interference suppression in cars

Electrical interference generated by cars can be a source of annoyance, not only to the car occupants, but also to users of other electronic equipment external to the vehicle. This article discusses some of the more common causes of interference and their cure.

Anyone who has installed a car radio and then discovered that the programme is drowned out by odd buzzes, pops and crackles will know how difficult it is to trace and suppress interference. Commercially available 'do-it-yourself' suppression kits often do not effect a cure, because the interference is not dealt with at source.

Interference in cars on radio and T.V. bands is caused by high-frequency energy, usually produced by arcing contacts, but also by discharge of static electricity. The interference may be continual, for example that originating from the ignition circuitry, or it may be transient, such as interference occurring when light switches or brake lights are operated. Windscreen wiper motors can also generate substantial interference when they are running.

Interference may be divided into two groups:

1. External Interference.
2. Internal Interference.

External interference affects not only electronic equipment in the car but also radios and televisions in the vicinity. Internal interference is usually restricted to bad reception on the car radio.

The principal sources of interference in a car are as follows:

ignition system
dynamo and regulator
screenwiper motor
electric fan (if fitted)
heater fan motor
petrol gauge
brake light switch
light switches
starter motor
starter relay and switch
trafficator flasher unit
relays
ignition switch

Some of these, such as the ignition switch and light switches, cause interference of a very transient nature and are probably not worth bothering with.

The ignition system is the most powerful source of interference and will be dealt with first. Interference can be suppressed at various points in the ignition circuit. Figure 1 shows a typical arrangement of the high-tension side of an ignition system. Screened plug caps provide a good degree of suppression. The screening makes contact with the plug base and covers the porcelain insulator. A typical screened plug cap is shown in figure 2. These are available from auto electricians. Plug caps with a built-in suppression resistor are also effective, or alternatively 'carbon-string' H.T. leads may be used, though the mechanical reliability of these is questionable. The distributor may already have suppression incorporated, but if not, suppressor caps may be fitted to the distributor cover. These should have a resistance of about 1 k. Alternatively, in-line suppressors may be fitted in the plug leads near the distributor.

If a radiotelephone is installed in a car, an extreme degree of ignition suppression may be necessary in the form of screened cables for all H.T. leads and connections to the coil. Under normal conditions the coil itself may be suppressed by connecting a capacitor of about 3 μ 400 V between the SW (ignition Switch) terminal of the coil and earth. Figure 3 shows how this is done.

The second important source of interference is the dynamo/regulator system of the car. Dynamos generally have two connections, one to the armature (via the brushes and commutator), which is the output terminal of the dynamo, and one to the field winding, the current

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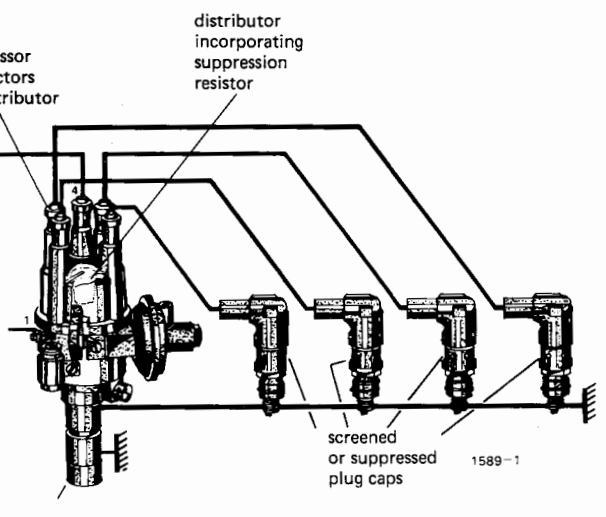

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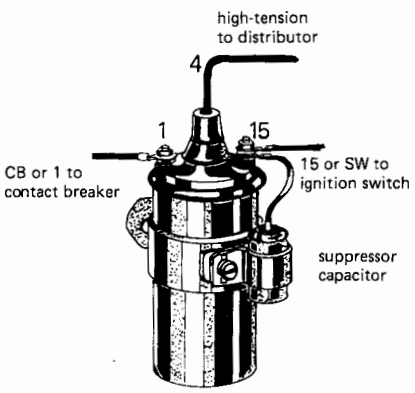

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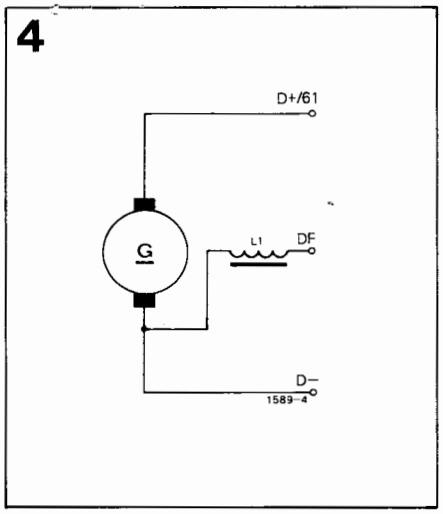
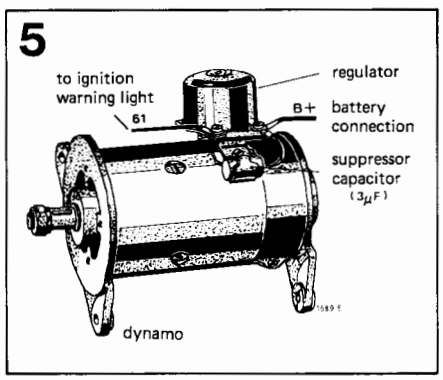
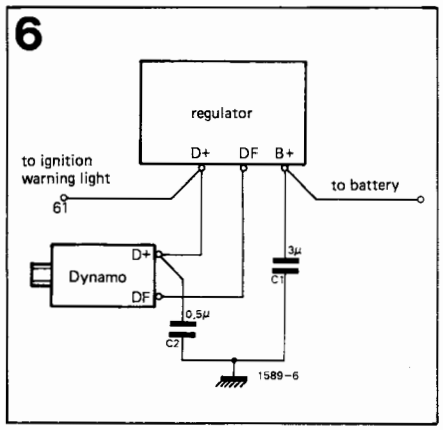
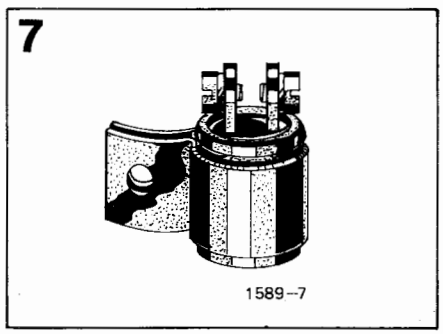
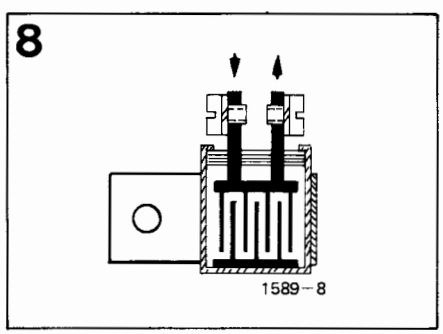










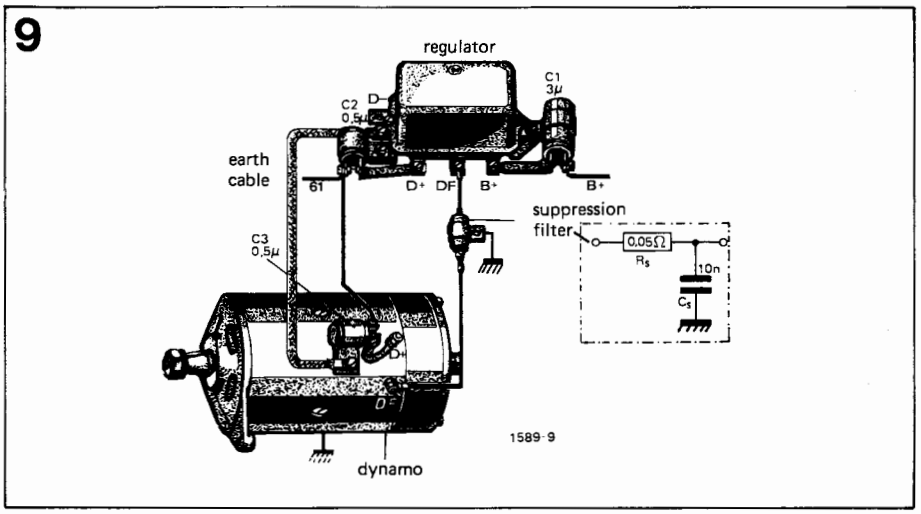


Figure 1. Diagram of the high tension side of a typical car ignition system, showing places to incorporate suppression.

Figure 2. Cut-away drawing of a typical screened plug cap.

Figure 3. Ignition coil showing where to connect suppressor capacitor. Numbers on various terminals are DIN standard codes for these terminals.

Figure 4. Connections to a dynamo. Usually only the armature and field connections are brought out to terminals and the common terminal is earthed to the frame of the dynamo. Again DIN standard codings are used for the terminals.

Figure 5. A low-power dynamo with an integral regulator showing connection of suppressor capacitor.

Figure 6. Circuit showing suppressor connections for dynamo with integral regulator. An 0.5 μcapacitor may be connected from the armature terminal if necessary, or if this is not directly accessible, from the ignition warning light terminal.

Figure 7. General appearance of a non-coaxial feedthrough capacitor.

Figure 8. Internal construction of a non-coaxial feedthrough capacitor.

Figure 9. Suppression of dynamo with remotely-mounted voltage regulator.

through which controls the output voltage. The commonest type of electro-mechanical voltage/current regulator has three relays that respond to dynamo output voltage and charging current and control these parameters. The contacts of these relays can generate interference, as can the dynamo commutator/brush contact.

Small cars with dynamos of less then 300 W output often have the regulator integral with the dynamo. In that case the terminals of the dynamo are not directly accessible and there are only two connections to the voltage regulator. One is the output terminal to the battery and the other is the connection to the ignition warning light. The battery terminal may be decoupled with a 3 μ capacitor and the indicator terminal with a 0.5 μ capacitor (no larger!) as shown in figures 5 and 6.

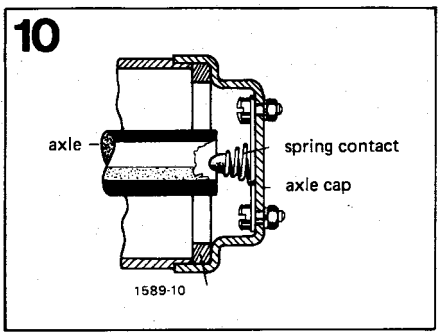
For larger dynamos with remotely-mounted regulator, suppression may be connected as shown in figure 9. For improved suppression, capacitors of the non-coaxial feed-through type may be used. These have a lower series self-inductance than the normal type of suppressor capacitor as the current flows in through one terminal virtually right up to the capacitor plates, and out of the other terminal. Any lead inductance is in series with the current-carrying input and output cables. With the normal type of capacitor a length of (inductive) cable connects it to the terminal it is supposed to suppress, which increases its impedance to high frequencies, when it should have a low impedance to shunt them to earth. A non-coaxial feed-through capacitor is shown in figures 7 and 8. If capacitors on the three regulator terminals and on the dynamo armature terminal do not provide sufficient suppression a suppressor filter can be connected in the field cable as shown in figure 9. This can be home-made from a 10 n low-inductance capacitor and a 0.05 ohm resistor wound from 2½ m of 19 SWG copper wire.

Electric Motors

All electric motors in a car (windscreen wiper, heater, electric cooling fan) are potential sources of interference. They can usually be suppressed by a 3 μ capacitor on the supply terminal. If this is not sufficient then non-coaxial feed-through capacitors of 0.5 to 2.5 μ must be used.

Electrostatic Charges

If annoying crackles and pops are heard from the car radio when driving on dry roads, this may be due to electrostatic charges building up on the tyres because of friction between the tyres and the road. Since the grease film in the wheel bearings forms an efficient insulator such charges cannot leak away to chassis except when they achieve a high



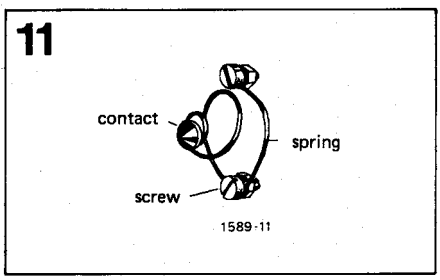


Figure 10. Making good contact between the wheel hub and the axle by means of a spring contact mounted in the axle cap.

