or SK-211. These are all excellent antennas, saving you the headache of tricky and improper installation. And if you're in the repair business, the *time* of installations. A short with any of these antennas can only be in the cable or the coax plug. Check the cable routing through the vehicle, as well as the coax plug. Factory crimped-on coax plugs often DO go bad.

B) Open-circuited Antennas:

An "open-circuited" antenna simply means that the center wire of the coax is broken somewhere, the loading coil is broken open internally, or the coax shield braid is somehow not grounded. In other words, you effectively have NO antenna at all; just a piece of coax cable. On a base-loaded whip, an open is often caused by the little metal "fingers" of the coil not making solid contact with the center pin of the threaded mount. Let's repeat again the typical symptoms of an open antenna:

1) SWR meter indicates exactly the same "FOR" and "REF" readings;
2) no noticeable increase in noise or signals as you plug and unplug the coax connector;
3) can sometimes hear signals with *center* pin of coax plug only; screwing on outer shell makes signals disappear;
4) you can not hear or be heard more than a block away.

Case #1:

If you're using a 102" steel or fiberglass whip, shortened fiberglass stick, or any *center*-loaded whip, the problem must be somewhere in the cable or coax plug, or the connection of the center wire of the coax to the antenna. (In very rare cases of 96" *fiberglass* whips, the wire running the length of the fiberglass has actually broken its connection to the ⅜" × 24 threaded bottom; you can easily spot this because the stud and the fiberglass rod are very loose and actually can be twisted by hand.)

After checking the antenna end first for broken wires, disconnect the coax plug from the CB and proceed as follows:

Connect your ohmmeter across the shell and center pin of the coax plug at the CB end of the cable. The meter should NOT move at all. Now connect a clip-lead across the antenna end connections; i.e., center wire lug and shield braid or mounting bracket. If you don't have a clip-lead, you'll have to use a second person to hold a piece of bare wire, screwdriver, etc., across the center and braid wires, deliberately shorting *this* end. On typical ⅜" × 24 threaded antennas, the coax connections are made with lugs on the center and braid wires. A heavy bolt passes through the center wire lug, collar washers, etc. The ohmmeter should now show a dead short; i.e., zero ohms. If it doesn't, you know that the center wire of the coax is broken open somewhere, or possibly the shield braid is not grounded to its mounting bracket or the car body. The usual cause is the coax connector itself, unless you mashed or cut the cable running it through the vehicle. Try wiggling the coax plug with the ohmmeter and clip leads still attached; sometimes this will confirm a bad or intermittent connection in the coax plug.

Case #2: Opens on Base-loaded Whips

This is probably the most common antenna to show an open circuit. This is because many people install the coax to the trunk lid mount completely wrong. Or the whip has been removed so many times that the little contact "fingers" inside the coil have either broken off or spread open so far that they no longer contact the center pin of the mount itself. (A quick look at the bottom of the coil will reveal the latter two cases.) Also inspect the mount's center pin where the copper coax wire comes up and folds over into the groove; often it breaks off.

Another common problem is that the "finger" contact pin in the coil has actually unscrewed itself from the bottom of the loading coil and is completely missing. This special threaded finger piece is very common to many major brands of CB base-loaded antennas. However, base loads such as Turner and Hustler use a different screw-on method, so this problem cannot occur. (They also come pre-assembled) The newer Antenna Specialists base-loads, designated "MR," such as the MR-131, MR-125, MR-276, etc., use a completely new spring-loaded, compression-type center contact so this problem won't occur anymore. If you find a base load with any of those 4 little "fingers" broken off, replace it. (This may be a VERY hard part to find. You can get them from A/S, part # 10-51-1, or GC, #19-109. They fit many brands.) Otherwise, you will have to buy the entire loading coil. For A/S, the older coil is part #19-1094-1 for use with a *36" rod,* and the newer 40-channel "Wideband" coil is part #19-971-20, for use with a *39½" rod.* The threads of these coils will fit ANY standard base-load trunk or roof mount.

Sometimes, especially on the bargain brands, the coil may actually break open or burn open if used with a linear. It's easy to check: Since you already have the antenna assembly off its mount, just touch one ohmmeter test lead to the rod and the other to the center fingers or contact pin on the bottom of the coil. It should show continuity; i.e., about zero ohms. While you're at it, touch one ohmmeter test lead to that center contact and the other test lead to the outer threads at the bottom of the coil; this should also show zero ohms or continuity. If you didn't get continuity through the coil from rod to center contact, the coil is bad and must be replaced; you can't fix it.

Note: It is quite possible to see continuity between center contact and outer threads, which is normal, but NOT see continuity from the center contact to the rod itself. For the coil to be good, you MUST see continuity *all the way through the coil* from center contact to the rod.

If you find a bad coil, you can most likely just buy the coil itself. Save the rod, rod adapter, and spring hardware. HOWEVER, realize that every manufacturer's coil is designed to work with a *specific* rod length, or it will be impossible to match up. And almost every brand is slightly different in the coil department! The older A/S 23-channel antenna coil uses a 36" rod; Turner uses a 42" rod, etc. And the 40-channel versions, which will look identical from the outside, generally use a *longer* rod. For example, the old A/S coil works with a 36" rod, but the new version, which says "Wide Band" on it, uses a 39½" rod. They are NOT interchangeable.

As another example, suppose you found a bad base-loading coil for a Radio Shack antenna that uses a 33" steel, fiberglass, or graphite rod. It would NOT work with the A/S coil. They look the same, the threads are the same. BUT THE ROD IS 3" TOO SHORT. But it might be easier and cheaper to buy a Radio Shack replacement coil. So if you had a bad A/S coil and wanted to use the Radio Shack coil, you could just ask the salesman to measure the rod length of a packaged Radio Shack antenna. Let's say it's 33". Then all you would have to do is cut 3" off the 36" A/S rod, and remount it to the rest of the coil/springhardware. (The spring and whip holder of almost all brands are close enough in length.) You would then be in the ballpark in terms of SWR and can proceed to match it more exactly. REMEMBER: 3" too long or too short, and you will NEVER get it to match. And to top it all off, you must also consider 23 vs. 40-channel rod lengths for replacement parts!

Note: Center-loading coils can break open also. You simply touch the ohmmeter test leads across the coil, touching both sides of the steel rod. A good coil will show continuity. (Zero ohms)

If the loading coil checks good, and the mount was assembled by the user, almost every case of an open will be traced to improper installation of the coax cable to the mount, improper installation of the coax plug, or a bad factory crimped-on plug.

Case #3: Coax Braid not Grounded To Vehicle Body

Very easy to check out: With the coax plug disconnected from the CB, (and a base-loaded antenna unscrewed from its mount) use the ohmmeter at the CB end of the vehicle to check for continuity between outer coax plug shell and the vehicle body. Touch one test lead to the outer shell, and the other test lead to some metal part of the vehicle, such as the carpet moulding plate, a bolt on the gas pedal, etc. The ohmmeter should deflect to about zero ohms. If the meter doesn't indicate continuity, you have an "open ground;" i.e., no ground at all.

Open grounds usually result from improper installation of the coax to the trunk mount. On the poorer brands, the outer shield braid has a lug attached to it, which you are expected to place under a nut and bolt on the mount. On other brands, you get a brass collar and a metal clamp; you are supposed to slip the collar and its clamp over the exposed shield braid and tighten it down with a nut and bolt provided. While all this is happening, you are expected to shove the copper coax center wire up through the threaded coil holder. You need about five hands! Both methods are awkward and troublesome.

The better brands use a very simple shield grounding method. They provide a special threaded cap with a hole in it to pass the center wire through. You flare out about ¼" of the braid, slip the cap over the center wire and tighten. It will mash the shield braid down, ensuring a good ground contact. Figure 15 shows exactly how to do this correctly. (Some brands provide both the brass collar and the threaded cap; throw away the brass part and use the cap method.)

Special Case of Shorts or Opens, Any Antenna Type:
If you're using a mobile slide mount with the built-in coax splice, (the type you were warned NOT to use) its coax connections may not be making good contact between the two halves of the slide mount. Attach the antenna DIRECTLY to the CB. If SWR drops down to normal, you've solved the problem. If you or the customer insist on using that part of the slide mount, and it is making a bad connection, either bend the copper or silver-plated contact strips up a bit higher, or with the flat contact type, melt some solder on the metal strips to make them slightly thicker and tighter.

Summing up, you can very easily troubleshoot these common antenna problems by using a cheap ohmmeter to check continuity, shorts, or opens. Try to buy or recommend antennas with factory pre-assembled mounts whenever possible.

COAX CONNECTORS - A *MAJOR* SOURCE OF ANTENNA PROBLEMS

I'm devoting a special section just to this, because it's so critical. Antenna problems resulting from bad coax plugs are *almost always* due to improper installation by the user. Other minor causes are extreme corrosion, such as in a marine installation, or bad factory crimped-on plugs.

There is a real art to properly installing the standard military-type "PL-259" coax plug (Amphenol 83-1SP) with or without the reducing adapter. (UG-175 for RG 58/U or UG-176 for RG 59/U). Very few people possess this talent. *I* can do it, a few old time hams and engineers can do it, and cable manufacturers can do it. It is extremely tricky; the shield must be soldered through little holes in the main piece. Too little heat, and the braid won't bond to the metal shell; too much heat, and you may melt the center wire insulation, shorting it out. And even if you could solder it, you cannot see inside the plug to know if the braid actually got soldered, or if maybe one of the hair-fine shield braid wires is touching the center wire, also causing a short. SO BE ADVISED: You probably cannot properly install a standard PL-259 plug. Anyway, why even bother? There are now much better solderless connectors available to CBers.

The solution is simple! For the common "thin stuff", i.e., RG 58/U, there is a fantastic solderless connector now on the market that *really* works, and is totally foolproof. The connector is made by Amphenol, number 83-58FCP, which retails for about $1.50 (They also have a *female* version, #83-58FCJ, that works on the same principle.) Figures 7B and 7C show how both these connectors attach. In my opinion the Amphenol plug is the ONLY foolproof, solderless plug for RG 58/U cable, and I've tried them all. You can install this one in 45 seconds flat after a little practice. I have been unable to tear one apart with 100 pounds of pull, and have also used them on my own ham station at 1000 watt power levels. Do NOT buy the type of solderless plug that uses a small plastic ring and plastic screw-on center pin; they are extremely easy to pull apart and short out.

As for the "thick stuff," RG 8/U, you CAN use the solderless plugs such as the GC Electronics #18-416 very easily. Follow package directions carefully and be sure to SOLDER the center coax wire to the center pin. The shield folds back over the outer vinyl covering and will make a solid ground contact as you push and twist the cable into the plug.

Special Coax Connector Problems
There are about 3 special cases where more than one coax cable go together in a single plug:

1) co-phase harness using RG 59/U;
2) CB marine antennas;
3) special shortened fiberglass base antennas (Shakespeare Big Stick II, etc.)

Generally you cannot repair these connectors once they break apart. In the latter 2 cases, the coax plug has two cables of *different* thicknesses tied together inside the plug. One of these cables is a short "stub" about 2 feet long. The length of this stub is *extemely critical* for proper SWR matching.

The co-phase harness *can* be repaired, but you must be very careful. See Figure 7. (Truckers suffer the most from this problem.) The easiest repair method is to use the Amphenol 83-58FCP plug just mentioned, leaving *just enough* RG 58/U (2 or 3 inches) to strip back and connect to the two RG 59/U cables. Or if you think you can install one properly, attach a short (2 or 3 inches) piece of RG 59/U to a PL-259 connector with the proper reducing adapter (UG-176) and strip it back. Then strip back the center and shield wires of the RG 59/U cables coming from each antenna, solder all 3 center wires together, tape well, then solder all 3 shields together and tape the whole thing. Even better than this, *if* you know how to install the PL-259 plugs, would be to put a plug on EACH antenna cable, and then use a coax "T" connector (Amphenol 83-1T) on the back of the CB to bring both antenna connections together into the single male end required. In the first two cases, you have simplified the repair by only having to connect a *single* coax piece to a plug, and then making the "Y" connection with the other two cables.

Note: Cutting a mere few inches off one antenna cable, or splicing those cables to a few inches of RG 58/U, WILL NOT upset the SWR. A *foot* or two, yes! Also, splicing 3 pieces of coax together, as in the first 2 methods, will not upset SWR if done within a few inches of where the "Y" splice and plug connect to the radio.

III. Problem: SWR very high, Well Into the "Red Zone" of the SWR Meter, but not high enough to qualify as an open or short. (Where "FOR" & "REF" are equal.) No noticeable change between Channel 1 & Channel 40.

This can be an extremely tough problem to cure, maybe even impossible with the particular antenna you're using. Usual causes are very poor grounds or cheap, off-brand antennas, which may actually be tuned to some frequency completely out of the CB band. Since you see no SWR difference between channel ends, you don't know which way to adjust the rod. Re-check these areas:

1) Good metal-to-metal contact of set screws, mounting plate, mirror bracket, etc.
2) Use of a *non*-tuneable fiberglass loaded whip;
3) Good contact between "fingers" and center pins of base-loads, and good contact of the center coax wire itself where it folds over into the center pin groove. (Check for corrosion and/or wire breakage.)

In situation #2, you're out of luck. With base and center loads, IF you can get your hands on some rods of different lengths, say, 3" shorter and 3" longer than the one supplied, you may get lucky by experimenting and see a definite SWR trend taking place.

Another trick to try: Remove the antenna from its mount, and use 2 clip-leads to connect your 50 ohm dummy load across the mount. Clip one lead from the outer shell of the dummy load plug to the shield or mount. Clip the other lead from the center pin of the dummy load plug to the center coax wire or center pin of the mount. If the SWR goes way down to a normal value, around 1.5 or less, you have at least confirmed that the coax and its connections are OK, so you definitely have a bad antenna. Clip-leading a dummy load this way is an excellent method to use anytime you suspect bad coax or coax connections.

There is one other possible cause for this problem, but it is EXTREMELY RARE. However, since it's happened to me a few times and nearly drove me crazy solving it, I offer it to you:

> Some older radios are so "broad-banded" in transmitter adjustments that they are capable of transmitting *several watts* of RF energy at a frequency completely *out* of the CB band, such as 23 MHz., rather than the 27 MHz. CB band. This frequency is usually one of the "mixer" frequencies used in the crystal synthesizer circuit, which means that there is actually an *internal* problem in the radio itself, not the antenna. A dummy load will never reveal this problem. It would take an expensive test instrument called a "Frequency Counter" to measure the actual frequency of the radio energy. Only a professional is equipped to do this. However, you could probably confirm that the CB is on frequency by listening for it on another CB tuned to the same channel. You should hear the carrier.

If none of these tricks work, you'll have to either buy a better brand antenna, or take the problem to a professional repairman. (In tough cases like these, I use a very special technique that I've never seen used by other repairmen. By coupling a special test instrument called a "Grid Dip Meter" to the antenna, I can find the approximate frequency where the antenna is actually adjusted, then shorten or lengthen the rod as necessary. Not recommended for amateurs.)

IV. PROBLEM: Stays "stuck" on transmit even after releasing mike button. Shows very high SWR. Doesn't stick when substituting dummy load for antenna.

This is also a very rare problem, but I've seen it enough to warrant a brief mention here. It only occurs in *electronically*-switched radios. (Refer back to Mike Wiring section to determine TX/RX switching.)

This is not a mechanical problem in the mike button. Technically, there is a switching diode somewhere in the CB which is "leaky", and the extra reflected RF voltage from high SWR is enough to make the diode stay switched on or off when it was supposed to do just the opposite. As an amateur, you will probably be unable to track down a leaky diode, so you must repair or replace the antenna. A low-SWR antenna will always cure this problem; you really don't have to worry about that diode inside the radio.

CO-PHASING DUAL ANTENNAS

If you insist on using dual antennas after all the previous warnings, (truckers excepted) they can often be very tricky to adjust and match up. If you use *good* duals to start with, such as the A/S MR-415 "Beer Cans", Hustler HTM-1, or Turner SK-855 on typical mirror mount installations, you'll probably be in the ballpark when it comes to SWR matching. DEFINITELY avoid the bargain-brand duals. If the SWR is around 1.5, you have lucked out; a quick check at the channel ends will tell you which direction to adjust the tip rods. And remember, these antennas often come with special co-phase harnesses of the RG 59/U type that CANNOT be cut.

If you're adding a second antenna to an already-existing system, all you need is a good co-phase harness. RG 59/U harnesses NOT recommended; you'll have a big mess of extra coax to hide out of the way. NEVER try to co-phase by just using RG 58/U for both antennas and going into a coax "T" connector with another piece of RG 58/U. (Yes, some people actually do this.) An excellent way to co-phase is to buy a special harness made by GC Electronics, #18-391, #18-392, or #18-393. These use RG 58/U with a special transformer so that you can cut any of the 3 coax legs to any length, making a much neater installation.

Unless you are very lucky and achieve a low SWR right away, there is ONLY ONE PROPER WAY to co-phase dual antennas: You must terminate one antenna coax end in a dummy load and adjust the other antenna as if it were a single antenna. You then reverse the process: Disconnect the antenna you just tuned, connect *its* coax to the dummy load, and tune the other antenna. Otherwise you will spend all day running up and down ladders between antennas. Remember, a dummy load is a perfect "50 ohm impedance" antenna. As a matter of fact, a good trick to check out the *phasing harness itself* is to use 2 dummy loads and connect one to each end of the harness. If the harness is good, it will show a perfect SWR of 1:1, also called a "flat" line.

Connecting dummy loads to coax ends is usually very simple on most brands of *mirror-mount* antennas; they use standard PL-259 type coax plugs at all three ends of the harness. So all you have to do is use a double female "barrel connector" (Amphenol PL-258, GC 18-410, Radio Shack 278-1369) to attach between the dummy load and the antenna end plug. This works great for any Turner, A/S, Radio Shack, or other brand using standard coax sockets on the antenna mounts.

On the Hustler duals, you'll have a problem trying to attach a dummy load to the ends; Hustler uses the "RCA" or "Motorola" type plug with a threaded coupling nut. This will require a special adapter, A//S #M-41, to temporarily convert their plug to the PL-259 type. Then proceed as above.

That leaves just one other type of connection: Lugs on both the coax center wire and shielded braid. To use the dummy load technique. you will have to physically remove one antenna at a time and use clip-leads between the lugs of the coax and the shell and center pin of the dummy load plug.

Note: Use of clip-leads with a dummy load will upset the "50 ohm impedance" of that coax end *slightly*, but not enough to worry about. And not nearly as much as a bad antenna!

Summing up, the use of alternating dummy loads on the ends of co-phase harnesses can help you solve those really tough dual antenna matching cases. And while we're on the subject, co-phasing two 102" steel or fiberglass whips does NOT REQUIRE any adjustment, since they are a natural ¼-wavelength anyway. With these whips, you'll have to settle for whatever SWR you get. But remember, the difference between 2:1 and 1:1 will not even be noticeable at the receiving end.

AND NOW FOR A LOOK INSIDE THE RADIO

By now you're an expert on 75% of CB radio problems and how to diagnose and repair them. Time to get into the "guts" of the radio to fix a few more things!

The very first thing to do after removing the CB from its cabinet is to make a careful visual inspection of both sides of the printed circuit board. (Hereafter called "PCB.") You don't have to be an electronic genius to see obviously-burned parts or broken wires. And bad solder connections are *very* common in solid-state radios, due to their mass-production methods.

For example: Suppose you have some intermittent problem that only shows up when you hit a bump in the road. Chances are you can find it by tapping or pressing on the PCB. Use something non-metallic, like the handle of a screwdriver, or press hard and flex the board by hand. (You may touch certain parts of the underneath of the PCB that make a buzzing or humming noise; this is normal.) If you manage to narrow down some intermittent problem to a small area, carefully re-heat ALL the solder connections anywhere near it. You'll be amazed how often you'll discover a broken foil pad or cure a cold solder joint.

Warning: NEVER touch anything in a tube-type CB with your hands! And even on solid state base CBs, never touch the "converter" section. (This is the smaller PCB on the chassis that changes the 110 volt AC house wiring to the 12 volts DC that runs the radio.) See Figure 16 for the general location of this section. Remember, there is still 110 volts floating around in that section somewhere; you may get zapped! Better to make repairs by using an external 12 volt "power pack", or plug the base into your car's cigar lighter.

PHYSICALLY LOCATING PARTS IN PROBLEM AREAS

In order to repair an internal CB problem, you obviously must be able to *physically* locate the part or section. This will not be difficult at all if you carefully follow my instructions, have a bit of common sense, and very sharp eyes.

Our discussion of parts replacement will deal only with solid-state CB units made since about 1970. ("Solid-state" means transistors rather than tubes.) The older tube radios rarely used PCBs; they were usually hand-wired back in the "good old days" before CB radio became so popular. But most important, tube-type radios use DANGEROUS HIGH VOLTAGES to operate the tubes. Tube CBs are very good, but they do require re-alignment periodically as the tubes age and surrounding circuit parts change value slightly from the constant heat of the tubes. I will explain how you can very easily re-align the receiver and transmitter sections of tube-type CBs without special equipment. But for any other problem in tube-type radios, you should take the set to a pro. Especially if you spent big bucks for a Browning Golden Eagle or Tram D-201.

Solid-State Construction

OK, we see all these parts stuffed into this big stiff board, with all those strange numbers and colors, and underneath, one big (usually) green-colored layer with little silver lumps all over the place where the parts were soldered in. This underneath is called the "foil" side of the board, because that's exactly what it is: copper foil strips that were layed down and etched out chemically into all sorts of strange-looking shapes. In fact, if you carefully scrape away a bit of that green solder-resist stuff with a single-edged razor blade or other sharp instrument, you will see some shiny copper under it.

When trying to locate or unsolder a part from a PCB, a good strong light, like a penlight, is very helpful; just shine the light through either the foil or component side of the board to locate the correct foil "trace" or "pad" that you want to unsolder.

You will be required for many repairs to check or unsolder a part from the "common" foil; the word has exactly the same meaning here as it did way back in the Mike Wiring section. It is "common to" or necessary to complete many circuits at the same time. It will *always* have a direct connection to the black power wire of the CB; i.e., it will show continuity or zero ohms on the ohmmeter. Also, the common foil covers the physically *largest* area of the board; you will see it weave around all over the place. See Figure 17 for an example.

Remember, the common foil can very easily be spotted by its large size, and by the fact that a quick ohmmeter check (with power off!) between the black wire or "minus" symbol stamped on the socket of a base or mobile and the common foil will show continuity. Base stations and many mobile CBs may have a few smaller printed circuit boards bolted to the main board. The common of these small boards will always be tied somewhere to the common of the main board. (None of the repairs discussed will apply to these boards, so don't worry about it.) You may have figured out by now that all this "common" stuff means the same thing as "ground." This is true, but not completely. Most modern CBs can be used on either positive or negative ground vehicles. The actual metal chassis of such radios will NOT show continuity between the metal case and the common foil of the PCB. The common foil of these radios is what is called "floating," because it can go either positive or negative. To repeat: The common and metal case are not directly connected electrically in these units. Exceptions to this rule are all Johnson mobile CBs, and all CBs designed for negative ground use only. (These ARE directly connected electrically between metal case and common foil or black power wire.) Don't be too concerned about all this positive/negative stuff; you'll be shown only what you need to know to repair the radio.

PROBLEM - Radio is dead. Won't even light up. May or may not blow fuses.

A. Fuse Problems:

What, you don't even *have* a fuse in the hot lead? GET ONE! In fact, if you were operating without any fuse, better skip to Section "C" now.

If the fuse checks OK by visual inspection or by touching your ohmmeter across its metal ends, and you ran the hot lead to another hot wire somewhere else in the vehicle, you might have blown *that* fuse. Check it out. Sometimes fuses blow open for absolutely no apparent reason except maybe old age. If you replace a blown fuse and the CB works again, don't worry about it any more unless it blows again after the set's been on for a while, or when you key the TX.

Caution: NEVER, NEVER, NEVER use a fuse larger than 2 or 2½ amps in *any* solid-state CB radio! (The fuse usually says "AGC 2" or "ACG 2½" on one metal end.) It's incredible how many people will stick a 10 or 20 *amp* fuse in their CB fuseholder, then cross the red and black power leads and see clouds of smoke come out of the radio.

A few 18-wheelers like the White Freightliner or other vehicles use a *positive ground* electrical system. In such cases, you'll also need a fuse in the black power lead to protect the radio. You'll never find a CB with fused red and black power wires, because 1), the manufacturer was too cheap to install one, and 2), they figure 99% of their radios will be used on standard negative ground vehicles anyway. So for positive ground use, spend the $1.50 to install the extra fuse and fuseholder. It's cheaper than the repair.

B. Bad Slide Mount Contacts:

Sometimes the contact strips of mobile slide mounts make bad connections. You may notice the CB go on and off when you hit a bump or wiggle the mount. If the CB is completely dead, and you have access to a 12 volt power pack converter or a cigar lighter power plug, see if the radio works that way. If it does, the problem is in the vehicle wiring itself. Use that trusty ohmmeter again, only *this time* switch it to the "DC VOLTS" range. Any range position which will display 12 volts is fine. Just touch the meter's red and black test leads to the copper slide mount strips where the respective red and black power wires connect. (On the bolted half of the mount, with the CB half removed.) The meter should show 12 volts. If the meter moves backwards, reverse the red and black test probes. You may have to turn the ignition key on, depending upon where you wired in the hot lead. If you don't get a voltage reading, you have a car fuse problem, a slide mount fuse problem, a fuseholder not making good contact between its 2 sections, or possibly even a bad ground. (The bad ground would be checked on "OHMS" again, with power *off*, to verify continuity between the black wire slide mount contact strip and the vehicle body.)

If you do see the 12 volts on the bolted-in half of the mount, and you know the CB works OK from some other 12 volt source, the problem is in the slide mount contact strips. Just carefully pry up the copper strips of the red and black wires with a fine screwdriver or needle-nose pliers on both halves of the slide mount. If the mount is the type that uses flat strips that don't actually move, just melt some solder on them to make them thicker. They should then mate firmly and solve the problem.

C. Blown reverse-polarity protection diode on mobiles. Keeps blowing fuses. Doesn't even light up. (A fancy description for a 50¢ problem.)

This is undoubtedly the MOST COMMON reason for dead mobile CBs. You hooked the red and black wires up backwards without a fuse, or with a fuse bigger than 2 amps.

The repair is very simple and cheap. To confirm that this is in fact the problem, disconnect the power leads or pull the CB out of the slide mount. Using the ohmmeter on the R×1 scale, attach the red test lead to the red power lead, and the black test lead to the black power lead. If you blew the diode, it will show up as a short; i.e., about zero ohms, or continuity. Then reverse the red and black ohmmeter leads; red to black, black to red. It should still show a short. And then even if you turn the set on (power disconnected!) it will *still* show a short.

Note: On a few CBs, the diode comes *after* the On/Off switch in the circuit, so you may not see the short until you turn the power switch "ON."

If your ohmmeter did not show a short both ways across the CB power wires, the diode is NOT the problem.

Special Note: Many mobile CBs use a 3 pin power wire socket. (3 pins in a row, middle pin off to one side.) Usually, the socket has the "plus" and "minus" signs stamped on the metal chassis. Lately I have been noticing that many of the newer radios are NOT wired the same as the *replacement* 3-pin female power socket cables, such as GC Electronics #18-508. In other words, even though the replacement power cord plug fits the socket, THE RED AND BLACK WIRES OF THE MOLDED PLUG ARE REVERSED. Naturally, the CB will never work; it will blow fuses forever unless you reverse the red and black wires. If the "plus" and "minus" are not stamped into the chassis, you will have to look inside the CB power socket; you'll see a short piece of red and black wire going down to the PCB. If the wires are *not* colored, just trace which one of the socket wires goes to the common foil; that will be the "minus," so you can then mark the proper pins outside on the metal CB case. Then you can easily "eyeball" the new molded replacement power plug; you will probably find it reversed. The easiest way to fix this problem is simply to cut the new cord a few inches from the plug, split the red and black wires, and criss-cross them, remembering to *solder and tape* well. Do NOT simply decide to hook them up reversed, thinking you'll always remember you have an oddball plug. And more important, you *still* need that protective fuse in the hot power lead, no matter what color.

Now on to that diode repair:

First you must find the diode. In most radios, it is usually located across the common and hot lead foils of the PCB *right at the point* where the red and black power wires enter from the socket or chassis hole. See Figure 18 for pictures of what it looks like, how it is mounted, and its location. Normally it is very easy to find. The diode you want will have the symbol of Figure 18 on the PCB, and possibly a number next to it such as D-12 or CR-12.

Note: On a few radios, they hid the diode somewhere else entirely. In such cases, you will have to try to find your CB in a SAMS FOTOFACTS. If it's in a SAMS, get somebody who can read a schematic diagram and photo layout to show you where it is.

Remember, the diode you're looking for should be in the immediate vicinity of where the power wires enter. It will be colored black with a white or blue band at one end. You may see diodes made of clear glass with banded ends; ignore any of those. Your diode will usually be right next to a small transformer that is *also right next to* the power wire socket or chassis hole. See Figure 18. Very often the diode will obviously look burned, blistered, and may even break in half as soon as you touch it.

In cases where you zapped the diode due to inadequate fuse protection, you many have even burned up some of the copper foil of the hot side itself. Inspect the foil around the diode to see if it in fact did burn open. If so, carefully scrape away some of the green solder-resist from both sides of the broken foil until you see shiny copper. Then "tin" the copper with solder. Finally, you'll have to bridge a very thin wire across the broken foil and hold it down while you solder both ends to repair the break, NEVER, NEVER, rely on just a big glob of solder to make the bridge. Use a piece of wire.

A few CBs, such as the Sharp CB-800, CB-700, Royce 1-600 and others, have *no* reverse-protection diode in them. If you know you accidentally reversed the red and black power leads and saw smoke, chances are you just burned open a piece of the hot lead foil, as described above. The repair is exactly the same. But after you bridge the broken foil, install a diode across it and the common foil for future protection. Read the next paragraph first though; diodes MUST BE INSTALLED a certain way.

Now we need a new diode. Ask in any electronic parts store for a "general purpose, silicon rectifier diode rated at least 2.5 amps, 50 PIV." They will be impressed by your expertise! But if you can't pronounce all that, just ask for the following:

1N4000 through 1N4007 type diode;
Radio Shack #276-1101;
Motorola HEP RO170;
RCA SK-3081;
Sylvania ECG-116;
General Electric GE-510, or any equivalent in another brand. (They will have a huge book of brand cross-references.)

The new diode should look like the old one: black with a white band on one end. Now refer back to Figure 18. THE NEW DIODE MUST BE WIRED TO THE PCB THE CORRECT WAY, OR IT WILL BURN OUT AS SOON AS YOU TURN ON THE CB.

You MUST connect the banded end of the diode to the line end of the diode symbol on the PCB. To put it another way, the *un*-banded end corresponds to the arrow end of the diode symbol. If you found the diode and your ohmmeter confirmed that it was in fact shorted both ways, but the CB does NOT have the diode symbol printed on the PCB, all you have to remember is this: Always insert the banded end in the hot lead foil. Or to put in another way, insert the *un*-banded end in the common foil or black power wire side. By the way, be sure the diode you buy is in fact marked with a band.

