AM-FM-CB

Noise Interference In Mobile Rigs How To Get Rid Of It

Eliminating interference in mobile radios can be simple when you find the source. Here's how to find and get rid of most noise.

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NOISE INTERFERENCE IS PERHAPS ONE OF THE MOST IRRITATING problems encountered when installing a mobile rig. Some noise problems seem so difficult to eliminate that many simply put up with the irritation, and accept it. However, most noise problems are relatively easy to solve, and are amenable to almost simplistic solutions.

The first step in troubleshooting any mobile noise problem is to identify the *types* (notice the use of the plural form!) of noise present. Generally, noises come in bunches, each of which must be solved by a slightly different approach. Is it, for example, spark plug/ignition noise? Is it alternator whine? Or is it the sloshy-sounding tick of the gasoline level sensor in the fuel tank? You should not fall prey to the trap of assuming that only one form of noise is present, even when they sound enough alike to mask each other.

Suppression methods

Table 1 shows the most common types of noise in mobile broadcast and communications receivers, along with their recommended cures. Be aware, though, that many transceivers may not be able to use all of these techniques because of the high current demands of the transmitter. For example, if the L-section filter is used to suppress alternator whine, the recommended choke will have too high a resistance for a 100-watt transmitter. In these cases, you could open the transceiver and insert the filter in the power-supply line feeding the receiver and thus leave the power-supply line feeding the transmitter circuits intact. If this is possible, it will also allow you to fuse the power-supply line feeding the receiver at a much lower current than the rating of the primary fuse for the transmitter. It has been known to happen, especially where solid-state receivers are used, that the receiver power supply could burn up rather spectacularly, yet the power-supply current would not blow the 25- to 50-ampere fuse needed to sustain the normal transmitter supply current.

Also, be aware that some automobile manufacturers will have installed some suppression techniques that could be superior to those given in this article for specific automobile models. This is especially true for alternator whine or where a grounding or shielding problem in the vehicle has been detected. A call to the local automobile dealership or to the field-service department of the auto maker often yields rich information.

The capacitor method of suppressing ignition noises works well on the old-fashioned Kettering coil/breaker-points type of ignition that is standard on almost all cars, but it may not work

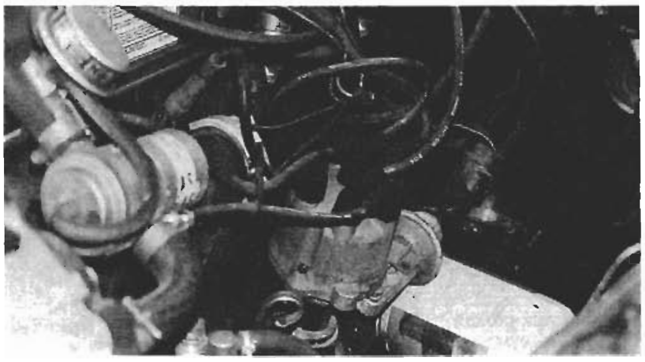

FIG. 1—IGNITION SYSTEM is the most dominant source of RF interference in automotive installations. Early amateur radio operators often used ignition coils from Model-T cars as transmitters.

or may cause damage to the newer solid-state ignition systems. In this case, contact the car manufacturer (either the car maker if it is O.E.M. equipment or the ignition manufacturer if it is an after-market product).

The ignition system (shown in Fig. 1) is not the only source of spark-like interference. There are numerous small DC motors in your car that are often overlooked. One of the prime offenders is the motor (see Fig. 2) that drives the blower in the heating/air-conditioning system.