Figure 11. Construction of spring contact.

enough voltage to flash over, hence the crackles and pops. A solution to this problem is to make a good electrical contact between the axle hub cap mounted in the centre of the hub (not the decorative hub cap) and the axle. See figures 10 and 11.

Fuel Gauge

The fuel gauge potentiometer may cause interference, as may other contacts such as the trafficator flasher unit. Such interference can usually be cured by a capacitor of about 3 μ between the offending contact and earth.

Conclusions

The ignition system is the principal source of interference and should be tackled first. To avoid possible unnecessary expense the results of suppressing the ignition system should be assessed before proceeding with further measures. With a good car radio suppression of the ignition system will usually be sufficient, but if a cheap car radio with poor selectivity and sensitivity is employed, additional suppression may be necessary. For car radios the adage 'you gets what you pays for' is certainly true, and a cheap radio may prove to be more expensive if a large degree of suppression has to be used. This is particularly true if the radio has an FM band as well as long and medium wave bands, as cheap radios often need a high degree of suppression if FM reception is to be satisfactory. A more expensive car radio is usually a sound investment, especially as a car radio cannot be tested in the shop under the actual conditions in which it will be used.

Cars which are fitted with radiotelephone equipment generally need very effective suppression and such installations are best left to specialists in the field. ◀

ELIMINATE FM AUTO RADIO INTERFERENCE

Ignition noise can destroy the advantages of FM radio—and a few simple tricks can eliminate ignition noise

By LARRY STECKLER
ASSOCIATE EDITOR

THE FM radio has often proved superior to AM when it comes to noise-free listening and full-frequency response. And now that you can put an FM set in your car (see photo), no matter where you go, pleasing high-fidelity music can be yours to listen to. But auto radio, FM or AM, brings with it a new set of problems, things that didn't exist when you kept your radio at home.

FM broadcasting (88–108-mc) uses a part of the vhf band and its characteristics are similar to those of TV frequencies. Under normal atmospheric conditions these waves travel in straight lines and reception is limited by the earth's curvature. A mountain or other large object may block the reception path. So from time to time you may find yourself in an "FM dead area" and unable to receive an FM signal.

Something else to contend with is the way an FM signal can be reflected by metal buildings, hills and power lines. Often, the signal arriving at the FM receiver is a mixture of the signal direct from the transmitter and one or more reflected waves. In the home receiver, located in a fixed position, this usually has no noticeable effect. But when you put the receiver in a moving vehicle this is no longer true.

When a car carrying an FM receiver is driven along a highway, the direct and reflected waves aid and cancel each other and the signal picked up has a rapid flutter. With a strong signal, it is not noticeable, as the limiter stages keep the receiver from reacting to these changes in signal strength. But in fringe areas, where signals are weak, the flutter can be heard and is annoying.

To reduce flutter caused by weak signals some special automotive FM antennas have been developed. Gonset makes a hoop (see photo) that fits over the standard antenna and is said to increase signal strength in fringe areas from 50% to 100%. So if FM reception in your car is not satisfactory, because of excessive flutter, try one of them. You will be surprised at the difference.

When you use your standard whip antenna for FM reception, remember a couple of points. First, keep the coax connecting the antenna to the set as short as possible. Rear-fender and rear-deck antennas usually are not satisfactory for FM reception as they cannot deliver enough signal through the long antenna lead. Another type of standard antenna that usually does not work too well for FM is the automatic unit that is normally recessed into a well into the car's fender. This well is usually just the right size to act as a trap and does not let the FM signal come through to the set. In both instances, the only cure

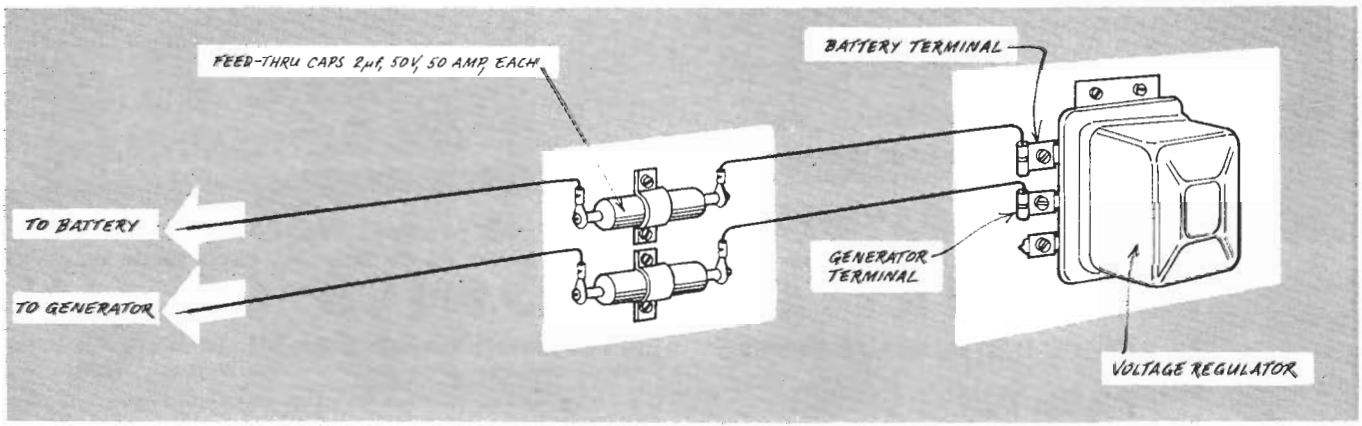


Fig. 1—Coaxial capacitors on the voltage-regulator leads stops the popping often caused by arcing breaker contacts. Although the drawing shows some lead length, leads must be short and the capacitors mounted as near the voltage regulator as possible.

is to use a standard whip on a front fender. As a last point, remember that your whip is not designed for FM frequencies so it should not be used all the way up or all the way down. Instead, extend it to about 30 inches. This will give the best possible results.

One of the first advantages you will notice after putting an FM receiver in your car is how the FM program rarely dies out, even when going over bridges or through underpasses. Then, too, FM in your car retains its most important advantage, freedom from the man-made noises produced by power lines, neon signs, street cars and most other sources of interference. But your own

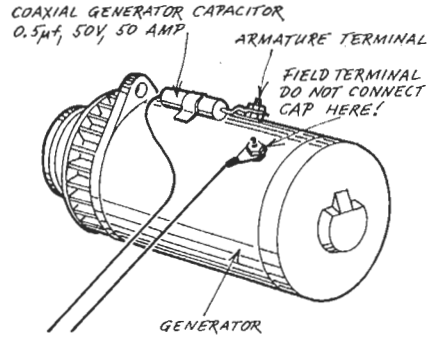


Fig. 2—Generator whine can be licked with a coaxial bypass capacitor.

car my produce enough interference to ruin reception.

Occasionally, when you put an FM receiver in a car, a considerable amount of noise is heard whenever the motor is running. Should this happen to you, there are a few things that need checking. The best place to start is at the antenna. (Incidentally, the following tips are also considerations when trying to get rid of interference in AM auto sets.)

Antenna troubles

The most common antenna fault is an improper ground. An auto antenna is usually grounded by a serrated washer which digs into the metal body of the car. If the washer is loose or if the car has an undercoating, the ground contact may be poor. For a loose washer, tighten the nut that holds it in place. A deep socket wrench is needed to do this job right. Space is at a premium and almost no other type of wrench will let you apply enough pressure to tighten the nut fully. If undercoating is the problem, loosen the antenna mounting nut, scrape the area contacted by the washer until it is bright and shiny, and retighten the nut.

Ignition interference

The car's electrical system is another common cause of interference. Spark plugs, the distributor, the generator and even the voltage regulator can be at fault. The best way to tell which component is making trouble is to carefully analyze the type of interference you hear. It usually breaks down into one of three types:

- A popping noise from the speaker which increases to loud buzz as engine speed increases.
- A whine which appears as engine speed increases.
- Erratic popping which changes only slightly in frequency with increases in engine speed.

The popping noise can be caused by spark plugs or the voltage regulator. When the plugs are at fault the popping turns into a buzz if you race the engine. If it's caused by the generator, the popping will be erratic and will change only slightly with changes in engine speed. If the trouble is in the spark plugs, replace them with resistor type plugs or use resistor cable between the plugs and the distributor. (Both are available either from Auto-Lite dealers or from the larger automotive parts shops.)

When the popping is caused by the regulator, it is usually the vibrating breaker contacts in the unit that are arcing. The solution is to use a coaxial capacitor between the battery terminal of the regulator and the battery lead —about a 2-μf unit should do the job (Cornell Dubilier NF-10270-1. These are rather expensive units and usually require a special order by your distributor to get them.). Its current rating should be around 50 amps. A similar capacitor should be placed between the

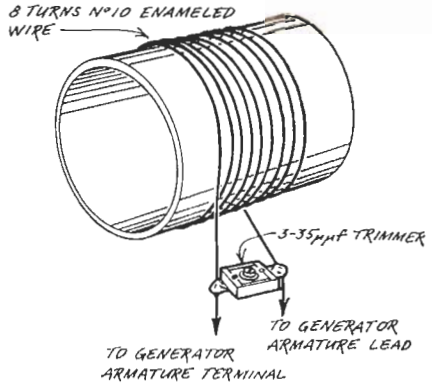
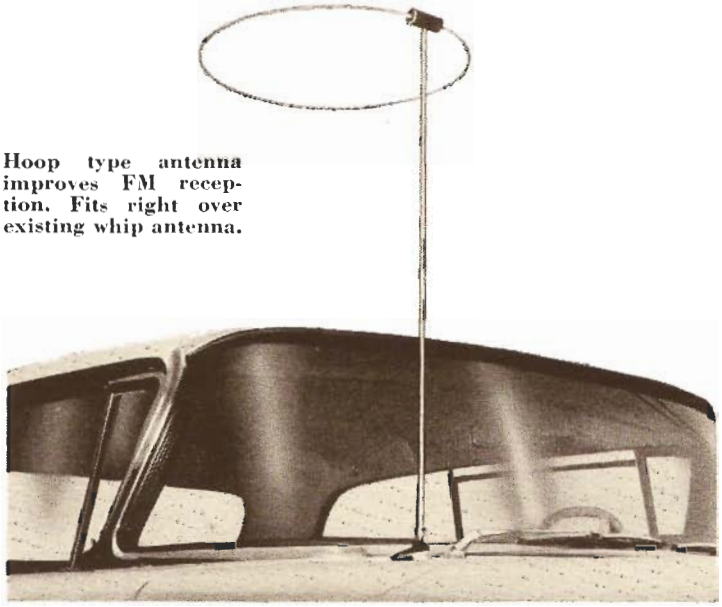


Fig. 3—Simple filter traps out generator whine above 20 mc.



Hoop type antenna improves FM reception. Fits right over existing whip antenna.

regulator's generator terminal and the generator as in Fig. 1. Make sure that the cases of the capacitors are securely grounded—use a braided metal grounding strap if necessary.

When you're up against a variable whine, check the generator. A coaxial 0.5-μf (Sprague 48P18) capacitor with a current rating that exceeds the generator's output should be inserted as shown in Fig. 2. Connect the capacitor case to the generator frame. Use the screw provided for the ground connection to the usual bypass capacitor, which is removed. The lead going to the generator's armature terminal is removed and connected to one end of the coaxial capacitor. The capacitor's other end is connected to the armature cable with a piece of No. 10 wire.

Sometimes, particularly at frequencies above 20 mc (definitely for the FM installer), a series trap is needed to stop generator whine. Such a trap is shown in Fig. 3. It is made from eight turns of No. 10 enameled wire wound on a 1-inch diameter form and shunted with a 3–35-μμf trimmer.

Another source of trouble can be the distributor. Noise originating here is usually caused by loose terminal connections or sparking in the unit.

Check all wiring and, if crimped-on terminals are used at the distributor end of the spark-plug leads, replace them with terminals soldered to the conductor. If sparking in the distributor seems to be the trouble, check the rotor. If it is worn, replace it.

In really persistent cases of interference, connecting all parts of the motor together with a heavy grounding strap is a big help. This means the motor block, generator, battery ground, regulator, distributor, and sometimes even the hood. You'll be surprised how much this can reduce noise.

So if your car is an interference trap, try these few simple suggestions and put yourself on the road to pleasant listening—AM or FM. END

FCC CAUTIONS CITIZENS BANDERS NOT TO RAG-CHEW

The FCC has taken note of excessive air time on the Citizens band for talk other than that authorized. It is cautioning new licensees not to use the Citizens radio service:

As a hobby in itself, as opposed to its use, for example, for controlling model aircraft.

For experimental use with radio on the air. However, it may be used for [*communications* in connection with other] experiments.

For "calling CQ"; that is, attempting to communicate with unknown Citizens radio stations for the sake of making "contacts," including such amateur activities as "directional CQ's" to contact other Citizens radio stations in as many states as possible.