D. Base Station CB Dead—Doesn't Light Up

The only difference between a base and a mobile CB, aside from looks and price, is the fact that base stations have a built-in converter to change your 110 volt AC house wiring to the regulated 12 volts DC used in all solid-state sets. In other words, there is *no* difference in operation between a base station or a mobile in the house with a "power pack" converter.) See Fig. 20 for "converter" location.

Most base sets also have a separate power plug and socket for use directly on 12 volts DC. So if you have access to a converter, or have the DC power plug to try it out in your car, that's the first thing to check. Most of the time you will discover that it works normally on the direct 12 volts DC. Therefore the problem is somewhere in the 110-to-12 volt converter subsection of the base CB. (If you are trying the direct method but do not have the necessary power cord, all you have to do is use a red and a black clip-lead on the radio's 12 volt socket, observing the "plus" and "minus" signs stamped on the chassis. If the chassis is not marked, you will have to remove the cabinet and figure out which is which using the exact same common foil method described earlier. Then just hook the other clip-lead ends to the respective "plus" and "minus" of the external power pack converter.)

If you discovered that the problem is in fact in the AC-to-DC converter section, this can almost always be narrowed down to one of two things:

1) Regulator transistor or IC.
2) rectifier diode(s) or bridge burned out. (What, THOSE things again?)

Regulator Transistor/IC

This is a very large "power" device which is usually bolted to a piece of aluminum, bolted to the metal chassis right alongside the converter subsection or maybe even sticking straight up from the PCB of that subsection. Don't worry about all this talk of "transistors;" all you need to know is what it *looks like* and the *correct* way to replace it. We won't get technical.

A "power transistor" is simply a physically big transistor; it must pass more electrical power through it, so it is physically larger than an ordinary transistor. Just like a 20 amp fuse is physically larger than a 1 amp fuse. All transistor repairs which will be discussed in this book will deal ONLY with power transistors, since these are the ones that burn out most often. The regulator device we're about to discuss, and the audio output and transmitter final output which will be discussed later, are all *power* devices. This is basically all you need to know; they will all look physically just like the illustrations of Figure 19. By their shapes and sizes they stick out like a sore thumb; you can't miss them.

Back to that repair. Refer to Figure 16 to locate the converter section of the base, and Figure 19 to see what these devices look like. The regulator device you want is almost always in the "TO-220" type case, which is a flat black-colored job with a large metal tab forming its backside. This device usually has a number such as D235, C1173, or C1096 on it. If you see a TO-220 type transistor in the converter section with a different number, that's probably it. (New devices appear all the time.) In some radios like the Cobra 139XLR, you will not find this type. It uses a *different* one in a "TO-3" type case. This is a very large, shiny, silver-colored transistor that looks just like a flying saucer. And some radios may use a transistor in a "TO-66" type case. This is another "flying saucer," but physically smaller. Figure 19 shows actual sizes. Both these "flying saucer" type transistors will always be bolted directly to the metal case. The newest rigs may use the "in-line" type of IC, also shown in Figure 19.

Now BEFORE attempting to replace any transistor, read the following section, and then carefully study the section, "How To Change Power Devices" coming up shortly.

Rectifier Diode(s) or Bridge Burned Out or Shorted.

If this is the problem in the converter section, it will definitely blow fuses. However, a bad regulator device may NOT necessarily blow fuses if burned open rather than shorted.

When diodes are used, as in most CBs, they will be found all together on the converter board, usually as 2 pairs of 2 each. They look just like those in Figure 18, and can be replaced with one of the types listed above. Sometimes it's very obvious that the diode burned up, or is cracked open, in which case you've just solved the problem. Otherwise, diodes can be checked as described on the next page.

Some CBs use a single bridge rectifier instead of diodes. This is a square block with 4 wires going to it, and a single bolt holding it down. There will be + and − symbols on 2 of its wires; a VOM connected across these should show about 15-20 volts DC. If not, unsolder the + wire and measure across the bridge again. If you get the correct DC reading now, the problem is most likely in the regulator device itself. However if you see no DC voltage output from the bridge, it's probably bad. Confirm by connecting your VOM on the "AC VOLTS" scale to the other 2 wires on the bridge, which are the actual AC input from the transformer. You should see about 18-25 volts AC. A typical replacement bridge is the Radio Shack #276-1171.

To check the four diodes, you should notice that there is just enough room where the diode wires go through the holes to the foil side of the PCB to touch those wires with the sharp points of your ohmmeter test lead probes. So using the meter on the R × 1 scale, touch the red and black test leads to the banded and unbanded wires of each of the 4 diodes, one at a time. As you touch across a diode, you should see that with the red and black test probes one way, there should be NO reading at all. Then, if you *reverse* the red and black test leads, you should get a meter reading of around mid-scale on most ohmmeters on the R × 1 scale. To repeat it another way: On a *good* diode, touching the red lead to the unbanded end and the black lead to the banded end should show either no reading or a mid-scale reading. Then if you reverse the colored test lead probes, you should get just the opposite ohmmeter reading. In other words, a diode will show NO reading with test leads one way, and SOME resistance reading the opposite way. If you find a diode that shows a *very low* resistance, say under 5 ohms, it is probably burned out. Confirm by reversing red and black test leads; if you get the same low reading, it is burned out.

Note: This diode testing method CAN NOT be used on every part of the CB board without knowing what is wired across the diode. For the converter section, you can use this method. But do not go around testing everything that looks like a diode all over the radio! You may be very surprised to discover that you think you found a bad diode somewhere, but after unsoldering one end and retesting, it tests good.

If you *do* find a shorted diode in the group of four, you should replace ALL FOUR of them; the bad one usually weakens the others. They're very cheap anyway, about 50¢ each. If either of these tests and/or replacements fail to get the CB working on its 110 volt cord, you'll probably need professional help; regulator circuitry can get very complex and sophisticated, and we can only deal with the most common causes in this book.

As a footnote, anytime you are considering buying a "power pack" supply to use a mobile in the home as a **base**, insist on the *regulated* type, rated at least 2 amps. A cheap, *non*-regulated supply can damage the CB. The term "regulated" as we have been using it simply means that the voltage stays exactly the same during RX and TX, even though transmitters draw about 3 times as much juice from the supply. Poor regulation is common in many CB sets, even major brands. It shows up as a flickering of the channel and meter panel lights when going from receive to transmit modes; i.e., the lights get *dimmer* on TX. Sometimes on a very poorly-regulated set, you'll even see the lights flicker on *receive* with a strong signal during modulation. This is one good way to test a new or used CB that you are contemplating buying; make sure it has excellent voltage regulation.

E. PROBLEM - Radio lights up, but is dead on RX & TX, except for weak hiss noise. Radio is of the "Phase-Locked-Loop" (PLL) type

This is a common problem which can often be traced to just a poor solder connection on the PLL "chip."

PLL is a very sophisticated method of creating all the necessary frequencies to run a CB radio. Think of it as a "crystal-less" radio. That's because it only has from 1 to 3 crystals in the *entire* radio. Possibly a few more if it's a sideband model. All 40-channel sets are PLL but only a few of the late-production 23-channel sets used PLL circuitry. A few examples are the SBE "Formula D," Horizon 29, Royce "Gyro-lock," and Midland 13-882C. You will ALWAYS know a PLL set by its obvious lack of crystals; almost all 23-channel sets use crystal synthesis, which will normally require 12 or 14 crystals in the typical AM set. (Refer to section on Crystal Repairs in case you don't know what a crystal looks like, and Figure 24.) If you are one of those people who bought a 23-channel CB during 1976 and had it *factory* converted to 40 channels, THEN it will be a PLL radio. What the factory generally does is remove all the crystals and solder on a small printed circuit board in the general physical area of where the crystals used to be. This sub-PCB contains the PLL circuitry.

Back to that problem: It is usually caused by a failure somewhere in the PLL circuit section. Often the problems are bad crystals, or poor solder connections to the PLL IC "chip" or crystals. Occasionally the PLL chip itself is defective. Unfortunately due to their extremely complex operation, you will probably be unable to repair that section yourself. You can try reheating all the pins of the PLL chip and crystals, and also try flexing and tapping the PCB. Figure 19 shows the general physical appearance of the PLL IC chip. The IC is always of the "dual-in-line" (DIP) type, and will be black and have 16, 18, 24, or 28 pins on it.

If these methods don't work, you'll have to consult a pro. However, you can still repair many other problems on PLL radios, such as bad finals, power leads hooked **up** backwards, peaking TX, etc. THOSE sections of all **CBs** are exactly alike, and even look physically alike and use the same power transistors.

If you have an older 23-channel set using crystal synthesis which shows these same symptoms, the problem can be due to several possibilities, all of which will be beyond your ability to repair without proper equipment and expertise. About all you can do in this case is flex the board, looking for bad connections. In this book we are going strictly by the odds, describing the problems that are MOST likely to happen, and those which you as an amateur can repair yourself.

HOW TO CHANGE POWER DEVICES. *VERY* IMPORTANT. DO IT *RIGHT!*

For repairs requiring you to change a power device, it MUST be done exactly right. Otherwise, not only will the set not work, there's a very good chance you'll zap that brand new transistor the minute you turn on the set.

All transistor/IC repairs in this book will be, as previously mentioned, of the power device type *only*, such as base station regulators, finals, and audio outputs. There are two main reasons for this:

1) These are the easiest for you to *physically* recognize and locate by their size, shape, and numbers, even without a photo layout;
2) These are the MOST LIKELY to fail, because of the high electrical power that passes through them. You must approach these repairs by understanding how the manufacturers think; mainly, CHEAP! In low-power electronic CB circuits, solid-state devices like diodes and transistors are very conservatively rated, and the price of two *low*-power transistors with very different breakdown ratings may be identical. But as soon as we get to the *high*-power stages such as the commonly blown "finals," there may be a *big* price difference related to breakdown ratings of 2 different "final" transistors even though their other electronic characteristics are identical. Therefore, the manufacturer will always try to sneak by with the most borderline-rated power device he can get away with. This applies to ALL CB radios, even major brands. Believe me, there is not *one single part* in these radios that is not *absolutely essential* to the proper operation of the electronic circuit. They won't give you one bit of window dressing without passing the cost straight on to you.

OK, now you know the "WHY" and you must learn the "HOW" of transistors. Transistors are delicate little devices that are very easily damaged by heat, just as your car engine would blow up without oil or a radiator to help cool it down. The method used to cool down transistors and high-power ICs is called "heat-sinking." It may take several common forms in CB radios, which you will quickly learn to recognize. These heat-sinking forms are:

1) Bolting the transistor or IC to the metal chassis or frame;
2) Bolting the transistor or IC to a separate large piece of aluminum, which in turn is bolted to the metal chassis or frame;
3) Clamping a specially-shaped piece of aluminum (sometimes painted black) around the transistor;
4) Pushing a tight-fitting aluminum piece, often with radiating fins, down on the metal transistor body.

The last two methods are generally used in *medium*-power stages; most of the devices we'll deal with use methods #1 and #2.

Now that you realize that transistors, diodes, and ICs are heat-sensitive, you must learn to solder/unsolder them *quickly* and efficiently. Refer back to the introduction and practice, practice, practice! Knowing HOW TO SOLDER is critical; I cannot emphasize this *strongly* enough. You wouldn't believe the butchering jobs I've seen, INCLUDING many done by paid repairmen who maybe even had a license.

Once you've decided the device needs replacing, unsolder the 3 heavy wires from the transistor (or more, if an IC). In the case of the TO-3 and TO-66 "flying saucer" transistors, they will be bolted directly to the metal frame. For the TO-5 and TO-220 types, they will most likely be bolted to a separate aluminum heatsink, which in turn will be bolted to the main metal frame. Carefully study which wires connect where on the foil, and make a sketch if necessary. The TO-3 and TO-66 types will only have *two* heavy wires; the actual case makes the third connection and will have a wire attached to it under one of its mounting bolts. Refer back to Figure 19 to see what all these power transistors look like.

You will notice the device is bolted to its heatsink in one of two possible ways:

1) it attaches to the heatsink with a threaded nylon screw;
2) it is bolted on with ordinary metal nuts and bolts, *but the bolt feeds through* a white teflon collar washer, so that the bolt does NOT contact the metal heat sink. This would short it out. In other words, the device is *electrically* insulated from the heat-sink, but heat can still transfer.

You will also note in either method that there is a very thin glass-like insulator BETWEEN the metal heatsink and the metal of the transistor or IC case. There will also be some clear or white greasy-looking stuff all over that mica insulator. Do NOT break or lose the mica insulator. Even though the heatsink itself is bolted directly to the metal frame of the radio, the transistor/IC is not making a direct metal-to-metal contact between its metal tab and that piece of aluminum. The glass-like mica piece insulates the transistor *electrically* from any other metal, but the greasy stuff allows the heat to transfer. Figure 21 illustrates both mounting methods.

The special greasy-looking stuff is called "heat-sink" or "thermal" compound. When you replace the device, you should spread a generous layer of it (GC Electronics *#8109-S, Corning 340, etc.) on both sides of the mica insulator. FAILURE TO APPLY THERMAL COMPOUND MAY BURN OUT THE NEW PART FROM OVERHEATING.* (As a matter of fact, I have seen brand new sets which blew a final because the factory forgot to put any on the power device.) Now very carefully re-bolt the device to its heat-sink, making sure the mica insulator is in between. DO NOT OVERTIGHTEN. Just a snug fit will do. Then immediately wash your hands and do NOT get any thermal compound in your eyes.

It is always a very good idea after attaching the new part to its heatsink, but BEFORE bolting the heatsink itself back on the metal chassis of the radio, to check for accidental shorts between transistor body and heat sink. With the nylon screw method, this is rarely a problem, but when the part uses the metal bolt and nut with the teflon collar washer, it is very easy to short that bolt to the aluminum piece by either overtightening it, crushing the mica, or not properly centering the metal bolt through the collar washer. Remember the collar washer keeps it *centered* in the hole, in exactly the same way as the bumper hitch collar washers keep the 102" antenna whip from shorting to the hitch and vehicle body.

All you have to do to test for shorts is to use the ohmmeter on the R×1 scale and touch the test probes to the aluminum heatsink and metal tab or metal case of the transistor body. It should NOT show any continuity; i.e., no reading. If it deflects over to zero ohms you have a short. Loosen and re-center the metal bolt and nut and try again. Any short at this stage will either burn out the new transistor or blow the fuse the minute you turn the set on.

Notes: 1) Many times with the nylon screw method, you may tear up the Phillips head of the screw or shear it off completely. Since these nylon screws seem to be impossible to find, the best thing to do in such cases is simply pass an INSULATED piece of solid hookup wire through the transistor tab hole, mica hole, and heatsink hole, twisting it tightly and cutting off all excess. This will provide enough pressure on the transistor, insulator, heatsink, and thermal grease to insure good heat transfer. Check for shorts as above.

2) TO-3 and TO-66 cases always use the collar washers on both ends. Therefore you risk twice the chance of shorting out one of its bolts to some metal. So *always* check these types for shorts by using an ohmmeter between main metal case and metal transistor body. Make this continuity check BEFORE you reconnect the two bottom transistor wires.

If you're OK up to this point, you may assume it's now safe to re-connect the two or three wires to the power transistor. (You DID make a drawing of which wire goes where, right?)

About 95% of all solid-state CB radios, including many well-known American brands like RCA, use Japanese transistors. The only exceptions I know of so far are a few Pace, Johnson, CPI, and Motorola sets. (exact transistor replacements are best for these sets, because they're readily available in electronics parts stores and can be directly soldered back in, pin-for-pin.) For Japanese sets though, do NOT use American cross-reference replacements, because 1) Japanese transistors/ICs are about ⅓ the price, and generally better anyway, and 2), Japanese replacements, especially "finals", are wire-for-wire interchangeable with each other; you can directly solder in several different devices if you don't have the exact replacement. For example, you could directly replace a 2SC1096 with a 2SC1173, or a 2SC1678 with a 2SC1306. American replacements, although they might have the same *electrical* characteristics as their Japanese counterparts, probably WILL NOT have the 3 lead wires in the same order. So you can't just stuff it into the circuit where a Japanese part was. And I can't begin to teach you all about transistor basing in a book like this.

PROBLEM: No sound from radio, but S/RF meter moves over normally during RX, indicating signals are present. Mike checks ok.

Other possible symptoms: *May* hear very weakly from speaker with volume turned all the way up, but no modulation on TX. Audio transformer may get very hot.

Make sure the problem is *inside* the CB first. Often the speaker just burns out. Or the wires to the speaker or the EXT SP/PA SP jack(s) break off. Confirm a bad CB speaker by plugging in an external speaker. If the internal speaker appears to be bad, confirm by unsoldering either of its two wires and touching your ohmmeter to both terminals on the R×1 scale. A good speaker will make the ohmmeter move most of the way over, and you will also hear a tiny crackling noise when you touch its connections with an ohmmeter.

If the problem is not in the speaker, the most common cause will be a blown audio output transistor or IC. This shows up as either no sound at all, even though the S/RF meter is moving, or a very weak sound with volume turned wide open. Also you will not hear anything on "PA" position either with an external speaker. And in any case, you will not get transmit modulation; i.e., a "dead carrier." If the transistors/IC are shorted rather than open (less common) it will cause the large audio transformer to get very hot. (This will be the *largest* transformer on the PCB. NOT to be confused with the AC transformer on base CBs. See Figure 22.)

You can also confirm using the modulation light/dummy load. It will probably light brightly when the CB is keyed, but fail to get brighter when you talk. ("Dead carrier" with no modulation.)

This problem is extremely common, and is exactly like the blown final in the TX section discussed later. Only in this case, just think of it as the audio final amplifier. Since these parts are common to *both* receive and transmit modes, the symptoms will show up in both modes. And since we are discussing power transistors, remember that they are the *most* likely devices to fail.

Almost all modern CB radios use either a matched pair of identical audio transistors in the TO-220 case, or an *integrated circuit* (IC.) A few older models, such as the Pace 2300, use a single TO-66 "flying saucer" type transistor, which runs very warm normally. Other older sets will use a matched pair of TO-66 type transistors. Refer back to Figure 19 for pictures of what all these devices look like.

You can always spot these parts very easily. The matched TO-220 pair will either be on the same piece of aluminum heat sink, or occasionally one side of the main metal case. An IC (which is the equivalent of several transistors inside one physical package) will also be bolted to its own piece of aluminum or a side of the case. The single or double TO-66 types will be bolted *directly* on one side or the back of the CB case itself. And in all cases, they will be located very close to the audio transformer, which is very large and can't be missed. (Refer again to Figure 22.)

Probably 80% of the CB sets made in the last few years, including all 40-channel sets, use the TO-220 type output transistors. (They are cheaper than the TO-66 types; remember how manufacturers think.) The rest of the current breed use IC outputs. Typical TO-220 type transistors in use now will have numbers like D235, C1173, C1096, C1014. Typical ICs are the TA7205P, such as used in many Midlands, Kracos, Hy-Gains, and others. Sharp has another type, the TBA810S-H. (Both these ICs are notorious for blowing out.) All of these transistors and ICs are black-colored with white lettering on them. RF finals and drivers are always individual transistors rather than ICs. However audio outputs, voltage regulators, etc. may be either type; in fact, a device in the plastic TO-220 package is often an IC and *not* a transistor.

As a footnote, American transistors usually begin with the prefix, 2N, while Japanese counterparts start with the prefix 2SA, 2SB, 2SC, or 2SD. HOWEVER, many times the Japanese prefix is not printed on the case. So when we talk about a "C1096," we *really* mean a 2SC1096. This is what you would buy.

If the audio problem happens to be the case of the weak signal with volume turned all the way up (but the S/RF meter registers a strong signal) then only one of the two transistors is burned out. But since they are designed to operate as a matched pair, you should replace BOTH; they're cheap, and the bad transistor may have weakened the good one. Review the discussion about power transistor replacement before attempting these repairs. You might forget something. And that also applies to the next section.

PROBLEM: Won't transmit, any channel, receives fine.

Undoubtedly the most common internal problem of all. (I assume you have thoroughly double-checked the antenna and mike wiring; you'd be amazed how often the problem is NOT inside the CB.) So we have now arrived at the case of those infamous "finals" you've probably heard about already. To set the record straight, it is WRONG to use the term "finals." This implies more than one. There is ONLY ONE "FINAL" RF amplifier transistor in a CB. Start talking like a pro!

Connect your modulation light/dummy load to the CB antenna socket. As you key the mike, one of the following things will likely happen:

1) Bulb won't light and S/RF meter won't move over;
2) Bulb lights very *dimly* and S/RF meter barely moves over;
3) Bulb may light brightly, but only lasts a minute or so before going out;
4) Bulb lights brightly, S/RF meter moves over normally, but talking or whistling into the mike causes the bulb to get *dimmer*, or S/RF meter jumps *lower* instead of higher.
5) Radio goes completely dead and/or blows the fuse as soon as you key the mike.

Typical causes of these TX problems are:

1) Final transistor blown, weak, or thermally intermittent (stops when heated);
2) Driver transistor blown, weak, or thermally intermittent;
3) Final stage(s) mistuned;
4) Driver stage mistuned, or both driver AND final stages mistuned.

NOTE: In 99% of blown finals, the problem was caused by a *bad antenna*. Therefore, if you replace a final or driver and get the CB working normally, *re-check* the antenna or it might happen again.

Let's briefly review a few things about high-power solid-state devices, such as finals, RF drivers (the stage before the final stage), audio output transistors, and audio ICs. These are the MOST likely parts to fail, because they are usually borderline-rated in terms of breakdown voltages, etc. When a power device in a CB fails, it does one of two things:

1) It shorts out internally
2) It opens up internally. (ICs usually short out.)

With transistors, shorts are probably about ⅓ as common as opens. Both problems will show *different* symptoms which you can usually recognize. In the case of an open, the circuit just doesn't work. But in the case of the short, it is quite possible that other obvious symptoms will occur: The set goes dead when you key it, the set goes dead as soon as you turn it on or some other part that is wired across the shorted part gets very hot, possibly even burning up. In most of these cases the fuse will blow. In the case of the shorted reverse-polarity diode discussed before, the fuse blows without even turning on the set. Keep these points in mind even if the problem seems unrelated to your problem. For instance, a shorted final *can* cause a completely dead radio that won't even light up. I did not mention it in the "DEAD RADIO" section. I am discussing it in the "TRANSMITTER PROBLEM" section to hopefully avoid confusion. You, however, must consider ALL possibilities after studying the entire book. Occasionally we have a lot of trouble narrowing the problem section down. In these cases, *as a last resort*, you may have to apply what many old-timers affectionately call the "smoke test." What you do is hook the CB up *unfused* to a very heavy duty power supply, say 20 amps, or a car battery, and wait to see what starts smoking. You'll know immediately what section to work on! I must emphasize this is a LAST RESORT; as an amateur, you may not notice something getting hot soon enough to prevent damage to other good components. Use your fingers and nose generously. A good repairman will notice the heat long before he has to replace half the burned up copper foil.

LOCATING FINALS, DRIVERS, AND THEIR "PEAKING OUT" ADJUSTMENTS

Since we're dealing with power devices, they will always be heat-sinked, although you may come across a rare CB where the *driver* is not; it just sticks up out of the PCB. The final will also always be very close to the antenna socket. And there will be several air-wound, slug-tuned vertical coils around both final, driver, and antenna socket. The "slug" in the coil is a piece of powdered iron. This slug and its coil form will appear one of two ways:

1) The slug will have a straight screwdriver-type slot on top; the coil form will be brown or tan-colored, and the top of the form will be sealed with wax. (If the slug is deep enough into the coil form, all you may see is the wax. This wax prevents movement once adjusted.) This type of transmitter tuning coil is the *most common* one.
2) The slug will have a hexagonal hole all the way through it, and be inside a plastic form, usually brightly-colored. These may occasionally have a drop of wax or glue in them also, although they are generally tight enough. This coil is used in perhaps 10% of most CBs. See Appendix C for specific adjustments of most PLL 40-channel sets.

All final transistors in Japanese sets are either in the TO-220 or TO-5 type case. The TO-5 transistor is less common in the newer sets. Also, it comes with a special oval-shaped aluminum mounting piece into which it is pressed, and the whole assembly is bolted to a heat-sink. Refer back to Figure 19.

Driver transistors can also be in the TO-5 type case, or more commonly, a flat black plastic case with white I.D. numbers similar to the TO-220, but smaller. (If the final or driver is of the flat type and has color bands around its black case, rather than white numbers, it is an American-made transistor.)

THE MOST COMMON TRANSISTORS WILL HAVE THE FOLLOWING NUMBERS ON THEM, & THE JAPANESE TYPES ARE INTERCHANGEABLE

FINALS in TO-220 Case:
C1237, C1678, C1306, C1307, C1377, C1814, C1974, C1975, C2075, C2029, C2078, C2166, etc.

FINALS in TO-5 Case:
C756, C799, C778, C1239, 2SF8, MRF 8004
American (Johnson, Pace): 4005

DRIVERS in FLAT CASE:

C495, C1018, C1226A, C1760, C1846, C2036, C1973, C2028, C2086, C1306 (used only in AM/SSB rigs together with C1307 final)

DRIVERS in TO-5 Case:
C775, C778, C781, C482
American (Johnson, Pace): 4004

Refer now to Figure 23. Looking down with the parts on top and the front towards you, there will be many coil adjustments all over the PCB. Many of these slug-tuned adjustments are inside a tiny metal shield "can" that is normally square, occasionally round. DISREGARD any of these for now. What you are looking for is the transmitter strip, which will be very easy to spot. Look at the antenna socket and work your way forwards or sideways. You will find the heat-sinked final, driver, and AIR-wound VERTICAL coils between and around them. They are usually lined up in a neat row; you can't miss them. Remember, the high-power stages of the TX will always be along one of the metal sides of the main chassis, where it is easy to bolt the transistors and heat-sinks right to the metal frame of the set.

Notes: 1) Officially you must either possess or be under the supervision of a person with the proper commercial FCC license to change these transistors, make tuning adjustments, or change crystals. If you do any of these things, you should have it checked out in a properly-equipped CB shop. This check will be a lot cheaper than letting them repair these simple problems.

2) The powdered-iron slugs in the tuning adjustments can crack VERY easily unless you have completely removed the wax or glue first. Once it cracks, it's impossible to adjust. If you cannot loosen it, or it seems frozen in place, leave it alone.

3) You must use special, NON-metallic tools to insert in the slugs; the steel in a screwdriver could add enough "inductance" to cause misleading adjustments.

The tools are very cheap; GC Electronics sells a complete set for CB work, #18-530, for about $7.00.

4) Do NOT touch any adjustments, even if you think you know which ones they are, until you read the rest of this book.

Generally most of these tuned transmitter stages are so broadbanded that just replacing the bad transistor will get it right back to its original power output, without even having to touch any coil adjustments. However, almost all CBs that I've seen lately, especially the 40-channel rigs, are averaging only about 3 watts output regardless of what the manufacturer claims. You are allowed 4 watts, and can often get that extra watt, or maybe even 2 watts. This brings up another important point: DO NOT BELIEVE any CBers who claim that their rigs put out 8 watts, 10 watts etc. *IMPOSSIBLE!* Of all the sets I've repaired, there are perhaps 3% that are capable of more than 4 watts output. The CBer was no doubt using a $29.95 SWR/POWER/MODULATION meter for measurements. Such accessories are grossly *inaccurate* for power OR modulation measurements. They are only reasonably accurate for SWR checks. I can take that "8 watt" CB back into the shop and check it with my $250 Bird wattmeter, where it suddenly shows the typical 3 watts output.

Back to those finals: Any of the Japanese TO-220 type transistors (the most commonly used nowadays) are directly interchangeable, wire-for-wire. The design of their amplifier stages have so much tolerance that just about any of them will work if you don't have the exact replacement number. For example, a 2SC1678 will work in any CB, even if the blown final was a 2SC1237, 2SC1306, etc. In such cases minor re-tuning may be necessary.

Exceptions:

1) SSB rigs typically use a C1306 *driver.* (This is heavy enough for the *final* in AM sets.) They pair this with a C1307 final, which can handle the most power, and is also the most expensive. Therefore, use exact replacements for AM/SSB rigs.
2) Do not try to replace a TO-220 type with a TO-5 type; they both bolt onto the metal chassis or PCB *differently*. And you can easily get the 3 wires crossed and hooked up the wrong way.

DO YOU EVEN HAVE A BAD FINAL?

Without a transistor checker, it will be almost impossible for you to diagnose a bad driver stage, but you CAN use a "cheap & dirty" trick to diagnose a bad final. This requires a *second* CB tuned to the same channel and placed a few feet away from the bad one. (Use the "AM" mode on sideband sets.)

1) Use a dummy load on the bad set;
2) Key the mike of the bad CB. Many times you can hear the carrier and see a slight meter movement on the S/RF meter of the good set. If this happens you most likely have a bad *final,* although in rare cases it is possible to have a bad driver which is leaking enough radio energy through to the final stage to be picked up on the good set.

What's usually happening here is that the TX is working fine all the way up to the final amplifier transistor, so even the tiny fraction of a watt radiating from the driver can be picked up by a very close receiver. But the final is not working and therefore cannot amplify the signal up to its normal 3 or 4 watts.

Occasionally a final RF output transistor has a heat problem; it only stops after it heats up for a few seconds or minutes. (This is called a "thermal intermittent.") Professional repairmen use a special "frost" or "freeze" spray, such as ARCAL SUPER FROST TEST, to confirm these problems. You would know this problem because your modulation light/dummy load would light up brightly for a few seconds and then go out. If you shot a blast of freeze spray on the final while it was keyed, it would cool down very fast and start working again. With a problem like this you must replace the transistor; it can't be repaired.

WEAK FINAL, DRIVER, or JUST OUT OF ALIGNMENT?

If the modulation dummy light bulb glows dimly or the S/RF meter only moves over a fraction of its normal distance, the problem is a weak transistor, or mis-tuned driver or final coil. Chances are a solid-state CB would NOT go out of alignment unless somebody had previously tinkered with it. The final can be weakend by a bad antenna with high SWR rather than completely blown out. In that case it still would have to be replaced. Try to repeak it first; if the coil slugs have little or no effect on increasing power output, it is most likely a weak driver, final, or even both.

1) Use a modulation light type of dummy load;
2) Use the set's S/RF meter; or
3) Use an external SWR meter in the "FOR" position with any type of dummy load on the SWR meter's "ANT" end. Try to set the meter's calibration knob to a mid-scale reading if possible (If tuning starts to increase power output, keep backing the knob down to around mid-scale.)

Since you now know where all the TX coils are located, start with the coils *after* the final; i.e., those closest to the antenna socket. These are the most likely to increase power. Work your way back down the TX strip to the coil *before* the driver stage. Tune all the slugs for either maximum brightness of the dummy load bulb, maximum reading on the S/RF meter, or maximum reading in the "FORWARD" position of the external SWR meter.

If none of these adjustments seem to increase TX power output, it is most likely a weak driver, final, or possibly both. Unless you have access to a transistor checker and know how to use it, you might as well replace *both* transistors; they're cheap enough. Remember these adjustments will only work if the test using the second-CB-set method showed a definite but weak signal present, or if the light bulb glowed dimly.