Standard suppressors

Some of the suppression techniques recommended (see Table

TABLE I

SYMPTOM	CAUSE	CURE	COMMENTS
Popping static at a regular rate. Varies with engine RPM.	Ignition system	Check for deteriorated resistance ignition wire. Bypass capacitor from battery terminal of ignition coil to ground (0.5-μF).	Check antenna ground.
High-pitched ragged howl.	Generator	0.1 to 0.5-μF from armature terminal to ground and/or L-section filter at radio power lead. Do *not* bypass field terminal.	Applicable only to older U.S. and some imported cars.
High-pitched, nearly "pure" whistle. Varies with engine RPM.	Alternator	Check car manufacturer's service manual. Install a 0.1 to 0.5-μF capacitor at alternator and/or L-section filter at radio power lead.	
"Frying eggs" sound.	Regulator	Bypass input and output terminals of regulator to ground with 0.1-μF capacitors.	May also indicate a defective regulator.
Popping (slow). Does not vary as engine RPM varies.	Gas gauge sender unit.	Bypass lead-in wire as close to tank as possible. (0.5-μF).	Usually found under carpet in trunk. Consult manufacturer's service manual.
Popping sound as brake is depressed.	Brake-light switch.	0.5-μF across switch.	
Horn noise.	Horn	0.5-μF across horn winding.	May be masked by sound of horn.
Electrical motor whine. Does not vary with engine RPM.	Motors	0.5-μF across winding.	
Capacitor types: For AM radios, use only automotive-type bypass capacitors or coaxial types. For FM or CB radios, use only coaxial automotive bypass capacitors.			

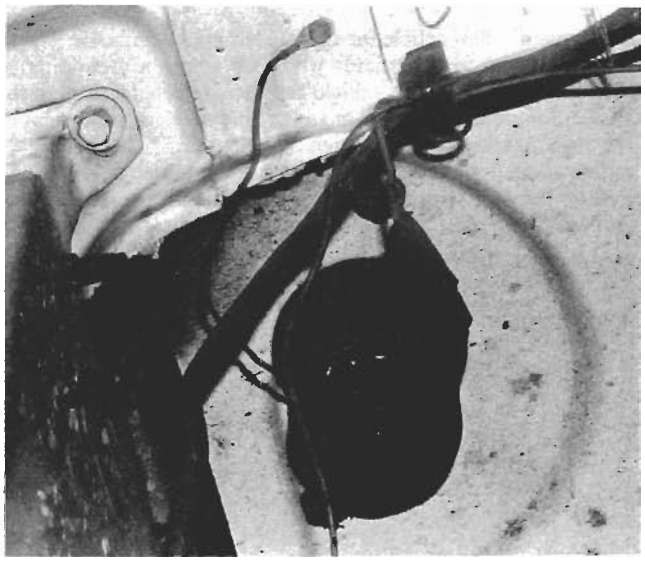

FIG. 2—HEATER/AIR CONDITIONER BLOWERS and other DC motors are often overlooked as sources of noise.

1) may already be installed in the car by the auto manufacturer, while you must add the others yourself. Note that vehicles equipped with only an AM radio may not have adequate bypass capacitors for high-frequency suppression, but many cars having AM/FM radios will have the correct capacitors. What is needed are *coaxial* bypass capacitors, such as those manufactured for amateur and CB use by Mallory and others.

Ignition system suppression uses a 0.1- to 0.5-μf capacitor across the primary side of the ignition coil and some resistance (approximately 10,000 ohms) in series with the spark plugs. Be absolutely sure to connect the capacitor to the battery terminal of the ignition coil (see Fig. 3) and not to the distributor terminal. (The distributor terminal of the coil is identified by the wire that runs to a grommet or connector on the side of the distributor, while the wire on the battery terminal of the ignition coil seems to disappear into the car's main wiring harness.) Use a coaxial bypass capacitor, then disconnect and discard the existing AM suppression capacitor.