Dx operation; that is, attempting to make long-distance contacts with unknown Citizens radio stations.

Operation of the station as a recreational activity in and of itself, for the pleasure to be derived from such operation.

Licensees violating the principles set out above face the possible loss of license and other penalties.

END AUTO RADIO INTERFERENCE

Protect mobile radio receivers against interference at all frequencies from below the broadcast band to 1,000 mc

By D. GIFFORD

THE MAIN SOURCES OF AUTOMOTIVE RADIO interference are the generator, the voltage regulator and the ignition system. The heater fan motor, electric windshield wiper motor and gas gauge also cause trouble at times.

The degree of suppression required depends on the frequency or band of frequencies covered by the radio installation and the intensity of the interference. The suppression described here is effective from below the broadcast band through to 1,000 mc. It is especially useful for Citizens-band installations.

Before applying suppression techniques to any unit of the vehicle, it must be properly adjusted and in normal operating condition. Otherwise your efforts may be in vain and the suppression could conceivably aggravate any abnormal condition of the unit.

Radio interference from the generator can be stopped with a 0.5 μf coaxial capacitor (Sprague 48P18 is ideal). It is readily mounted on the end of the generator. Clean the area thoroughly (removing the paint) from the spot where the capacitor is to be mounted to get a good rf bond between the capacitor case and the generator housing. Remove the lead attached to the armature terminal of the generator and connect it to the output side of the coaxial capacitor (the side farthest from the generator armature terminal). Connect the other end of the capacitor to the armature terminal with a short direct lead. Should a capacitor already be connected to the armature terminal, it is probably a pigtail type. Remove it completely.

This suppression is so effective that interference from the voltage regulator that was hidden by the generator interference can be heard.

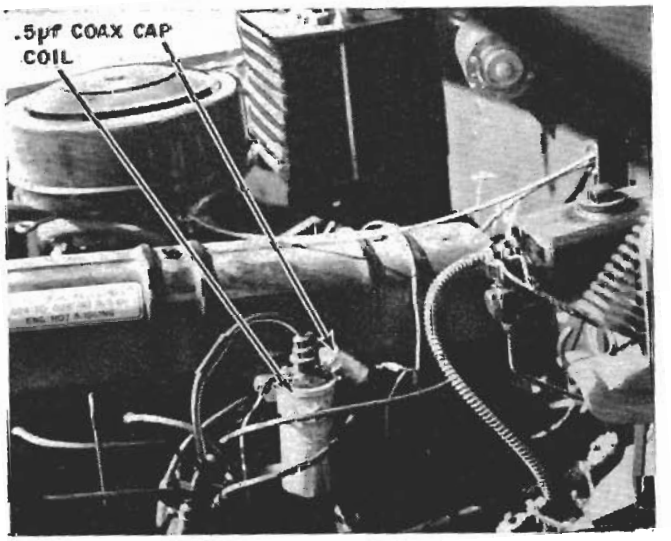
Regulator interference may occur at engine idle speed or at the point where the relay begins to chatter. If your car has an ammeter, you can spot this point by watching the quivering motion of the ammeter needle.

The point at which this interference occurs depends on several things—the condition of the battery, the idle rpm of the engine, and the generator output. Mount a 0.5-μf (Sprague 48P18) coaxial capacitor under one of the regulator mounting screws. Remove the lead from the battery terminal of the voltage regulator and connect it to the end of the capacitor farthest from the regulator. Connect the other end of the capacitor to the battery terminal of the voltage regulator with a short direct lead.

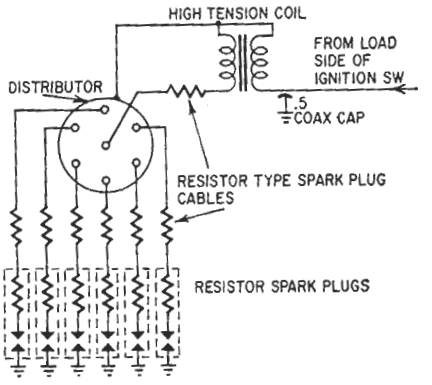
If you have a "hot" receiver installation and still have some regulator interference at 9 to 14 mc and at the second harmonic of these frequencies, install a small mica capacitor from the field terminal of the regulator to the regulator case. The capacitance of this mica capacitor depends on the frequency or frequencies affected and is determined experimentally. If there is a pigtail type capacitor already on the regulator, remove it.

Automotive manufacturers do not recommend connecting capacitors to the field circuits of the regulator or the generator. However, in my more than

INSTALLATION ON HIGH-TENSION COIL

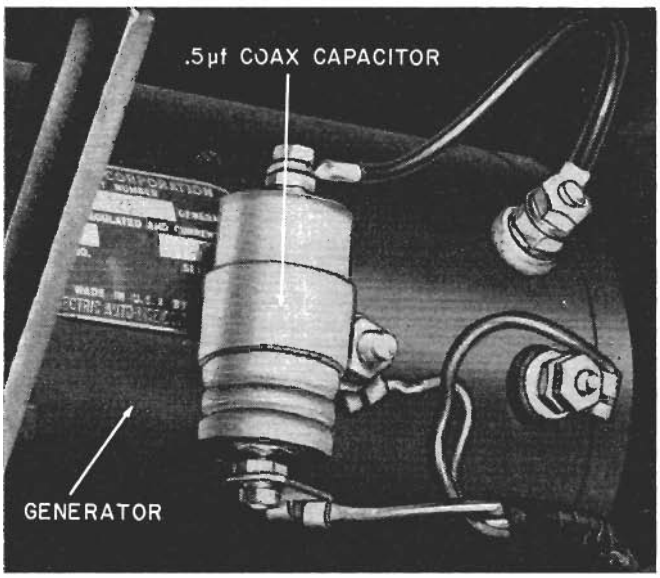


Typical noise-stopping coax capacitor installation on high-tension coil.



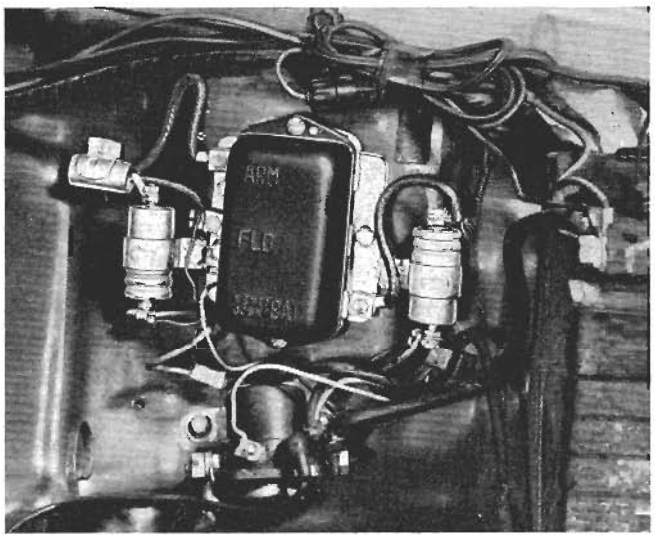
Resistor spark plugs, resistance spark-plug cables and a 0.5-μf coax capacitor at the high-tension coil will stop ignition noise.

ON GENERATOR ARMATURE



Coax capacitor connected at generator armature quiets that noise maker.

ON VOLTAGE REGULATOR



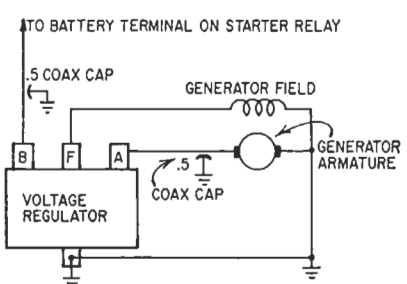
Motorola photos

To silence the voltage regulator, you'll need some more coax capacitors.

24 years' experience with interference suppression, I have yet to learn of a case where these capacitors have caused trouble or have been detrimental in any way to the operation of the regulator or the generator.

Ignition interference is another nuisance that must be dealt with. Unlike regulator or generator interference, it varies from car to car of the same make and model as well as from make to make. V8 engines are among the worst offenders. The place to start is at the spark plugs. If they are the standard type, replace them with resistor type plugs. Check the gap. It should be smaller than for standard plugs. I set the gap about .010 inch less than for standard plugs. Measure the resistance of the resistor plugs—they should be 10,000 ohms; some run as low as 6,000 ohms.

Replace the spark-plug cables, including the high-tension cable, with resistor type cable (4,000 ohms per foot). This may reduce your gas mileage slightly and prevent you from taking off like a rocket, but, if the engine is properly timed and tuned, it will present no great hardship and ignition interference will be greatly reduced if not eliminated. A 0.5-μf coaxial capacitor (Sprague 48P18) on the high-tension coil battery terminal will help considerably at some frequencies.



Coax capacitors at the voltage regulator and generator stop interference caused by these units. B, F, & A are battery, field and armature terminals.

If ignition interference is still objectionable, check the distributor rotor. If it has an aluminum contact bar, replace it with one that has a copper contact bar. This will reduce interference 10 db or more. The copper contact rotor will last much longer, too, as it will not burn or corrode as readily as the aluminum type. It also gives a cleaner spark.

Shielding the distributor cap will reduce the interference another 10 or 12 db at some frequencies, depending on make and model of the car. A simple and economical way of doing this is to cement aluminum foil around the body of the cap, being sure to bring the foil down over the rim of the cap so it contacts the distributor housing when in place. Wrap a layer of plastic electrician's tape over the foil to protect it. Commercial shielding harnesses such as Hallett (Hallett Manufacturing Co., 5910 Bowcraft St., Los Angeles 16, Calif.) are available, but I am sure the suppression outlined in this article is adequate for most if not all radio installations.

One of the things we are apt to lose sight of in dealing with interference from an automobile is that a car is essentially a broadcast station—the engine and electrical system being the oscillator and the car body the antenna.

The hand-brake cable system of the 1959 and 1960 Studebaker Lark is a lovely rhombic at 48 or 49 mc. Use ½-inch copper braid and bond the brake cable on the right side of the car to the muffler tailpipe, then to the floor of the car body.

Most car bodies are poorly bonded, rf-wise, to the car frame. Use ½-inch copper braids to bond the body to the frame at strategic points—hood, trunk lid, etc.

At some frequencies it is better not to tie the antenna transmission-line shield to the car body or frame (remember, it is the interference radiator) as this only forms a loop and may cause more interference to be fed into the receiving equipment. This also applies to bonding the receiver chassis to the car body. If the equipment operates from the car battery, it is often better to run the power leads directly to the battery than to risk forming loops by depending on the receiver chassis and the car body to be thoroughly and directly connected to the battery. It may be good enough electrically but we are dealing with rf.

Fundamentally, interference suppression simply creates a low-impedance path to ground for the rf at the source of the interference, ground being the electrical return of the source. END

Auto Radio Noise Reduction Techniques

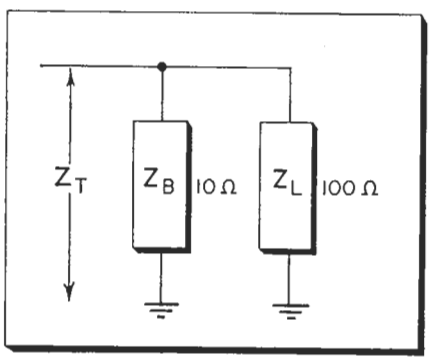
Coaxial Type Capacitors Prevent Ignition Noise From Interfering With Radio Reception

WILLIAM ASHBY
Cornell-Dubilier Electronics Div.

• A natural byproduct of an automobile's (or marine craft's) ignition system is an r-f signal that interferes with radio receiver reception. Any part of the ignition system that sparks due to make-break electrical contacts can be an interference offender, which includes the distributor, voltage regulator, and spark plugs.

One method employed to reduce noise due to contact arcing is the *confinement* method. Here, any source of noise is isolated and the entire area is completely shielded to prevent r-f radiation. Although this procedure is effective, it is a relatively expensive way to reduce interference. In most cases, noise due to spark discharge, arcing contacts, generator brushes, etc., can be economically reduced to reasonable levels by noise *suppression* methods. This is accomplished by bypassing r-f energy to B- through capacitors.

Fig. 1—To be highly effective a bypass capacitor's r-f impedance should be small compared to the r-f load impedance.



