TM 11-483

WAR DEPARTMENT TECHNICAL MANUAL

SUPPRESSION OF RADIO NOISES

WAR DEPARTMENT • NOVEMBER 1944

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IC 71 : T/O 71–10–1S.

For explanation of symbols, see FM 21-6.

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SECTION I

RADIO INTERFERENCE

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1. Purpose

The purpose of this technical manual is to acquaint the reader with the types of radio noise which cause interference and to give him a knowledge of the technique of noise suppression so that radio communication may be maintained in localities where interference would otherwise make it impossible. The information contained herein is intended as a guide to enable the reader to determine the type of interference, to locate its source, and to provide a means for its elimination.

a. Interference and noise, as applied to radio reception, refer to any disturbance which interrupts or interferes with radio communication. Failure to remove these disturbances is often responsible for lack of communication between radio stations. Some interference such as static due to atmospheric disturbances cannot always be suppressed. However, other types of interference which are inherent in the installation of the radio set or in its location may be removed by using suitable suppression materials.

b. In order that interference may be suppressed, it is first necessary to know the type of interference present. After the type of interference has been determined, it is necessary to determine its source. In cases where it is not possible to suppress the noise source, steps must be taken to reduce the effect of the interference. Whenever possible it is best to suppress the noise at its source.

2. References

The information in this technical manual is not to be used when it conflicts with any information contained in technical manuals for any specific equipment or installation. When information is supplied for noise suppression, make sure all suppression components (bonding, etc.) are in good order before adding any more suppression. It is important to do this since the performance of some equipment can be seriously impaired when suppression is applied to circuits that should not be suppressed.

3. Natural Static

One of the largest sources of radio interference is the natural static caused by atmospheric conditions which depend upon the time of year, weather conditions, etc. This manual will not cover the removal of natural static from radio sets.

4. Heterodyne Noise

a. EXTERNAL. Heterodyne noises usually are the result of the beat produced by two or more transmitters operating near the same frequency. It is not always possible to remove this type of interference at the receiver. The amount of background noise, heterodynes, and other noise and interference which usually will be heard is determined by the characteristics of the receiver. The reception of one station and the reduction or elimination of the interfering signals and noises depend largely upon the skill and technique of the operator.

b. INTERUNIT. The high-frequency oscillators of two or more superheterodyne receivers may also cause heterodyne interference when they are operated near each other.

5. Receiver Component Noise

Some noise present in the output of a receiver is due to the design of the receiver. The vacuum tubes and the aging of the resistors and capacitors which are components of the set and loose or corroded connections are causes of noise. This noise may be kept to a minimum by the careful selection of tubes, the checking of the resistors and capacitors, and the inspection of the connections throughout the set.

6. Man-made Interference

Man-made or local interference is caused by many types of electrical installations. These installations include ignition systems, power units of various types, power lines, electric motors, and many other types of electrical units. This manual will deal primarily with methods for determining the type of interference and eliminating those caused by man-made installations.

7. Direct Radiation

Directly radiated interference is transmitted from the source to the receiving antenna, and usually does not travel any great distance.

8. Conducted Interference

This type of interference is conducted directly from the source through the power lines to the receiver. It generally occurs in a-c operated receivers in the form of a low-frequency hum or noise, or both. Conducted interference may also be present in vehicular and aircraft installations.

9. Reradiated Interference

Reradiated interference is the most common type of interference. Power lines, telephone and telegraph lines, and ungrounded metal structures conduct interference which has been transmitted to them from the noise source by direct radiation, by conduction, or by induction. Strong interference may thus be conducted long distances by power or telephone and telegraph lines which in turn may radiate from their entire length to any antenna located near them.