SHORTED FINALS

If the CB set blows a fuse as soon as you key it, or you see an obviously-burned up resistor right near the final or driver, the most likely cause is an internal short in the transistor itself. Shorted finals are not quite as common as open ones in CB transmitters. Recall that in any electronic circuit, when a part burns up, it is almost always *another part* connected to it that is the real villain. In other words, if you spotted a burned resistor right near the final or driver transistor(s), you might think the solution would be to replace the *resistor* itself. This is incorrect, and would NOT cure the problem because the new resistor would immediately burn up too. You'd have to replace the transistor that caused it to burn up in the first place. (Another example would be the modulation/audio output transformer of Figure 22 getting *very* hot; the transformer is not defective, but rather the audio power transistor(s) or IC that are connected *across* that transformer need replacement.)

The burned up resistor right next to a final or driver, or the hot transformer, are both dead giveaways that their transistors are shorted internally. And since we're running with the odds, the odds are very great that the power devices themselves are the MOST likely parts to blow. (By the way, if you don't know what a resistor looks like, refer to Figure 18. It is the same size and shape as the diode, but always has 3 or 4 colored bands around it.)

OTHER PROBLEMS RELATED TO PEAKING OUT TRANSMITTERS

There is a special problem you may stumble across if you see enough CB radios. It occurs in solid-state and tube-type rigs, is normally very rare, and goes by the fancy technical terms, "downward modulation" or "negative carrier shift." You'll recognize it immediately because the modulation light/dummy load bulb will actually get *dimmer* as you speak, rather than brighter, or the S/RF panel meter will kick *backward* rather than forward with modulation. You'll get radio checks describing a "great carrier, but extremely weak modulation" on AM.

With normal modulation of an AM CB radio, you are adding the power of your voice to the power of the carrier itself, so the light gets brighter and/or the S/RF meter kicks higher. With downward modulation though, you are actually *subtracting* from the carrier, making the signal weaker as you talk. So the person at the other end hears the carrier "wall-to-wall", but can barely hear your voice.

The cure for this problem is normally very simple. Although textbooks on transmitter theory will list many causes, for all practical purposes I have only seen two causes for downward modulation:

1) Poor or dirty ground or hot lead connection on a mobile installation, which can cause a severe voltage drop during TX. Recall our discussion about voltage regulation; this is a case of *extremely* poor regulation. The TX requires about 3 times as much electrical power as the RX, so you may never notice anything wrong while listening.
2) Mis-tuned final coils in the TX stages. I've never seen this in a new or never-worked-on radio, only those in which some amateur "screwdriver wizard" played with it. If you qualify as one of these people, you can now learn the right way.

The first thing to do is check for Cause #1, a large voltage change between RX and TX. All you have to do is stick your trusty ohmmeter test leads across the appropriate red and black power wires from the CB. Only THIS TIME, you are using the meter as a DC voltmeter, so switch to a DC VOLTS range on the VOM that will easily show 12 volts. While listening, you should see about 10-14 volts, depending on whether or not the engine is running. Now key the mike. The voltage should NOT change. If it goes down drastically, you have a bad ground or hot wire connection. Many times you will find that this is caused by putting the black ground wire under a nut that has some paint on it. Or perhaps you had to splice on some extra wire for the ground or hot lead, and just twisted the wires together unsoldered, or made a cold solder connection. All it takes is the slightest dirty contact to form a high resistance that will drop the voltage the most just when you need it the most!

Note: Sometimes this problem will only show up with the engine off, and will transmit normally with the engine running. In this case, you may have a weak battery or another problem in the vehicle itself.

On to Cause #2, mis-tuned TX coils:

There are normally 1, 2, or 3 air-wound, slug-tuned coil adjustments between the antenna socket and the final power transistor. It is most likely one of these coils that is misadjusted, although occasionally it can be one of the other air-wound coils in the driver stage. (In solid-state CBs, both final *and* driver are modulated.)

To check for proper TX peaking, you'll need the light bulb type dummy load, the S/RF panel meter on the set, or an external SWR meter in the "FORWARD" position *terminated in a light bulb type dummy load.* (If using an SWR meter, do not go by the fact that the SWR meter may kick backwards; there are some tricky interactions here that can kick the meter backwards even with normal upward modulation. So just rely on what the light bulb is doing in this case.)

During the course of peaking the TX coils, you probably noticed definite highs and lows of power output as you screwed the slugs in and out. The power would gradually rise and fall, and one point would show a distinct peak maximum output. With downward modulation, *you have tuned to the wrong side of the peak.* In other words, you'll have to turn the slug slightly off the peak either clockwise or counter-clockwise, constantly checking modulation by whistling until it returns to normal. To repeat: In some CBs the dummy load bulb gets dimmer as you talk or whistle, so you must experiment with the final (and driver) tuning slugs until you find a combination that gives maximum transmitter power but with normal, upward modulation. The odds are in your favor that you'll never see this problem, but be aware it can be created by improper TX tuning.

Note: Secure the coils again from vibrating out of alignment when you finish all peaking adjustments. Wax is messy; I normally dab some Elmer's type glue on the slug and coil. This holds well but can be easily picked off again with a sharp instrument if re-tuning is ever necessary.

It is extremely important to realize that power means *nothing* without enough modulation. Maximum transmitting range is determined just as much by *audio* power as by transmitter carrier power. In other words, it is very possible that a CB with only 2 watts carrier at 100% modulation will talk *farther* than a 4 watt CB with only 70% modulation. Better to see a dim light bulb that gets very bright with modulation than a very bright bulb that barely flickers at all with modulation.

PROBLEM: Very poor on receive. Can only hear signals from very close stations. Transmits normally.

Assuming the antenna has been thoroughly checked and is connected and working properly, there are typically two main causes for poor RX sensitivity:

1) Blown RX "front-end" transistor. A common problem, but particularly among truckers, who often use linear amplifiers or park at truck stops alongside other truckers using high-powered linears.

2) RX out of alignment. More common to older, tube-type radios.

All solid-state CBs have built-in overload protection, in the form of diodes. What happens in the presence of strong signals is that the protective diodes "clip off" the signal after it reaches a certain predetermined level. Such protection is often not enough. Especially when you're parked next to somebody with a 200 watt linear, or if you live next door to another CBer with an even bigger linear or a high-gain beam antenna pointed your way! If your CB set uses a special type of transistor in the front-end stage called an "FET", it is even *more* sensitive to very strong signals.

Unfortunately, this repair problem requires at least a schematic diagram and parts layout; I cannot describe the transistor's physical location in general enough terms as in the case of power transistors. There may be two dozen transistors that look exactly alike to you, and the one you want could be almost anywhere on the PCB. If the CB was working fine and suddenly went quiet, and you *knew* you were very close to somebody using a high-powered linear, a blown front-end RF amplifier transistor would be a definite suspect. (Consult a SAMS FOTOFACTS for locations of these transistors.) If the problem is one of the radio being out of alignment, the following procedures may improve reception.

Alignment of Tube-type CB Radios

In old tube-type radios of the 1965 era, the TX and RX coils may look physically the same to you, unlike solid-state radios. Therefore you *must* have a schematic with photographs so you'll know where to look and what to look for. The easiest way to get this information is from an excellent publication called SAMS FOTOFACTS. It's actually a whole numbered series of books with several CBs in each book. All you need is the SAMS with your set in it. Most tube-type rigs are in SAMS because back in those days there were only a few makes and models around. Any large electronics store carries SAMS FOTOFACTS, and the last page has an index listing every radio up to that volume. Just find a very recent volume to use as an index, then buy the one you need. (At this writing, there are 300 volumes!) The references at the end of this book lists the address of the publisher if you need it.

Once you have the proper SAMS, carefully study the photographs and the alignment instructions, but do not worry about all the fancy language describing exotic test equipment set-ups; you'll never need them. Just read over the column that shows which adjustment you need for RX or TX, then find that adjustment by looking at the photo layouts. All you will need in the way of test equipment is your trusty modulation light/dummy load for TX, and an antenna or second CB set for RX alignment.

Since tubes go bad, change values, or cause other circuit parts to change value from many years of heat, there is a very good chance that poor RX sensitivity in a tube-type CB is simply a matter of weak tubes or re-tuning. Naturally the first thing to do is to test all the tubes on a drugstore-type tube tester, and replace any that indicate bad, leaky, or borderline good.

Warning: There are DANGEROUS high voltages floating around all over tube CBs. Never try to move the set by grabbing the chassis with *both* hands while turned on! In fact the safest and easiest way to align them, since you'll need to get at both sides of the chassis anyway, is to lay the radio on one side before you ever turn it on. If you lay it on the side with the heavy power transformer down, its weight will help keep the CB from sliding around.

After studying the SAMS and replacing any bad tubes, you can proceed with RX alignment by several methods:

1) Tune in a CB signal of average or weak strength;
2) Use a second CB set/dummy load keyed on the same channel for your signal source;
3) Disconnect the antenna and turn the volume (and noise) to maximum.

If the set has an S/RF meter, this makes a simple, accurate way to measure alignment, although your ear is surprisingly accurate. Use the meter for methods #1 and #2, and your ear for method #3.

Remember that all the coil adjustments require the use of a NON-metallic tool, such as those contained in the GC Electronics kit #18-530 mentioned earlier. Now, using the tool that fits in the metal "cans", slowly tune the slugs for maximum meter deflection from whatever signal source you're using, or maximum hiss noise if using the disconnected antenna method. These metal cans will normally have *two* adjustments, one directly through the top of the can, and one on the bottom or wired side of the radio. If you look at the bottom of the can from the wired side, you'll see the second hole for the adjustment. When you read in the SAMS something like, ". . .adjust A2/A3 for maximum", it is understood they are referring to a *single*, double-tuned can.

Note: Most of the slugs in these cans are of the hexagonal hole type. You must carefully feel your way through the can with the plastic alignment tool until you know the tool is in the slug hole. If the slug is glued, or otherwise feels stuck or frozen, better forget it and move on to the next one.

A typical SAMS alignment will label these RX cans something like A1/A2, A3/A4, A5/A6, etc. There are normally 3 or 4 cans for receive, meaning 6 or 8 slugs to tune. (On *transmit*, there will usually be only 1 or 2 of the double-tuned cans, and several screwdriver-type adjustments.) You can easily tune the RX slugs by ear for maximum hiss noise without any special equipment, although it would be best to use methods #1 or #2. (Regardless of all the fancy, expensive test equipment that electronic manufacturers would like to sell, I can easily hear a "10 Db. signal-to-noise ratio" without such equipment. My equipment only confirms what an experienced, well-trained ear already told me, and you can do it yourself with a little practice.)

After re-tuning all the cans you are about 90% finished and should already hear a big difference. This procedure is called "IF", or "Intermediate Frequency" alignment. The only adjustment left is the "RF" section. There may be one or two RF coils; they will appear as threaded brass rods with screwdriver slits on top, sticking up vertically from the metal chassis.

Caution: Many TX coils look the same; don't confuse them.

The receiver RF adjustment will often be called something like "L-1" in your SAMS. Just screw the slug in or out for maximum signal, hiss noise, or S-meter reading, exactly like the "IF" alignments.

Occasionally "IF" alignment of a tube-type CB using only your ear will throw the RX off frequency enough so that the delta-tune won't have enough range to pull in the signal; i.e., you may receive Channel 13 better on Channel 14, etc. If this happens you will need an accurate CB signal rather than just your ear for proper peaking. (The "RF" coil doesn't affect this.) The easiest and cheapest way to do is to use another CB attached to a dummy load, keeping it far enough away from the set you're adjusting so that the signal is not too strong. Or have a friend transmit to you on a specific channel.

Note: The most accurate peaking methods in any type CB will be with the use of the *weakest* possible signal source. Either back down the RF gain control, move the second CB farther away, or short out the antenna socket with a clip lead to reduce signal strength. Recalling the earlier discussion about Db., the ear can detect changes in weak signals *much more easily* than strong ones. Also, perform the alignment with the set near the middle of the CB band, around Channel 11; this will give best performance on all 23 channels. (On 40-channel solid-state sets, use Channel 20 for both TX and RX peaking.)

Transmitter Peaking of Tube-type CB Radios

This procedure is very easy following the SAMS FOTO-FACTS. Just use the modulation type dummy load, peaking all TX coils for maximum brightness. Or use the radio's S/RF meter and peak for maximum meter deflection. Then double-check your alignment to make sure you have not accidentally created the "downward modulation" problem discussed earlier.

Usually there will be only 1 or 2 double-tuned type metal cans (A5/A6, etc.) and 1 or 2 of the vertical threaded brass rods in the TX section. Often there may be 1 or 2 screwdriver-type adjustments on the rear side of the chassis next to the antenna socket. They usually appear as small white ceramic "trimmer capacitors" about the size of a penny. Use a *non*-metallic tool. Sometimes these trimmers are stamped or labelled "plate tune" and "plate load", or just "tune" and "load." Tune these for maximum brightness or S-meter deflection, and check for downward modulation again. (The "load" adjustment is the most likely to cause downward modulation; if it happens, re-tune the trimmer to the *other* side of its peak.) Do NOT touch any adjustments marked "TVI". You may also spot another penny-sized white ceramic trimmer or similar adjustment somewhere near the crystals. Do NOT touch this adjustment unless you have an accurate frequency counter; you may throw the whole radio off frequency on all channels.

Receiver Peaking of Solid-state CB Radios
Because there are now literally thousands of CB makes and models on the market, there is a chance you may not find your radio listed in a SAMS, especially off-brand makes and very new 40-channel sets. Without a SAMS or factory service manual, you will be unable to physically locate all receiver tuning controls, although transmitter adjustments will still look exactly like those already described. Many of those little metal cans look similar, and may even be in the *transmitter* section. Therefore, we will only describe a partial "IF" alignment; the "RF" section is impossible to locate without the proper parts layout and schematic.

Looking down on the component side of the PCB, you will see all kinds of shiny metal cans which house various sizes of coils and slugs. About 4 or 5 of them will have very large slugs with a screwdriver slot on top about ¼" wide. Often they will have colored paint on the slugs too. (You may find a pair of large slugs in a single metal can occasionally.) In some CBs, the large slugs are encased in a round metal cover instead of the more common square can. All the remaining cans in the radio will have small coils with very tiny slugs in them, perhaps 1/16" wide. DO NOT TOUCH any of these. Turning the wrong one could kill the entire RX, TX, or both; the crystal/PLL oscillators are among these adjustments. Also they will generally not have nearly as much effect on peaking the RX or TX as the large ones. (The only exceptions here are the "RF" and "mixer" cans shown on a schematic.) Often these critical cans are sealed with a drop of wax. In other words, the large slugs are the only ones you want. You can't miss them; the slug sizes are very large compared to all the rest. See Figure 23.

Now that you know what to look for, all you need do is tune these large slugs with a non-metallic screwdriver tool for either the loudest hiss noise by ear, or the strongest S-meter reading when using an actual signal or second-CB-set method. These stages are called the "low intermediate frequency" or "low IF"; they rarely need re-alignment in solid-state CBs because they are very tight-fitting. Unfortunately, it is those other adjustments, the "high IF" and "RF" cans that get out of whack more easily unless sealed with wax, and these are exactly the ones you can't find without a service manual. But remember, if these re-alignment procedures don't work for your CB, you may have a more complicated problem or defective part somewhere that will require professional help.

Note: CB CITY now offers exact RX/TX alignment data for over 1500 makes and models. Write for details.

PROBLEM: Dead on certain channels only. May be only on RX, only on TX, or both. Radio is of the crystal type.

This has to be another of the major CB problems of all time. But it is one of the easiest to repair yourself; the problem is caused by a bad or intermittent crystal 99% of the time. Sometimes the crystal just has a cold solder connection to the PCB. Occasionally the crystal only works within certain temperature ranges. And in some rare cases, the tiny metal "fingers" on the channel switch are dirty or not making good contact.

Finding the faulty crystal in modern CBs is very easy. These radios use a process called "synthesis" to generate all the necessary RX and TX signals that are required for various stages in the set. What this means is that 2 or 3 crystals are mixed together electronically to produce the CB channel frequency. Otherwise it would take 46 separate crystals, 23 for RX and 23 for TX in an AM rig, or 80 crystals in the new rigs. And for sideband sets, even more crystals would be needed. There isn't enough quartz crystal left in the world to give it all to the CB manufacturers! Besides, it would take up an awful lot of room on the PCB. So some very smart guys figured out a way to arrange things so that an entire 23 channel AM CB set could work on typically 12 or 14 crystals, with a couple more for sideband.

All of the 40-channel radios, and a few of the more advanced 23-channel sets, such as the SBE Formula "D", Horizon 29, Midland 13-882C, and Royce 1-601 "Gyro-Lock" use a special crystal-less process called "Phase-Locked-Loop", or "PLL". If after carefully inspecting the CB, you can only locate 1 to 3 crystals for AM, or 1 to 6 for AM/SSB, you definitely have a PLL-type radio. This is an entirely different problem area; when a PLL radio goes dead, it is completely dead on all 40 (or 23) channels during RX, TX, or both, unless the channel switch is bad.

Is there anybody out there who doesn't know what a crystal looks like? If so, study Figure 24. A CB crystal is simply a flat, rectangular-shaped metal can about the size of a dime, but thicker. (In old tube-type radios, you will find either the HC 18/U or more likely, the HC 6/U crystal, which is about the size of a quarter.) The crystal will either have its frequency stamped on the metal can, or the can will be covered with gray or black plastic with the frequency printed on it. (The larger HC 6/U crystals are not covered with anything.) The crystal will also either be soldered directly to the PCB, or else plug into a plastic socket which is soldered to the PCB. Crystals stick up vertically from the board, usually in 1, 2, or 3 rows. In some radios they are soldered directly to the channel switch. (Lots of fun to replace!) Sometimes, as in the new Royce "Wireless" models, the entire crystal assembly is on a separate PCB which is completely sealed in its own metal can and soldered to the PCB. (The can is about the size of a sardine can.) With plug-in types, the rows of crystals are often covered with a piece of tape across them to hold the entire row down on their sockets.

Figure 25 shows the crystal synthesizer schemes used in about 90% of all AM 23-channel radios. See if your crystals have the same numbers on them. If you find *different* numbers, especially for sideband sets, the "mixing" scheme is not the same; you will need a SAMS FOTO-FACTS, factory service manual, or crystal mixing chart such as that available from CB CITY. There are literally dozens of mixing schemes, especially for AM/SSB, and we cannot possible show them all here.

Dead channels on a CB radio will follow a *definite pattern*, usually in groups of 4 or 6 dead channels. You'll need an antenna, or possibly a second radio, to find out which channels are dead on RX. And you'll need a dummy load/light bulb or S/RF meter to determine dead TX channels. You may find the set is dead on *both* RX and TX for specific channels. Write down the affected channels, and refer back to Figure 25 or your own service manual.

As an example, let's say the CB has no RX *and* TX on Channels 1, 2, 3, 4. The only crystal *common* to all these channels for BOTH RX and TX would be the 37.600 MHz. of Scheme #2, or the 23.290 MHz. of Scheme #1. Looking at the chart will make it very obvious which crystals control which channels and function(s). Another example: Channels 1, 5, 9, 13, 17, and 21 are dead. In Scheme #2, this crystal could only be 10.635 MHz. for *TX only* or 10.180 MHz. for *RX only;* they are the only crystals *common* to those channels. In Scheme #1, this would be the 14.950 MHz. crystal, but it would affect *both* RX and TX modes. In Scheme #1, you will also note two additional crystals: 11.275 MHz. for TX, and 11.730 MHz. for RX. If either of these were bad, it would kill *all 23 channels* in that particular mode. And if the crystal(s) in a PLL set go bad, all 40 channels are dead.

Caution: Sideband is extremely touchy to properly tune in or "clarify." If you have ever used SSB, you already know this. All AM/SSB radios have tiny frequency trimmer adjustments wired across each crystal to set them on their exact operating frequency. Therefore, in replacing a crystal on a sideband set, the radio may work fine on AM but be impossible to tune in or clarify on SSB; it will seem like the clarifier control doesn't have enough range. If you experience this after changing a crystal, it will be necessary to use an accurate frequency counter, or consult an experienced repairman, to get the new crystal on its exact frequency. But you will still save money by doing the basic repair yourself!

Before you replace any crystals in a dead-channel problem, try these simple checks first:

1) After locating the correct crystal, re-heat its solder connections and test again.
2) Follow the colored wire that is soldered on the crystal's foil side to its switch connection. Re-heat this connection also.
3) Carefully inspect the tiny metal "fingers" on the channel switch, especially the one attached to that crystal wire. Rotate the switch all the way around to see if the finger is in fact touching the other metal switch sections in the appropriate positions. The movement of the metal finger is *very* slight; you will need sharp eyes and probably a penlight type of flashlight.
4) Many times, especially in the older tube-type radios, there is just some dirt or grease on the switch contacts. Try cleaning the switch first. Use a very good TV tuner type of degreaser, such as Chemtronics' TUN-O-WASH, followed by a lubricant such as Tech Sprays' BLUE STUFF. (Really!) Avoid the combination cleaner/lubricants; they're not as good. These chemicals come in spray cans with long plastic straws or flexible plastic tubes to make it easy to reach otherwise inaccessible places. And by the way, they are also excellent for cleaning "scratchy" squelch, volume, and switch controls.

If none of the preceeding steps cures the dead-channel problem, you definitely have a bad crystal. When you know which one, the hard part will be in finding one! The typical CB shop rarely stocks CB synthesizer crystals, due to the enormous cost and numbers involved. If you can't find one anywhere else, you can get one specially made for about $6-$7 from:

CAL Crystal Lab, Inc. 1142 N. Gilbert Anaheim, CA 92801 (714) 991-1580	or	JAN Crystals 2400 Crystal Dr. Ft. Myers, FL 33907 (813) 936-2397

When ordering, be specific. For example, tell them you need a ". . . .37.700 MHz. solder-in (or plug-in) synthesizer crystal for a CB radio." (Holder types are normally HC 18/U for solder and plug-in leads, and HC 6/U for older tube-type sets.) Don't forget to specify make and model!

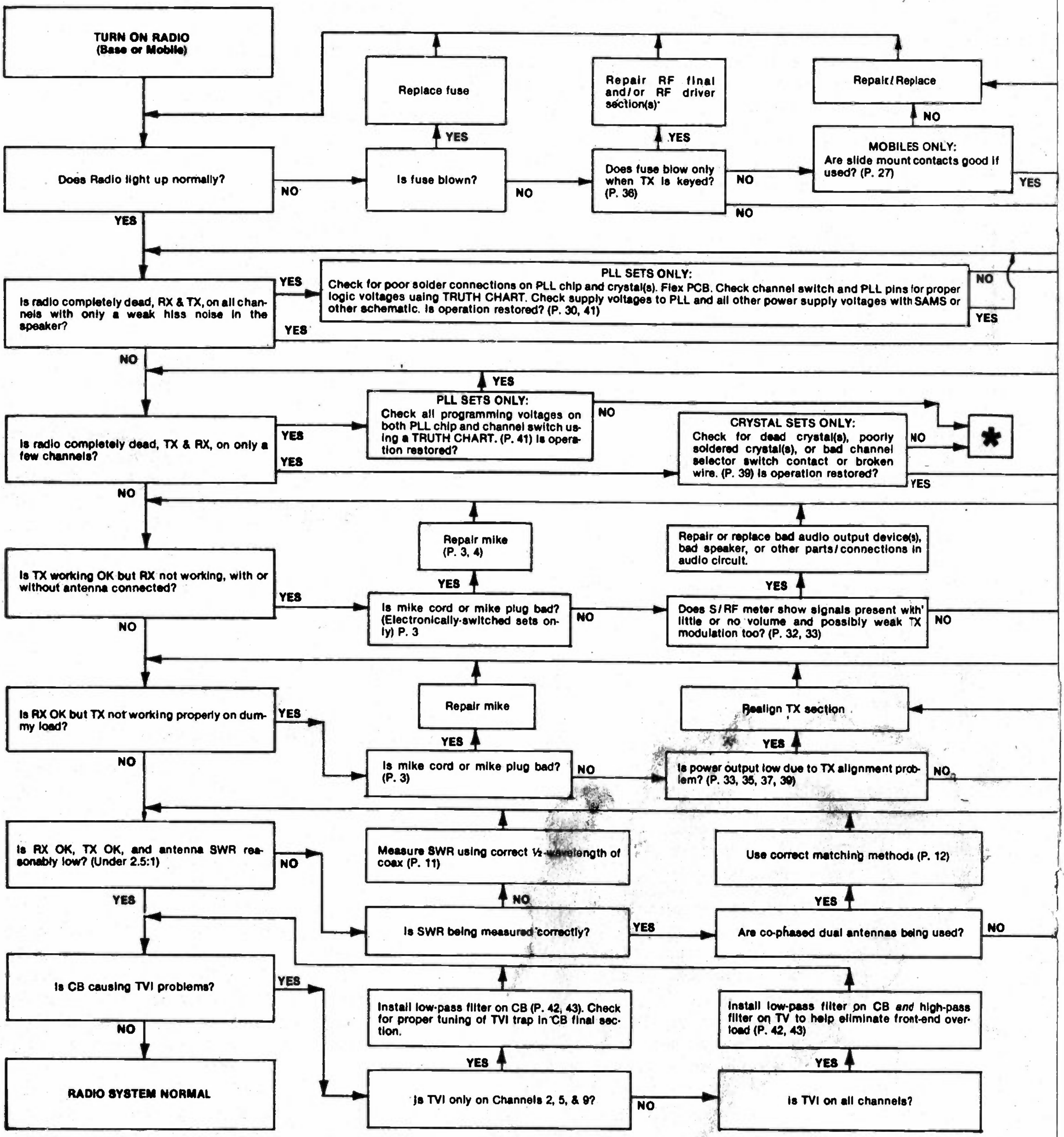
Information for crystals used in almost every kind of CB radio can be found by sending $2 to:

CTS Knights, Inc.
400 Reimann Av.
Sandwich, Ill. 60548 (815) 786-8411
(Ask for CB crystals catalog.)

PHASE-LOCKED-LOOP (PLL) RADIOS

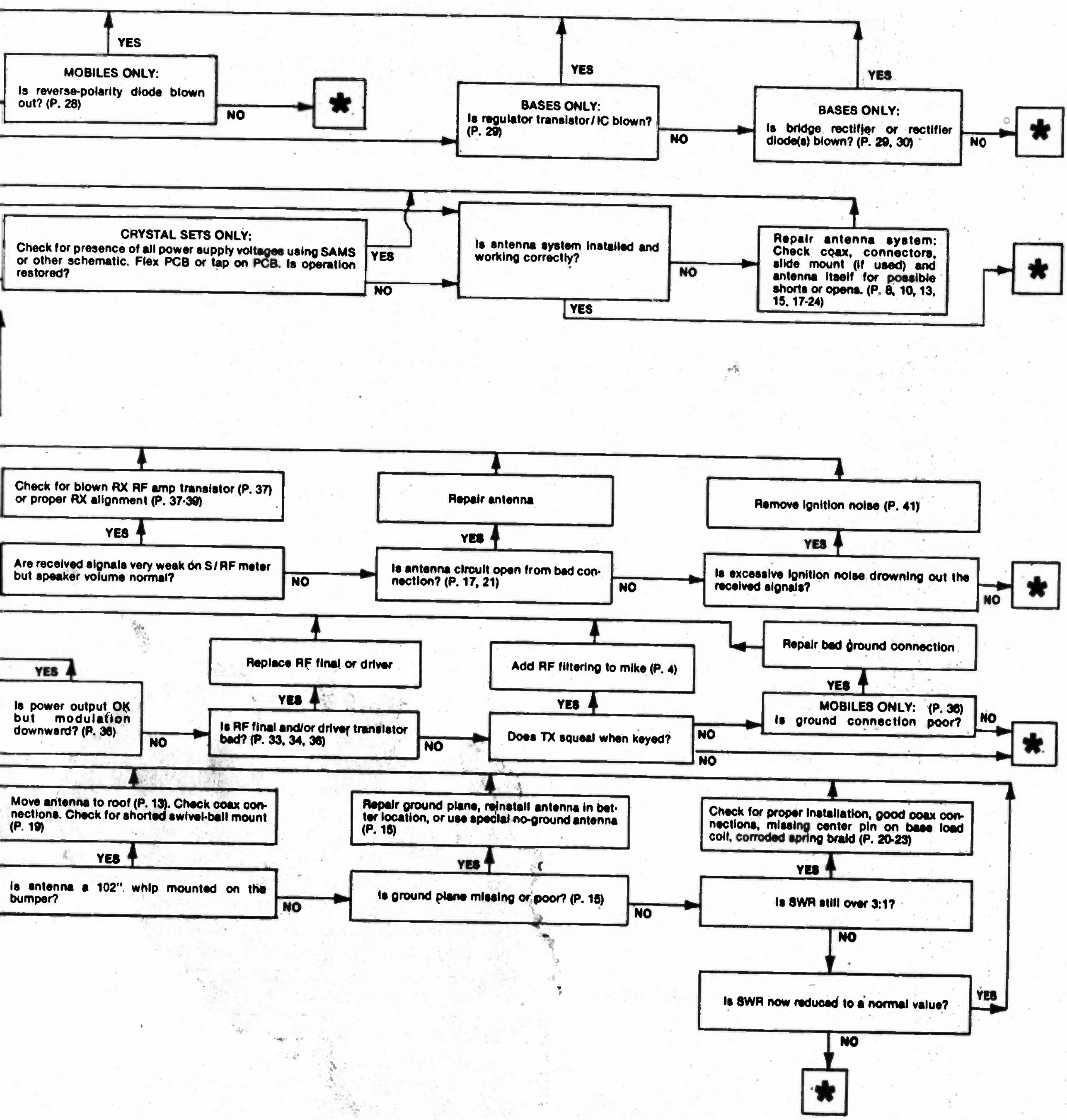
These are the ultimate in solid-state computer technology. All of the 40-channel CB radios and a few of the more advanced 23-channel sets use PLL to generate all the frequencies necessary to operate the CB. Typical PLL circuits for AM use one to three crystals, and sideband sets may have a few more. The entire PLL circuit is a microscopic "mini-computer" that is housed inside a little black multi-pinned Integrated Circuit, or IC. The newest radios use a single IC of 16 to 28 pins; older versions may use several individual 14 or 16 pin IC "chips." (A good example, the 23-channel SBE Formula "D".) Refer back to Figure 19 for an example of what these ICs look like. In addition to the IC, there are only a few external circuit parts used, the most important being the crystals themselves, which look exactly like regular synthesizer crystals, and a control to set the PLL on the exact frequency, such as a "mini-pot", also in Figure 19. In every other way, they will look EXACTLY like regular 23-channel sets, and you can still peak out TX, RX, and modulation

TROUBLE-SHOOTING FLOWCHART



INSTRUCTIONS: The flowchart is a logical step-by-step way to solve problems. Simply follow the arrows after answering the question "Yes" or "No". You will be guided to the general problem area and also may be referred to specific pages in the book for more detail.

✱ Indicates you have proceeded as far as possible without needing greater knowledge, more test equipment, or professional help.



adjustments once you know what to look for. As a matter of fact, almost every 40-channel set I've seen can easily be peaked out to perhaps 2 watts *more* than when it left the factory. (This may put you over the 4 watt legal limit for AM, or 12 watt PEP limit for sideband. However if a brand-new set puts out only 3 watts unmodulated, you are still entitled to that extra watt, which you can often get.)

Because of the PLL's complexity, an amateur without proper equipment and information may not be able to correctly diagnose PLL-related problems. Fortunately these ICs are very reliable, and it's rare to see one go bad.