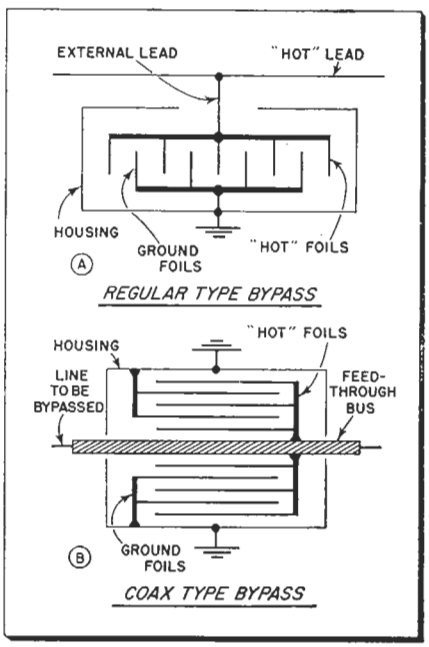
Noise Suppression Capacitors

Noise suppression capacitors are utilized to prevent ignition noise from entering the receiver and, thereby, causing static. This can be accomplished with conventional bypass capacitors that are specially enclosed in weather-proof metal housings which also act as a "ground" lead. Their effectiveness depends on actual circuit conditions. That is, capacitors have different load impedances to r-f at the point of bypass. This results in varied noise component bypassing abilities. Further, their bypassing effectiveness greatly diminishes in Citizens Band and FM receiver megacycle frequency areas.

In order for a bypass capacitor to be effective when shunted across a load, Z_L, the bypass impedance, Z_B, should be relatively small. As shown in Fig. 1, the bypass impedance, including capacitance and lead inductance, forms a parallel circuit. The bypass effectiveness may be calculated by considering the reduction in total impedance, Z_T, caused by shunting the bypass across the load. For example, a Z_B of 10 ohms placed across a Z_L of 100 ohms reduces the Z_T from 100 to 9.1 ohms: $(10 \times 100)/(10 + 100)$. So the bypass effectiveness is 90.9%. If, however, Z_B were 10 ohms and Z_L were only 1 ohm, a similar calculation would show only 9% effectiveness. Cross sectional basic structure of a regular type bypass capacitor is shown in Fig. 2.

A better capacitor for noise suppression is the co-axial or feed-thru capacitor. This capacitor is designed to completely surround the conductor carrying the r-f component. Since r-f currents travel on the conductor's surface, removal of the noise component is more effec-

Fig. 2 (top) Basic structure of a regular type bypass capacitor, and (bottom) coaxial type structure which provides more effective filtering at higher frequencies.



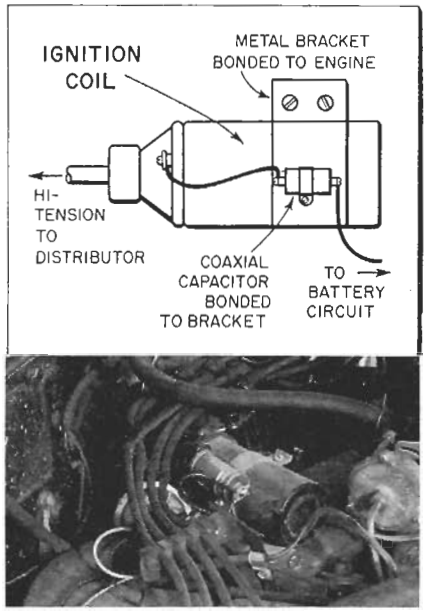


Fig. 3 (top) Drawing of ignition coil terminals, cables, and proper placement of coaxial capacitor. (Bottom) Spark coil with coaxial capacitor securely attached and grounded to coil's mounting strap.

tive using co-axial capacitors than conventional bypass capacitors (See Fig. 2).

Receiver Installations

When a technician installs a receiver in an auto or boat that has not been properly prepared for noise suppression, he must naturally accomplish this work, too. The freedom of static displayed by the receiver he installs will be largely determined by his installation and noise suppression considerations.

To begin with, mobile radio equipment must be correctly installed according to manufacturers' instructions. All equipment must be properly bonded to ground, and shielded cable having adequate size wire must be used from the d-c supply source to the equipment. Secondly, ignition suppressors or resistor type spark plugs—plus a distributor suppressor will minimize r-f radiation.

Particular care should be taken to properly bond the engine in several places directly to the main frame or common ground system. Heavy tinned copper braid should be used for bonding. This reduces radiation from the engine itself. Metal parts in proximity with the ignition system should also be bonded to the engine block. All metal-to-metal connections, such as the metal case of an ignition coil, should be cleaned and firmly bonded to the engine. All bonding leads should be as short as possible. All metallic hose lines, mechanical linkages, etc. from the carburetor or engine accessories, should be similarly treated. Exhaust pipes should be bonded to the engine frame in several places.

Eliminating Interference

After the receiver has been installed, together with the proper antenna, the technician faces the "acid" test: is there any static interference? If a sharp, "popping" pulse type noise is heard in the receiver when the engine is running, try a 0.5 μf, 40 amp, 50 volt coaxial capacitor at the spark coil as shown in Fig. 3. Remove the low voltage primary wire (battery cable) from its terminal on the spark coil. Bolt the capacitor directly to the coil mounting bracket—as close to the coil terminal as possible. Connect a very short lead from one end of the capacitor to the spark coil primary terminal. Attach the previously removed primary wire (battery cable) to the opposite end of the coaxial capacitor.

Start the engine. While it is running, loosen the generator bracket and relieve tension on the drive belt until the generator stops turning. Turn on the radio receiver—with the squelch or noise clipper controls turned off. Tune the receiver to a weak signal. Listen for the "popping" pulse type noise which will vary with engine speed. The noise should be greatly reduced and weak signals should be much stronger than the noise.

Re-tighten generator bracket so that the generator is again operating normally. Listen for a grinding noise or "whine" from the receiver. If present, this interference will probably be caused by sparking at the generator brushes.

To reduce this type interference stop the engine and remove the generator. Clean mounting bracket and bosses to insure good bonding of the generator to engine block ground. Bond the generator and its mechanical mounting to the block with heavy braided strap. After the generator is replaced, install a 0.5 μf, 40 amp, 50 volt coaxial capacitor close to the armature terminal on the generator, as shown in Fig. 4. Make certain the capacitor mounting bracket makes clean contact with the generator frame. Attach the shortest possible lead from the generator's voltage regulator terminal to one side of the capacitor. Attach the voltage regulator cable to the other side of the capacitor.

Start the engine again, and tune in a weak station on the receiver.

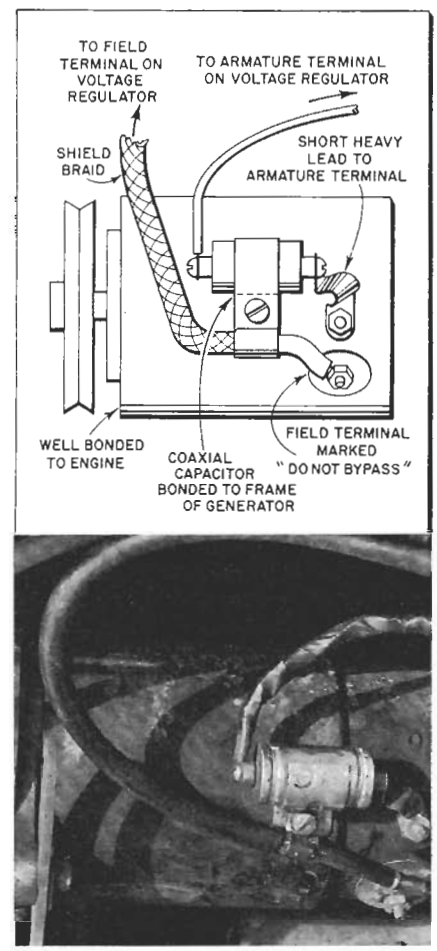


Fig. 4 (top) Drawing of generator terminals, cables, and coaxial capacitor placement. (Bottom) Generator armature is connected to coaxial capacitor with short heavy copper lead. Generator field cable is shielded from terminal to voltage regulator.

The generator brush noise should have disappeared or dropped to a very low level. Overall noise from high level sources should now be well below the bothersome level.

When spark coil and generator noise have been reduced, other low level noise may become apparent.

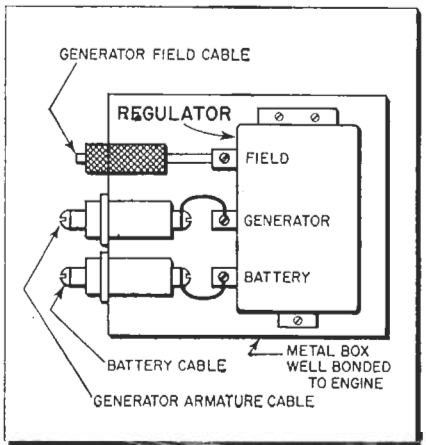
(Continued on page 65)

Auto Radio Noise

(Continued from page 45)

An intermittent, rough, "burping" noise can originate in the voltage regulator. This can be reduced in the following manner:

Obtain a metal box large enough to contain the voltage regulator, with sufficient additional room for 2 bulkhead mounting type feed-thru coaxial capacitors. Capacitors should be .25 μf rated at 20 amp, 200 volts. Mount the two capacitors in holes drilled in one end of the box, as shown in Fig. 5. Two short leads are connected from each capacitor to the regulator's generator and battery terminals respectively. The generator and battery leads are then connected to the proper capacitor terminals on the outside of the regulator shield box as shown.



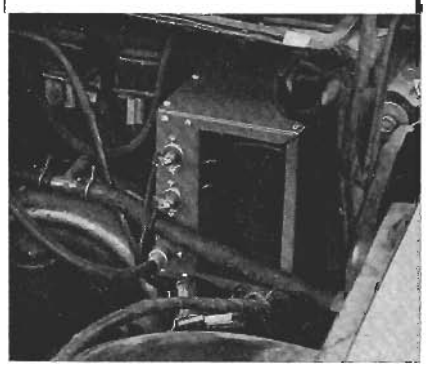


Fig. 5 (top) Regulator, terminals, and coaxial capacitor placements in shield box. (Bottom) Regulator shield box showing standard coaxial cable connector at end of generator field cable.

Do not use a capacitor on the generator field lead. A piece of braided cable shield should be pulled over this lead, from the

For more data, circle 4-65-1 on coupon, p. 50

For more data, circle 4-65-2 on coupon, p. 50

shield box to the generator. The braid should then be bonded to the generator frame and to the regulator shield box (see Fig. 2 also). Regular coaxial cable connectors may be used on this cable at the regulator shield box to facilitate bonding and connecting. This operation should reduce regulator "burping" to a very low level.

Brush-type motor interference from windshield wiper, fan, blower, etc., can be quickly isolated by switching them on-and-off while listening to weak signals on the receiver. Any offending device should first be bonded to the main frame or ground. Install a specially designed bypass capacitor rated at .25 μf, 100 d-c volts as close to the low voltage terminal as possible (see Fig. 6).

On equipment in non-metallic marine hulls, run a very heavy main ground—a copper plate at least four inches wide from stem to stern along the inside hull—as far below the water line as possible. Bond all metal used on the boat to this ground. Use heavy copper braid. Bond engine block, drive

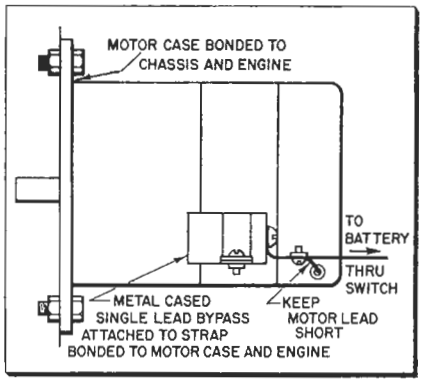


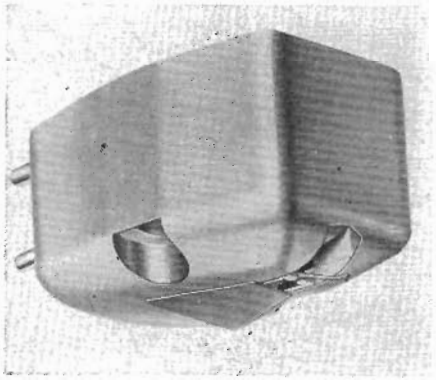
Fig. 6—Method of mounting special type bypass capacitor to eliminate interference from accessory motors.

shaft, rudder posts, etc. directly to the main ground strap. Every piece of metal in contact with the water must be bonded to this common ground.

A check of the effectiveness of the steps that have been taken to eliminate interference to radio reception can easily be made by observing noise being radiated by other idling or moving vehicles. They will generate much more noise in your receiver than your own engine—unless they have been equally "de-noised." •

Audio STEREO CARTRIDGE

Announced is the ADC-1 stereo cartridge reported to track at less than 1 gram and provide lateral and vertical compliance of 10. Sensitivity, 7 millivolts per channel $\pm$ 2 db at 1000 cycles per second (5.5 cm/sec velocity). Frequency response, 10-20,000



cycles a second $\pm$ 2 db. Useful response extends beyond 30,000 cps. Channel separation, 30 db from 50 to 7000 cps. Stylus tip radius, .0006". Stylus tip mass, 0.5 mg. $49.50. Audio Dynamics, Inc., 1677 Cody Ave., Ridgewood, N. Y.