SECTION II

DETECTION OF SOURCE OF RADIO INTERFERENCE

10. Isolation of Source

a. Antenna or Ground Connection. A poor antenna or ground connection to the receiver, or a vehicular antenna striking a grounded object will cause a crackling noise in the output of the receiver. One of the first things to check when there is noise in the average radio set is the connection at the antenna and ground binding posts and at the antenna and ground of the set. Firm connections eliminate many of the noises which interfere with the reception of radio signals. Disconnecting the antenna and ground, connecting the antenna terminal to ground, and listening for the noise under these conditions will often give a clue to the source of the interference. If the noise continues when the antenna and ground are disconnected, the trouble is not caused by the antenna or ground system; if the noise disappears when they are disconnected, it is likely that the antenna is picking it up. Therefore, the noise is the directly radiated or the reradiated type.

b. Receiver. The receiver should be checked to determine whether the noise present in the output is due to the component noise of the receiver itself. For detailed instructions in this case consult the technical manual of the specific receiver.

c. Power Source. Interference from the power source, particularly in a-c operated receivers, is generally indicated by a low-frequency hum. This hum may sometimes be reduced by reversing the receiver power input connection. If this operation reduces the hum, use line bypass capacitors or filters as described in paragraphs 20 and 21.

d. Noise Analysis. The following table lists a number of types of noise and the possible sources.

Table I

Type of noise	Possible source
Clicking, regular or irregular	Calculating machines, electric. Code machines. Flashing signs. Mercury arc rectifiers. Relays. Switches. Telephone dials. Teletype machines. Thermostatic controls. Traffic signals. Typewriters, electric.
Popping	Ignition systems. Regulators of vehicular charging generators.
Buzzing	Buzzers. Electric razors. Vibrators.
Humming	Antenna too close to power line. Faulty receiver. Ground of set poor. Poor tubes.
Heavy rushing	Shot effect. Thermal agitation.
Whining	Many devices using electric motors. Generators, running fast. Magnetos.
Loud continuous sputtering	Arc welders. Defective lamp sockets, switches, and wiring. Generators, running slowly. High-frequency apparatus, diathermy, etc. Loose fuses. Neon signs. Power lines grounded on tree limbs. Reproduction equipment. Street cars.

11. Location by Radio

It is often possible to use a radio receiver to locate the source of interfering noise. The following paragraphs describe the most common methods of determining the noise source.

12. Location by Radio Triangulation

In this method a battery-operated receiver with a loop antenna is used. The loop is turned so that maximum noise is heard in the output of the receiver. The loop is then turned until the noise is minimum, indicating that the source is 90° from the direction of the plane of the loop. The direction of the noise source should be plotted on a suitable map, and the receiver moved to a new location. The loop is again turned for minimum noise, and the position and direc-

tion should be plotted as before. Figure 1 illustrates the location of the noise source by the intersection of the lines plotted from each of the two receiver positions.

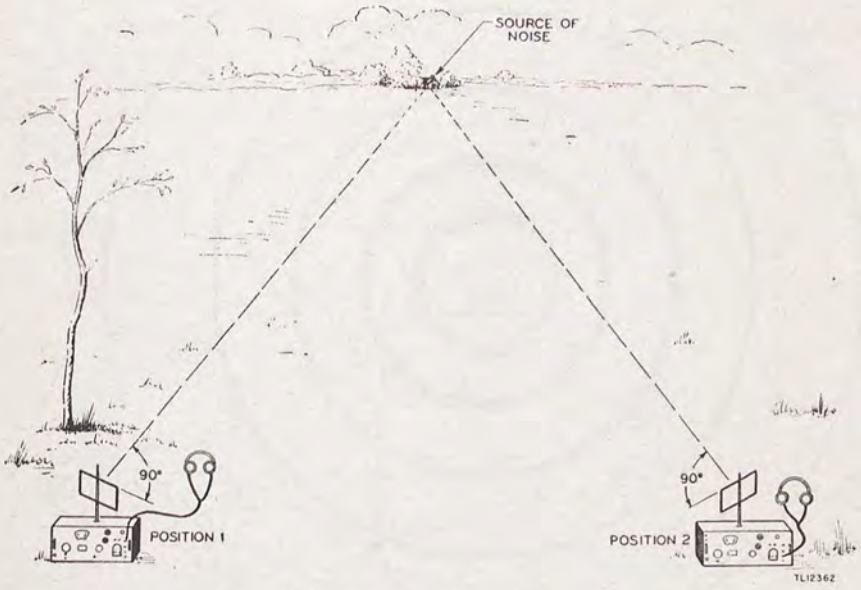


Figure 1. Locating source of noise by triangulation.

When the duration of the noise is short but the noise is very severe, it may be necessary to use two receivers operating at the same time to determine the location of the noise source. Simultaneous readings from two receivers will give more accurate results than two separate readings from a single receiver.