The series resistance can take any of several forms. You could, for example, use copper ignition wires and then insert one

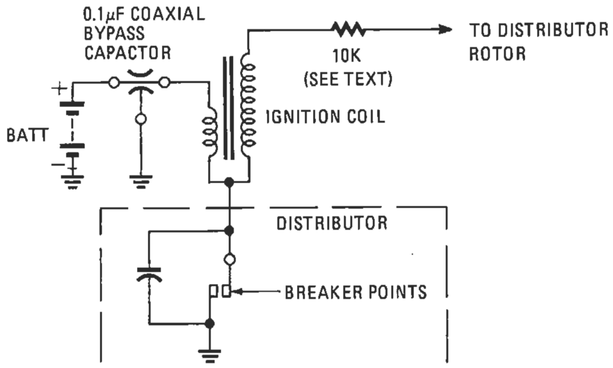

FIG. 3—KETTERING IGNITION SYSTEM was the most common before the electronic ignition system was introduced. Noise suppression involves adddding a 0.1-μF capacitor on the primary side of the ignition coil and some resistance in series with the spark plugs if the engine does not already have this resistance present. The series resistance can take the form of resistance-type ignition wires or barrel-type resistors that are inserted in the spark plug wires.

of those little black barrel-shaped noise-suppression resistors in the line. I do not recommend this method, however, because the resistor could work loose and leave you stranded in the middle of nowhere. The car manufacturers usually supply the vehicle with either radio resistance wires or resistor spark plugs. In the case of some imported cars, resistor inserts or caps that attach to the spark plug electrodes are installed. The resistance wire, used on most American cars, works well in suppressing spark plug noise, but has the habit of deteriorating every couple of years. It does, however, provide very credible suppression of spark plug noises!

Figure 4 shows how to mount the coaxial bypass capacitor to the alternator frame to reduce the high-pitched whistle-type interference. As in *all* noise suppression capacitor installations, it is critical to keep the leads between the capacitor and the alternator as short as possible.

The *correct* terminal on the alternator (or generator if your car is older or imported) is the larger of the two terminals. This high-current terminal carries the charge to the battery. Do not

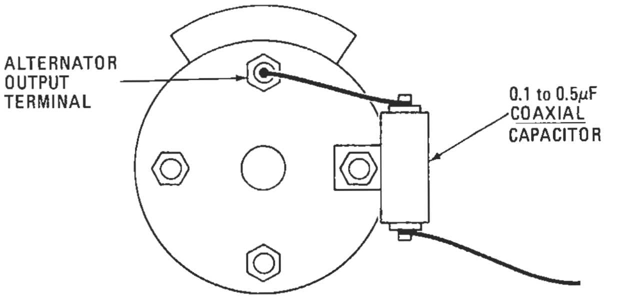

FIG. 4—ALTERNATOR WHINE is reduced by adding 0.1 to 0.5-μF coaxial capacitor to alternator as shown. Check with auto manufacturer for correct value or damage may result. To further reduce noise, an L-section filter can also be added at the input power line feeding the radio.

attach a capacitor to the smaller terminal, or damage may result.

Also, check with the automobile manufacturer about the correct capacitor value for your particular car model. A value between 0.1 to 0.5 μF is usually recommended. However, there have been several cases reported where certain alternators have resonated with the added capacitance, and this resonant condition resulted in alternator damage. It is better to check it out than not!

In the "old days" when generators were used and the voltage regulator was a chattering bank of three high-current relays in a little black box, the recommended cure was a 0.1-μf capacitor connected to both the battery and generator terminals of the regulator and a series R–C network with a short (less than 1 μs) time constant from the field terminal to ground. But this is no

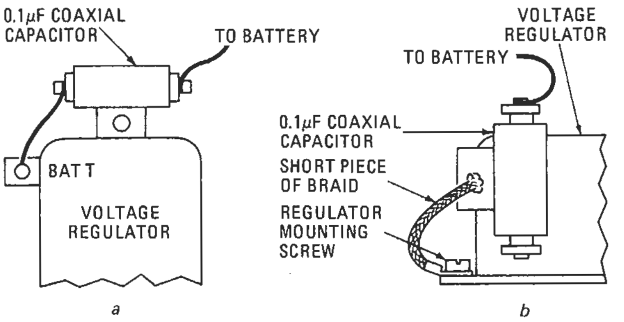

FIG. 5—REGULATOR CAUSED NOISE is reduced by adding a 0.1-μF coaxial capacitor in series with the battery terminal. Two possible methods for mounting the capacitor is shown in *a* and *b*.