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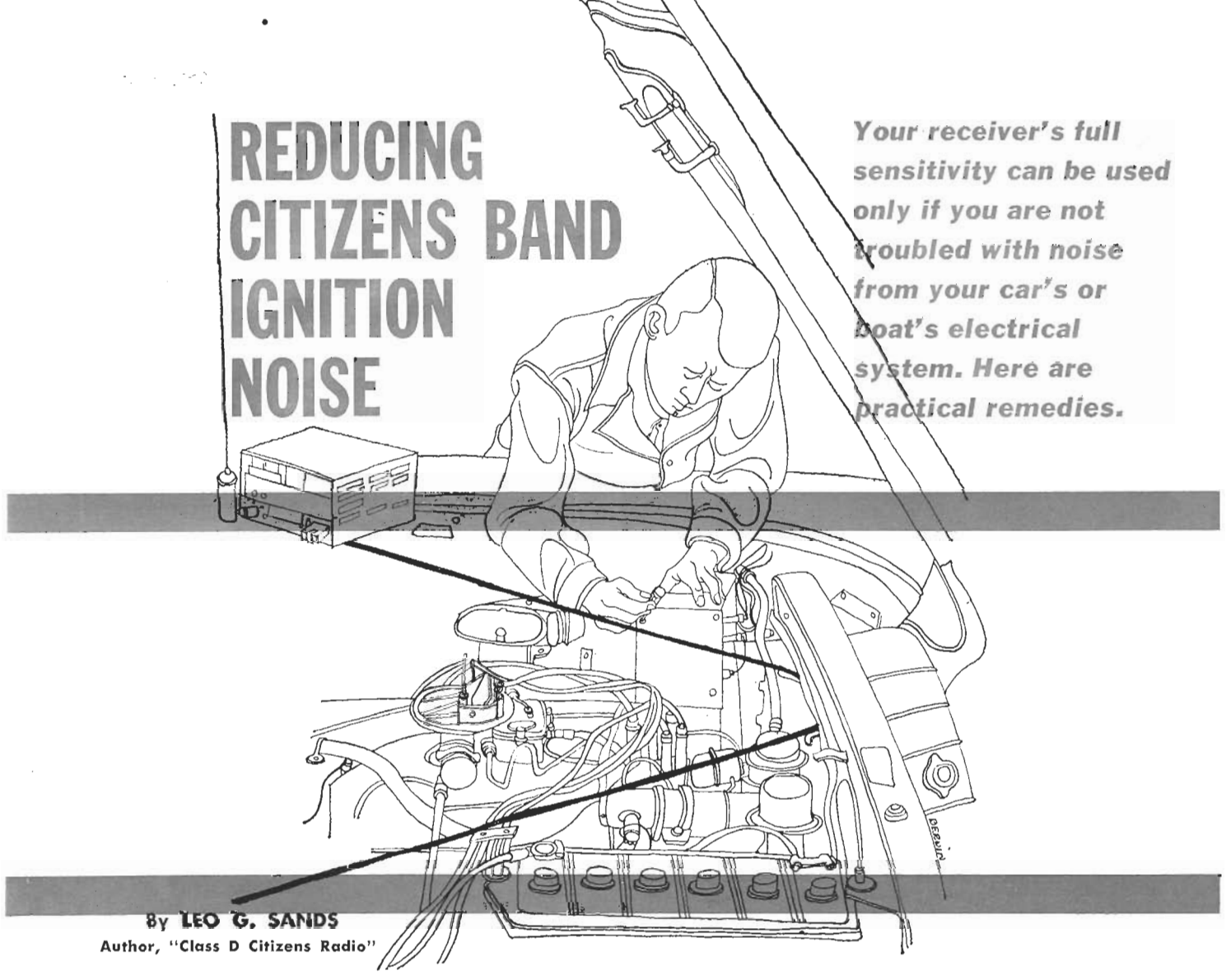
REDUCING CITIZENS BAND IGNITION NOISE

Your receiver's full sensitivity can be used only if you are not troubled with noise from your car's or boat's electrical system. Here are practical remedies.



By LEO G. SANDS
Author, "Class D Citizens Radio"

IGNITION noise is one of the prime factors limiting the range of Citizens Band radio in mobile installations. The range would be considerably greater if the full sensitivity of receivers could be utilized but what use is it to have a receiver with one-microvolt or better sensitivity if the ignition noise level is several microvolts?

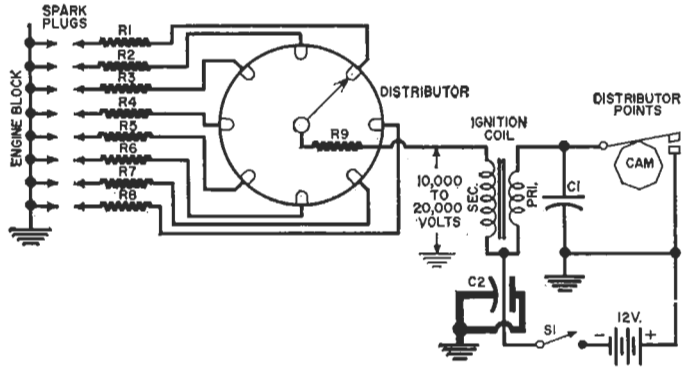
Unfortunately, the automobile ignition system creates and radiates radio-frequency energy whose level is maximum at frequencies close to the 27-mc. band. This is bad for the CB operator.

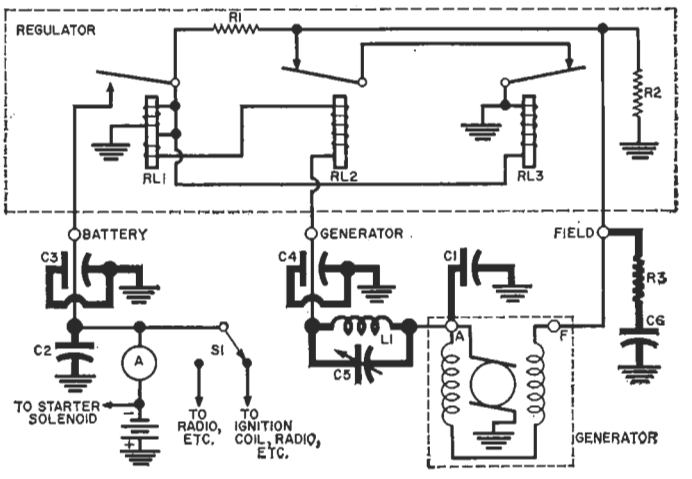
You can do something about suppressing noise generated by your own car, but there is nothing you can do about stopping the noise generated by other cars. You will, however, experience less noise from other cars if your receiver incorporates a noise limiter.

Sometimes the noise-suppression procedures that are followed when a standard AM broadcast-band auto radio is installed will suffice—but not always. It is common to install spark-plug suppressors at all of the plugs and a suppressor in the distributor rotor ignition coil lead in order to reduce ignition noise. Also, a filter capacitor is usually installed across the armature terminal of the car's generator to reduce generator-produced noise. If these measures do not stop the noise, coax or conventional capacitors are also installed at the hot (battery) primary lead of the ignition coil, the ammeter, dome light, and dashboard instruments to bypass to ground the ignition noise signals picked

Fig. 1. (Below) Ignition-system circuit for 8-cylinder car.

Fig. 2. (Right) Regulator and generator circuit. The 3 relays are the cut-out, current regulator, and the voltage regulator.





up and re-radiated by the vehicle's low-voltage wiring.

Ignition noise exists because each of the four, six, or eight spark plugs in the engine are small, but potent, "spark transmitters"—which are still fondly remembered by old-time hams and ship radio operators. In addition, there is another spark transmitter under the distributor cap.

A very high-potential pulse, ranging from 10,000 to 20,000 volts, is generated every time the distributor points open. The points, shown in Fig. 1, are opened and closed by a cam at a rate determined by the speed of the engine. When the points close, d.c. flows from the vehicle's battery through the ignition switch, S_1, distributor points, and the primary winding of the ignition coil—setting up an intense magnetic field which envelopes the ignition-coil secondary. When the points open, the d.c. flow in the primary winding ceases abruptly, causing the magnetic field to collapse and inducing a potential in the secondary winding of the ignition coil.

The e.m.f. induced in each turn is in series-aiding with the e.m.f. in the other turns. The high voltage results not only because of the very high turns ratio of the windings in the ignition coil but because of the sharp magnetic kick caused by sudden cessation of current flow through the primary.

The ignition-coil turns ratio ranges from 40:1 to 100:1. As a straight transformer, the 12 volts would be stepped up from 480 to 1200 volts but because of the inductive kick, the voltage is actually ten to twenty times greater.

The voltage across the secondary is so high that it causes a discharge across two series-connected spark gaps. It jumps across the air space between the distributor rotor and one of the electrodes of the distributor and through the pressurized vapor between the points of a spark plug.

Each of these gaps looks like a very high impedance until the dielectric (air or vapor) breaks down and an arc is formed across the gap. Then, each gap looks like a low impedance and, for the very short duration of the spark, the current flow is large and a magnetic field is developed around the ignition wires. Thus we have a spark transmitter whose resonant frequency is determined by the inductance and capacitance of the ignition circuitry.

Suppressors

A high voltage is required to cause a spark to jump across a gap; the current can be infinitesimal. For this reason, we can reduce the current to reduce the noise-radiating field, without reducing the effective voltage. Even if a 1-megohm resistor (R_1) is connected in series with the spark gap, as shown in Fig. 3A, the source voltage, E_1, will be equal to E_3, the voltage across the gap. There will be no voltage (E_2) across R_1 because there is no current flow before the gap breaks down and is arced across.

But, this ideal gap condition does not exist. As shown in Fig. 3B, there may be leakage resistance across the gap (dirty spark plugs). This leakage resistance, R_2, is in series with R_1 and the voltage applied to the spark gap, E_3, is equal to the voltage E_1 minus E_2.

It is for this reason that the distributor suppressor is usually a 7500-10,000-ohm resistor and each spark-plug suppressor has a resistance of about 5000 ohms. The total 15,000-ohm resistance in series with the two gaps (distributor and one spark plug) has negligible effect, except when spark plugs are badly fouled.

It is the general consensus that the use of spark-plug and distributor suppressors does not interfere with engine performance nor increase fuel consumption.

To reduce the direct radiation of ignition interference, suppressors can be installed on each spark plug and at the distributor. These suppressors consist of a resistor encased in a tubular insulating housing with terminals on each end to fit the spark plugs or distributor

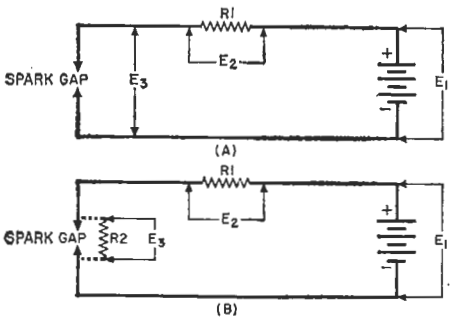
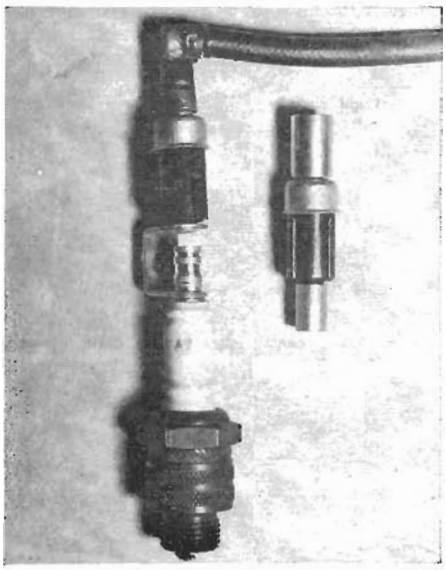
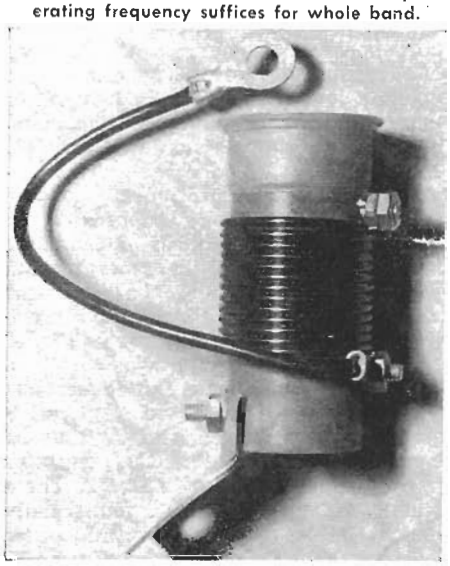


Fig. 3. (A) Suppressor resistor does not reduce voltage significantly when spark plugs are clean. (B) With dirty or fouled plugs there is a reduction of gap voltage.