13. Location by Radio Signal Intensity

In this method a receiver with a nondirectional antenna is used. An output meter should be used in conjunction with a headset, since the human ear is not sensitive to small changes in noise level. The receiver is moved in the direction of the greatest noise intensity as indicated by the output meter (fig. 2). When investigating interference the receiver should be tuned so that no intelligible signal is received. An output meter will indicate all the interference, and it is only by listening that the kind of interference and its probable source can be determined. Any of the standard output meters issued with Signal Corps test equipment will be satisfactory for this work.

Note. Use a receiver which does not have automatic volume control or one in which it may be cut out.

14. Location by Radio Probing

In this method a battery-operated receiver with a probe antenna is used. This type of antenna restricts the pick-up to noises produced

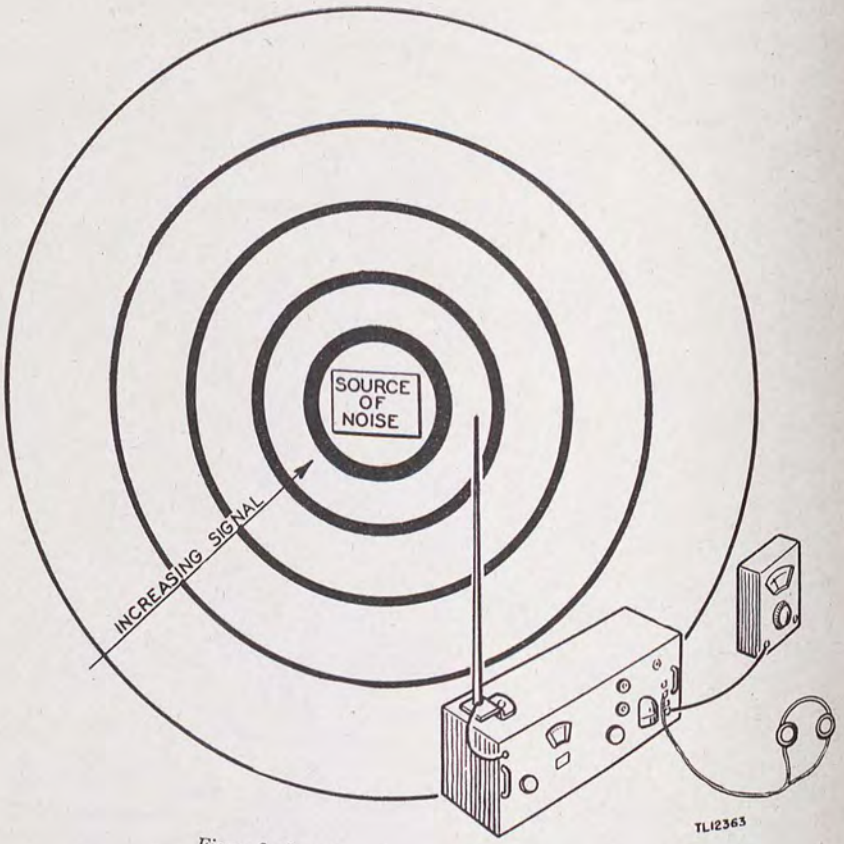


Figure 2. Locating source of noise by signal intensity.

in the vicinity of the probe as it is placed near the source of noise, and is much more accurate than the first two methods described above. The probe may consist either of a short length of wire coiled into a ring about 2 inches in diameter or of a small coil. Either type probe is connected to the receiver through a shielded cable. Figure 3 illustrates one type of probe antenna and figure 30 illus-

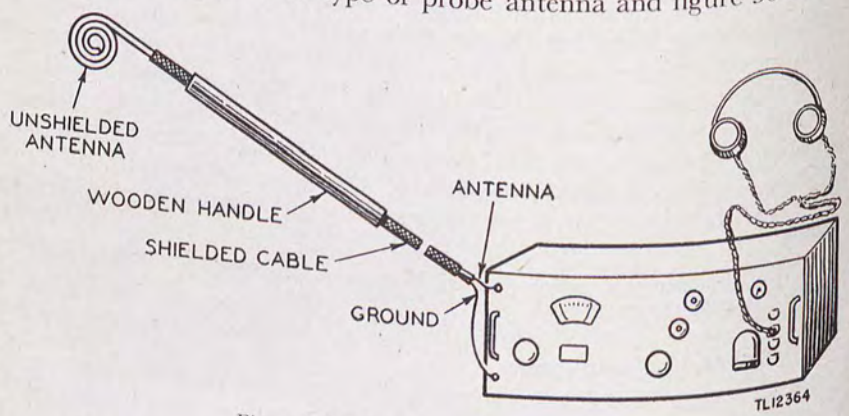


Figure 3. Probe antenna connected to receiver.