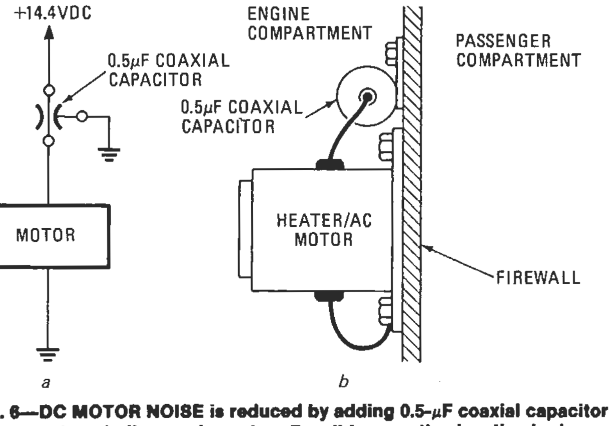

FIG. 6—DC MOTOR NOISE is reduced by adding 0.5-μF coaxial capacitor across motor winding as shown in *a*. Possible mounting location is shown in *b*.

longer the best advice. In modern cars, the regulator is either all solid-state or partially solid-state (the high-current pass element is a relay), so only a 0.1-μF coaxial capacitor from the battery terminal to ground is required.

Figure 5 shows two alternate methods for mounting the coaxial capacitor. Note that any existing AM suppression capacitors must be removed prior to installing the coaxial capacitors. Figure 5-a shows what can be termed the "common-sense" mounting method, while Fig. 5-b shows a little more clever method if the mechanical construction of the regulator allows it. Most regulator terminals are threaded to accept a No. 10-32 machine screw to hold the wire, so use a Mallory bypass capacitor that is similarly threaded. If only the female version is available, cut a No. 10-32 stud from a machine screw. Be absolutely sure that the connection between the capacitor and the terminal is tight or problems will occur at high charging currents. Use a piece of battery grounding braid or the tinned shield from a RG-8 or RG-11 coaxial cable to ground the capacitor body. Solder the end of the ground strap to the capacitor.

Figure 6 shows the method for suppressing the noise from a small DC motor such as the heater/air-conditioner blower. The 0.1-μf coaxial capacitor must be mounted as close as possible to the motor, a feat that is a lot easier to write about than actually do in most cases! Also, be sure that the motor housing is well grounded; the antirattle compounds that are sometimes used often provide a good DC ground but a poor RF ground.

Receiver defects

Component failures can create a noise problem in a vehicle that is otherwise free of excessive interference. The most common problem is the failure of certain noise-suppression components in the power-input circuit to the receiver.

Figure 7 shows a typical (well almost typical) power-input

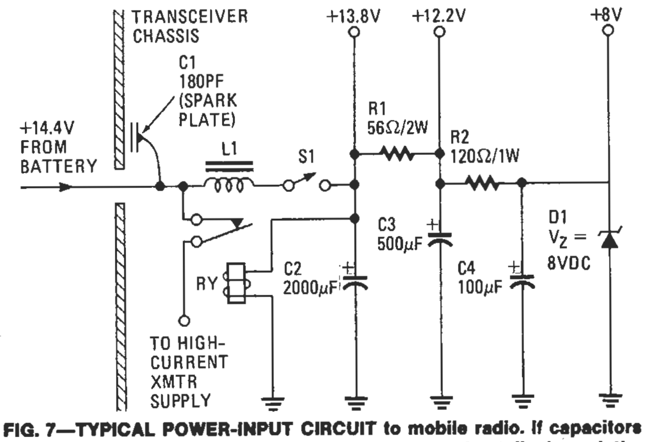

FIG. 7—TYPICAL POWER-INPUT CIRCUIT to mobile radio. If capacitors C1-C4 open up or if L1 should short, noise will enter the radio through the power supply line.

circuit to the receiver portion of a transceiver. Capacitor C1 rarely opens up (if it is used at all) because it is a spark-plate capacitor that consists of two pieces of copper foil sandwiched across a small square of fishpaper insulator. But if capacitors C1–C4 (especially capacitor C2) should open up, or if coil L1 should short out without shorting to the chassis (in which case it would burn out the fuse), then noise will result.