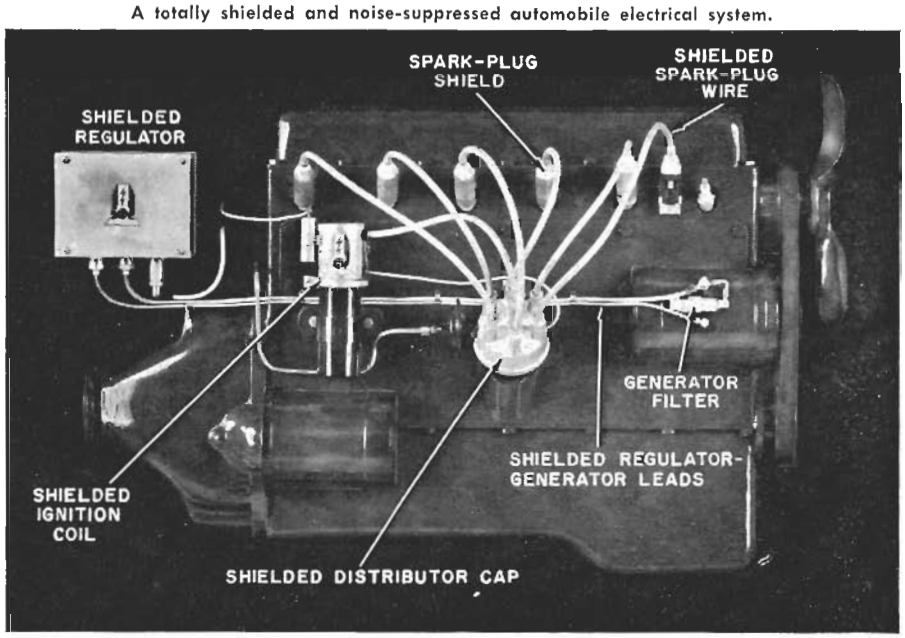


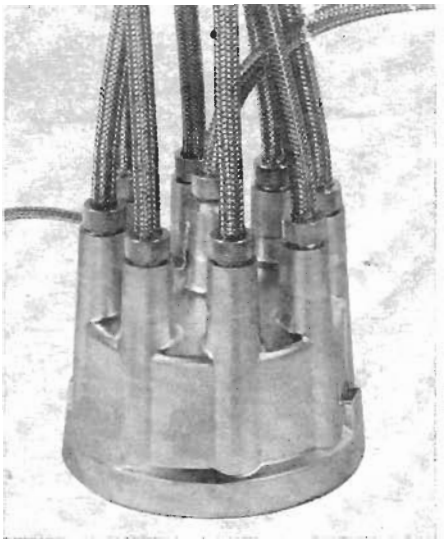
◀ Spark plug with suppressor attached. The suppressor resistor at the right is of the universal type and may be used at the spark plugs or in the hot secondary lead of the automobile's or boat's distributor.

Generator-whine suppressor for CB. The lugged lead connects to the generator (armature) output terminal. The generator output lead is connected to the screw at the other end of the coil. The strap at the bottom is for mounting. Inside the phenolic tube, around which the coil is wound, is a variable trimmer capacitor for tuning the circuit to parallel resonance. The circuit response is broad enough so that one setting at the transmitter's operating frequency suffices for whole band.



A totally shielded and noise-suppressed automobile electrical system.





Shielded distributor cap and ignition wires.

to the ignition cables. Instead of suppressors, spark plugs which have built-in resistors can be substituted or, alternatively, special ignition cables with built-in resistance (provided in many new cars) can be used. Series resistance in the ignition circuits has two effects. It reduces the radiated field by limiting current and broadens the resonance (lowers the "Q") of the wiring.

Additional Remedies

In addition to the high-voltage ignition system, electrical noise is caused by the vibrating contacts within the current-voltage regulator, the brushes and commutator of the generator, the opening and closing of the distributor points, and the charging and discharging of the distributor capacitor (C_1 in Fig. 1).

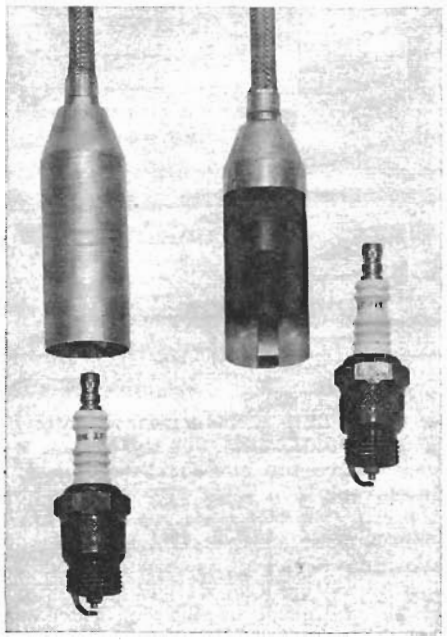
For an ordinary auto radio, generator "whine" is adequately suppressed by installation of a 0.1- to 0.25-μf. capacitor between the frame of the generator and the output terminal of the generator which is connected internally to a brush that contacts the armature. In Fig. 2, this capacitor is shown as C_1.

However, for Citizens Band reception, this may not be adequate. A parallel-resonant wavetrap (L_1 and C_3) may be connected in series with the generator output lead, as shown in Fig. 2. These wavetraps are available commercially under *G-C*, *Globe*, *Johnson*, and other tradenames. Typically, L_1 consists of 13 turns of No. 10 enameled wire, wound on a 1-inch diameter phenolic tube. The coil is shunted by a variable trimmer capacitor (C_3), with a maximum capacity of 50 $\mu\mu$f.

With the engine running and the receiver on (unsquelched), C_3 is adjusted for minimum generator whine. When tuned correctly, L_1-C_3 serve as a very high impedance at the CB operating frequency. The trap is used in conjunction with C_1 to cut out generator whine when using the regular auto radio.

The noise caused by the vibrating contacts of relays RL_1, RL_2, and RL_3 (Fig. 2) of the regulator may be minimized by connecting a 0.1- to 0.25-μf. capacitor (C_2) between the grounded cover of the regulator and its battery terminal and another capacitor (C_4) between the cover and the generator terminal of the regulator.

Filters are usually not connected to the field terminal of the generator or regulator because of possible damage to the regulator relay contacts. But a circuit that is sometimes recommended for connection here is a resistor (R_3) with a value of 3.9 to 6.8 ohms and a series mica or ceramic capacitor (C_6) of around 200 $\mu\mu$f., as shown in Fig. 2, between the regulator cover and its field terminal.



Shields for fitting over spark plugs. Resistor plugs may be used for noise suppression. One of shields has been cut away (at right).

Filter Capacitors

Ordinarily, capacitors used for noise suppression are paper types enclosed in a metal cylinder, as shown in Fig. 4A. The protruding wire is for connection to the "hot" side of a circuit and the mounting lug of the capacitor enclosure is fastened to the generator or the regulator cover, firewall, or other grounded surface. To be effective, the lug must make firm contact with clean metal (paint or grease removed) or to the mounting bolt. Suppressor capacitors with two leads (one to ground), as shown in Fig. 4B, do not have to be mounted rigidly.

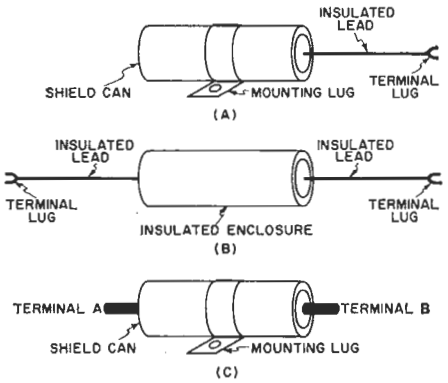
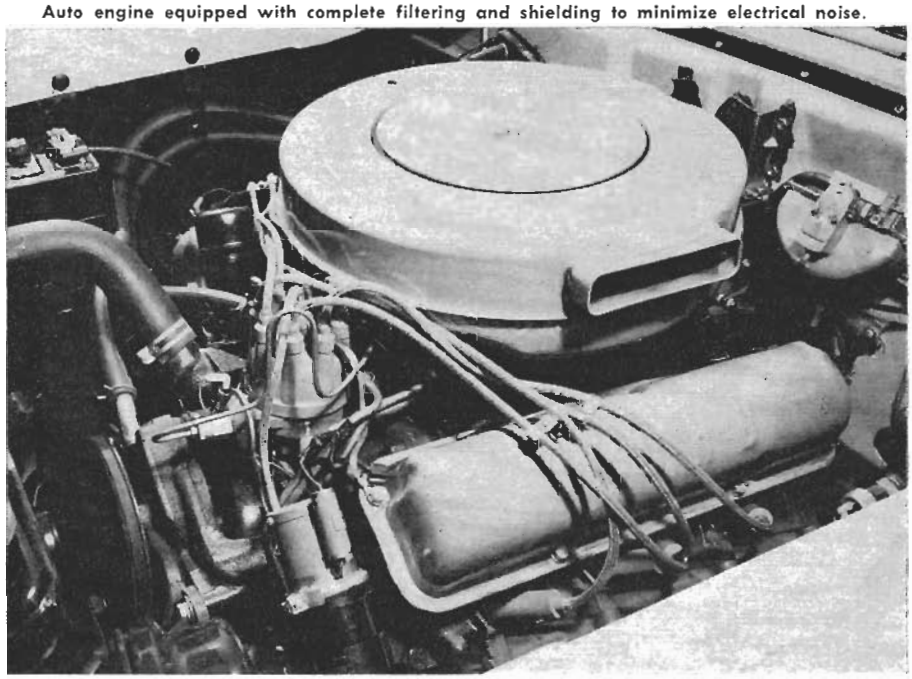


Fig. 4. (A) Conventional capacitor suppressor. (B) Insulated capacitor suppressor for ammeter and other instruments. (C) A coaxial or feedthrough capacitor.

Although these standard auto-radio noise suppressors are adequate for AM broadcast-band reception, they may not be adequate for CB reception. This is due to the fact that standard paper capacitors possess inductance as well as capacitance. This inductance has no significant effect at relatively low frequencies, but may be so great at 27 mc. as to offset the bypassing effect of the capacitor. Sufficient bypassing at both broadcast-band frequencies and at 27 mc. can often be achieved by shunting ordinary capacitor suppressors with a

(*Continued on page* 96)

Auto engine equipped with complete filtering and shielding to minimize electrical noise.



THIS MONTH'S COVER

AN installation of a Hallett shielded ignition system has just been completed on car's engine shown on this month's cover. The shielded leads between car's distributor and spark plugs, as well as the shielded ignition-coil cover, are clearly seen in the photo. The technician is just screwing down the cover on the shielded voltage-regulator box prior to testing out the effectiveness of the noise suppression with Citizens Radio transceiver at left.

(Cover photo by Jacques Saphier)

Reducing Ignition Noise

(*Continued from page 38*)

0.001-μf. ceramic unit, which has very low inductance.

An even better arrangement is to use coaxial capacitors. Instead of conventional suppressor capacitors (C_2 of Fig. 1 and C_3 and C_4 in Fig. 2), coaxial types may be substituted. A coaxial capacitor is a feedthrough type, as shown in Fig. 4C. The lead to the "hot" primary terminal of the ignition coil, for example, is removed and connected to terminal "A" of the capacitor. Terminal "B" is connected to the ignition coil. The current flows through the capacitor from "A" to "B" *via* a conductor which is internally connected to the ungrounded electrode of the capacitor. The grounded electrode is connected to the shield can of the capacitor. Thus, the capacitor is shunted across the circuit. A coaxial capacitor is designed to have very low inductance and thereby effectively passes high-frequency r.f. to ground.

Bonding & Shielding

If all of these measures do not reduce noise adequately, try bonding the hood to the firewall and the tail pipe to the car's frame, using one-half-inch wide tinned copper braid.