The crystals used to control PLL circuits are no better or worse than those that were used in the older 23-channel sets. Manufacturers have tried to claim that since the PLL circuit uses fewer crystals, the crystals that are used are better quality. Pure baloney! I've seen many with bad crystals. Manufacturers of products for the mass consumer market are going to "think cheap" anytime they can, so keep this in mind. If the crystals should fail in a PLL-type radio, the entire set will be dead on all channels, both TX and RX. All you'll get is some weak background hiss noise from the speaker.

On the positive side, many PLL problems are simply a matter of cold solder joints where the PLL chip or crystal(s) is soldered into the PCB. So if the CB shows the "all dead" conditions just described, try wiggling the PCB and reheating connections first.

Occasionally a PLL rig goes dead on only a few channels, TX and RX. This is usually caused by a problem with the channel switch itself, or its connections to the PLL programming lines. You can easily check this out by measuring the DC "logic levels" on the PLL programming pins. To do this, you'll need what's called a "Truth Chart." This is simply a list, by channel, of what DC voltages you should see on each of the PLL's program pins. However instead of actually showing voltages, the chart shows a group of "1's" and "0's" which represent the voltages. All you need to do is remember that a logic "1" is some DC voltage of about 4-8 volts in most radios, and a logic "0" is usually 0 volts DC. So just connect your trusty VOM with the black (–) lead on the chassis common foil or black power lead, and then touch red (+) lead to the programming pins shown on the chart. By going right down the list of Channels 1-40, you'll quickly see if the correct programming voltages are getting to the PLL. If not, you'll have to trace back (using a schematic diagram) to the channel switch itself to find the fault. Incidentally, by studying the sequence of numbers used in the PLL Truth Chart, you can figure out exactly what numbers are missing from the chart that control the 5 "A" channels (3A, 7A, 11A, 15A, 19A) so that you can modify the set for those frequencies. Truth Charts are available in the SAMS Fotofacts and from CB CITY. Detailed modifications are described in our PLL DATA BOOK. Write for current prices.

Note: Occasionally one of the actual PLL programming lines itself goes bad, especially if somebody has been tampering with the IC and accidentally shorted out a pin. In that case, the PLL IC must be replaced.

Introduction To Frequency Conversions

With today's crowded channels, many people in our hobby are looking for some more "elbow room," and often ask me about conversion of 23-channel sets to 40 channels, or adding entirely new frequencies to 40-channel rigs. The methods for doing this depend of course upon whether we're talking about crystal radios, or PLL radios. Since crystal-controlled sets are getting a bit scarce these days, we're not going to go into great detail about them. (At the end of this text is an Appendix which describes PLL conversions more specifically.)

With regard to crystal radios, you can convert your old 23-channel rig to cover the 17 additional frequencies, or any others, in one of two possible ways:

1) You could replace one or more of the synthesizer oscillator's "mixing" crystals to get a new group of channels, at the expense of losing 4 or 6 of the older channels. (Remember, each synthesizer crystal controls 4 or 6 channels.)

2) To get really fancy, you could build or buy a "crystal selector box" to add all the other necessary crystals without losing the original 23 channels. This is more expensive and complicated. What you do is unsolder one of the crystals from the rig, and replace the now-empty holes in the PCB with a shielded wire, such as RG274/U, which runs from the output of your external crystal box. This can get tricky, though, because even the tiny bit of capacitance from a short piece of coax can be enough to upset the oscillator circuit, pulling it off frequency or worse, killing the synthesizer oscillator completely.

   Many people simply wire in one additional "special" crystal right into the rig and use a panel switch such as the PA/CB switch to change frequencies. However you still may have the problem of that extra capacitance in the shielded cable which runs to the switch.

Here's a quick example of Method #1:

Refer to the crystal chart of Figure 25. In Scheme #2 you see a 37.800 Mhz crystal, which controls both TX and RX for Channels 17-20. By replacing this with a crystal of say, 37.950 Mhz (and possibly some retuning), you would get Channels 31, 32, 33, and 35 in the expanded CB band. The possibilities for conversion are endless, depending upon whether or not you don't mind losing a few of the older frequencies to gain some new ones. This method is quick and easy, and you don't have to worry about killing the oscillator circuit with unwanted extra "shunt" capacitance across the crystal, as you would if using Method #2.

PROBLEM: Vehicle Ignition Noise

It is pure bad luck for CBers (and hams) that automobile ignition noise just happens to be "vertically polarized," because so is your antenna. This makes it easier to pick up ignition noise right out of the air from the antenna. Magnetic antennas are especially subject to this because they are ungrounded. Often just replacing a magnetic with one using a direct metal-to-metal vehicle contact mounting will completely eliminate the noise.

Any electrical discharge that causes a spark, like spark plugs, electric motors, lightning, etc., is actually a form of radio wave. Oldtimers who remember the "spark gap" days of radio know what I mean. THE ONLY WAY TO ELIMINATE CAR IGNITION NOISE IS AT ITS SOURCE; i.e., the engine. I have never seen *any* add-on hot lead filter or spark noise suppressor that really worked. Certain makes of cars, and certain CB models, are notorious for noise. Combine these and you have a real problem.

There are so many excellent books and articles available in CB and electronic magazines describing noise cures that it would be pointless to repeat it all here. You are referred to them to learn what each type of noise sounds like. Keep in mind there are two basic types of noise troublesome to CB radio:

1) Noise generated by any electric motor, such as the windshield wiper motor, electric fuel pump, generators or alternators. These noise problems will normally stop with the proper filtering at the source.
2) Engine ignition noise. This is the most common, and the hardest to cure. None of the filters for spark plugs, hot leads, etc., seem to work. The correct way to cure the problem is to completely shield the ignition system with special, metal-covered ignition wires, and a metal can over the distributor. This is *very* expensive! Cheap filters don't work at all.

So, what to do? There is only one item on the market I know of that will greatly reduce ignition noise. And even this does not eliminate the noise; it only masks it so you cannot hear it. After you've banged your head against the wall and tried all the usual filters that don't work, be prepared to spend about $35 and get yourself an ignition "noise-blanker", Model INE-70, available from:

TEST, Inc.
16130 Stagg St.
Van Nuys, CA 91409 (213) 989-4535

It will probably take you an hour to figure out how to install it, but will be worth it. This works on a very similar principle to the noise-blankers found in better CB radios, although many of *them* never seem to work either. What a noise blanker does is to literally punch "holes" in the received signal so fast that the human ear cannot hear it. This is theoretically very easy, because noise has a much shorter time interval than a CB radio signal. So if you can "blank out" the noise pulse, you still hear the signal, minus the noise. What you hear is just one nice clean, continuous signal.

The TEST unit is a unique device that connects between the vehicle ignition spark coil/distributor and the CB radio speaker leads. It is therefore electronically synchronized perfectly to the running engine, regardless of RPM. (I find that it works even better at high RPM than at idle speeds. And high RPM is normally the noisiest.) When the coil fires it electronically disconnects the CB speaker; this occurs so fast your ear cannot detect it, in exactly the same way your eyes cannot see the flourescent lights in a room flashing on and off 60 times per second. This device will only work for *ignition* noise, and only on your own vehicle. So make sure the noise problem is in fact ignition noise. And if you have a souped up, racing-type engine with dual points, etc., there's no guarantee it will work perfectly.

PROBLEM: TV and/or STEREO INTERFERENCE. (How To Peacefully Co-exist With The Wife Or Neighbors)

Unless you're using a linear amplifier to boost TX power, the problem is most likely *not* in the CB radio. Trying to convince the neighbors is another thing, especially when they have to pay for the filters and/or repairmen. Unfortunately about 90% of all TVI/RFI problems are due to poor design and filtering in the affected equipment. These manufacturers simply refuse to spend the extra $2 in parts to prevent the interference, reasoning that such extras will increase the retail price of their products to all consumers, even though only a small number of people will ever actually need the filtering. There were several unsuccessful attempts in Congress to make the equipment manufacturers do this, but so far, no luck. Thus the real problem is in trying to explain the situation to your neighbor!

Assuming the station is completely legal, what do you do? Stereo or audio interference (RFI) is usually much more complicated to track down and cure than television interference (TVI), due mainly to the greater number of interference entry points in a fancy sound system. But stereo manufacturers are just as cheap and competitive as CB manufacturers when it comes to that extra $1.00 worth of filter parts. Because RFI can get very complicated, it will not be discussed here. Informative articles have been published by several excellent sources, and you are referred to them:

1) Stereo Review Magazine, May, 1977. (One Park Ave., New York, N.Y. 10016)
2) Radio-Electronics Magazine, March, 1977. (200 Park Ave. South, New York, N.Y. 10003)
3) American Radio Relay League, 225 Main St., Newington, CT. 06111. Ask for "RFI Packet." Free to members.
4) In June, 1977, the U.S. Government Printing Office published a book, "How To Identify & Resolve Radio-TV Interference Problems." This book is sold directly from the Federal Communications Commission, 1919 "M" St., Washington, D.C. 20554. Price $1.50.

An even better idea is to become friendly with a sharp ham radio operator. An experienced ham may have a lot of personal expertise in the area of RFI/TVI, and can also introduce you to a great new hobby.

CURES FOR TELEVISION INTERFERENCE (TVI)

TVI is usually easy to cure. But first you must know which of the two main types of TVI you can create. These are:

1) Interference only to TV channels 2, 5 and 6, 9;
2) Interference to all TV channels.

With TVI only on Channels 2, 5, 6, or 9, the problem is caused by "harmonic radiation" from the CB. CB sets have built-in filters for this, but they are rarely good enough. All you need do is add a *good* "low-pass filter" to the antenna socket of the CB through a small length of coax with plugs on both ends. (If using an SWR meter and/or other station accessories, refer back to Figure 11 for proper placement of the filter.) A good filter has absolutely no effect on the performance of a CB. DO NOT BUY bargain brands! The only kind I recommend are made by J. W. Miller or Drake, such as the Drake TV42LP.

If the low-pass filter is not sufficient, you can also add a "high-pass filter" to the TV set itself where the antenna connects to it. The best ones are made by Drake, J. W. Miller, Microwave Filter Co., and VITEK Electronics. A typical example, the Drake TV300HP. For cable TV, TVI is rarely a problem because the cable is all shielded anyway. If you find yourself needing a filter though, you can get good ones from RMS Electronics (#2600F), or VITEK. They make special filters for cable TV interference problems.

You can also make your own low and high-pass filters using a few "cheap & dirty" techniques:

Low-pass filter
Get a coax "T" connector, such as Amphenol 83-1T, or Gold Line GL-271. Connect the male end to the CB, and one of the female ends to the antenna. Then make up a 9 foot piece of RG 8/U or RG 58/U (doesn't matter which) with a connector on one end, which you connect to the remaining female side of the "T". Stick a pin or sewing needle through the end of that piece so that it shorts out the center coax wire to the shield braid. (Make *sure* it shorts out.) Tune the TV to Channel 2 or 5, key the mike, and start moving that pin or needle about 1" at a time until TVI is minimized. At that point, cut the 9 foot piece and make a permanent center-wire-to-shield connection. See Figure 26. Technically this is called a "¼-wave trap."

High-pass filter
For non-cable TV systems only. Connect a 7 foot piece of standard 300 ohm TV Twin-Lead across the 2 TV antenna screws right along with the twin-lead that's already on it from the TV antenna. Do NOT short it out this time. Now tune to TV channel 2 or 5, key the mike, and start clipping off about 1" of the extra piece at a time until TVI is minimized. This will usually occur somewhere around 6 feet. Just leave that extra piece hanging there. This is also a "trap". See Figure 27.

TVI on all TV channels:
This problem is called "front-end overload." It rarely occurs on cable TV systems, but only on "rabbit ears" or outdoor TV antennas that are physically very close to the offending transmitter. It happens because the TV manufacturer was too cheap in his design to include the necessary filtering, so the TV is unable to reject *any* strong, unwanted nearby radio signal, whether from CBer, ham, police, etc. The first thing to do is to physically separate the CB and TV antennas as far as possible, AND mount both antennas in *different* horizontal elevations; i.e., make sure they're different heights above ground. A high-pass filter also helps greatly.

If your problem with front-end overload still persists, I have another simple (and little-known) trick:

> Cut off the TV twin-lead about 6" from where it connects to the TV set. Strip and twist together both wires of each of the two cutoff ends. Now, while observing the TV picture on the lowest channel you would normally use, lay the two flat shorted twin leads *over each other* so that they overlap. See Figure 28. Start with about 2" of overlap, and slowly slide the two twin-leads over each other until you have *just enough* overlap to eliminate the "snow" from the TV picture on all channels you normally use. Then just tape the two overlapping twin lead sections together at that point. This trick will often cure or greatly reduce the worst cases of front-end overload. (We'll skip the technical explanation on this one!)

One final word: Be sure the SWR on the base antenna is as low as possible, and especially be sure there are no corroded coax connections anywhere. A corroded connection is a sure-fire cause of harmonic generation, so all the filters in the world at the CB won't help if the harmonics are created up at the antenna. Also a high SWR can cause the CB signals to be radiated *from the coax shield itself;* we want only the antenna to radiate signals.

23 vs. 40-CHANNEL PERFORMANCE

As you probably know, 23-channel CB radios are no longer legally sold in the U.S., but many people still use them, and will continue to do so for a long time. Unfortunately, there was a great deal of bad publicity and some totally misleading information about the capabilities of the 40-channel PLL sets, particularly in regard to the power output and modulation. This information was totally false. Dealers and distributors who got caught "with their pants down" at the time of the FCC 40-channel decision were desperate to sell radios which they thought you would consider obsolete. They were willing to say *anything* to move those older models, and that's how those nasty rumors got started.

The 40-channel sets are better than their 23-channel counterparts in almost every respect; even the prices of comparably-equipped models are the same. The sets I've seen have just as much TX power output as the 23's, with very clean, high modulation levels near 100%. A few lines such as Motorola and President have sophisticated speech processors already built in; these give more talk-power and range than any 23-channel set ever could.

The PLL design is more dependable and accurate than crystal control; when everybody has one, there will probably be no need at all for delta tune and clarifier controls, even on SSB! And, the increased filtering and shielding required by the FCC will greatly help to eventually stop TVI/RFI problems. So don't be too concerned about the lack of performance in these radios; there really is none, and it's always going to be a good choice when upgrading your equipment.

THE FUTURE OF CB RADIO
SSB Means Real "Talk Power!"

With the CB channels as crowded as they are today, you need every bit of help possible to establish and maintain a good QSO. That's where SSB is a great advantage over AM (**A**ncient **M**odulation!). Because the RF power is transmitted only when you talk into the mike on SSB, there is very little power wasted in generating a "carrier," as with AM. In fact, the theoretical advantage of SSB over AM is a whopping *9 db.* — that's a power increase of 8 times! And just as important, a sideband signal only occupies half the space of AM, which means that it's possible for two stations, one on USB and one on LSB, to be talking on a single channel together where only a single AM station can fit. It makes a lot better use of our channels.

There's been a large push toward the establishment of SSB-only channels to help reduce the interference problems of the two incompatible modes. Maybe by the time you read this, such channels will already exist. It's a giant step forward for CB radio.

As far as repairs go, the increased complexity of SSB makes special equipment a necessity; specifically, a good frequency counter and oscilloscope for certain problem areas. You can still perform the peaking adjustments already described in exactly the same way. Also the modulation and ALC adjustments. However, for problems with PLLs and other frequency control circuits and modifications, you'll really need a counter. Fortunately, current technology is such that you can buy any number of good counters for under $100; maybe even less if you're clever or can assemble a kit. You could probably get by without the 'scope, unless you're a professional or studying to become one.

Many of the operating techniques used on SSB, such as the use of first names and Q-codes, have been borrowed directly from ham radio. However being a ham myself as well as a CBer, I've noticed a definite lack of certain really useful SSB-type accessories. It seems hams have always had these around, but they've been sorely absent from CB-type sideband. If you'll please pardon the commercial plug, I'd like to tell you about a few of our newest offerings; we think they'll interest the serious SSB operator. They include:

DYNAMIC SPEECH PROCESSOR: An inexpensive and very effective way to get maximum "talk power" the way the pros do. Ever wonder why TV commercials always seem louder than the rest of the program? Speech processing is the reason. This tiny IC module operates on the well-known principles of audio clipping and selective filtering of low-power and harmonic frequencies. The result is that your voice power is concentrated in the sounds having the most power, and can often create a dramatic increase in apparent signal strength. Available kit or asembled.

VOX VOICE-CONTROLLED T/R SWITCH: Long used by hams, you key the rig simply by speaking into the mike. Pauses in speech cause the radio to return to the Receive mode after a delay determined by the operator. This is a very compact module which easily installs in parallel with the existing T/R radio circuits, so that normal push-to-talk switching is still possible. It even contains its own tiny relay so that it will work with virtually any type CB rig having electronic or relay switching. Available kit or assembled.

MICROMONITOR PLL FREQUENCY EXPANDER: This highly sophisticated PLL controller takes over all frequency-determining functions of the radio, so that the operator is free to move anywhere within the tuning range of the radio's circuits in 5 Khz steps. Frequencies are punched in directly on a hand unit, just like a pocket calculator. It also scans in several different modes, can store 5 frequencies in memory, and has no permanent effect on the controlled radio; radio operation is completely normal when the device is unplugged or turned off. Very similar to having a VFO, but a lot more!

Write for details on all these new products.

900 MHZ AND YOU

Someday soon there's going to be a new CB-type radio service available for the serious business (and possibly hobby) operator. The 900 Mhz band is the most likely candidate; this is a *very* high-frequency area almost in the microwave region. Yep, you can talk with the same stuff that cooks your dinner! I foresee the time when many people will use this band for skip-free communications in a local area. It's very quiet, and the frequency used makes it possible to have very high-gain antennas that are no more than 8-10" long! Because its radio waves only travel "line-of-sight," there is no skip, ever. However, by the use of a "repeater" in a high spot, you could talk reliably up to about 100 miles! Don't look for this service to ever replace the 27 Mhz CB service. It's not a replacement, only a new choice. The serious skip-shooters and hobbyists among us will always want our good old Class D for a long time. But soon we'll have a choice of two different types of radio! And naturally, when this band becomes popular, CB CITY will try to provide specialized information and accessories for it.

Well, that's about it, my friends. You should now be armed with enough knowledge and insight to repair about 95% of your CB radio problems yourself, and maybe even make some money at it. Just keep in mind that like the cars we drive, the only thing science will never perfect is the "nut behind the wheel." We'll still see plenty of *bad* mikes, *bad* antennas, and *bad* installations. Which still leaves you plenty of chances to cash in big on the CB repair business! As our great CB radio hobby continues to grow and improve, CB CITY will try to offer you new products and specialized technical information. Write us any time for a current catalog, or just to say "Hello!" and pass along your comments. Meanwhile, good luck, good numbers, and don't solder your thumbs together!

73s,

Lou Franklin

"SUPERSPARKS"
KZB4389/K6NH

REFERENCES

Japanese replacement parts:

New-Tone Electronics 44 Farrand St. Bloomfield NJ 07003 800-631-1250	or	FUJI-SVEA P.O. Box 40325 Cincinnati, OH 45240 1-800-543-1607

These companies usually advertise in the back pages of POPULAR ELECTRONICS, RADIO-ELECTRONICS, CB, S-9, etc. Both are about half the price of equivalent American-made transistors/ICs.

Antenna Information:

Wm. Orr. *The Truth About CB Antennas, Beam Antenna Handbook, & All About Cubical Quad Antennas.* Radio Publications, Inc. Box 149, Wilton, CT 06897.

Wm. Orr, *Radio Handbook.* Editors & Engineers, Div. Howard W. Sams Co., Indianapolis, IN 46268

American Radio Relay League, *ARRL Antenna Handbook,* and *The Radio Amateur's Handbook.* ARRL, 225 Main St., Newington, CT 06111

Radio-Electronics Magazine, October, 1976, P. 82. (200 Park Av. South, New York, NY 10003). Excellent discussion of SWR & coax length.

Antenna Facts & Fables, The Antenna Specialists Co., 12345 Euclid Av., Cleveland, OH 44106. An excellent, non-technical freebie.

Service Information:

CB CITY (address on inside front cover). Specific tuneup, modification and parts information and other technical services.

SAMS Fotofacts, Howard W. Sams Co., 4300 W. 62nd St., Indianapolis, IN 46268. Thousands of schematics, photo parts layouts, etc., for almost every CB radio ever made.

APPENDIX A
Frequency Modification for PLL Radios

At this writing, there are several methods for adding extra frequencies to PLL-controlled CB radios. However, please be warned that the CB manufacturers, under pressure from the FCC, are beginning to use some very sophisticated ways to prevent this. Their main method is to use an IC which, first of all, only requires a single crystal, and secondly, is internally programmed to reject any non-legal channel codes on its programming pins. What happens is that the PLL IC has a permanent "memory" inside it which can only recognize programming voltage codes that are part of this memory. This method is call **"ROM"**, a computer-type phrase meaning "**R**ead **O**nly **M**emory". The best possible way to outsmart this is to replace the reference oscillator with a homebrew of your own design. Appendix B does show an example of the crystal-exchange method. (One PLL using this special technology is the TC9109P, which is used in some Cobras, Presidents, and Teaberrys.) So if you're planning to modify, it's best to have a CB that uses a simple binary programming code, such as the PLL02A, PLL03A, MB8719, etc.

Meanwhile, there are two main ways to get those extra channels which can be used in about 90% of the current PLL radios. To really understand these methods, you must become familiar with some simple digital electronics. The way you can do this is to study what's called a "Truth Chart." This is simply a summary, by channel, of what "logic" voltages are needed on what PLL program pins to produce a certain frequency. Here's an illustration of part of a Truth Chart:

	÷ N Code	Pin 9	Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Pin 15
Ch. 1	74	1	0	0	1	0	1	0
Ch. 2	73	1	0	0	1	0	0	1
Ch. 3	72	1	0	0	1	0	0	0
Ch. 3A	71	1	0	0	0	1	1	1
Ch. 4	70	1	0	0	0	1	1	0

Anywhere you see a "1", this means that there is a DC voltage, usually from about 4-10 volts, present on that particular IC pin. The "0" means that there is normally no voltage present; i.e., that pin is now grounded. Each channel shows a set of 1's and 0's associated with it. This set represents a number called "N". All you have to understand is that for each frequency, there is a specific "N" number which is used to **divide** the programming crystal's frequency down by a certain amount. You've probably seen the term "Divide-by-N" used where PLLs are explained, and that's what this means. Each PLL circuit has a definite set of these "N" numbers from Channel 1 to Channel 40. These numbers are all consecutive, *except that they skip a number any time there is no legal CB channel for that number, or the legal CB frequencies are not consecutive.* For example, Channel 3 is 26.985 Mhz, and Channel 4 is 27.005 Mhz. Notice anything? That's right — they skipped 26.995 Mhz! This is Channel 3A, an unauthorized CB channel. It's quite obvious that if you had the correct "N" code, you could get that channel! Any PLL using a "binary" code can thus be changed.

Another example is what happens around Channels 22 through 26. These are assigned *out of order*, as shown:

Channel 22	27.225 Mhz
Channel 23	27.255 Mhz
Channel 24	27.235 Mhz
Channel 25	27.245 Mhz
Channel 26	27.265 Mhz

Thus when you examine the "N" codes for these channels, they will also be out of order.

By now you're probably wondering about all this "binary code" stuff I just mentioned. Well it's really very simple, and you don't have to be a math genius! Shown here is a single channel's program code. There are 7 "bits" of 1's and 0's used, although there could be as many as 8 bits, or as few as 5 bits on some older 23-channel PLL sets. (Midland 13-882C, etc.) Above each bit is a number which is a "power-of-2". This is simply the number "2" multiplied by itself up to 7 times (for 7 bits). Thus, 2x2x2x2x2x2 is 64, or 2x2x2x2 is 16, etc. These powers-of-2 are what is meant by "binary" numbering, since the word "binary" itself means "a group of 2 things."

	Pin 7	Pin 8	Pin 9	Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Pin 15
Powers of 2	256	128	64	32	16	8	4	2	1
÷ N Code is									
330 (Ch. 1)	1	0	1	0	0	1	0	1	0

NOTE: Bits on Pins 7 & 8 are shown here but would *not* be shown in normal TRUTH CHART because they never change.

Now looking again at our example, let's simply add up all the powers-of-2 for every bit where there is a "1", and ignore all "0" bits. If we do this, you'll see that this program code set adds up to 74 in our normal everyday decimal number system. (64 + 8 + 2 = 74) Now, according to the manufacturer's specs, the "N" codes used for this radio, or divide-by-N code for this particular channel, is "divide by 330." Well, we only have 74 so far, so where do they come up with 330? Surprise! There is also a 1's bit on Pin #7 of the PLL chip. And Pin #7 represents the power-of-2 number 256. So, 256 + 74 = 330. Simple! They didn't bother to tell you this or show you this on the Truth Chart, because these extra programming pins (7 & 8) are permanently wired to make them either a "1" or a "0" *on all 40 channels*. This gives them (and us!) the divide-by-N codes we need to get the final frequency. And even though they didn't tell us, it's usually very simple to figure this out by simply examining the PLL connections on the schematic diagram. If you did, you would see that Pin #7 is tied to a high DC voltage ("1" bit) while Pin #8 is tied to ground. ("0" bit.) Also, most PLL ICs use consecutive pin numbers for programming such as Pins 7-15 for the PLL02A. However, this is NOT always true for every PLL chip used, so you'll have to study the schematic carefully.

You should realize by now that if you can place the correct N-code on the PLL, you can change the frequency to almost anything you want, within the tuning range of the radio's circuits. In the above example, the N-codes are divide-by-330 for Channel 1 up to divide-by-286 for Channel 40. If you now look again at our sample Truth Chart, you will see the following:

	÷N Code	Pin 9	Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Pin 15
Ch. 1	330	1	0	0	1	0	1	0
Ch. 2	329	1	0	0	1	0	0	1
Ch. 3	328	1	0	0	1	0	0	0
Ch. 3A	327	1	0	0	0	1	1	1
Ch. 4	326	1	0	0	0	1	1	0
⋮	⋮							
Ch. 40	286	0	0	1	1	1	1	0

NOTE: Pins 7 & 8 not shown.

We already learned that Channel 1 is divide-by-330. Channel 2 is 329, Channel 3 is 328, *and Channel 4 is 326*. They skipped divide-by-327, because this is not a legal CB channel. However, if you could set up a divide-by-327 code, you could get this channel. (#3A, 26.995 Mhz.) By the exact same reasoning, you can get "Channel 41", 27.415 Mhz, by setting up a divide-by-285 code. And since CB frequencies change in 10 Khz increments, you could continue changing the N-codes to get even higher (or lower). As far as programming, most CB PLL chips are capable of up to 128 or 256 channels! However there are other problems too that appear when trying to expand the set's frequency range. More on that later.

Powers of 2		4	2	1	8	4	2	1
	CODE SUM	Pin 13	Pin 14	Pin 15	Pin 2	Pin 3	Pin 4	Pin 5
Ch. 4	0,5	0	0	0	0	1	0	1
Ch. 5	0,6	0	0	0	0	1	1	0
Ch. 6	0,7	0	0	0	0	1	1	1
Ch. 7	0,8	0	0	0	1	0	0	0
Ch. 7A	0,9	0	0	0	1	0	0	1
Ch. 8	1,0	0	0	1	0	0	0	0
Ch. 9	1,1	0	0	1	0	0	0	1

Now let's examine another type of Truth Chart coding. Shown at the bottom of the left-hand column is another 7-bit program code. Look carefully at Channels 6, 7, 7A, and 8.

If we were using the straight powers-of-2 counting method as in the binary code just described, we would suddenly jump from a value of "8" for Channel 7 to "16" for Channel 8. Obviously something's wrong here. What's happened is that we have changed over to a new type of code, called **"BCD"** for "**B**inary **C**oded **D**ecimal." All this means is that the group of 7 bits is simply broken down into one group of 4 bits (Pins 2, 3, 4, 5) and one group of 3 bits (Pins 13, 14, 15). Each group is counted up for its binary value just like before; the sum total we get by adding up each group separately is then represented *by a single decimal number*. So in the case of say, Channel 7, our code is "0, 8." Then for Channel 8 the code jumps up to "1, 0." Again, they skipped over Channel 7A, because it's not a legal CB channel. However, we can fill in the gap very easily again by seeing what would logically go in this empty space. The answer is, "0, 9!" So we could get Channel 7A by connecting the correct logic voltages to the PLL IC pins. The BCD coding method is used in about 15% of PLL circuits. Usually this is done because many channel selector switches are already set up to spit out a BCD code rather than a straight binary code. And since most 40-channel rigs also have digital LED-type channel displays, this type of code simplifies the method of also displaying the channel at the same time. (Most decoder ICs that drive the display LEDs require BCD inputs.) We could also have a 6-bit or 8-bit BCD arrangement. You have to study the Truth Chart for your own set before attempting these frequency conversions.

Now we'll look at one last type of Truth Chart, a section of which is shown here.

Powers of 2		8	4	2	1	8	4	2	1
	CODE SUM	Pin 8	Pin 7	Pin 6	Pin 5	Pin 4	Pin 3	Pin 2	Pin 1
Ch. 6	0,6	0	0	0	0	0	1	1	0
Ch. 7	0,7	0	0	0	0	0	1	1	1
Ch. 7A		no N-code possible							
Ch. 8	0,8	0	0	0	0	1	0	0	0
⋮	⋮								
Ch. 23	2,3	0	0	1	0	0	0	1	1
Ch. 24	2,4	0	0	1	0	0	1	0	0
Ch. 25	2,5	0	0	1	0	0	1	0	1
Ch. 26	2,6	0	0	1	0	0	1	1	0

This code appears to be a simple 8-bit BCD type, where each group of 4 bits is represented by a single decimal number such as "0, 7" for Channel 7. Notice though that there is no way to fill in the gap for the "A" channels. Also notice that Channels 23-26 do not skip around but are called out directly by their own code, *even though the frequencies of these channels do skip around.* This chart happens to be one of those sneaky cases I first talked about; namely, the Divide-by-N code is controlled *internally* in the IC chip, and not by any logic voltages on its program lines. The PLL uses internal ROM, and is really a very slick mini-computer. It has a permanent memory built in which can only recognize the legal 40 channels and then proceed with its divide-by-N circuit. There is no way you can make it give you any other frequencies, as in the previous examples. The only possible way to get other frequencies is by changing the reference crystal, and this is not advisable since too many internal IC functions depend upon it. What you could do is actually build a small oscillator on a frequency which would mix with what you need, and disconnect the radio's own oscillator. Better to modify a set which uses one of the more common BCD or binary coding methods. By the way, examples of ROM-controlled PLLs are the TC9106P, TC9109P, uPD861C, uPD2810C, uPD2814C/HD42851, and uPD2816C. If your set uses one of these, you're out of luck.

MORE CONVERSION PROBLEMS
(Easily Solved!)

An important section of the PLL circuit which you should know about is called the "Lock Detector" or "Out-of-Lock" switch. Most PLL ICs have one pin on them devoted to this function. What happens is that this pin produces a DC voltage (or removes a DC voltage) at the transmit mixer stage to completely kill the transmitter if the PLL circuit is not "locked" on frequency. This usually happens only when the programming commands are such that a frequency is programmed that is too far away from the VCO's operating range for it to "capture" and lock up. This is not necessarily caused by tampering, but could just as well be a failure somewhere in its own circuit.