If the antenna input choke, or the lead from the antenna terminal on the transmit/receive relay, is placed parallel and beside the power-supply line from the battery, then there is a good chance that noise pulses will be picked up and cause interference in the RF amplifier. This type of noise problem, which incidentally is seen fairly often, is best corrected by either repositioning the antenna line or by placing it inside a shielded enclosure.

The best way to determine whether the problem is in the radio is by substitution, although this is not the most practical way where amateur mobile installations are concerned. But if it is possible to temporarily install some other rig then try it. If there is *reduction* in noise with the new rig (or, very rarely, the elimination of noise), then the problem is in the rig.

Antenna and radio grounding

Do not overlook the grounding connections for the antenna and the transceiver chassis as a possible cause of noise problems. The antenna should be checked by substituting it with a known good antenna. Although it is not resonant at the HF or VHF ham bands, you may use for test purposes only, an ordinary low-cost AM car-radio antenna. Attach the correct cable adapter and plug it into the transceiver antenna connector. Ground the base of the test antenna to a conductive chrome or bare steel fixture on the car—it is not usually necessary to mount the antenna.

When checking ground connections, it is advisable not to rely on an ohmmeter because the readings can be highly misleading. Like the tube tester, if the reading indicates it is bad, then you better believe it, but if it indicates it is good, then it may *still* be bad. In the case of the antenna, if an ohmmeter indicates that the coaxial cable shield is open, then you have found the source of your trouble—not to mention transmitter tune-up problems. However, if the ohmmeter reads some low resistance, then you must make the substitution test to verify that the ground is the cause of the problem.

Similarly, the radio chassis may look grounded to the DC power supply but to RF it actually might be at a sufficiently high impedance to produce a noise voltage high enough to interfere with reception.

Modern automobiles frequently use a clay- or putty-like anti-rattle compound between the dashboard and the firewall. Noise may result if the dashboard and the firewall are used as the ground return for the transceiver's DC power supply. The solution is to connect a heavy conductor between the radio chassis, the major dashboard braces *and* the firewall. Use either battery braid or an outer shield from a length of heavy coaxial cable.

The problem of noise caused by poor chassis grounding has been compounded in recent years by the use of lock-mount brackets and antitheft consoles over the transmission hump. This type of mounting is particularly popular with CB'ers, but is also used in low-power HF and two-meter amateur rigs.

Many less experienced mobile installers will use the coaxial cable shield as the DC ground return wire. This will not cause any DC-related problems unless the transmitter is a high-power unit that requires a large current from the supply circuit. It does, however, create potential noise problems because the RF impedance is quite high! If the radio has a ground wire, use it; if not, make one.

If you use a slide mount, you should take special care of the copper-finger connectors that bring power to the set. As long as they are not corroded and have not lost their spring tension, they work well, but let them deteriorate and you will hear it in the loudspeaker! The best solution is to route the ground wire directly to the firewall, but if theft is a problem in your area, then be sure to maintain the connections on the slide mount.

Antenna or power-line noise

Once the radio chassis and antenna grounding have been attended to and eliminated as possible sources of the noise, the next consideration is whether the noise is entering via the antenna or the power line. To determine this, disconnect the antenna and note whether or not the noise level is reduced. Some amateurs seem to believe (erroneously) that the type of noise indicates how it enters the set. Ignition noise, especially, can enter the set by either the antenna or power line, and the proper corrective action for each is different.