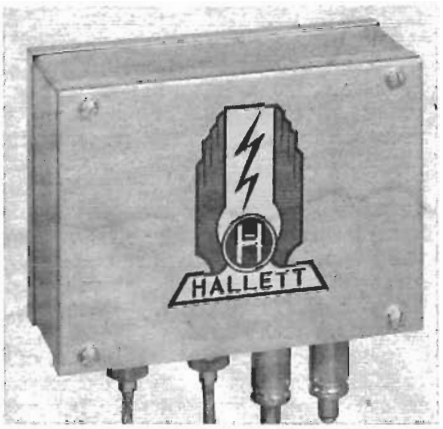
It may also be necessary to shield the leads between the regulator and the generator, grounding the shield to the generator frame. Or, existing wires may be replaced by shielded cable with inner

Shield and filter for ignition coil.

conductors of adequate size and insulation for the voltage to be carried.

Tire static may be eliminated by blowing static powder (*G-C* and other brands) into the tires, using the injector provided with the kit. Wheel noise can be eliminated by installing springs under the hub caps to ground the axle to the wheel. Such springs are available at radio parts jobbers.

If all these measures fail to reduce noise to a sufficiently low level, a shielded ignition system can be installed. Available in kit form from *Hallett* and others, the system includes shielded cables to replace all the ignition wiring plus shields for the ignition coil, distributor, the spark plugs, and the regulator. A kit for a typical car costs about $50.00 and is available from those



This regulator cover provides shielding and filtering. Note 2 coax feedthroughs.

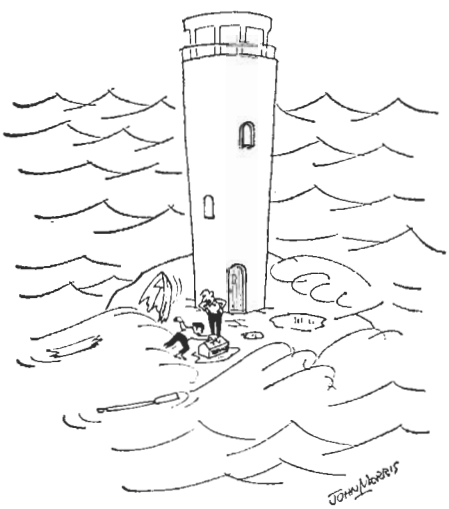
of the larger electronic parts dealers who have industrial departments. Such shielded systems are widely used in military and public-safety vehicles.

To determine if your car needs noise suppression, or to determine if the elimination methods have been effective, turn on the CB set (unsquelched) and listen to the noise with the engine on and the car moving. Then stop the car and turn off the engine and note the difference in background noise level. The most effective test is run when receiving a very weak radio signal.

Although effective noise suppression may take some time and trouble, the results are worth the effort. –30–

TUBE INDEX FOR SECO 107 TESTER

A NEW, 70-page manual, thumb-indexed for quick reference, has been issued by Seco Electronics, Inc. for its Model 107 tube tester. The up-to-date reference lists all domestic, industrial, and foreign tube types. The earlier chart for this tester, FC-3, was designed to fit into a metal list finder. Having outgrown this format, the new index, FC-4, is bound into a 13-ring plastic binder so that it will lie flat when opened to any page. Price of the 1961 index is $2.00. For further information, write Seco Electronics Inc., 5015 Penn Avenue South, Minneapolis 19, Minnesota. –30–



"What kept you?"

kill that mobile noise!

By D. A. DUDLEY

Valuable tips on noise suppression for car-borne CB, ham, FM radios

WITH THE EVER-INCREASING USE OF TWO-way—especially CB—radio in motor vehicles of all kinds, users are finding out that mobile noise often prevents effective communication. Particularly in low-power CB work, motor, generator and tire noise can make a tremendous difference in useful operating range.

The generator, sparkplugs and wiring harness, the voltage regulator, coil, distributor points, condenser and gages are the chief contributors to motor noise.

Sparkplug and wiring harness noise is a machine-gunlike popping sound that varies with motor speed. In tracking it down, be sure the sparkplugs are clean, properly gapped and, of course, of the type recommended by the manufacturer. Check the sparkplug leads for continuity. In newer vehicles, the manufacturer has usually installed radio-resistance wiring. Its resistance should be about 10,000 ohms. If a lead opens, the spark has to jump the gap, causing noise. The ends of the leads should be recrimped or, better still, soldered for positive contact. Make sure the holes in the distributor cap are cleaned out before the leads are pushed all the way down in their sockets.

In the distributor, check or replace the points and condenser to prevent them from contributing noise.

Ignition noise

This is the noise caused by actual firing of the spark plugs. It is generally suppressed by resistive sparkplugs, radio-resistance wiring, or both (Fig. 1). When both are used, the reduced voltage may cause the motor to idle roughly. A 5,000-ohm resistor can be connected right at the sparkplug in series with the plug leads, but radio-resistance wiring is superior. A 10,000-ohm suppressor can be installed in series with the distributor center lead. Install a 0.1-μf coaxial capacitor (Sprague No. 48P9) in series with the terminal marked BAT, located on the coil, if previous methods have not been successful.

[This is a coaxial feedthrough capacitor. "In series" here means that the inner element (of practically zero dc resistance) is connected in series with the lead to be bypassed, and the outer element is grounded. The *capacitance* is actually in *shunt* with the lead, not in series.—*Editor*]

What now? In occasional stubborn cases, we have to try other means to combat noises. (And believe me, "combat" is what you're engaged in!)

If some old coaxial cable is handy, try slipping the outer shield off. This shielding can now be used as a shield for the sparkplug lead. If you push the sparkplug lead through the side of the shielding about 5 or 6 inches before the end, you can use the free end of the shielding as a ground. Connect it to a bolt on the motor. Belden makes shield braid (type 8663 or similar) for bonding or shielding.

If sparkplug leads happen to be of a length that resonates at the receiver frequency, shortening will cut radiation and reduce noise. Rerouting wires that come too close to the sparkplug leads has also helped. Any lead at a potential higher than common ground can cause interference by radiation or by capacitive coupling to other leads. Shielding on those leads will sometimes help in eliminating such interference.

Generator noise

Generator noise is identified by a high-pitched whine that varies with the speed of the motor. To verify, get the car moving, turn off the ignition switch and push in the clutch. The noise will appear when the clutch is engaged and disappear when the clutch is pushed in. Make certain the brushes are in good condition. Then install a 0.5-μf capacitor (Sprague No. 48P18) in series with the armature lead (Fig. 2). Leads should be as short as possible. Mount the capacitor directly on the generator. In most cases, this cures the generator whine.

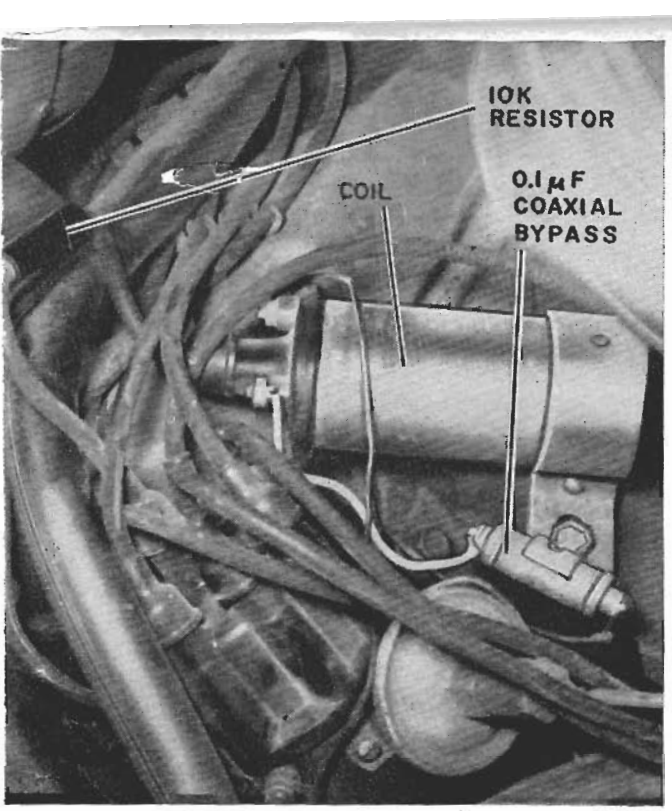
If the trouble persists, connect 0.5-μf capacitors in series with the ARM and BAT terminals on the regulator. Some technicians use a parallel-resonant trap tuned to the receiver frequency, in series with the armature lead. Install the unit as close to the generator as possible. If you wish to make your own tuned circuit, make the coil of wire heavy enough to carry the generator current. The coil should have as low a resistance as possible. No. 10 wire is good.

Noise caused by the voltage regulator is a rubbing or a rasping sound. It can be suppressed by installing a 3.3-ohm resistor in series with a .002-μf capacitor. Connect this from the FLD terminal on the voltage regulator. Do not connect a capacitor directly from field to ground—it may damage the regulator.

Other noises

Interference developed by gages, wheels and tires is most difficult to identify. When in doubt, bypass all gages right at the terminals with a large capacitor—about 0.1 to 0.5 μf. The best way to determine which one is the troublemaker is to disconnect them one at a time. The gas gage should be bypassed right at the tank. In extreme cases, bypassing the dome light will help.

Wheel static noise can be identified by applying the brakes when the car is in motion. If the noise in the receiver disappears, install grounding springs. They can be purchased at auto and electronic parts and stores. Anti-static powder in tires will suppress any tire static (usually more noticeable at 30 mph and



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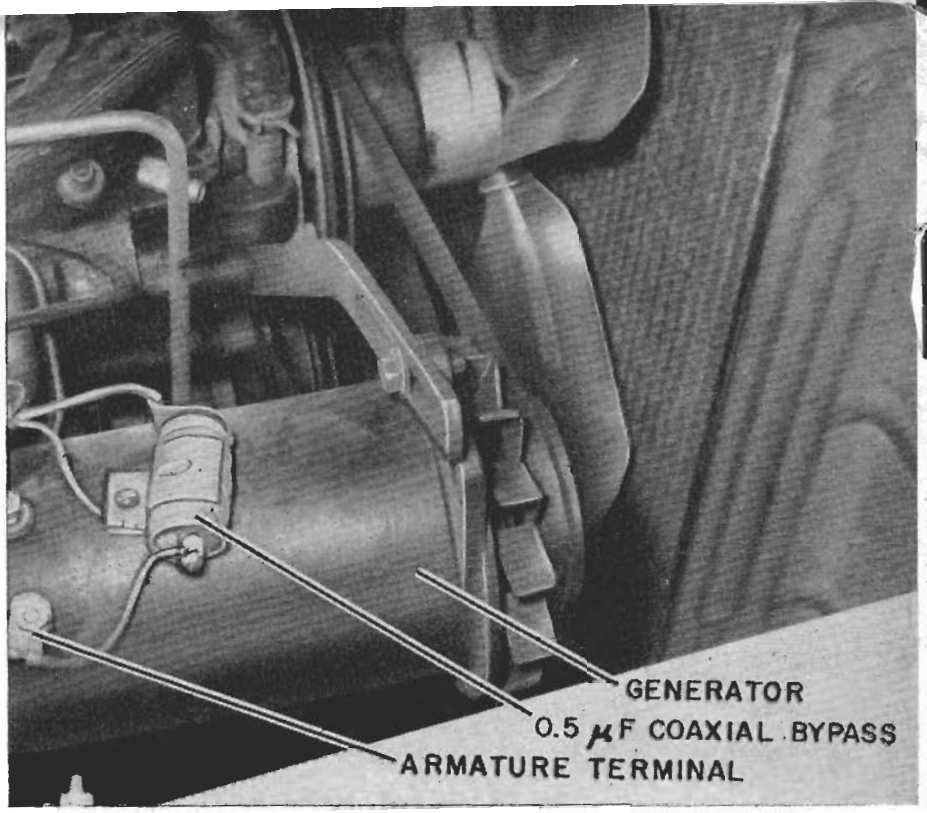

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1/*Ignition suppression is the first step. Bypass and resistive suppressor help.*

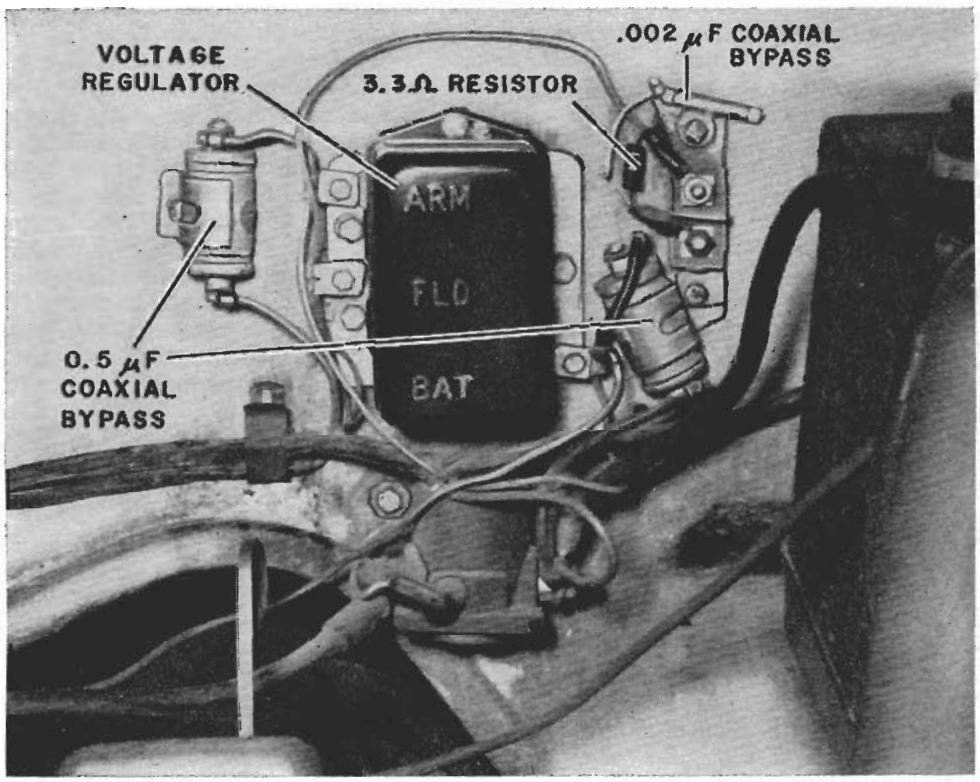
2/*Coaxial capacitor in armature lead shuts up the generator.*

3/*If noise persists, bypass the regulator, too, but watch the field terminal — don't connect a capacitor directly to it.*

up). There is a high-pitched whine heard in the receiver when driving at high speeds on dry pavement. Commercial antennas have a plastic ball on top to discharge this velocity static slowly, so that it cannot be heard in the receiver. If you have this trouble, a piece of plastic tubing can be cemented at the antenna tip.