If you are simply trying to get the five "A" channels, or just a few upper and lower frequencies near the CB band edges, you probably will never have to worry about the lock detector being activated; most VCO's (**V**oltage **C**ontrolled **O**scillator) can swing a wide frequency range around the CB band. However if the intended modification involves a large shift, say, 1 or 2 Mhz (such as in ham 10-meter conversions) this circuit will probably turn on and disable the transmitter. So what you must do first is to disable the disable circuit itself. You can do this easily in most cases by simply cutting the foil on the printed circuit board that connects to the PLL's lock detector pin. You'll need a schematic to figure out which pin this is. (CB CITY also provides this information.)

After doing this, you may still have problems. The program code you set up may still swing the VCO too far out of its range to lock up. Often you can simply retune the VCO coil into the new range with no complications. However in some cases it may be necessary to actually change the value(s) of frequency-determining parts such as capacitors in the VCO circuit. Since every CB is different, we can't possibly describe this further here. You'll have to read up on PLL theory from some of the CB/Ham magazines and books if this is your situation.

HOW TO DO IT

We first mentioned two main ways to change or add channels. Now we'll show you some actual examples of each. These methods are:

Method #1 — Change the reference crystal.
Method #2 — Change the PLL's programming logic voltages.

Appendix B shows some examples of the crystal-exchange method. By changing the crystal, you get an entirely new set of 40 channels. Sometimes you can simply use a switch, such as the CB/PA switch, to change crystals. However as already explained, this method will definitely require retuning and possibly defeating the Lock Detector circuit too. This method is commonly used for ham conversions where permanent retuning is OK because the original 40 CB channels will never be used anyway. However if you expect to get the normal 40 channels as well as new ones, you cannot stray too far from the radio's design limits. You can't have your cake and eat it too! For getting just a few channels without a lot of realignment, Method #2 is better.

NOTE: Some PLLs can be changed just as easily by either method. For example, the PLL02A (a very common chip) can be changed by swapping out the reference crystal according to the formula:

New Crystal = ⅓ N ± 11.806,
where N = desired frequency
above or below Channel 1.

This applies only to sets using an 11.806 Mhz crystal, such as the Midland 13-882C, RCA 14T300, or HyGain 2702. (There are many others.)

Example of new crystal: Suppose we wish to move up 900 Khz above Channel 1. (26.965 + .900 = 27.865 Mhz for Channel 1 position.) Your new crystal would thus be:

⅓ of 900 + 11.806 = 12.106 Mhz

The PLL01A (23-channel HyGains, Kracos, etc.) can be modified the same way, except that the formula now changes to:

New Crystal = ½ N ± 11.806

CONVERSION BY PROGRAMMING LOGIC CHANGE

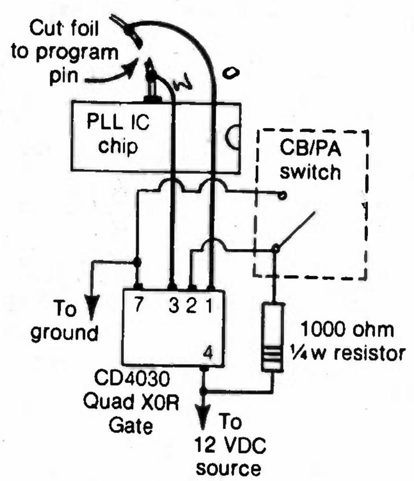
You've already learned about changing PLL programming codes to get new frequencies. Now you're probably wondering, "How do I actually do it?" I'm going to suggest two simple ways to apply logic signal voltages on the PLL IC's programming pins. Then the rest is up to you!

Method A — Getting The 5 "A" Channels

I've devised a very simple and clever way to get the 5 in-between "A" channels. These channels are:

Ch. 3A	26.995 Mhz
Ch. 7A	27.045 Mhz
Ch. 11A	27.095 Mhz
Ch. 15A	27.145 Mhz
Ch. 19A	27.195 Mhz

Refer to the sketch. All you have to do is cut the foil leading to the PLL program pin which is the **L**east **S**ignificant **D**igit. **(LSD)** This pin is of course the one on the farthest *right*-hand column of any Truth Chart, and represents the 1's bit. (The farthest left-hand column is the **M**ost **S**ignificant **D**igit or MSD, and represents the 32's bit in a 6-bit code, the 64's bit in a 7-bit code, or the 128's bit in an 8-bit code.) After cutting the foil, you simply wire in a special logic IC called an **Exclusive-OR Gate (XOR)** in series with the cut foil, and tie its other input to a resistor and switch as shown. You will need to use a CMOS type of IC because it can work over a wide voltage range, such as the 12 volts DC normally found in a CB radio. A typical device is the RCA CD4030 or equivalent. (HEP C4004P, ECG4030B, GE4040, etc.) The IC costs about $1.00 and actually contains 4 of these gates, so if you're really clever, you can use all 4 to control 4 program pins. A convenient switch might be something you hardly ever use, like the CB/PA switch.

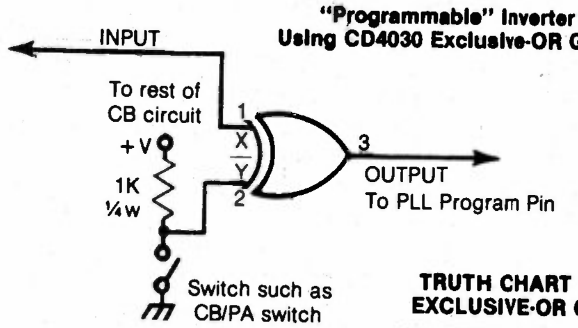


How It Works

The idea is very simple. Refer to the sketch. When the switch is closed, the output of the gate is exactly the same as whatever the programming input happens to be. That is, a "1" coming into the gate also appears as a "1" coming out of the gate. A "0" input produces a "0" output. It's as though the gate were not even there, so the N-code programming is whatever the N-code should be for the channel selector in that position. Now look what happens if the switch is opened: whatever input comes in, whether it be high ("1") or low ("0") will come out of the gate *exactly the opposite logic!* Thus if you need a high bit to get the correct A-channel N-code, you've got it. And if what you need is a low bit on the LSD to get the A-channel, you've also got it!

The advantage of using an XOR logic IC is that you don't need 2 separate switches, one to connect a high voltage, and one to connect a low or ground voltage, to change the programming codes.

"Programmable" Inverter Using CD4030 Exclusive-OR Gate



Switch Closed = Normal programming bit
Switch Open = Inverted programming bit

TRUTH CHART FOR EXCLUSIVE-OR GATE

X	Y	OUT
0	0	0
0	1	1
1	0	1
1	1	0

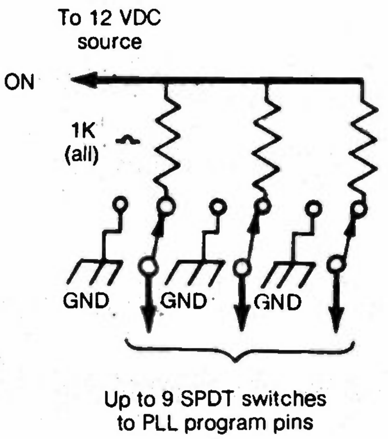
There's just one small hitch when dealing with A-channel operation. You will not be using the channel selector switch in exactly the same way for all 5 of the "A" channels, because of the way in which the N-codes change. For example, you may need to place the channel switch on Channel 4 for 3A, 12 for 11A, and 20 for 19A, but have to select 7 for 7A and 15 for 15A. It all depends on your particular N-code, which you can easily figure out by studying your CB's Truth Chart. Then you may need to tape a note on the rig to remember which is which!

Method B — Getting Several Higher (or Lower) Frequencies

The background theory for doing this has been explained. You simply need to expand the N-codes beyond Channel 1 or Channel 40, following the logical sequence shown in your Truth Chart. Just remember that trying to expand the operation too far may result in Lock Detector/VCO complications.

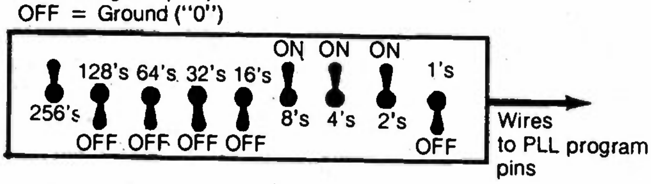
Now what you need is a whole row of ON/OFF switches connected to the PLL chip, so that you can literally create your own binary or BCD programming codes. After you know what codes you need, you'll have to cut the foil traces, top and bottom, to every PLL pin involved and run the trace ends through switches instead. For example, suppose your rig uses the PLL02A with an N-code of Divide-by-330 at Channel 1 to a Divide-by-286 at Channel 40. We know that CB channels are spaced to change in 10 Khz "chunks". So what would happen if we continued the countdown sequence past the 286 on Channel 40 to say, 270? This would give us an additional 16 x 10 Khz or 160 Khz above Channel 40. (286 − 270 = 16.) Adding 160 Khz to Channel 40 (27.405 Mhz) would give us a final frequency of 27.565 Mhz. You then proceed to apply the necessary logic voltages and grounds to those pins that will add up to the number 270 in our binary counting system. (See example)

One final note: PLL IC s are CMOS devices, which means that, among other things, they are *very* delicate. They can be blown out by static electricity or improper connections. To help protect the chip, you should ALWAYS apply your programming voltages through a small resistor of about 1000 ohms. Shown here is the kind of switching arrangement that can be used for frequency modifications. Good luck!



EXAMPLE OF PROGRAMMING SWITCH BOX (÷N = 270)

ON = High ("1")
OFF = Ground ("0")



Pin 7	Pin 8	Pin 9	Pin 10	Pin 11	Pin 12	Pin 13	Pin 14	Pin 15
tied 1	tied 0	0	0	0	1	1	1	0
256's	128's	64's	32's	16's	8's	4's	2's	1's

TRUTH CHART for ÷N = 270
(256 + 8 + 4 + 2 = 270)

IN CASE YOU'RE REALLY LAZY

This discussion may seem a bit complicated if you're one of those people who's just not technically-minded enough to attempt these modification methods. In that case, there's another solution for you: Why not just buy yourself a good PLL Expander box, such as the DIGI-SCAN UFO ELITE or the MICROMONITOR MM1?

These gadgets are really slick. In addition to being able to change frequencies at the push of a button, the frequency is automatically displayed in bright digital readouts. So, no math, no N-Code figuring, no guesswork! Other neat features are the ability to scan up and down the band, home on a pre-selected channel, or store several of your favorite channels in memory for instant recall at the push of a button. Best of all, since these "black boxes" contain their own PLL circuits which function independently of the radio's own PLL, you won't run into the problem of Lock Detector activation or inability to cover a wide enough frequency range to satisfy you. Finally, the installation is usually very easy, with only a few wires to connect. You probably won't need an engineering degree to do it!

NOTE: The MICROMONITOR FREQUENCY EXPANDER is the only device that can be used to modify most of the newer rigs now being sold. These radios in general use a single 10.24 Mhz crystal and a ROM-encoded PLL IC; this makes it impossible to change with either an external switching arrangement, or a different crystal. Therefore if you're hoping to "go upstairs" with your radio, you need the older type rig, or one of these accessories.

You can get full details on these frequency-expanding add-ons by writing to:

CB CITY INTERNATIONAL
P.O. Box 31500
Phoenix, Arizona 85046 U.S.A.

APPENDIX B

PLL Conversion of Some Popular Models Using the Crystal-Exchange Method

Listed here are examples of PLL frequency conversions where the change is made by different reference oscillator crystals. Shown are the radios with the standard crystal and PLL IC chip, and then examples of the new frequencies obtained by changing crystals.

NOTE: As explained previously, this method is usually more complicated than simply swapping out crystals. You could do that with the old 23-channel rigs, but not here! You'll need at minimum a good frequency counter and the radio's schematic, because re-tuning of the PLL circuit and disabling of the out-of-lock detector circuit are mandatory.

G.E. 3-5810B, HyGain 2680, 2681, Midland 13-830, 13-882C, 13-888B, 13-857B, RCA 14T300, 14T301, and all other 23-channel sets using PLL02A and 11.806 Mhz crystal.

NEW CRYSTAL
11.505 gives 26.065 to 26.355
11.605 gives 26.365 to 26.655
11.705 gives 26.665 to 26.955
11.905 gives 27.265 to 27.555

HyGain 2679A, 2682, 2701, 2702, Pearce-Simpson Tiger 40A, and all other 40-channel sets using PLL02A and 11.806 Mhz crystal.

NEW CRYSTAL
11.505 gives 26.065 to 26.505
11.655 gives 26.515 to 26.955
11.955 gives 27.415 to 27.855

Cobra 29XLR, 89XLR, Teaberry T-Command, President "Dwight D", Realistics, Robyn AM500D, and all other 40-channel sets using uPD858 PLL and 36.570 Mhz crystal.

NEW CRYSTAL
36.120 gives 26.515 to 26.955
37.020 gives 27.415 to 27.855

Browning Baron, Cobra 132/135XLR, Tram D62, and all other 40-channel sets using TC5080P PLL and 17.0555 Mhz crystal.

NEW CRYSTAL
16.515 gives 26.065 to 26.505
16.815 gives 26.465 to 26.905
16.865 gives 26.565 to 27.005
17.265 gives 27.365 to 27.805
17.315 gives 27.465 to 27.905
17.365 gives 27.565 to 28.005

Cobra 140/142GTL, President "Washington" (new), Teaberry Stalker IX, Midland 78-900, and all other 40-channel SSB sets using MB8719 PLL and 11.1125 Mhz crystal.

NEW CRYSTAL
10.700 gives 25.725 to 26.765
10.850 gives 26.175 to 26.615
11.000 gives 26.625 to 27.065
11.250 gives 27.375 to 27.815
11.300 gives 27.525 to 27.965
11.400 gives 27.825 to 28.265

Boman CB-950, Colt 480, 485, 1000, Gemtronics GTX-77, G.E. 3-5825A, 3-5875A, HyGain V, J.C. Penney 981-6247, Lafayette Telsat SSB-140, Midland 79-892, Palomar 2900, RCA 14T302, SBE LCBS-4, Truetone CYJ4837A-87, and all other 40-channel SSB sets using PLL02A and 10.0525 Mhz crystal.

NEW CRYSTAL
9.940 gives 26.515 to 26.955
10.165 gives 27.425 to 27.865

President "Grant" (new), Cobra 148/2000GTL, and all other 40-channel SSB sets using MB8719 PLL and 11.325 Mhz crystal.

NEW CRYSTAL
11.000 gives 25.995 to 26.435
11.050 gives 26.145 to 26.585
11.150 gives 26.445 to 26.885
11.200 gives 26.595 to 27.035
11.450 gives 27.345 to 27.785
11.495 gives 27.475 to 27.915
11.500 gives 27.495 to 27.935
11.505 gives 27.505 to 27.945
11.600 gives 27.795 to 28.235
11.640 gives 27.915 to 28.355
11.650 gives 27.945 to 28.385

IMPORTANT: You cannot easily modify PLL radios that use only a single 10.24 Mhz crystal; too many circuit functions will change! Examples of this type PLL are the uPD861/HD42851, TC9106, TC9109, uPD2814, uPD2816, and uPD2824. For a complete explanation of why this is so, refer to our PLL DATA BOOK.

APPENDIX C

Specific Power / Modulation Data

Shown here is peaking/modulation data for many of the most popular 40-channel PLL radios. It is arranged alphabetically by PLL IC type. Check the main circuit of your set to determine its PLL. Then look it up here. Given are the transmitter adjustments having the greatest effect on increasing power output, followed by the modulation control (AMC) for AM-only radios and the additional control(s) for AM/SSB rigs. (ALC control on SSB, AM carrier power, etc.) In some cases there is no AMC adjustment, but rather a limiting transistor, called TR32, Q301, etc. This part could be removed to boost modulation. Almost all the better radios have the parts clearly marked on the board, so you should have no problem locating the adjustment. It will become very obvious that many radios are absolutely *identical* inside; the only difference is in the outside appearance!

CCI3001:
Royce 582, 651 (T302, L303, VR201) Royce 639 (L12, L4, L3, VR7-AMC, VR11-ALC)
Pace 8093, 8193 (L12, L4, L3, L2, VR7)

CCI3002:
PACE 8003, SBE LCM-8P (T302, L302, R201)
Royce 607 (T302, L303, CT301, L304, VR201)

F9316PC:
SBE 26CB/A, 32CB, 43CB (L6, L8, L9, R4)
Pace CB166 (L10, L14, L15, R207)

LC7110:
G.E. 3-5804A, 5871B (L901, L903, L905, VR7)
Sanyo TA2000, TA4000, TA6000 "
Realistic TRC-470 "
Realistic TRC-454 (L903, L907, L908, VR702B)

LC7113:
Realistic TRC-480 (L7, L10, VR13, SSB-VR4, AM PWR-VR14)
Realistic TRC459 (L6, L9, L10, VR13-AMC, VR5-ALC, AM PWR-VR14)

LC7120:
Midland 77-100, 77-101B, 77-101C, 77-824C, Colt 222 (L304, L305, L306, RV201)
SAWS MIKAL
Realistic TRC462, (L11, VR3, L14, L15, VR2-AMC)
SBE 47CB/Stowaway (L11, KVR5, L14, L15, VR4-AMC)
Robyn SB54OD (L451, L454, VR311-AMC, VR312-ALC)

LC7130:
Midland 2001, 3001, 4001, 150M (L304, L305, L306, RV201) VICE PRESIDENT ROY, COMMANDO I,

M58472P:
G.E. 3-5801A, 3-5800A (L903, L905, VR7)
Teaberry "T" Charlie "
Channel Master CB6830, 6834, 6835 (L903, L905, VR6)
G.E. 3-5810A, 3-5871A "
Teaberry Racer "T" "
G.E. 3-5821A (L903, L905, L906, VR10)

M58473P:
Wards GEN702A, 730A, 774A, 775A, 828A (L208-L211, VR206)
ITT 4400M "
American Motors 32311847, 1848, 1849, 1850 (L302, L304, L305, L306, VR303)
Kraco KCB-4005 (T401, T402, L402, L403, L404, VR201)

MB8719:
Cobra 148/2000GTL (L38, TR24-AM, VR11-SSB, VR12-AM PWR)
President "Grant" (new), "Madison" (new) "
Cobra 140/142GTL (L36, TR32 or VR6-AM, VR7-SSB, VR6-AM PWR)
Courier Galaxy "
Midland 79-900 "
President "Washington" (new), "McKinley" (new) "
Realistic TRC490 "
Robyn SB505D (new version) "
SBE LCMS-8, LCBS-8 "
Teaberry Stalker IX, XV, XX "
Tram D80, D300 "

MB8719:

Cobra 46/47XLR, 50/55XLR (L112, L109, VR105)
Midland 63-445 "

MM55104N: (SM5104)

Kris XL-45 (L308, L309, VR201)
Pearce-Simpson Super Tiger 40A (L12, L9, L6, VR13)

MM55107N:

Pace 8155 SSB (L407, L408, C432, R310-AM, SSB-none)
Pace 8010A, 8015A, 8113, 8117 (L304, L307, L308, R220)

MM55108N:

Lake 410 (L304, L305, L306, RV202)

MM55116N, (MM55126N, MC145106)

DAK Mark V (L306, L307, RV202)
Robyn 440 "

Browning Mark 4A (T303, C602, R603-AMC, R318-ALC)

Lake 600 (L202, L203, L204, VR2)

Regency CB501 (L103, L102, L101, Q109)
COBRA 148GTL DX

MN6040:

Robyn GT410D, SX402D (L15, L18, L19-21, VR13)
Robyn SX401 (L12, L15-18, VR7)

MC14568: (with MC14526)

Craig L101 (L305, L308, L309, R226)
Lake 650 "
SBE 44/45CB "

Royce 1-601 (L203, L204, VR201-AMC)

SBE 27CB/A, 39/40CB (L505, L502, L507, VR803-AM, VR302-SSB)

Craig L102 (L311, L313-316, R348)

MSC42502P/ SC42502P, 3001-201:

Johnson & GM 4170, 4175 (T17, T18, L5-L7, AMC-none)

Johnson Messenger 191, 4120, 4135, 4140, 4145, 4230, 4250, Viking 200 (T8, L3, L4, AMC-Q10)

Johnson Messenger 40, 50, 80, Viking 230, 260, 270, 430 (T85, L84, L85, L86, L87, R49)

Johnson Viking 4330/4360 (T8, L3, L4, L6, R227)

MSM5807:

Alaron B4900 (L403, L406, AMC-Q201)
Palomar 49 "

Kraco KCB-4000 (L2, L3, L6, L9, VR4)

Tenna #11302 (L607, L609, L610, AMC-Q701)
Tenna #10901 (T11, L3, R54)
Tenna #10902 (T16, L4, R71)
Realistic TRC-205 W/T (L302, L303, TR306-AMC)

MSM5907:

Gemtronics GTX-4040 (L451, L463, VR481)
Shakespeare GBS-240 "

Gemtronics GTX-5000 (L801, VC901, VC902, VR4)
Robyn T240D "
Teaberry Model "T" "

NDC40013:

Craig L131, L231, SBE Sidebander VI (L109, L106, R605-AMC, R130-ALC)

Pace 1000MC (L112, L102, L109, R521-AM, R134-SSB)
Johnson Viking 4740 (T704, T705, T706, R212-AM, R726-SSB)
NDI PC200, PC201, Tram D64 (L706, L709, R217-AMC, R721-ALC)

NIS7261B:

Pearce-Simpson Jaguar 40B (L22, L25, L26, FVR3)
Vector 770, 790 "

Vector X (L53, L55, L57, SVR260)

NIS7264: Kraco KCB-4088 (L407, L404, L402, VR104)
Pace 8340 "
Surveyor 2630 "

Kraco KCB-4003 (L203-L206, VR202)
Morse/Electrophonics 2001 "

PLL01A: Kraco KCB-2310A, 2320A, 2320A (L106, L109, L110, RV102)
HyGain 681, 682 "

PLL02A: AM-only using L7, L11, L12, RV2-AMC

Boman CB910, 920, 930, CBH990
Colt 290, 390, 800, SX33
Delco (GM) 1978 series
Gemtronics GT44, GT55, GTX66
G.E. 3-5804D, 5811B, 5812A, 5813B, 5814B, 5819A
HyGain 2702, 2703
JC Penney 981-6204, 6218
Kraco KCB4010, 4020, 4030, 4045
Lafayette HB640, HB740, HB940, Telsat 1140, LM100, LM300, Comstat 525
Midland 76-858, 76-863, 76-886, 77-830, 77-838, 77-849, 77-857, 77-882, 77-888, 77-889, 77-899, 77-955, 77-963
Medallion 63-030
Mopar 4094176, 4094177, 4094178
Morse/Electrophonics 3005
Palomar 4100
Pearce-Simpson Lion 40, Tiger 40
Ray Jefferson CB845
RCA 14T260, 270, 275, 303, 304, 305
Truetone CYJ4832A-87, 4834A-87, 4862A-87

PLL02A: AM-only using L106, L109, L110, RV102-AMC

23 Channel:
- Delco (GM) 1977 series, CBD-10
- G.E. 3-5810B
- HyGain 2680, 2681, 2683 , 2679
- Kraco KCB2320B, 2330B
- Lafayette HB650, HB750, HB950, Telsat 1050, Com-Phone 23A, Micro 223A
- Midland 13-830, 13-857B, 13-882C, 13-888B, 13-955
- Pearce-Simpson Tiger Mark 2
- RCA 14T300, 14T301
- Truetone MCC4434B-67, CYJ4732A-77

40 Channel:
- HyGain 2679A, 2682, 2701, 2720
- Pearce-Simpson Tiger 40A

PLL02A: SSB using L7, L11, L13, RV12-AMC, RV2-SSB, VR4-AM PWR:
- Boman CB950
- Colt 480, 485, 1000, 1200
- Gemtronics GTX77
- G.E. 3-5825A
- HyGain 2705 (V) , VIII
- JC Penney 981-6247
- Lafayette Telsat SSB-140
- Major M588
- Midland 78-976, 79-892
- Palomar 2900
- RCA 14T302
- Truetone CYJ4837A-87

PLL02A: (Cont.)

SSB using L209, L212, L214, RV9-AMC, RV201-SSB, VR1-AM PWR:
G.E. 3-5825B, 3-5875A
Midland 78-574, 78-999, 79-891
SBE LCBS-4

PLL03A:

G.E. 3-5813A, 5814A, 5819B, 5818A, 5869A (L5, L9, L10, RV2)
JC Penney 981-6216 "
Midland 77-821, 77-859 "

G.E. 3-5817A (T4, L3, RV2)

SBE LCM-8 (L7, L11, L12, RV2)

Delco (GM) 90BCB1, 90BCB2, 90BFTC1, 90ECB1, 80BCB2 (L4, L8, L9, RV2)

REC86345:

Courier Nightrider 40DR, Ranger 40D (L116, L118-L120, VR301)
Fanon Fanfare 185PLL, 185DF, 190DF "

Courier Blazer 40D, Renegade 40, Rogue 40 (T14, T13, L9, VR9)
Fanon Fanfare 125F, 182F, 184DF "

Realistic TRC448 (T206, T207, L208, VR5-AMC, VR4-SSB, VR204-ALC)

ROYCE:

1-617, Lake 5100 (L311, L310, L319, L317, VR401)

same PLL unit:
Kraco KCB4070, Lake 5000, Mopar 4094173 (L311, L310, L319, L317, VR402)

1-625, 653B, 655, 658, 660, 662, 673, 675, 678, 680, 682 (T402, L403, L404, AMC-Q301)

1-632 (L6, L4, L1, VR7-AM, VR5-SSB)

1-641 (T15, L6, L1, VR7-AM, VR8-SSB)

1-648, 621 (T7, L4, VR3)
Ray Jefferson CB740 "

604, 608, 609, 611, 619 (T302, L303, VR202)
K-Mart D-40 "
Kraco KCB4001 "

SM5104:

Courier Caravelle 40D (L407, L404, C430, R504)
Fanon Fanfare 880DF "
Realistic TRC-455 "

Midland 77-825, 77-861 (T4, T5, L3, TR9-AMC)

Utac TRX-500, TRX-4000 (L15, L14, L17, VR7)

Sears 934.3826, 3831, JC Penney 6246 (T406, T407, T408, Q303-AMC, RT402-ALC, RT01—AM PWR)

Robyn LB120, 007-140, DG130D, WV110 (L15, L13, L12-L10, VR6)

Sears 934.3827 (L702, L704, Q405-AMC)
JC Penney 981-6241 "
JC Penney 6248 (T406, T407, Q303-AMC, RT402-ALC, RT301-AM PWR)
Panasonic RJ3050, RJ3150 (L14, L16, L25, R117)

SM5107:

SBE41CB, 42CB (L303, L304, L306, VR203)

Lafayette LM200, Telsat 1240 (L402, L405, L406, VR305)

Sears 370.3805 (T302, T303, R18)
Lake 650 "

Pace 8008 (L4, L7, R218)

SM5118:

Automatic CBR-2175 (L905, L903, VR903, VR901-AM PWR)
Boman CBR-9940 "
Pannasonic CR-B4737EU, B4747EU "
Pearce-Simpson Leopard B "
RCA 14T405, 14T410 "

SM5118 (Cont.)

Pace 8041, 8046, 8047, CB185 (L13, L14, R302)

Pace 8092 (L8, L10, L13, R307-AM, C306-SSB)

Chrysler 4048076, 8077 (L206, L204, VR252)

TC5080P:

Cobra 32/86/87XLR (L5, L3, C301, Q18-AMC)
Browning Sabre, SST-2 "
Sears 562.3820 "
Tram D42 "

Tram D12 (L5, L6, L3, R61)

Browning Baron (L7, L3, R134-AM, R130-SSB)
Cobra 132/135XLR "
Tram D62 "

Sharp CB750A, CB800A, CB2260, CB2460 (T304, L302, L303, R112)

Kraco KCB4095 (L613, L610, L609, VR401)

TC9100P:

Lafayette LM-400 (L205, L204, L203, L201, VR201)
Sears 242.3816 "

TC9102P:

Midland 76-860, 77-861B (T2, L3, L4, R57 or VR6)

Sharp CB2170, CB4370, CB4470, CB4670 (T304, L301, L302, R110)

TC9103P:

Medallion 63-540 (L5, L3-L1, VR501)
Motorola CT950AX "

Wards GEN-680A, 696A, 716A (L6, L7, L9, VR3)

TRS Challenger 730, 1200 (L204, L205, VR1)

TC9106P:

G.E. 3-5804B, 5815A (L903, L905, VR8)
Realistic TRC-425, 426 "
Teaberry Stalker III "

Midland 77-824B (L12, L15, VR5)
Realistic TRC-427 "

~~G.E. 3-5804F (L12, L16, TR17)~~
President AR-7 "

Cobra 21/25GTL (L14, L10, VR5 or VR4)
Craig L104 "
Midland 200M "
President "Andrew J", "
" AR-44, AR-711 "

NDI PC101, PC102 (T502, T503, VR203)

TC9109P:

Cobra 19GTL, 78X (L12, L15, VR6)
President "Veep", AR-14 "
SBE LCMS-4, LCM5 "
Sears 663.3802 "
Teaberry Stalker IV, VIII "
Craig L103 (L13, L16, TR17)
Sears 663.39009 "

G.E. 3-5804G (T5, L3, VR5)

uPD857C:

Regency CR-240 (L214, L217, VR213)
Standard Horizon 29 "

uPD858C:

(L32, L30, VR7-AMC, CT7-ALC, VR8-AM PWR)
Cobra 138/139XLR
Palomar SSB500 (early)
President "Adams", "Grant" (old), "Madison" (old), "Washington" (old)
Realistic TRC457/458, TRC449
Robyn SB510D, SB520D, SB505D (old)
Teaberry Stalker 101, 102, 202

(L15, L12, L11, VR5)
Cobra 29/89XLR
President "Dwight D" (old), "Honest Abe", "Teddy R", "Zachary T" (old)
Robyn AM-500D
Teaberry "T" Command, "T" Bear, Titan "T"

uPD858C (Cont.)