trates another type. Details for making probes are contained in the technical manuals for installation of equipment.

15. Screen Room

Screen rooms (fig. 4) are used when it is necessary to check vehicles or power units in extremely noisy locations. The function of the screen room is to prevent static as well as man-made interference from affecting the measurements being made. These rooms are generally used for production testing, etc.

SECTION III

METHODS OF SUPPRESSION

16. General

Sometimes it is possible to arrange operation of the source of interference so as to reduce its effect on radio communication. Careful arrangement of communication schedules may sometimes eliminate severe radio interference which cannot be removed in any other manner. In many cases, after the source of noise has been determined by one of the methods suggested in section II, it will be possible to eliminate the trouble completely by one of the methods discussed below.

17. Shielding

A shield is a metallic sheet or covering used to prevent the radiation of interference from electrical wiring or equipment in which noise voltages are present. The three main types of shields used are the solid metal cover, the flexible metal conduit, and the shielded cage.

a. Metal Can Shield. This type of shielding is a solid metal can which surrounds the noise source to intercept the radiation and conduct it to ground. It is used to cover small electrical devices. Even when the metal covering is intended mainly for the support of the parts of a device it will, when properly bonded (par. 19), also act as a shield to prevent radio waves from being radiated to the antennas of nearby receivers.

b. Flexible Metal Conduit. The flexible metal conduit which is used to surround wires to intercept radiation is another type of shielding. This method is used to suppress transmission lines, lead-in wires and power supply lines to receivers, and the high- and low-tension wiring of various engines. It is sometimes used on automobile engines; but the simpler resistor-suppressor system which is more economical, is usually sufficient.

18. Screen Rooms

Certain types of interference, such as that produced by diathermy apparatus, are best limited to the area in which they are produced by inclosing the equipment in a screen room. Figure 4 shows the construction of a typical double screen room. All joints and seams must be thoroughly soldered. In addition, a filter should be used in the incoming power supply line. Paragraph 21 contains a detailed discussion of filters. The two screens are insulated from each other except at the point where the power line enters. At this point they are connected together and grounded. A screen room keeps noise from entering the room as effectively as it keeps noise from leaving it.