Bonding

Bonding is an important item in tracking down motor noise caused by the sparkplugs or generator. Bonding is tying all parts together at common ground potential. Connect heavy copper bonds from all four corners of the motor to the frame of the automobile. Check that the ground strap from the battery has not developed any resistance. In some tough problems, run a copper strap



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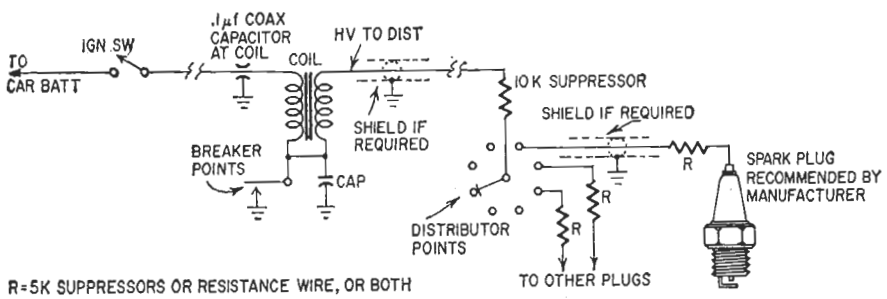


Fig. 1—Using suppressor resistors or resistance wire with coaxial capacitors attenuates ignition hash. Shielding helps in serious cases. Keep leads short as possible.

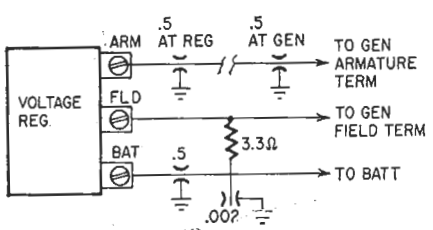


Fig. 2—Much of the noise that remains after ignition is silenced comes from the generator and regulator. Ground capacitors at nearest convenient point.

as a common ground from the voltage regulator and generator to the motor. Install bonding at both hood hinges and place a flexible piece of tin at the other end as a hood wiper. This will do much to keep the noise under the hood and out of the receiver.

The tail pipe is usually suspended from rubber supports. To keep it from acting as an antenna, bond it at intervals. Even putting a bond on the steering wheel helps in some cases. Be sure there is a good ground at both ends of the coax antenna lead. Some cars have undercoating or rust or dirt on the fender at the antenna. Be sure the fender is clean and, if convenient, run a bonding strap from it to the frame of the car. In the initial installation of the antenna, a place of minimum motor noise can be determined. Placing the antenna on the top of the car will generally improve performance. The roof then acts as a good ground plane and gives a non-directional pattern.

I have mentioned coaxial capacitors. These should not be replaced by the paper bypass variety. Although more expensive, coaxial capacitors are considerably more effective at higher frequencies.

By metering the receiver and keeping the motor at the same rpm, you can determine how effective you have been in eliminating noise. This is helpful when you have more than one source of motor noise to contend with. The meter reading will decrease as motor noise is suppressed. Also radiating a signal on the receiver frequency will aid in determining what type of noise is being intercepted in the receiver, and if any improvement is being made.

In an FM receiver, a balance point for impulse noise is reached at some point in alignment. At this point, the motor noise will be reduced. Tune the i.f. coils for minimum motor noise, being careful not to detune the receiver. And be sure that your receiver is in good operating condition, of course. In some cases, a defective tube may show up as an increase in motor noise rather than a decrease in signal level. It is also advantageous to run the receiver direct from the battery. The battery then acts as a large capacitor, bypassing noise impulses to ground. END

CB Scene

By Len Buckwalter

TAKING THE BARK OUT OF SPARK

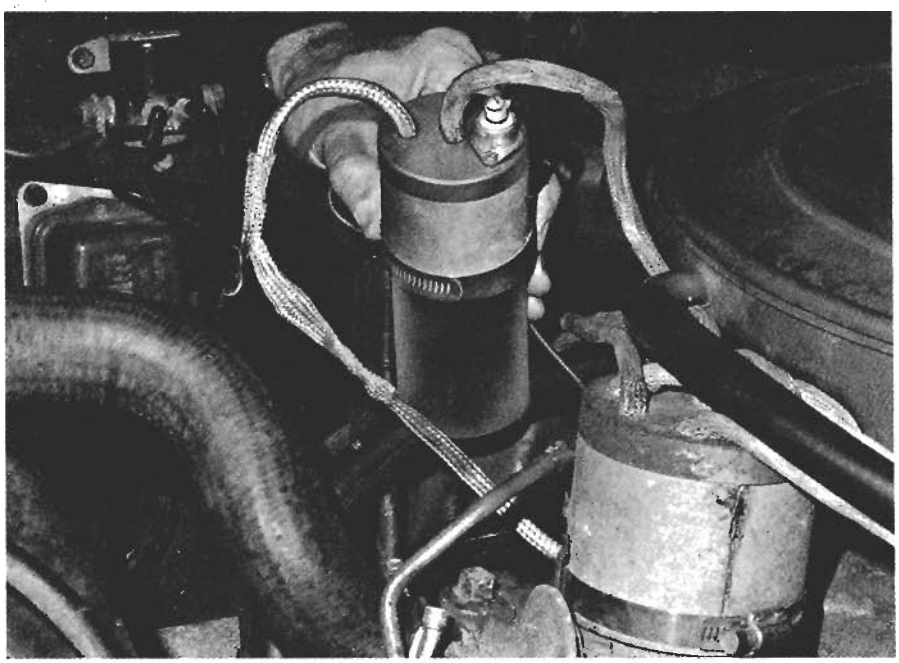
I THOUGHT I knew something about ignition noise until I met Harry Bichsel. He probably knows more about the snaps, crackles and pops that tear up our mobile rigs than any other CB'er around today. Harry's a retired electrical engineer (from Westinghouse) and he's spent 25 years tracking down the nasty noises that disable the communications of a mobile rig. As I drove up to his home, he was puttering with a huge contraption that looked like a barn door painted black and covered with plumbing pipes. I soon found out it was designed to capture energy from the sun. But I was more interested in the two vehicles parked next to Harry's infernal solar machine—a 1971 Ford LTD and a perky Mustang. They looked like ordinary cars, but something beneath their bonnets made them the most interference-free mobiles for miles around. They had *shielded* ignition systems.

CB manufacturers have already done their part in trying to lick mobile radio's greatest problem. Noise limiters on today's sets are a far cry from the simple diode clippers of an earlier time. The diode simply clips the sharp spike created by a noise pulse just before it passes into the receiver's audio circuits. Since the pulse is almost always stronger than the voice modulation, the desired audio goes through unaffected. Well, almost, because clippers aren't perfect and they can reduce the set's intelligibility. If you get one of the newer r-f noise-silencer circuits, chances are it does a better job by attacking noise much earlier in the receiver, before those spikes slop up the i-f circuits. But noise limiters aside, it's generally agreed that in mobile rigs it's best to suppress the noise where it begins—in the car's electrical system. Let the noise limiters in the receiver deal with noise from the *other* fellow's car.

Harry had tried the usual suppression measures years ago. He had installed filters, bypass capacitors and other items to short-circuit offending r-f hash to ground before it rides into the receiver through antenna or power leads. If ignition noise causes an S-meter reading of S7, he explains, that's about 42 dB, considering that each S-unit might be equivalent to 6 dB. It means an incoming signal must rise to considerable strength to override the noise. The weak ones are never heard. As he demonstrated the point, I recalled a friend of mine who runs a vending-machine route and calls his office on CB to get messages. It's a great moneysaver in his business. But he has to stop and turn off his truck engine to hear anything! Harry found he could reduce an S7 noise reading to about S5, mostly by treating the voltage regulator and instruments (such as the gas gauge). But a whopping difference happened when he went all the way and shielded the ignition system.

The big culprit is the spark plug, and it's easy to see why. If you could somehow bring back Heinrich Hertz and show him the diagram of a car's ignition, he'd likely say, "Looks like the radio transmitter I built around 1890." There's a high-voltage generator and spark-discharge gap reminiscent of turn-of-the-century radio apparatus. A steeply peaked electrical discharge across an air gap creates a wave rich in harmonics that easily extends to 27 MHz. To make matters worse, the wires from each spark plug to the car's distributor act as a multi-element transmitting antenna. You can't bypass high-tension wires because it would warp the clean waveform needed for good ignition, and cost a fortune anyway. In a high-compression engine, spark-plug voltages occasionally reach 30 to 40 kilovolts. Thus, the practical answer is to shield the ignition wires.

At center is the distributor with a shield can clamped over it. In the technician's hand are high-tension wires encased in shield braid.



The ingnition coil is shielded where the wires connect to it. Shield braids are pulled over the primary wires going to the coil.

How to Shield. Harry has some good pointers on how the job is done. The first is to draw your own diagram that shows where each spark plug and coil wire are connected in your car. Also find the indexing mark on the distributor that orients the wires with respect to the ignition timing. (If you reverse a spark plug wire, it'll mess up the firing order.) All the old spark plug wires should be removed and replaced because these leads must be in excellent condition in a shielded system. Any cracks in the insulation will surely cause an engine miss, since the spark is attracted to the easy ground afforded by the copper braid pulled over each wire. One end of the braid is soldered to a metal shield that covers the spark plug. The other end of the braid is soldered to a can fitted over the distributor cap. (That cap is plastic and radiates considerable noise.) Another metal cap is fitted over the plastic end of the ignition coil to contain noise emitted from that area. Shielded braid is also pulled over the primary wires to the coil, and a 0.1-μF bypass capacitor is fastened to a coil lead.

That's the basic routine for shielding an ignition system. Good insulation around the plugs inside the shield is important to avoid any possibility of arcing. The bypass capacitor on the ignition coil is needed to establish a good r-f short for noise currents circulating in the shield braids. Since Harry does his own ignition tuneups, he overlaps some braid on one lead to the ignition coil so he can slide back the braid and attach a tach or dwell meter. He's found no difference in engine performance or distributor point life after shielding the ignition system.

Is it worth all the trouble? I'd always thought shielding an ignition system was something done only in airplanes and text books. Much too exotic for us civilians. The answer came as Harry fired up the big V-8 and turned on a CB transceiver that had a *plastic* case, no less. The little radio hardly protested.

Of course, some cars are quiet, while another of the same make can create the sound of hail on a tin roof. I challenged Harry to remove some of the shielding. All he did was slide back the shield braid from a coil wire and the radio made noises like Baron Frankenstein's laboratory. The receiver's S-meter, which had been idling at a gentle reading of 1 or 2 units swung to S7.

Maybe the time and trouble to shield the ignition are worth it after all. I recall only one mobile rig I operated in the past that wasn't troubled in some way by ignition interference. It was aboard a boat a couple of years ago. Boats, like cars, are prolific noise generators. But come to think of it, that boat was powered by a *diesel* engine. It had no spark plugs! ◈