(L10, L7, VR8-AM, VR7-SSB, VR6-AM PWR)
Fanon Fanfare 350F
Midland 79-893

(L15, L12, L11, RT4)
Cobra 21XLR
President "John Q"

(L212, L214, VR207)
Cobra 21X, 77X
Courier Rebel PLL, Rebel 40A
Fanon Fanfare 100F1
Realistic TRC-452

(L212, L215, VR401)
Midland 77-883

(L211, L212, L215, VR213)
Midland 13-883B

(L13, L15, L301, VR3)
Teaberry "T" Dispatch

(L110, L111, L113, RV105)
Boman CBR-9600

(L19, L15, RT601-AMC, CT3-ALC, RT14-AM PWR):
Courier Centurion 40D, Centurion PLL, Gladiator PLL, Spartan PLL

uPD861C: (HD42851)

(L104, L106, Q107-AMC)
Realistic TRC440, TRC-466/467

(L11, L14, L15, VR2)
Realistic TRC-461

(L907, L910, VR7)
Realistic TRC-431

(L34, L37, R121)
Colt 350
Convoy CON-400
SBE 49CB

(L407, L409, L410, Q601-AMC)
Marantz Superscope Aircommand CB140, CB340, CB640

(T13-T15, Q10-AMC)
JC Penney 981-6237
Sears 934.3806, 3808
Realistic TRC-468

(L906, L909, L910, VR9)
Realistic TRC-424

(T704, T705, Q502-AMC)
JC Penney 981-6221, 6255
Sears 934.380817, 381107, 381207

(L7, L10, R94)
Panasonic RJ3600, RJ3660

(L7, FL1, FL2, R50)
Panasonic RJ3450

(T214, L208, VR1)
TRS Challenger 600

(L313, L314, L334, Q221-AMC)
Boman CBM-6100

(L903, L905, VR8)
Realistic TRC-456

(L303, L302, L303, R541-AMC, R542-ALC, C31-AM PWR)
Sharp CB-5470 SSB

uPD2810C:
(L202, L207, R279)
Audiovox MDU-6000, COLT 444) AM/FM AND SOME AM.
(L2, L5, VR1, VR15)
TRS Challenger 850, 1400

uPD2812C:
(L206, L204-L201, VR101)
J.I.L. 615CB
(L202, L204, R268)
Audiovox MCB5000

uPD2814C: (KM5624, HD42853)
(L9, L12, Q11-AMC)
Realistic TRC-421/422
(L11, L9, VR5)
President "Old Hickory"
(L15, L17, VR2)
President "James K" , Cobra 66GTL
(L107, L104, Q114)
Realistic TRC441
(L12, L15, VR5)
Midland 77-856, Realistic TRC469

uPD2816C:
(L14, L11, VR3)
Cobra 63GTL
(L16, L13, VR6)
Cobra 87/89/1000GTL
President "Zachary T" (new), "Dwight D" (new)
SBE LCB-8
Teaberry Stalker XII
(L16, L14, VR4)
Cobra 29GTL
President "Thomas J"
Teaberry Stalker V
(L14, L16, RV9-AMC, RV8-SSB)
Midland 6001, 7001

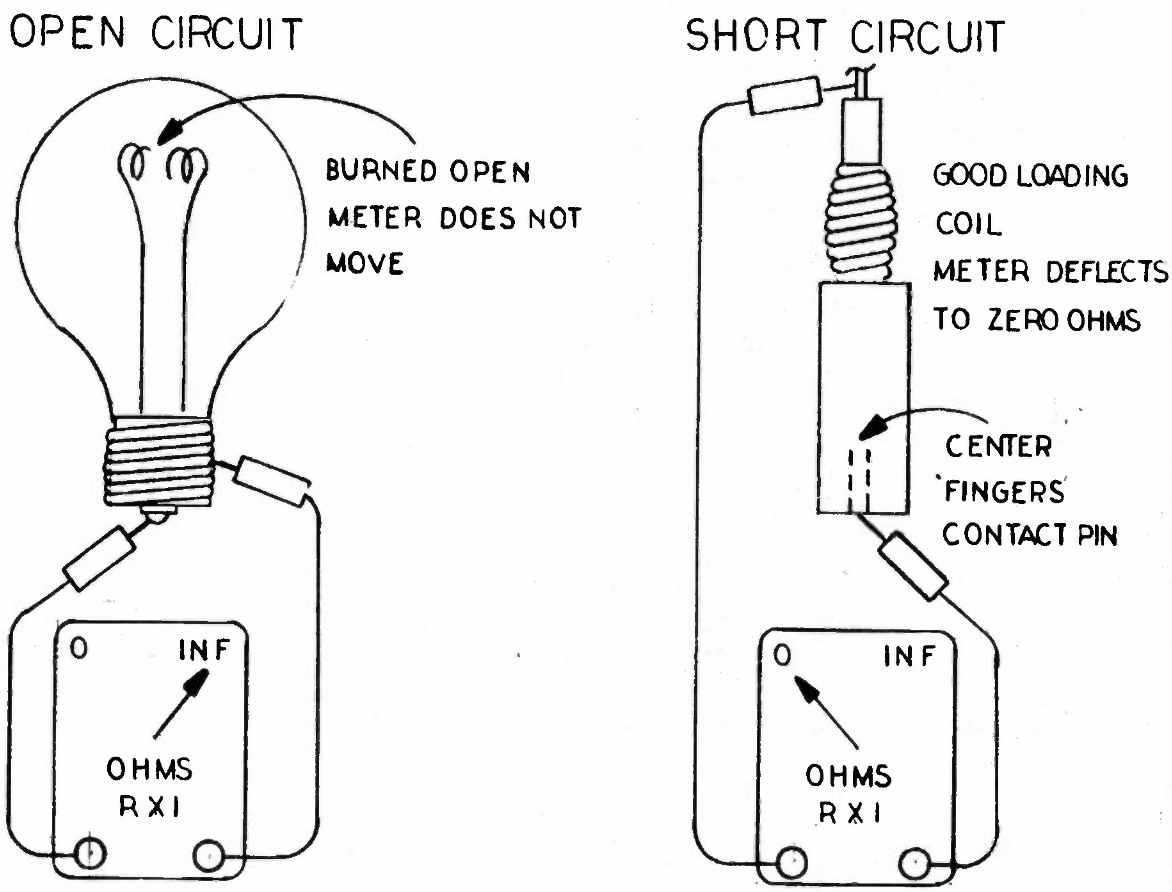
uPD2824C:
(L28, L29, L36, TR32-AMC, VR7-ALC, VR6-AM PWR)
Craig L132
Wards 719A

(L38, L37, L27, VR5-AMC, VR6-ALC, VR10-AM PWR)
Cobra 146GTL
President AR-144
Realistic TRC-451

SPECIAL PLLs:

(L306-L309, R219)
Alaron B-4075, B-5050A
(L4, L3, L1, VR2. PLL same as Royce)
Boman CBR-9950
G.E. 3-5830
Lafayette HB4000
Realistic TRC-471
Superscope CBR-40
Pioneer GT6600, GT1100G

(T204, L202, L205, R207)
Kraco KCB-4004
Automatic CBH-2265
Surveyor 2610
(L5, L8, L9, VR4)
Alaron B-5200
Fanon 10-40
(L22, L25, Q113-AMC)
Convoy 450
Handic 230



TEST PROBES TO SHELL AND CENTER CONTACT OF LIGHT BULB

TEST PROBES TO WHIP ROD AND CENTER 'FINGERS' CONTACT PIN

OPEN CIRCUIT

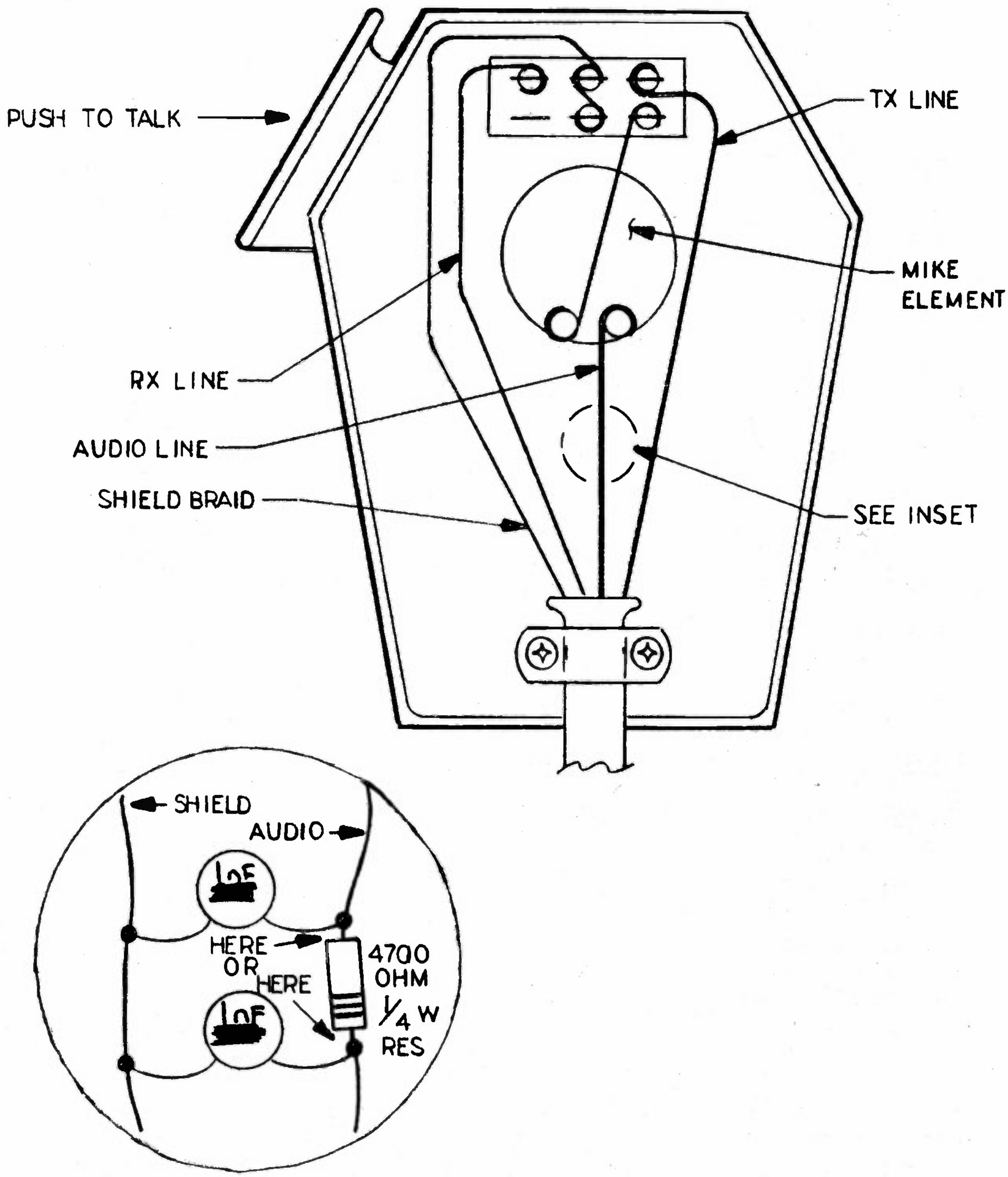
SHORT CIRCUIT

FIGURE I

USING OHMMETER TO TEST FOR CONTINUITY

FIGURE 2 - MIKE CLOSE UP

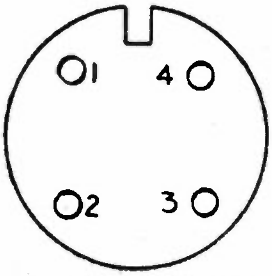
HOW TO CURE RF FEEDBACK SQUEAL



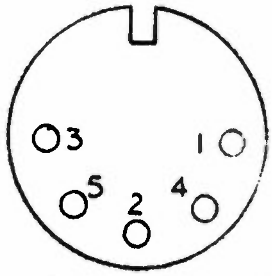
INSET

FIGURE 3 MICROPHONE PLUGS

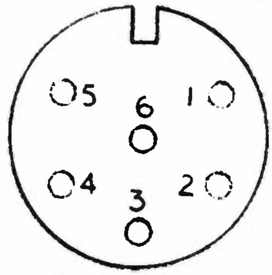
ALL VIEWS ARE SOLDER SIDE (INSIDE VIEW)



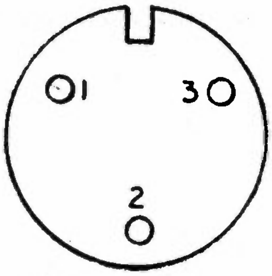
4 Pin Female with threaded coupling nut. (Most common)



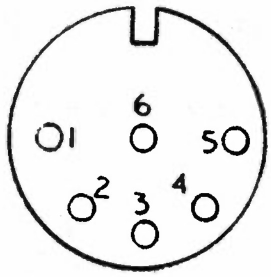
5 Pin DIN



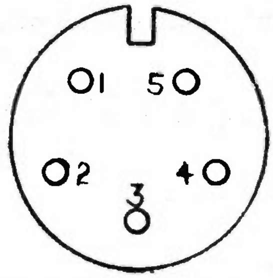
6 Pin DIN



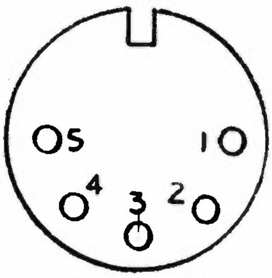
3 Pin Female with threaded coupling nut. (Pearce-Simpson, Robyn, etc.)



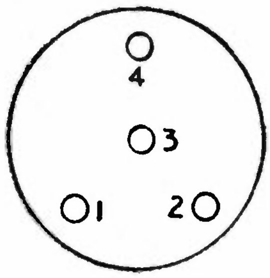
6 Pin Female with threaded coupling nut (Midland, etc)



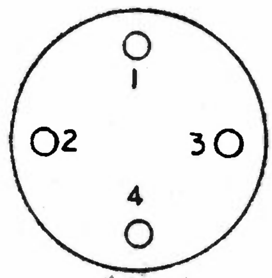
NEW 5 Pin Female with threaded coupling nut (Cobra, President, etc.)



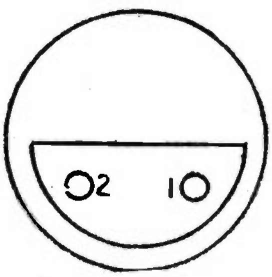
5 Pin DIN Widespaced with twist lock(Craig, Johnson,etc)



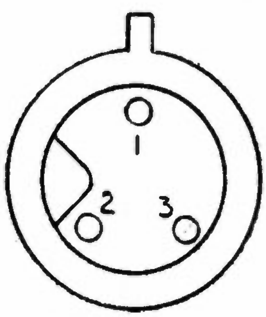
4 Pin "Y"



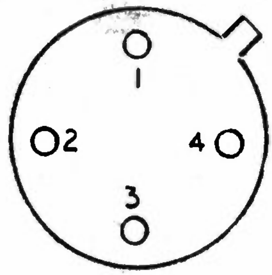
4 Pin Male



2 Pin Male with spring (Amphenol)



3 Pin Male with spring (Amphenol)



4 Pin Male with spring (Amphenol)

FIGURE 4
MIKE COLOR CODES

TURNER

"J" Indicates Electronic Switching, as in JM+2U, JM+3U, RK60J, RK70J, and +3 Base in "E" position.

shield .... common
white .... mike or audio
black .... TX
red .... RX

Note: Turner is eliminating the 3 wire/shield cable and will eventually sell its mikes with 5 wire/shield. This is to accomodate sets requiring more wires than the old cable provides. Otherwise, the mike is EXACTLY the same except for model number. For example, the 3-wire JM+3 becomes the 5-wire+3B. You can convert as follows:

OLD TURNER 3 wire/shield

shield .... common
white .... mike or audio
black .... TX
red .... RX

NEW TURNER 5 wire/shield

red & shield .... common
white .... mike or audio
blue .... TX
black .... RX
yellow .... not used

MURA and RMS Electronics

Models DX-114, DX-115C, DX-115D, DX-116, DX-120.
Models CBM 5004, 5006

red & shield .... common
yellow .... mike or audio
blue .... TX
green .... RX

Model DX-119 Model CBM-5009

red & shield .... common
yellow .... mike or audio
violet .... TX
white .... RX

ASTATIC

D104-M, T-UG8-D104

shield .... common
white .... mike or audio
red .... TX
black .... RX

T-UG9-D104

blue & shield .... common
white .... mike or audio
red .... TX
black .... RX
yellow .... not used

GC Electronics

Models 18-000, 18-010, 18-030, 18-032, 18-034

black & shield .... common
red .... mike or audio
yellow .... TX
blue .... RX
white .... not used

RADIO SHACK (REALISTIC)

Regular and power mikes

shield .... common
white .... mike or audio
red .... TX
black .... RX
blue .... not used

CAL COMM

Model 9867

black & shield .... common
red .... mike or audio
white .... TX
blue .... RX

ULTRATEC

E70-123

shield .... common
red .... mike or audio
white .... TX
black .... RX

370-245, 2466 (wires/shield)

shield .... common
yellow .... mike or audio
red .... TX
violet .... RX

E70-245, 246, 247 (4 wires/shield)

red & shield .... common
yellow .... mike or audio
blue .... TX
green .... RX

TRU BEAM MFG. #DM 101A Power mike

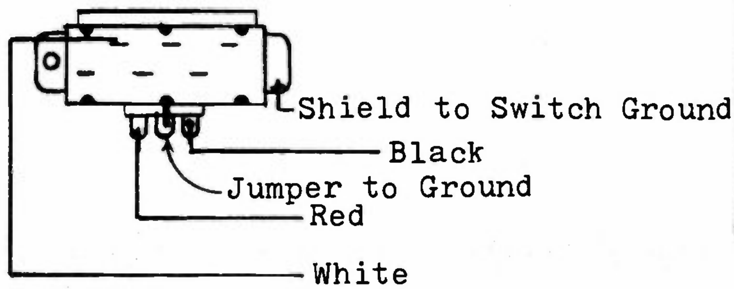
red & shield .... common
yellow .... mike or audio
blue .... TX
green .... RX

FIGURE 5

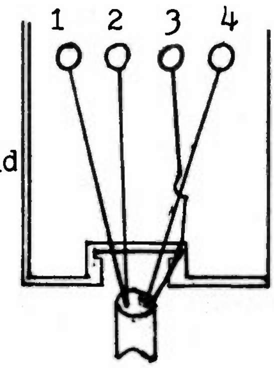
TURNER POWER MIKES

HOW TO CONVERT RELAY TO ELECTRONIC SWITCHING

ELECTRONIC:
JM+2U, JM+3U,
etc.



RK60J, RK70J,
JM+3

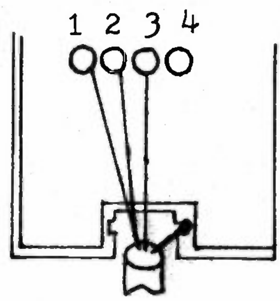


1.White 3.Jumper
2.Black to shield
4.Red

TO CONVERT RELAY TO ELECTRONIC SWITCHING:

Unsolder red wire from switch and mike amp. Move switch wire from center to left as in above switch drawing. Then connect jumper wire from shield to lug formerly occupied by red wire. On mike amp, move red wire from #3 to #4 as in drawing above. Then connect jumper wire from #3 to cable shield as shown above.

RK60, RK70,
M+3



1.White 3.Red
2.Black 4.NC

RELAY:
M+2U, M+3U,
etc.

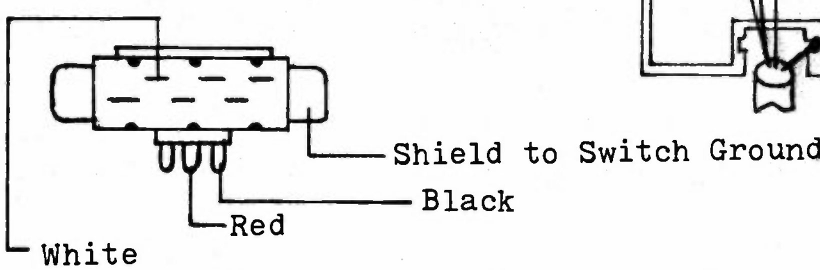
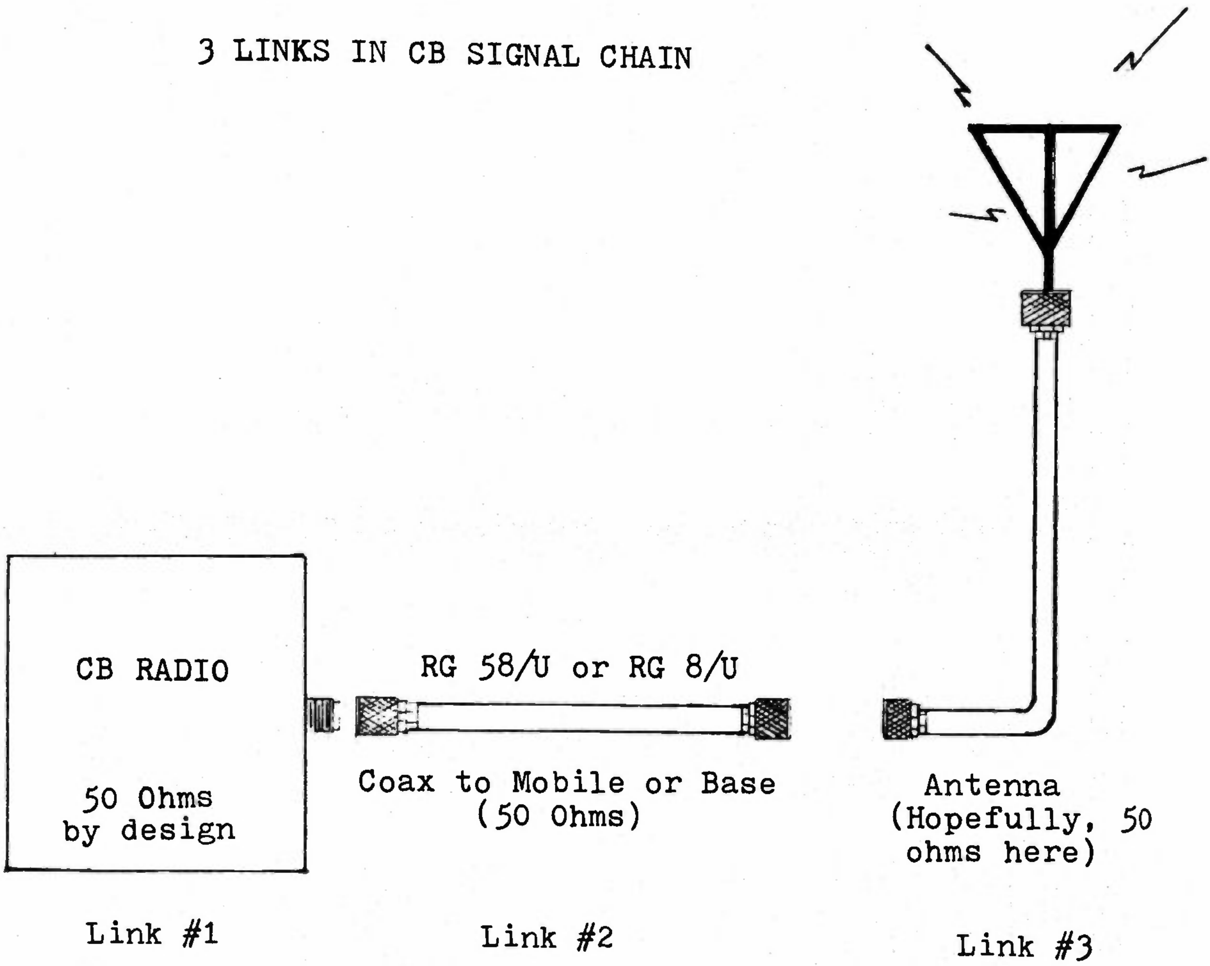


FIGURE 6

3 LINKS IN CB SIGNAL CHAIN



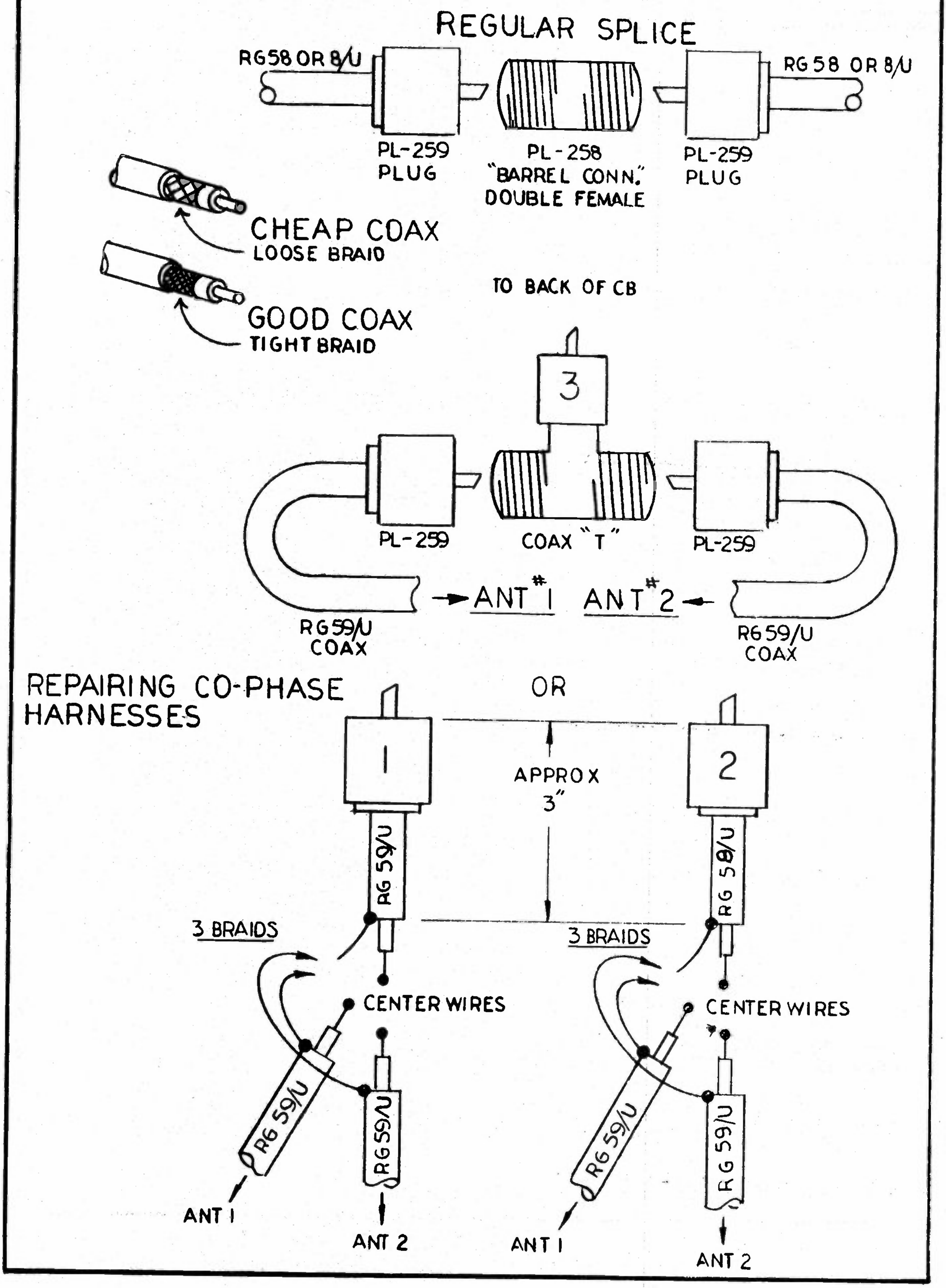
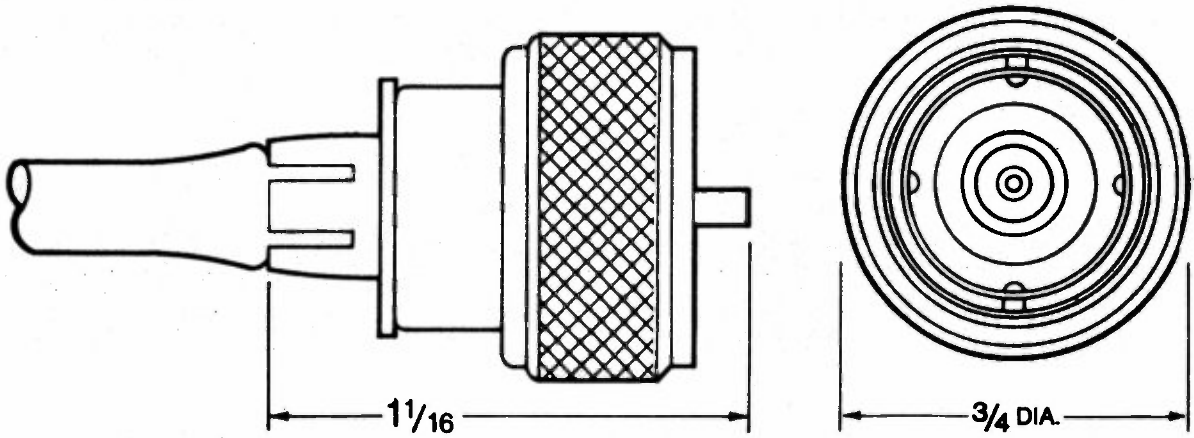


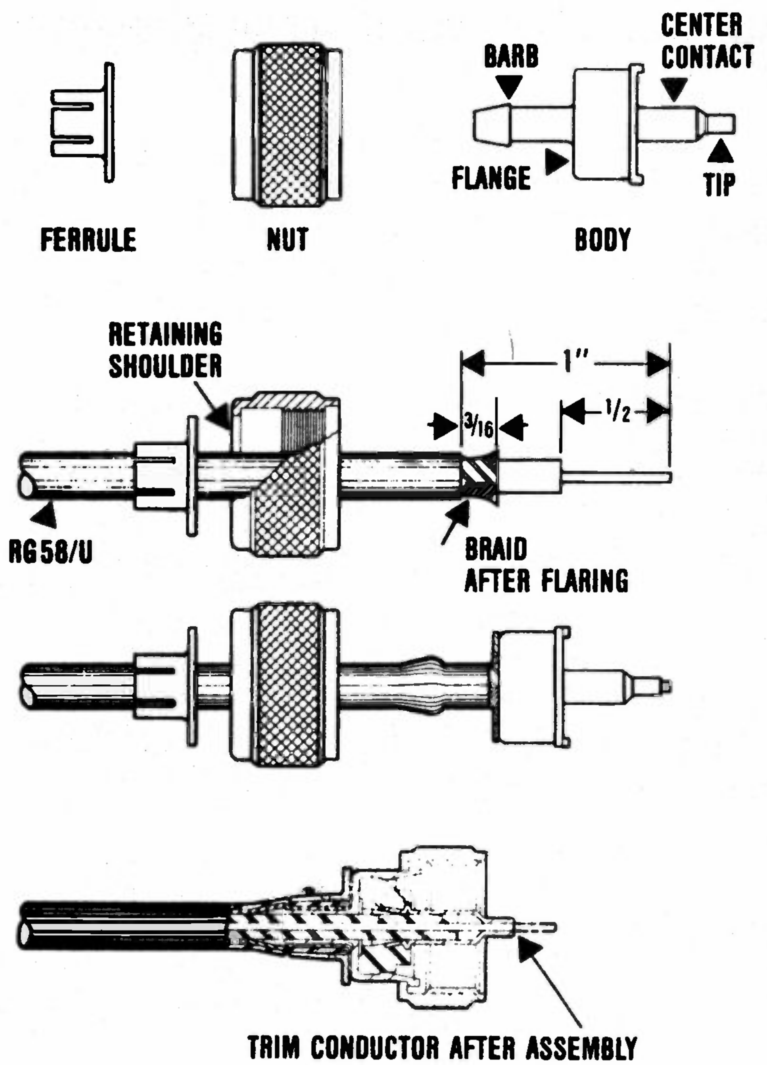
FIGURE 7 REPAIRING & SPLICING COAX

AMPHENOL 83-58 FCP Coax Plug

FIGURE 7B

OUTLINE DRAWING





ASSEMBLY INSTRUCTIONS

1. Slide ferrule over cable end, slotted end first. Slide nut over cable end, retaining shoulder end first.

2. Strip cable to dimensions shown. Flare braid slightly by rotating center conductor and insulator in a circular motion (do not twist). Leave center conductor straight.