Antenna-related noise, for example, is often caused by the inadequate shielding action of the hood or body panels, or it can be caused by RF reradiation from the tailpipe of some other vehicle. Noise that enters on the power line, on the other hand, is often caused by the incorrect placement of the power cable itself, or by induction from another cable.

It is good practice to take note of whether the car has recently been serviced, or has recently been returned from the body shop following accident repairs. Sometimes, the fiberglass and plastic components materials used to repair body damage, or an incorrectly reinstalled antenna ground, can cause noise that did not exist before. For instance, in an actual case of a car with an all fiber glass body, the AM/FM radio has a great deal of motor noise that had not been there prior to repairs on the right rear-quarter panel. It turned out that the antenna ground to the tailpipe had not been reconnected, which was causing the interference.

After the tune-up

Another possible cause of a flare-up in motor noise is an improper motor tune-up job. If the noise occurs for the first time right after a tune-up, then suspect that something was wrong with the job.

In some cases, I have discovered that the mechanic substituted straight copper high-voltage wires for the resistance wires specified by the manufacturer. Use an ohmmeter to check whether the mechanic substituted the incorrect wire. First, check the wire from the high-voltage terminal on the coil to the center terminal on the distributor. If this wire does not have a resistance of several thousand ohms, then get back to that garage and have the mechanic install the correct spark-plug wires.

It is equally important to check the wires if the noise has appeared gradually, and it has been 25,000 miles or two years since the high-voltage wires were last replaced. The carbon-wire filament used in these cables deteriorates after a while and to a point where internal arcing occurs. Besides causing rough engine idle, this will also cause radio-frequency interference in the radio receiver.

A sure sign of deteriorated ignition cables is a low-speed popping noise that is most noticeable when the car is idling. This condition is caused by having one open-circuited spark plug. If you have ever observed the ignition waveforms of a multicylinder engine with such a problem on an automotive oscilloscope, then you probably saw the pulse amplitude on the offending cylinder go so high that it passed right off the top of the screen!

Some amateurs operating in the low-frequency (75-meters, mostly) bands use a low-value RF choke in series with the receiver antenna line inside the transceiver cabinet. This RF choke is usually placed in the receiver side of the transmit/receive relay circuit. Figure 8 shows an RF choke made up of a

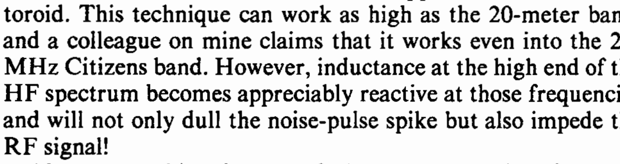

FIG. 8—NOISE CAN ALSO BE REDUCED by placing an RF choke in series with the antenna line inside of the receiver.

few turns of No. 22 enameled wire wrapped around a red-core toroid. This technique can work as high as the 20-meter band, and a colleague on mine claims that it works even into the 27-MHz Citizens band. However, inductance at the high end of the HF spectrum becomes appreciably reactive at those frequencies and will not only dull the noise-pulse spike but also impede the RF signal!

Alternator whine is one of the most annoying forms of interference to mobile rigs. It usually enters through the power line and is difficult to suppress. It even affects two-meter rigs, (normally immune because of the remoteness of 144-MHz from the stronger noise-pulse harmonics) because the whine penetrates the audio stages.

Figure 9 shows an L-section filter, long popular in the auto entertainment electronics market. The problem with using this filter is that the choke's high DC resistance will cause appreciable voltage drop when the transmitter is keyed. The choke is

continued on page 114

continued from page 50

the same kind of choke shown as L1 in Fig. 7. The choke is a common stock item available in car radio repair shops or in stereo sales outlets. Those made by Delco seem to have a lower DC resistance for a given inductance. A DC resistance of 0.20 ohms may not seem like much, until you key the transmitter and draw 30 amperes through the coil. Even if it didn't burn up (it will!), the voltage drop by Ohm's law would be 6 volts. This technique can be used successfully with a low-powered 2-meter