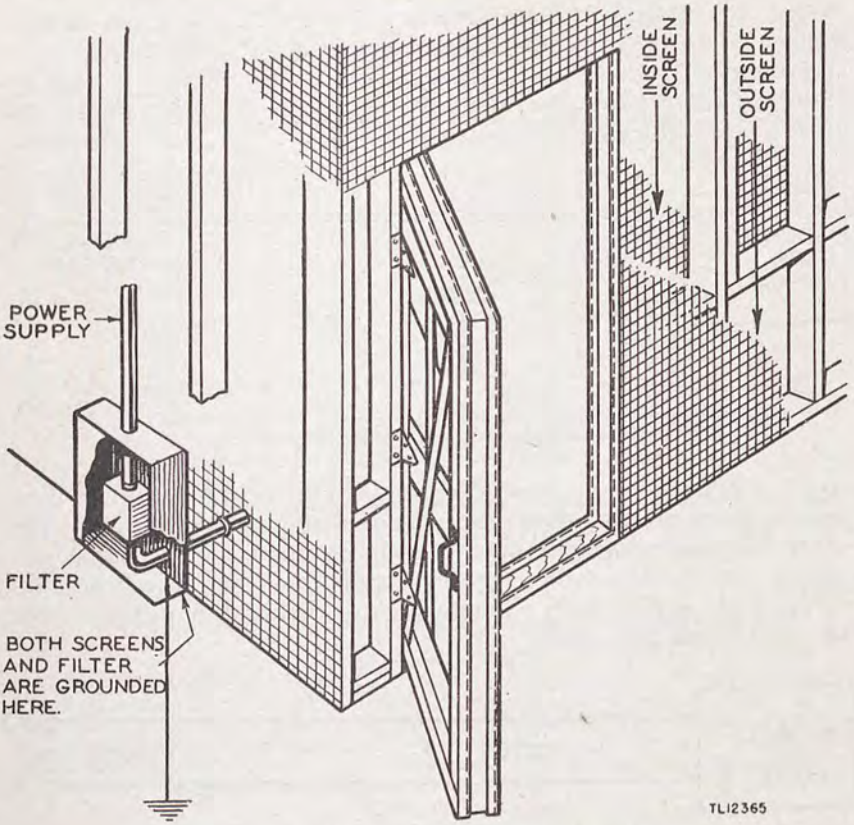


Figure 4. Typical double screen room construction.

19. Bonding

Bonding is the term applied to the method of electrically connecting two surfaces. All metal components within the field of any device which produces radio noise must be bonded together to prevent them from reradiating the noise. Bonding can be accomplished either by connecting the surfaces together by bolts and tooth-type lockwashers or by flexible metal bonding jumpers when the two surfaces cannot be bolted together. *A bond is of little value in the suppression of noise unless the bonded surfaces are clean and tight and the contact resistance is extremely low.*

20. Bypass Capacitors

To be most effective, bypass capacitors should be mounted as close as possible to the noise source to permit short leads. When long leads are used their added inductance acts to reduce the bypassing effect of the capacitor. When the line to be suppressed is carrying alternating current, the capacitor should be as small as possible and should have sufficient voltage rating to withstand the line voltage. Figure 5 shows how a capacitor is connected to filter a grounded

power line. Figure 6 shows three ways in which capacitors can be connected to filter an ungrounded line supplying equipment with a grounded metal frame. Greater suppression efficiency may be obtained when two capacitors, connected 6 to 18 inches apart, are used instead of a single capacitor.

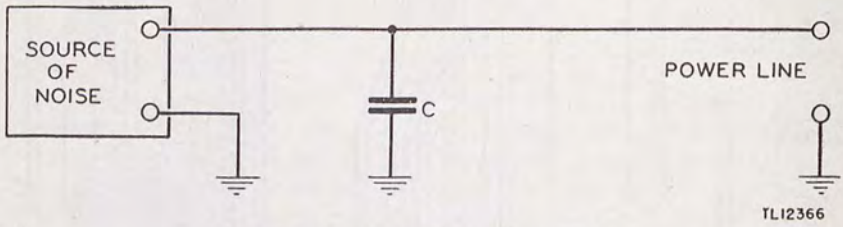


Figure 5. Bypass capacitor filter for grounded line.

When vibrating contacts are suppressed, a capacitor should be used with a series resistor where the voltage is above approximately 100 volts. In high-voltage circuits the discharge current of the capacitor, which must be relatively large to absorb the spark when the contacts break, will be high enough to cause welding or pitting of the contacts when they close.