3. Slide body on insulation with barb going *under* flared braid. Push body until flange is against outer jacket. Braid will flare out against body flange.

4. Slide nut forward over body. Grasp cable with hand and push ferrule over barb until braid is captured between ferrule and body flange.

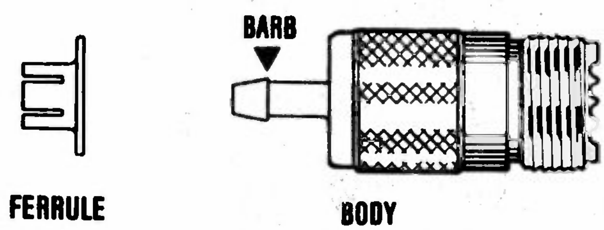
5. Squeeze-crimp center contact (tip only) with pliers. Trim center conductor. Assembly is complete.

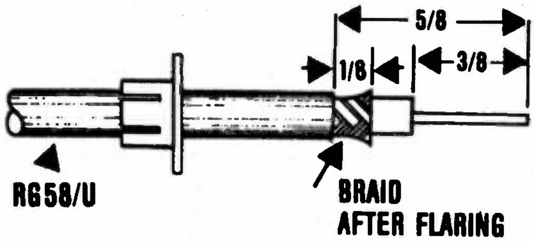
Courtesy AMPHENOL NORTH AMERICAN

FIGURE 7C

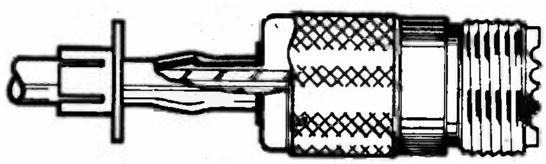
AMPHENOL 83-58 FCJ Coax Splice

ASSEMBLY INSTRUCTIONS



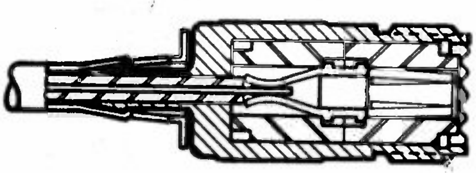


1. Slide ferrule over cable end, slotted end first.



2. Strip cable to dimensions shown. Flare braid slightly by rotating center conductor and insulator in a circular motion (do not twist). Leave center conductor straight.

3. Slide body on insulation with barb going *under* flared braid. Push body until shoulder is against outer jacket. Braid will flare out against body shoulder and center conductor will engage center contact.

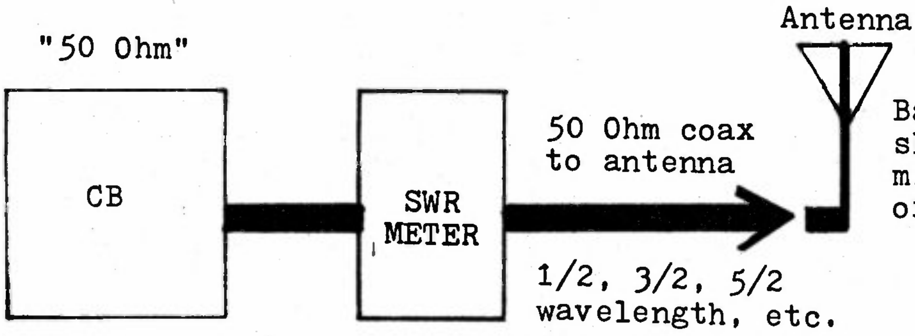


4. Grasp cable with hand and push ferrule over barb until braid is captured between ferrule and body shoulder. Assembly is complete.

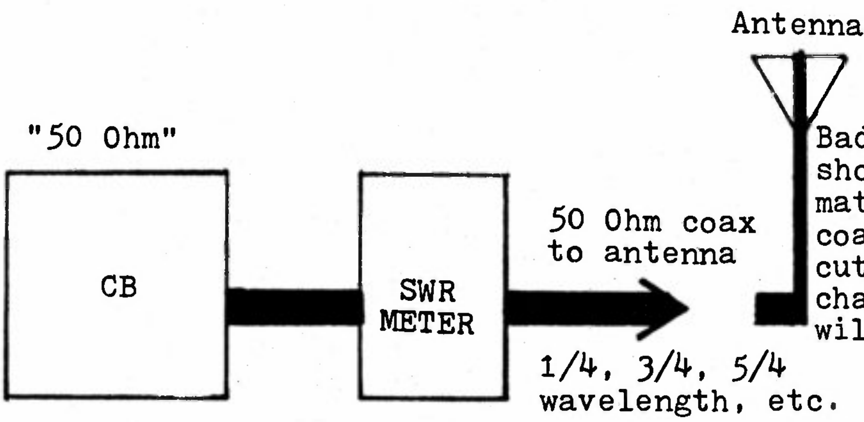
Courtesy AMPHENOL NORTH AMERICAN

FIGURE 8

COAX LENGTH CAN FOOL SWR METERS!



1.
Bad antenna will show <u>correct</u> SWR mismatch at <u>CB</u> end of the coax <u>line</u>.

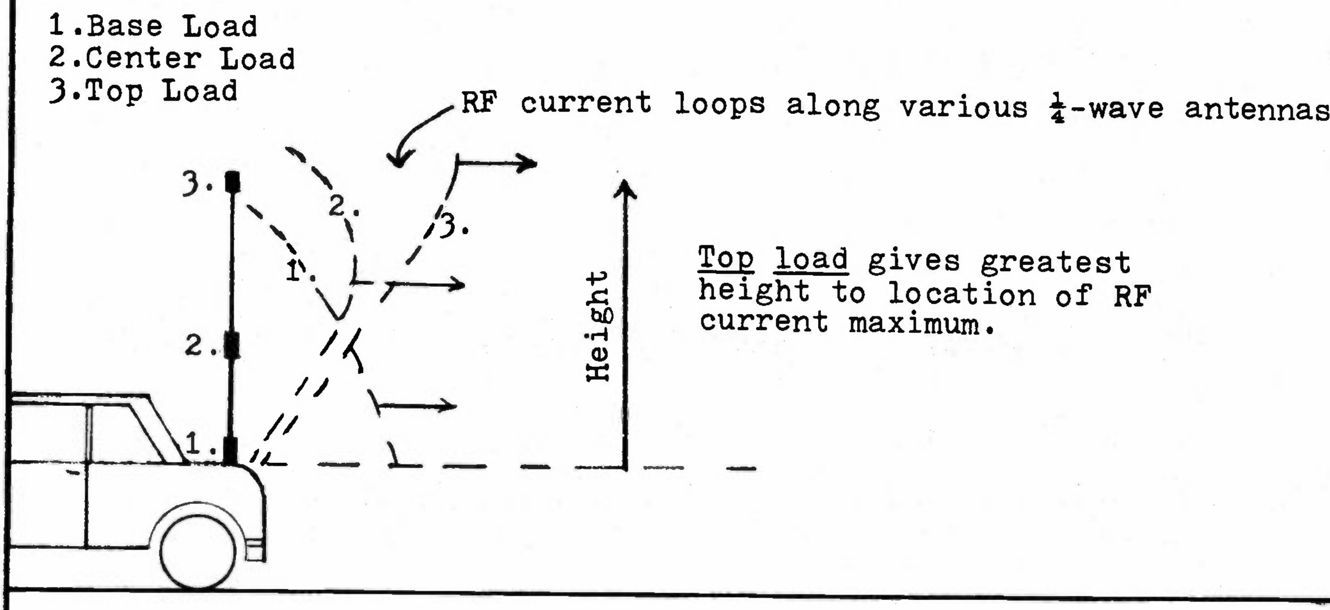


2.
Bad antenna will not show correct SWR mismatch at CB end of the coax line. If coax is cut, SWR will <u>appear</u> to change, but antenna will still be mismatched.

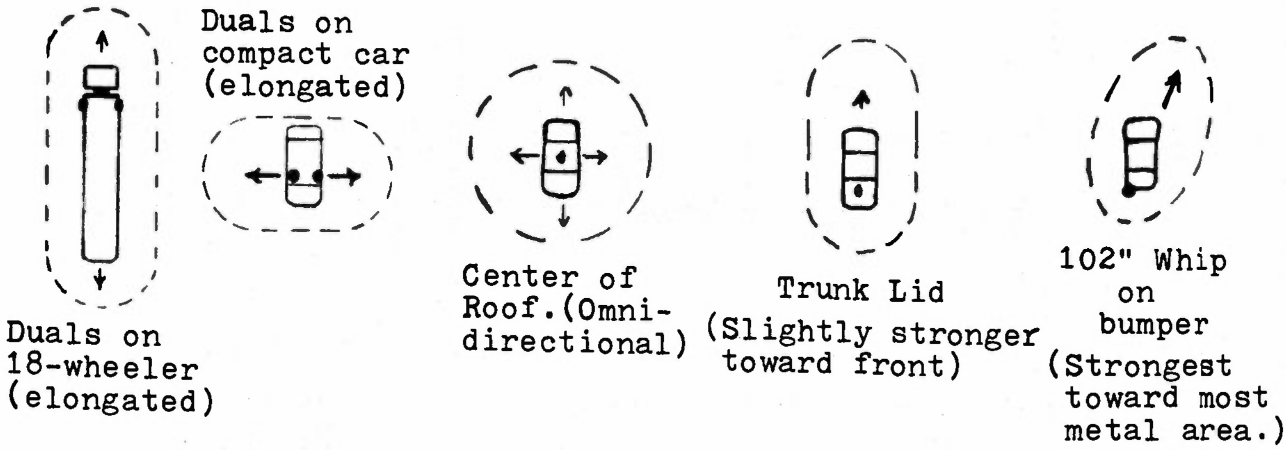
1/2 wavelength = 17 feet
1/4 wavelength = 8½ feet

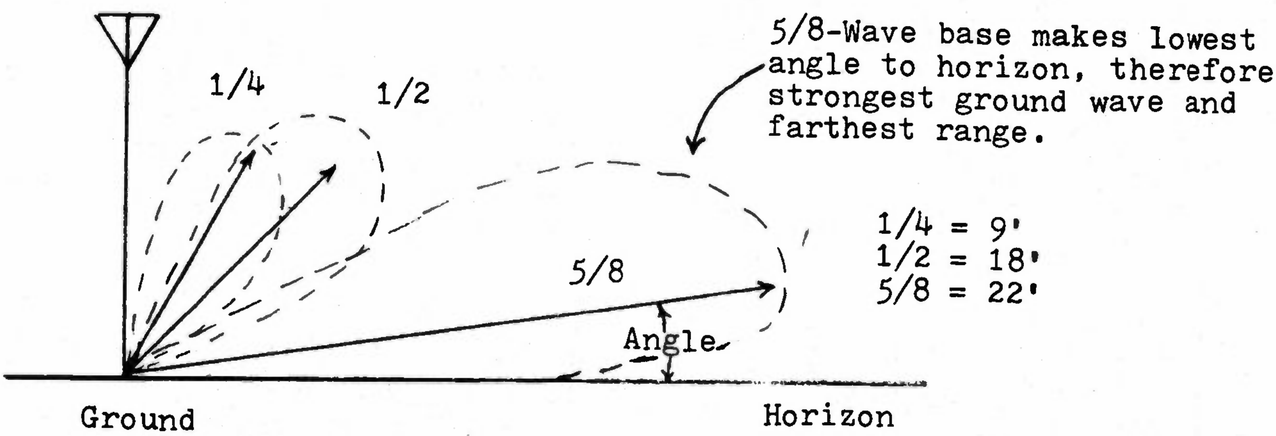
FIGURE 9

ILLUSTRATING RANGE EFFECTS OF DIFFERENT LOADED WHIPS



MOBILE ANTENNA PATTERNS

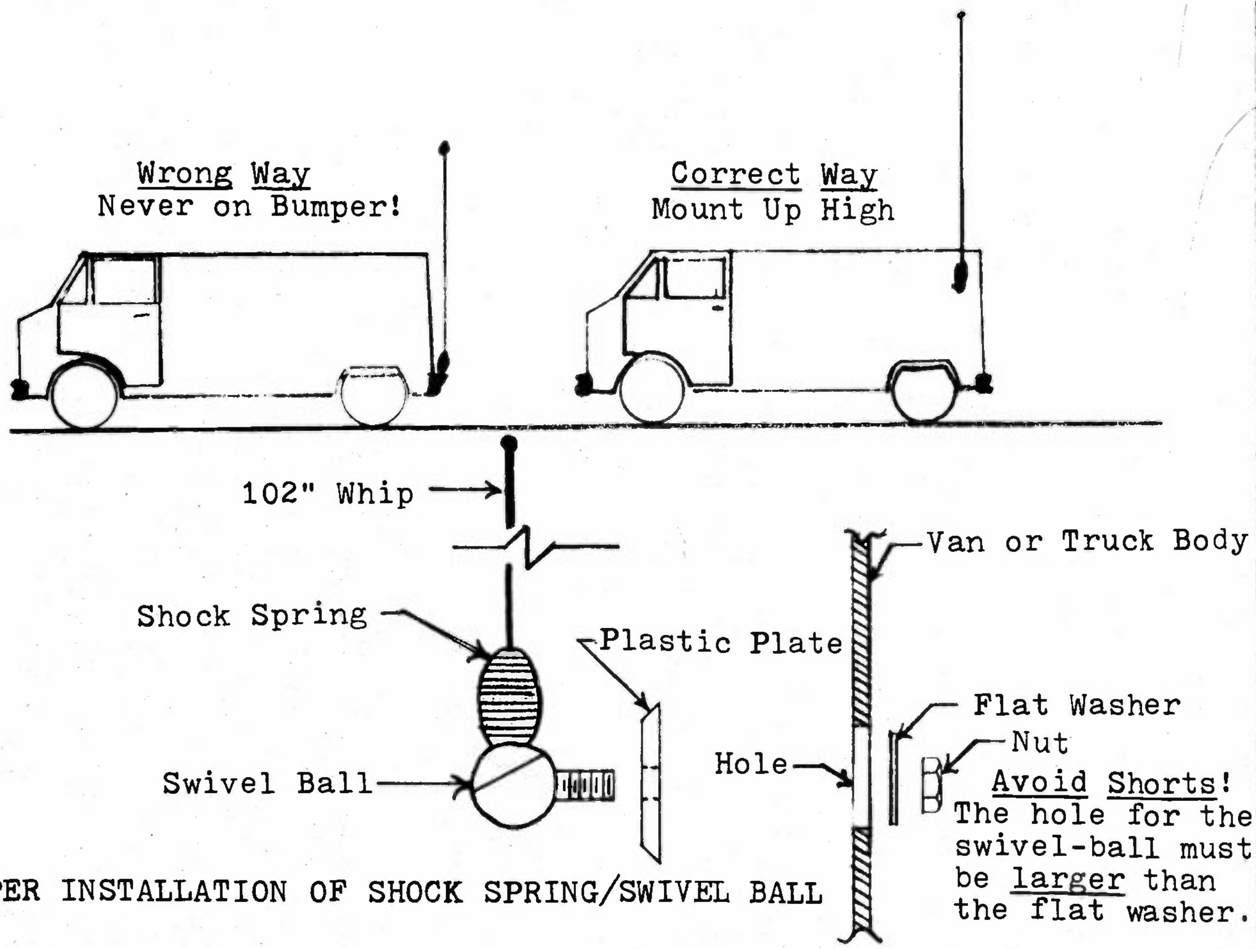




HOW VARIOUS BASE ANTENNAS EFFECT RANGE

FIGURE 10

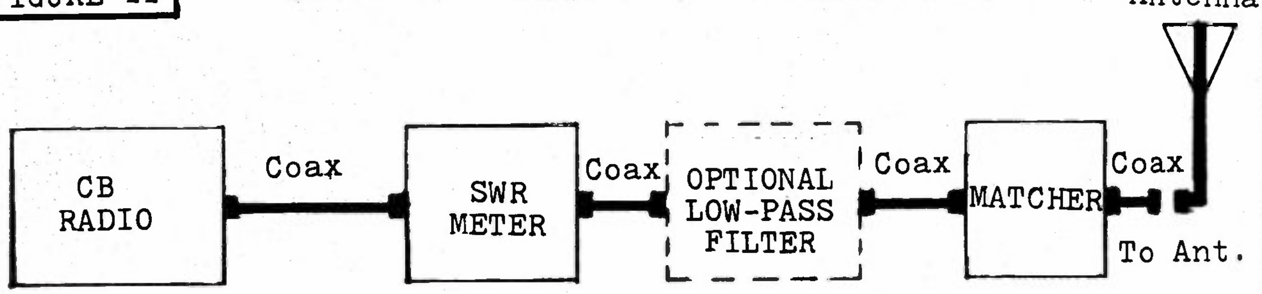
MOUNTING 102" WHIP ON A VAN



PROPER INSTALLATION OF SHOCK SPRING/SWIVEL BALL

FIGURE 11

PROPER PLACEMENT of ACCESSORIES in LINE



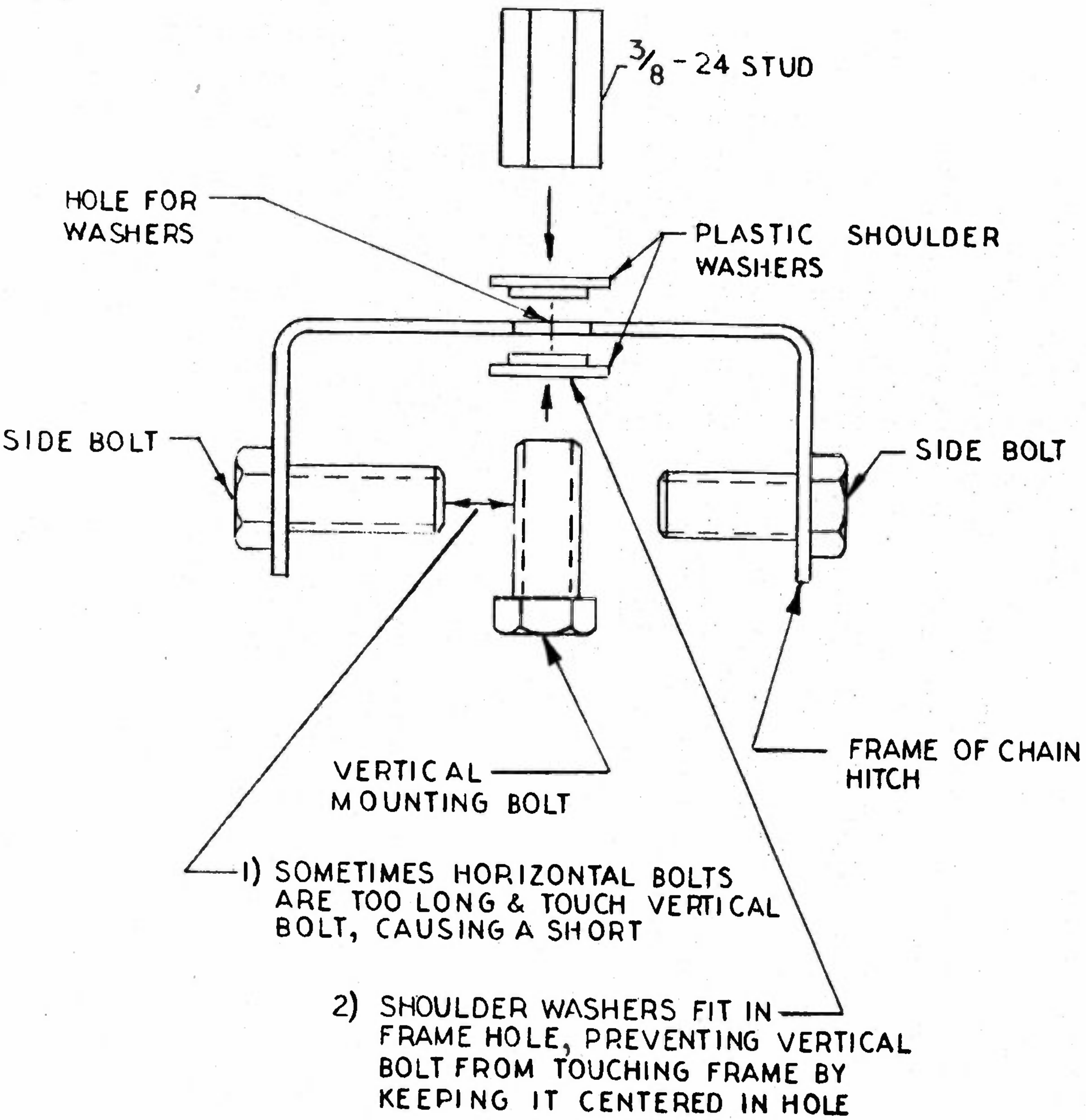


FIGURE 12 ASSEMBLY OF 3/8-24 WHIP STUD ON CHAIN BUMPER HITCH

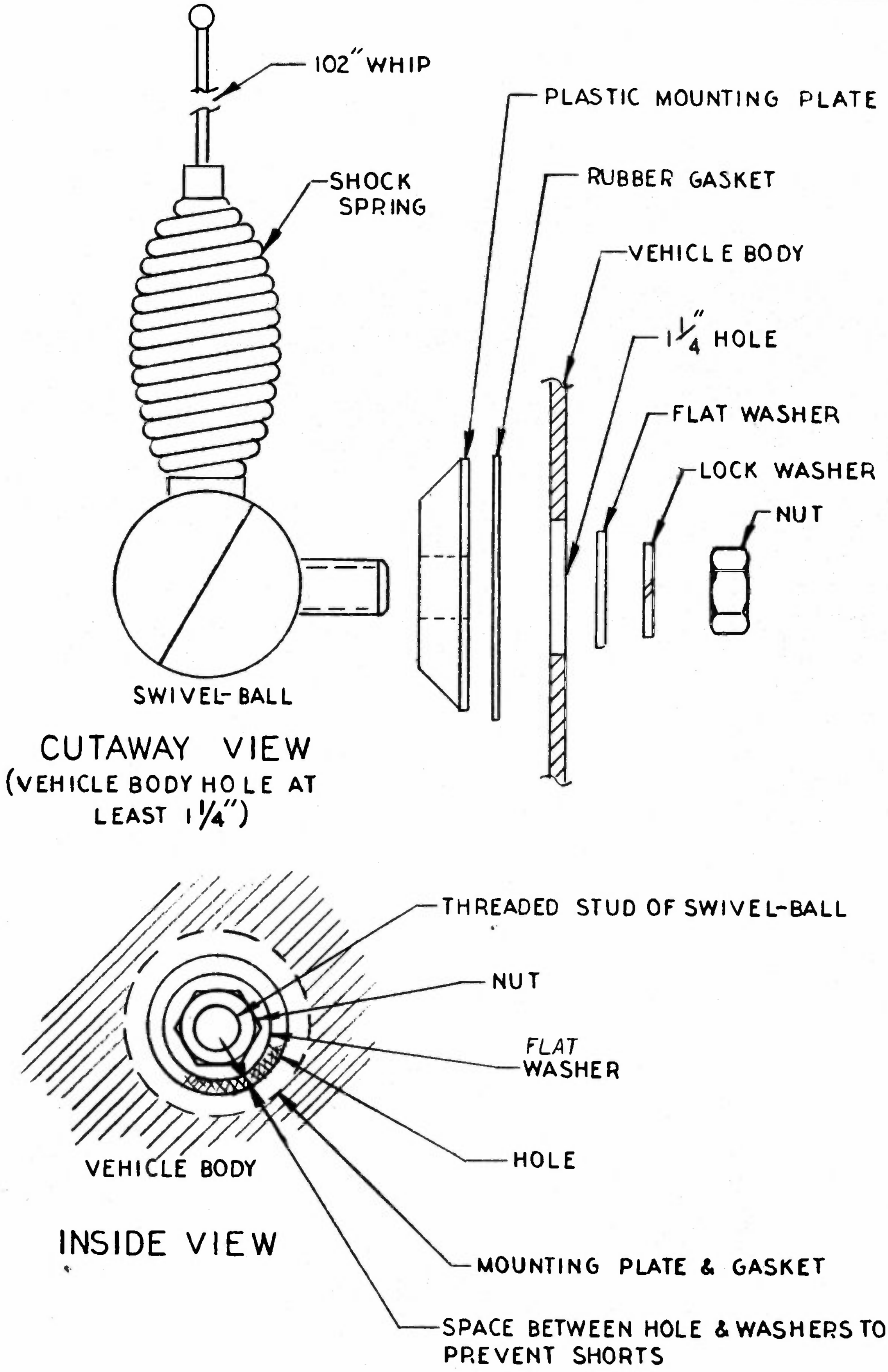


FIGURE 13 - PROPER SWIVEL BALL MTG.

FIGURE 14

PROPER COAX ROUTING ON TRUNK LID MOUNT

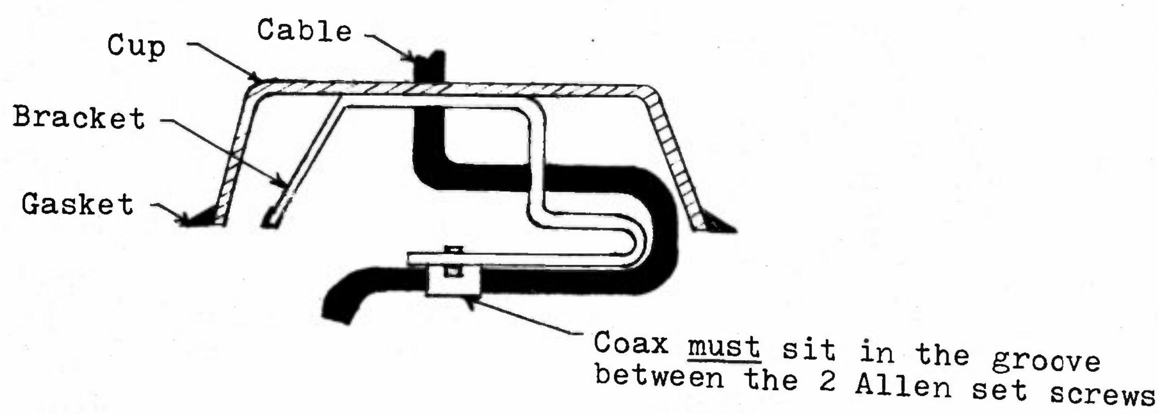


FIGURE 15

PROPER ASSEMBLY OF 3/8" SNAP-IN MOUNT
USING THREADED BRAID NUT FOR GOOD GROUND

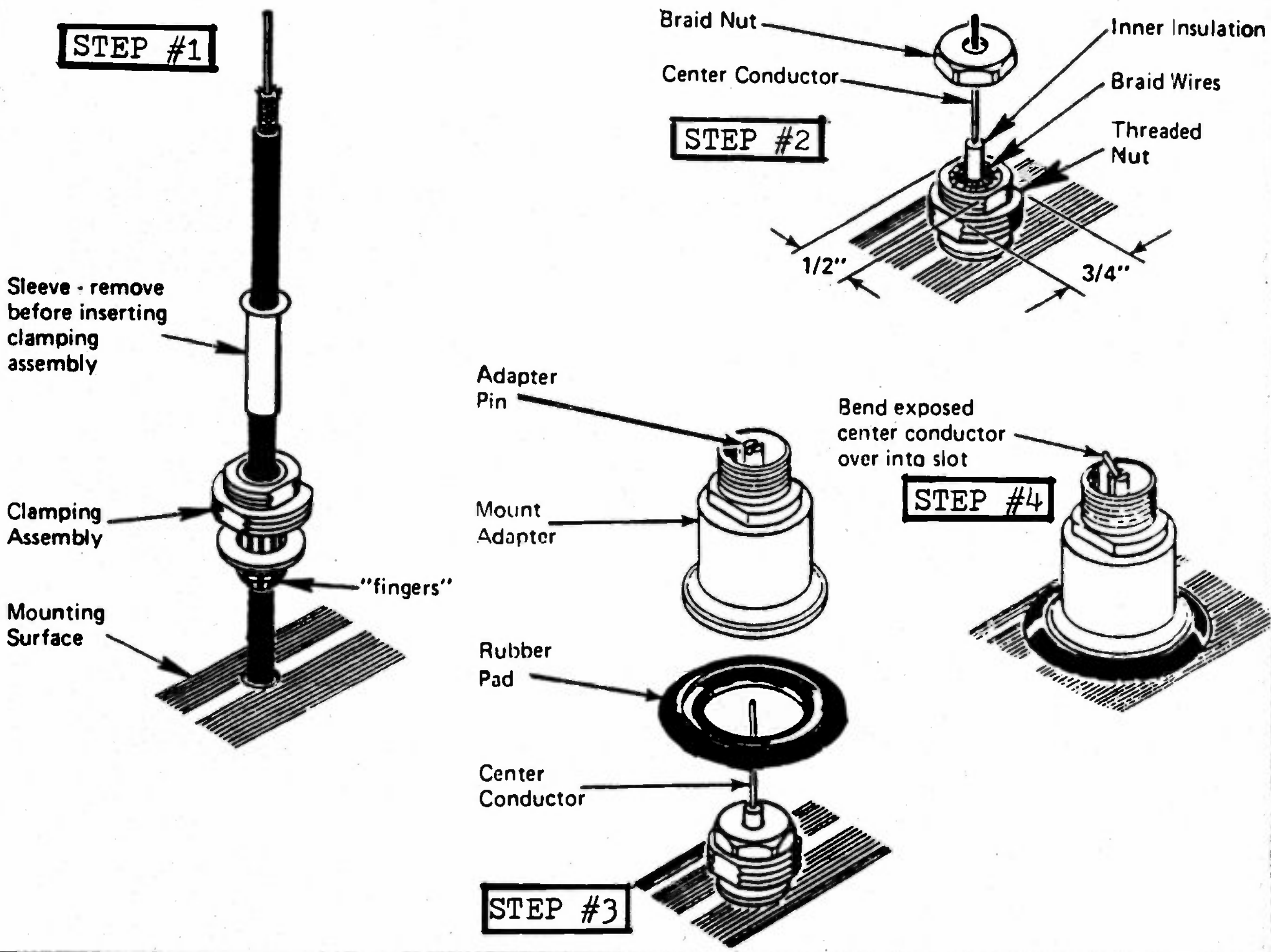
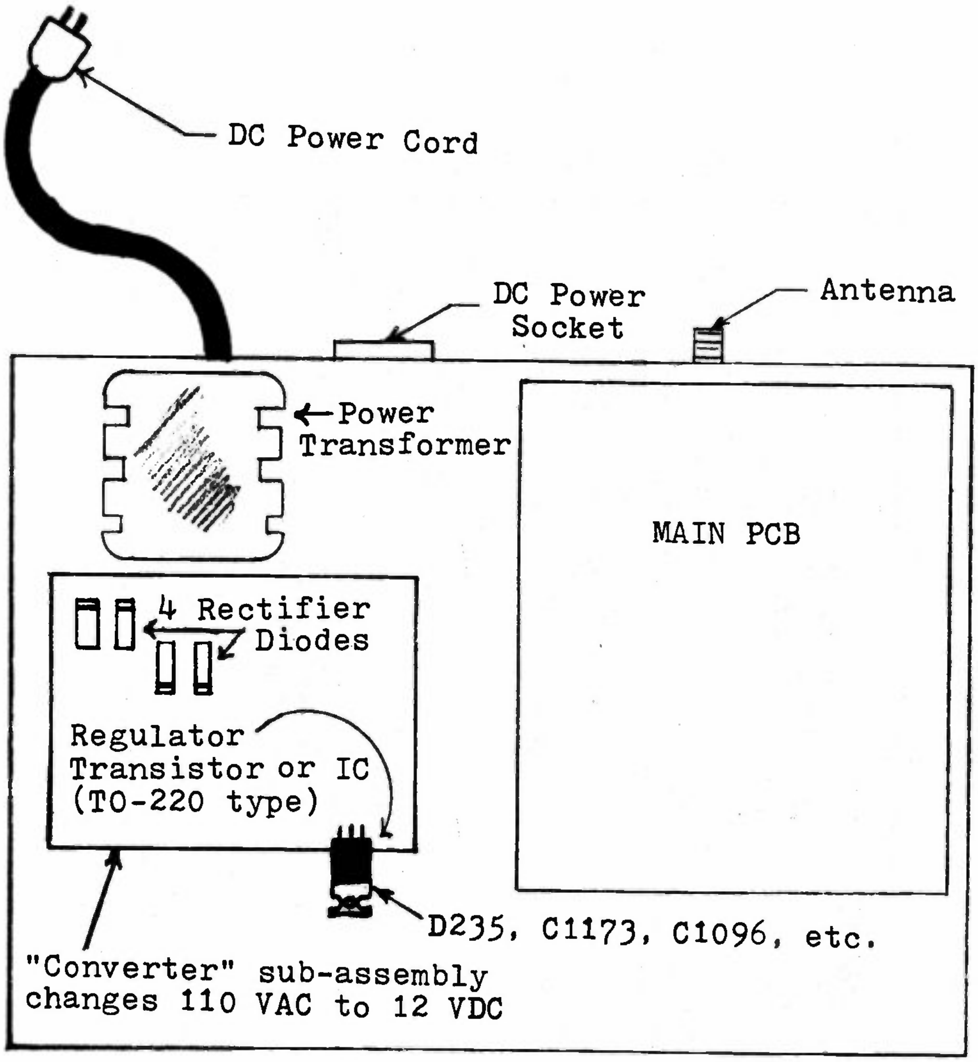


FIGURE 16

"CONVERTER" LOCATION IN BASE CB

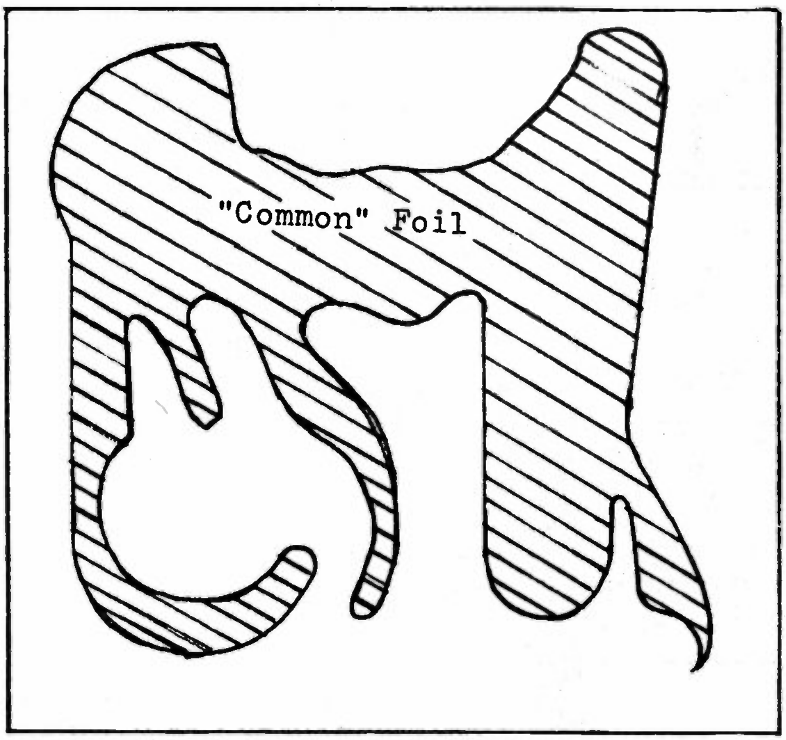


TOP VIEW

FIGURE 17

LOCATING TYPICAL "COMMON" FOIL

Foil Side of PCB



NOTE: "Common" Foil covers the largest area on the PC board. Also, there is no definite shape of foil surface.