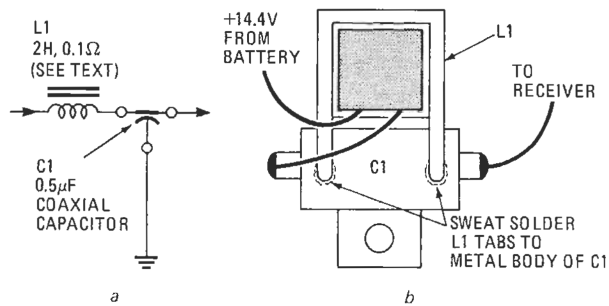

FIG. 9—L-SECTION FILTER shown in *a* is added to power supply line feeding radio. L-section filter is constructed as shown in *b*.

mobile rig, but if you have a high-powered transmitter, it is advisable to separate the DC lines from the receiver section, if possible, and bring them out on their own connectors.

Inductive and capacitive pickup

Up to this point we have discussed almost every type of noise encountered in automotive installations. The sources that remain are often very difficult to locate, although most are easy to fix once found.

Figure 10 shows one example. The exhaust pipe on your car may reradiate noise, and if it is of the correct length, it may also resonate the noise components inside the RF band. This problem is particularly prevalent in 10-meter and 11-meter CB installations. The solution is to ground the tailpipe. It is generally assumed that the tailpipe is already grounded at the engine, but three other factors can contribute to interference: gaskets, rust and the tailpipe length being close to a one-quarter wavelength. Install ground clamps every few feet to reduce the severity of this problem.

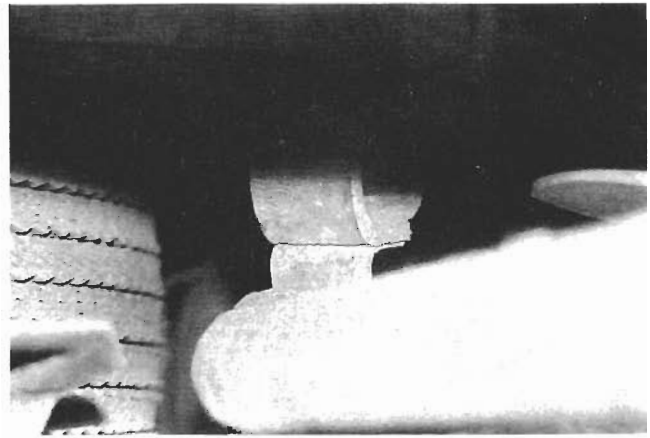

FIG. 10—INSULATED TAILPIPE HANGERS can make tailpipe RF source.

The chrome strips on some cars can also cause motor noise in mobile rigs. If the strips are an appreciable fraction of a wavelength on the band of interest, then it could reradiate if the grounding action of the holding clamps is reduced by corrosion or loss of the clamps. This was the cause of a very tiring and most perplexing source of noise that I had to troubleshoot once many years ago. I still get a backache just thinking about it!

Noise detector

Channel Master has developed a device that is probably the first tool specifically designed to track down sources of motor noise. This is the *model 5270* RF noise detector, also called the *Sleuth* and shown in the head photo.

The *Sleuth*, which sells for about $17, is approximately 25 inches long, and 1 inch in diameter. It has a 17-foot coaxial cable fitted at the free end with a PL-259 coaxial connector. This connector is attached to the radio's antenna connector, so that the receiver can be used as a noise indicator. **Do not key the transmitter with the *Sleuth* connected!**

When the *Sleuth*, which is nothing more than a directional RF detector, comes in close contact with the offending noise source, it lets you know through the radio speaker. The device will pinpoint noise sources wherever they are located, even most reradiation sources; such as the tailpipe, the emergency brake cable, a wire or cable bundle or the various rods and linkages passing through the firewall. Most reradiation problems can be then cured by grounding, bypassing or shielding. **R-E**