FIGURE 18

REVERSE-POLARITY DIODES

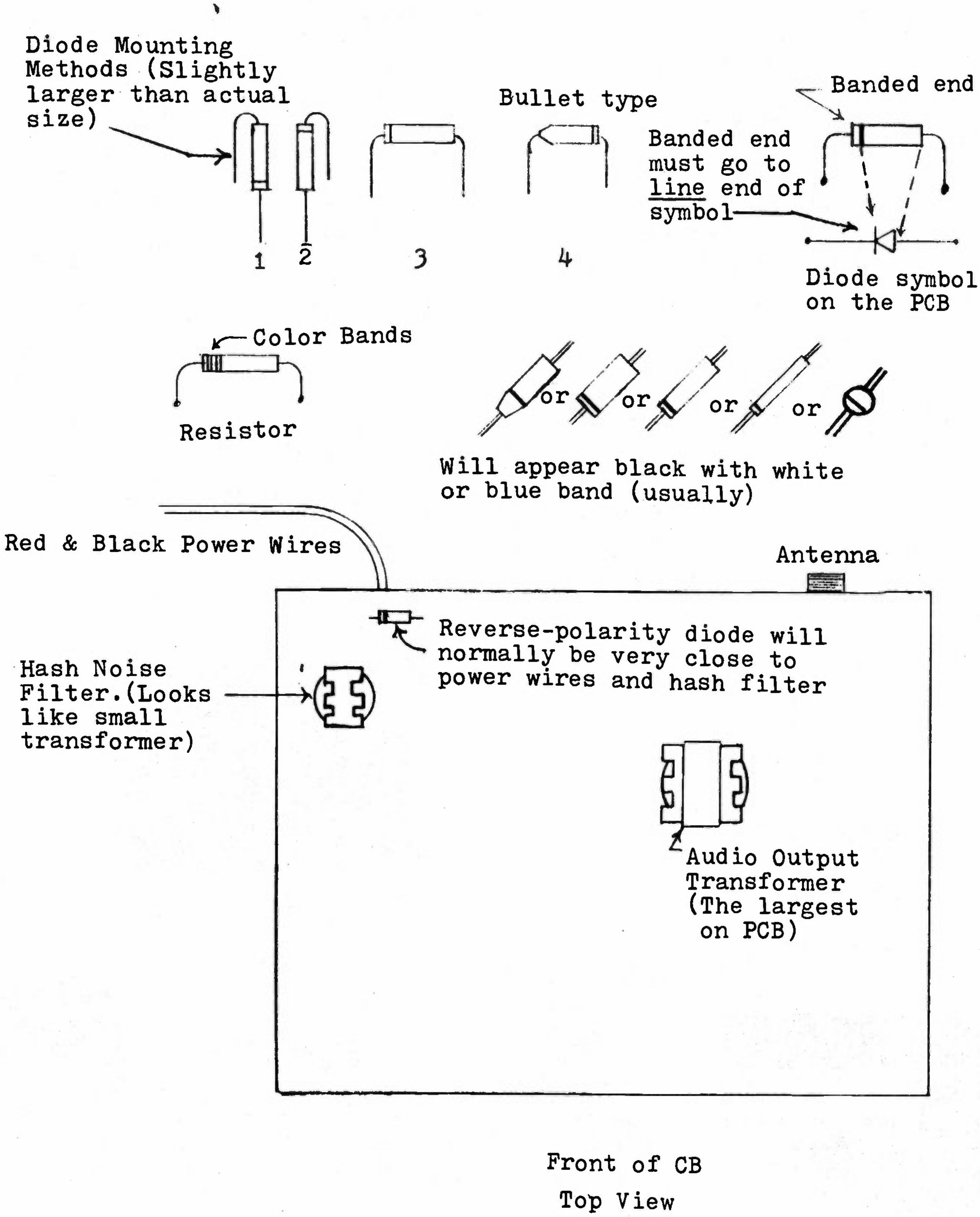
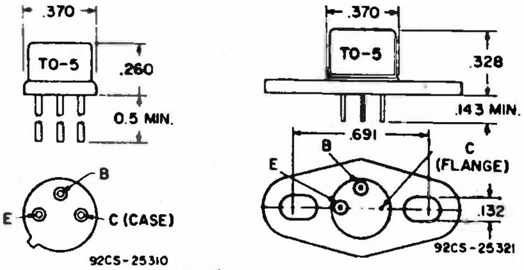


FIGURE 19

SOLID-STATE DEVICES

TO-5 CASE

ACTUAL SIZE



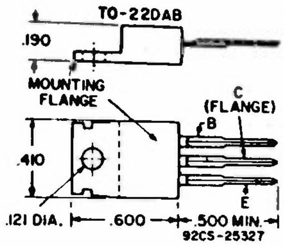
(WITH HEAT-SINK)

SHINY SILVER-COLORED

Eg., Finals & Drivers: 2SC756, 2SC799, 2SC778, 2SF8, MRF8004, 4005, 2SC775, 2SC778, 2SC781, 2SC482, 2SC1239.

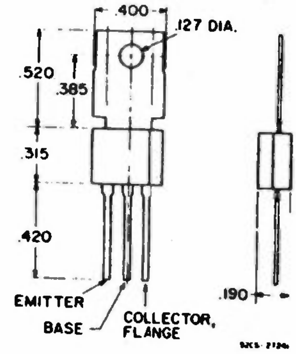
TO-220 CASE

ACTUAL SIZE



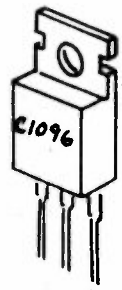
BLACK with WHITE LETTERS

OR

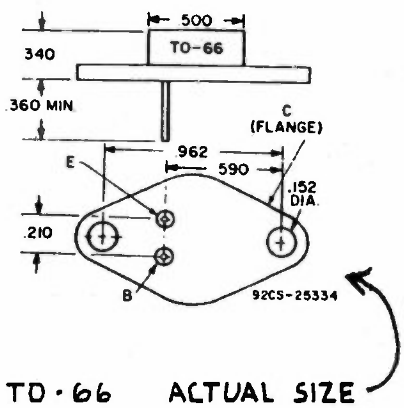


BLACK with WHITE LETTERS

Eg., Finals: 2SC1237, 2SC1678, 2SC1306, 2SC1307, 2SC1377, 2SC1814, 2SC1974, 2SC1975, 2SC2028(driver), 2SC2029, 2SC2075, MPS-U31, 2SC1760(driver). Audio Outputs & Voltage Regulators: 2SC1096, 2SC1173, 2SC1014, 2SC1018, 2SD235, 2SC1226A. (Some also used for TX drivers.)



TO-220



TO-66 ACTUAL SIZE

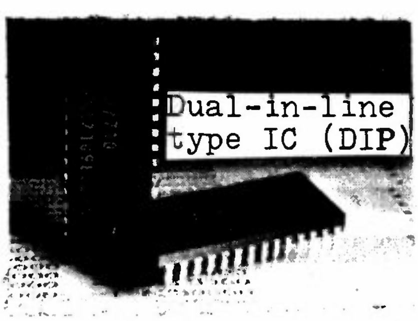
(TO-3 SAME BUT LARGER)

SHINY SILVER-COLORED

Typically 14 or 16 Pins

Shown about 3 times actual size

INTEGRATED CIRCUITS (ICs)



PLL "CHIP"

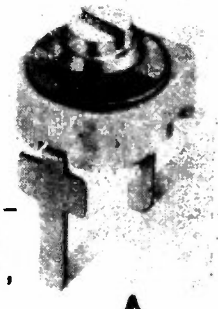
Size approximate. Usually has 16, 18, 24, or 28 pins. E.g., PLL02A, uPD858, SM5104, TC9109P, uPD2816C, etc.

MINIATURE "TRIM-POT"

May lay flat on PCB or mount vertically. Used for modulation, SSB, and PLL adjustments, etc.

"IN-LINE" TYPE IC

Audio output, voltage regulator, SSB balanced modulator, VCO mixer, etc.



TRIMMER "CAP"

Adjusts crystals (SSB rigs) and PLL circuits to exact operating frequency. Do NOT touch without a way to check frequency accurately, such as a good frequency counter.

FIGURE 20

LOCATION OF RECTIFIER SECTION IN BASE CB

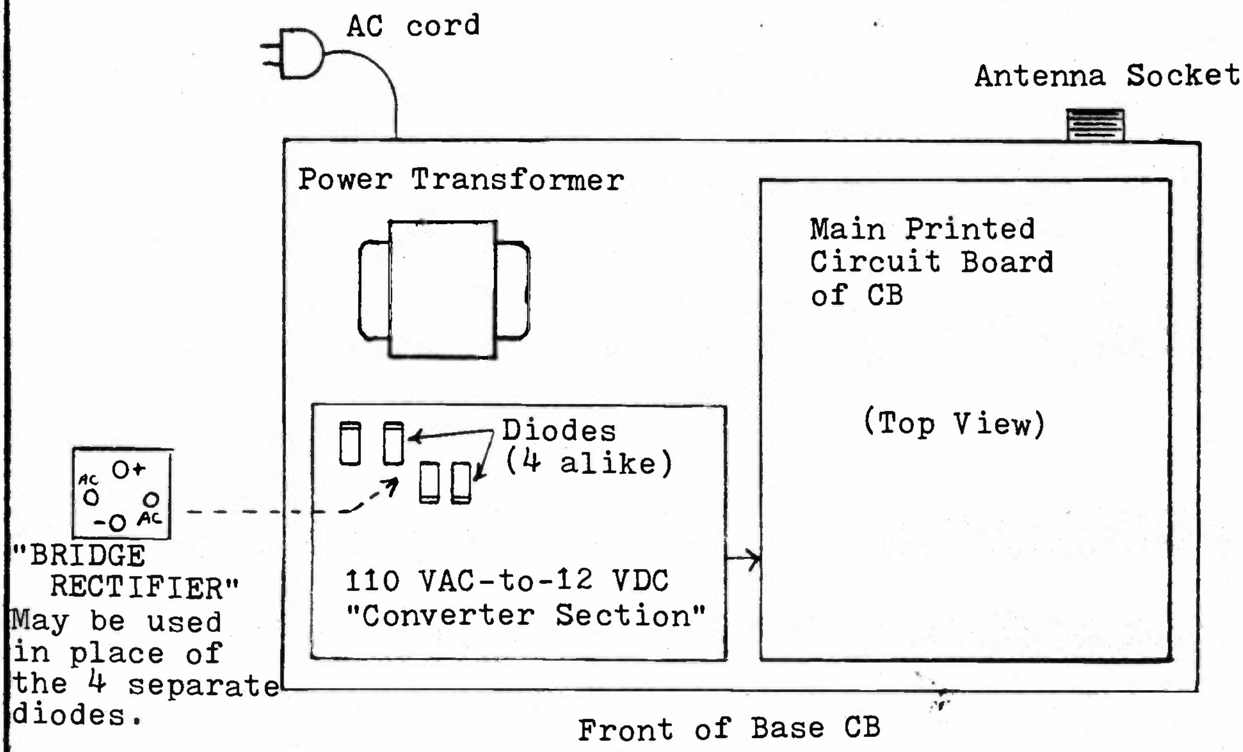


FIGURE 21

HEAT-SINK BOLTING METHODS

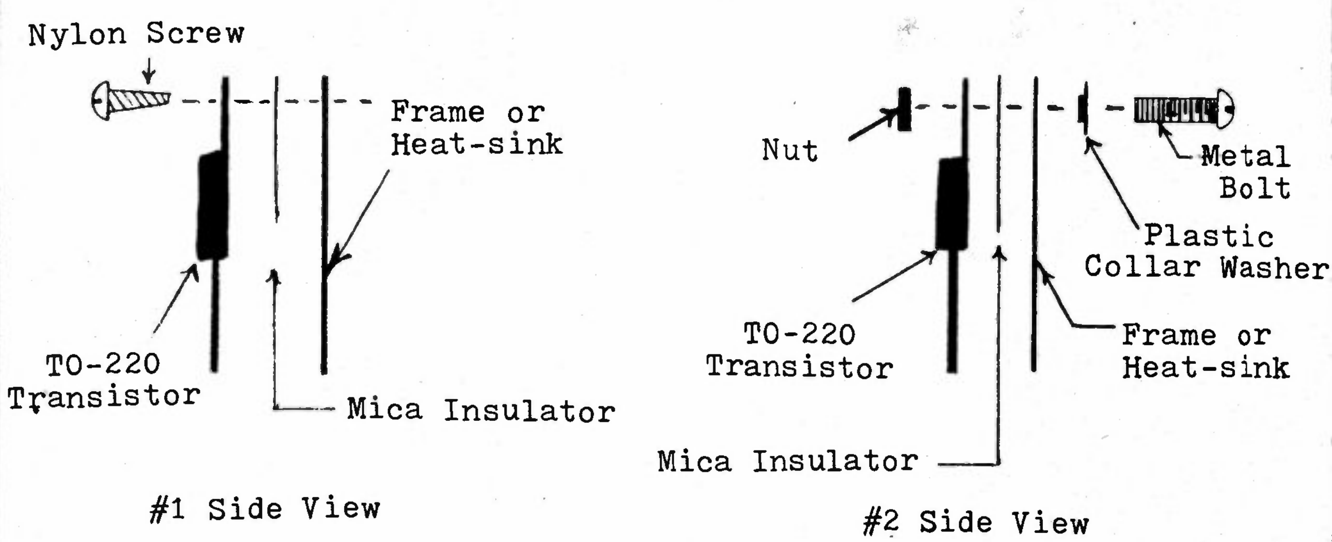
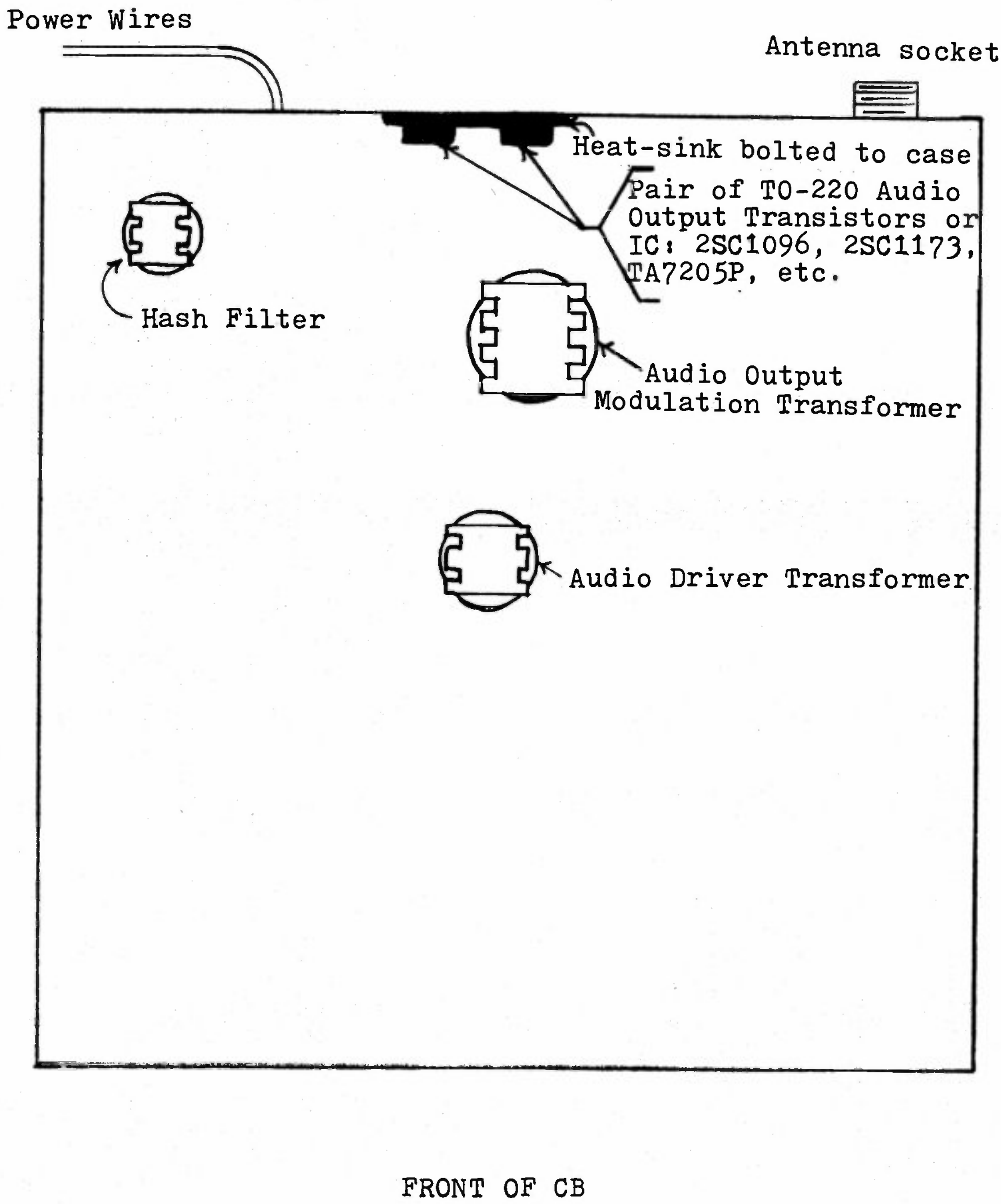


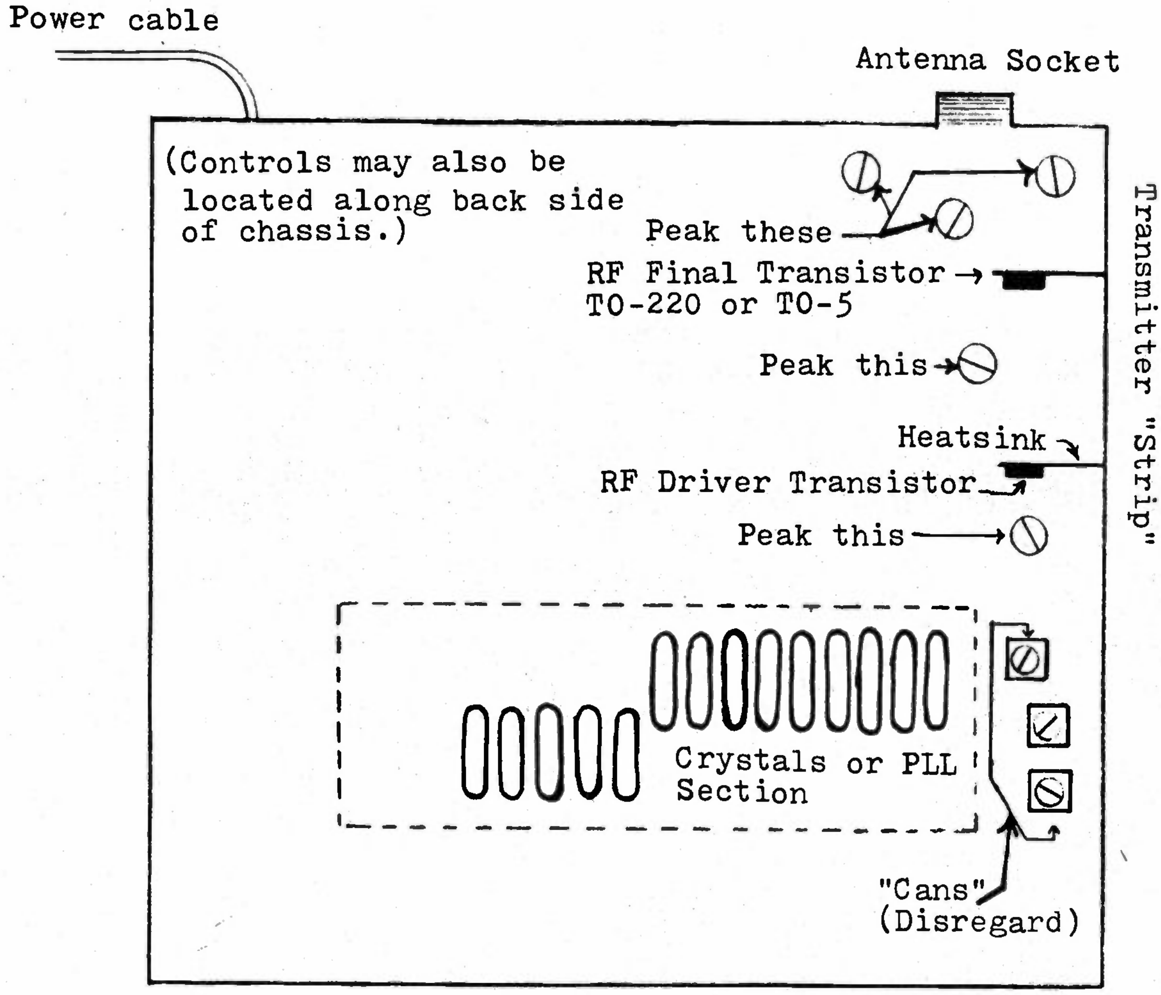
FIGURE 22 LOCATING AUDIO-MODULATION PARTS



Top View

FIGURE 23

TX PEAKING CONTROLS



Front of CB, Top View

FIGURE 23, continued

PHOTO LAYOUT SHOWING ACTUAL TX ADJUSTMENTS

Shown here, Johnson Messenger 123A. Transmitter "strip" is along top side. The 4 hexagonal-hole coils are seen in photo.

Heat-sinked TO-5 Final

Heat-sinked TO-5 Driver

Peak

Peak

Peak

ANT.→

HASH FILTER

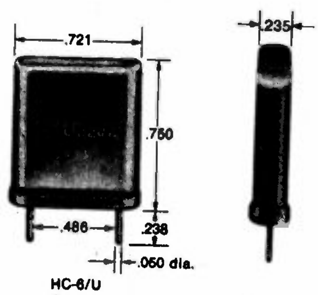
Audio-modulation Transformer

Crystals (On switch)

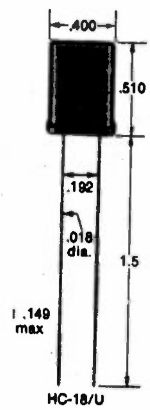
RF & Synthesizer Oscillator "cans." Do NOT touch without a schematic!

FIGURE 24

CRYSTALS



HC-6/U
(Tube-type sets)



HC-18/U
Solder-in and plug-in.

Used in both PLL and synthesized CB sets.

ACTUAL SIZE

FIGURE 25

HOW TO DETERMINE "DEAD" CHANNELS AND THEIR CRYSTALS

Frequency Synthesizer Methods of Most 23-Channel AM CB Radios

SCHEME #1

	RX & TX	RX & TX
Ch. 1	23.290	14.950
Ch. 2	"	14.960
Ch. 3	"	14.970
Ch. 4	"	14.990
Ch. 5	23.340	14.950
Ch. 6	"	14.960
Ch. 7	"	14.970
Ch. 8	"	14.990
Ch. 9	23.390	14.950
Ch. 10	"	14.960
Ch. 11	"	14.970
Ch. 12	"	14.990
Ch. 13	23.440	14.950
Ch. 14	"	14.960
Ch. 15	"	14.970
Ch. 16	"	14.990
Ch. 17	23.490	14.950
Ch. 18	"	14.960
Ch. 19	"	14.970
Ch. 20	"	14.990
Ch. 21	23.540	14.950
Ch. 22	"	14.960
Ch. 23	"	14.990

SCHEME #2

	RX & TX	TX Only	RX Only
Ch. 1	37.600	10.635	10.180
Ch. 2	"	10.625	10.170
Ch. 3	"	10.615	10.160
Ch. 4	"	10.595	10.140
Ch. 5	37.650	10.635	10.180
Ch. 6	"	10.625	10.170
Ch. 7	"	10.615	10.160
Ch. 8	"	10.595	10.140
Ch. 9	37.700	10.635	10.180
Ch. 10	"	10.625	10.170
Ch. 11	"	10.615	10.160
Ch. 12	"	10.595	10.140
Ch. 13	37.750	10.635	10.180
Ch. 14	"	10.625	10.170
Ch. 15	"	10.615	10.160
Ch. 16	"	10.595	10.140
Ch. 17	37.800	10.635	10.180
Ch. 18	"	10.625	10.170
Ch. 19	"	10.615	10.160
Ch. 20	"	10.595	10.140
Ch. 21	37.850	10.635	10.180
Ch. 22	"	10.625	10.170
Ch. 23	"	10.595	10.140

ALSO USED: (Scheme #1 ONLY)
11.275 TX all 23 Ch.
11.730 RX all 23 Ch.

FIGURE 26

DO-IT-YOURSELF LOW PASS FILTER

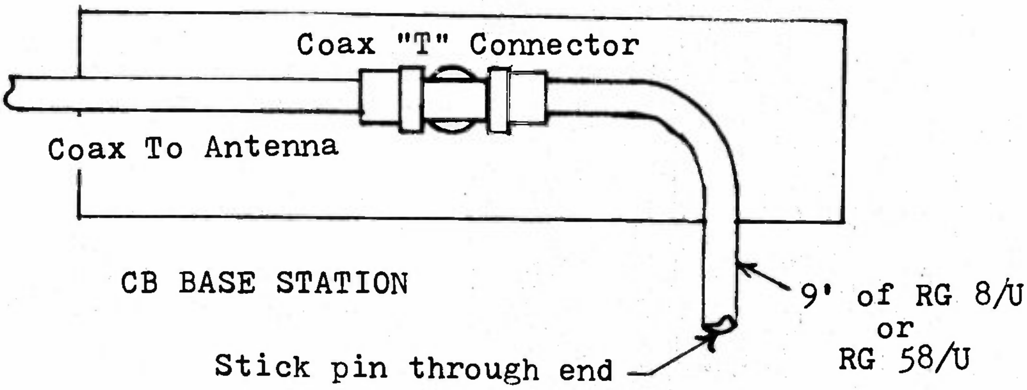


FIGURE 27

DO-IT-YOURSELF HIGH PASS FILTER

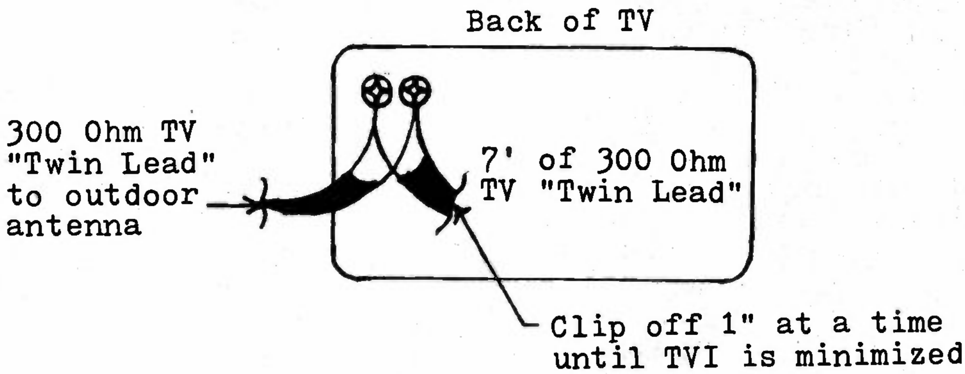


FIGURE 28

CURE FOR TV "FRONT END" OVERLOAD