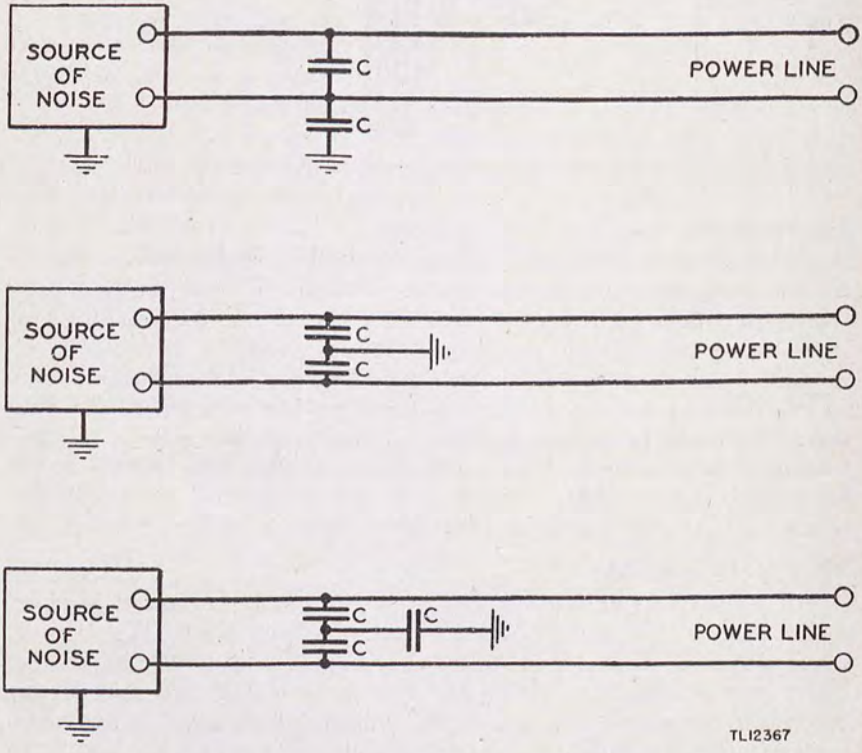


Figure 6. Bypass capacitors to filter ungrounded lines supplying grounded equipment.

Figure 7 shows how capacitors are used when neither the line nor the equipment can be grounded.

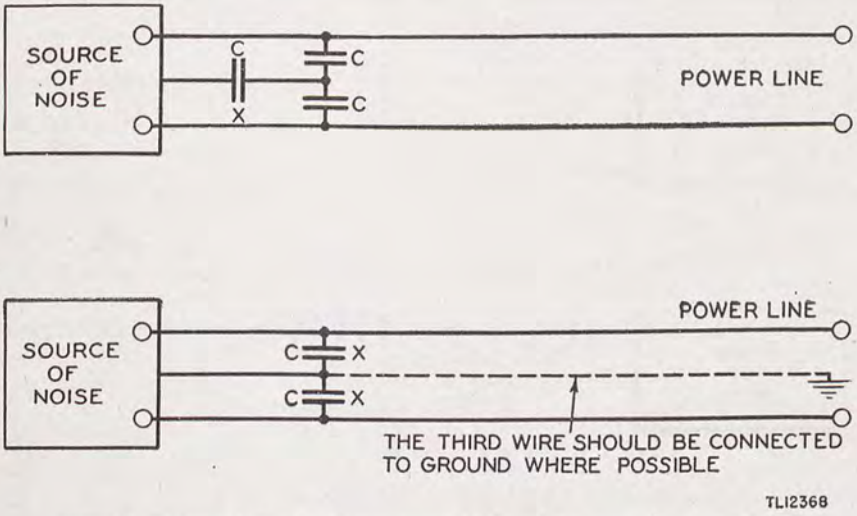


Figure 7. Bypass capacitors to filter ungrounded lines supplying ungrounded equipment.

Note. The capacitors marked X in figures 7 and 10, when used with portable a-c operated equipment, should not exceed 0.001 microfarad for 110-volt circuits or 0.0005 microfarad for 220-volt circuits. The current passed by larger capacitors is dangerous to the operator standing on damp earth or touching a grounded object. For other voltages divide the constant 0.11 by the line voltage to obtain the maximum capacity in microfarads which will be safe to use.

21. Filters

The capacitors discussed in the previous section are simple filters. A more complex filter is one which contains both capacitance and inductance. The capacitors of such a filter provide a low-impedance path to ground for the interfering currents to prevent them from traveling along the line, and the inductance retards the flow of the currents along the line. Under certain conditions the use of these complex filters is considerably more effective than the use of capacitors alone. Whenever a capacitor alone will adequately suppress the noise, it is undesirable to use a more complex filter. There are three basic types of filters: the "L" type, the "pi" type, and the "T" type. Each of these basic types is shown in figure 8. The selection of the type of filter to use is based on two things: the nature of the

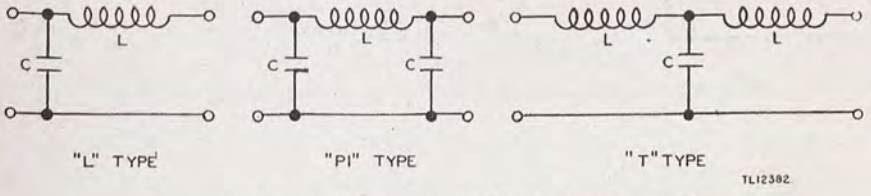
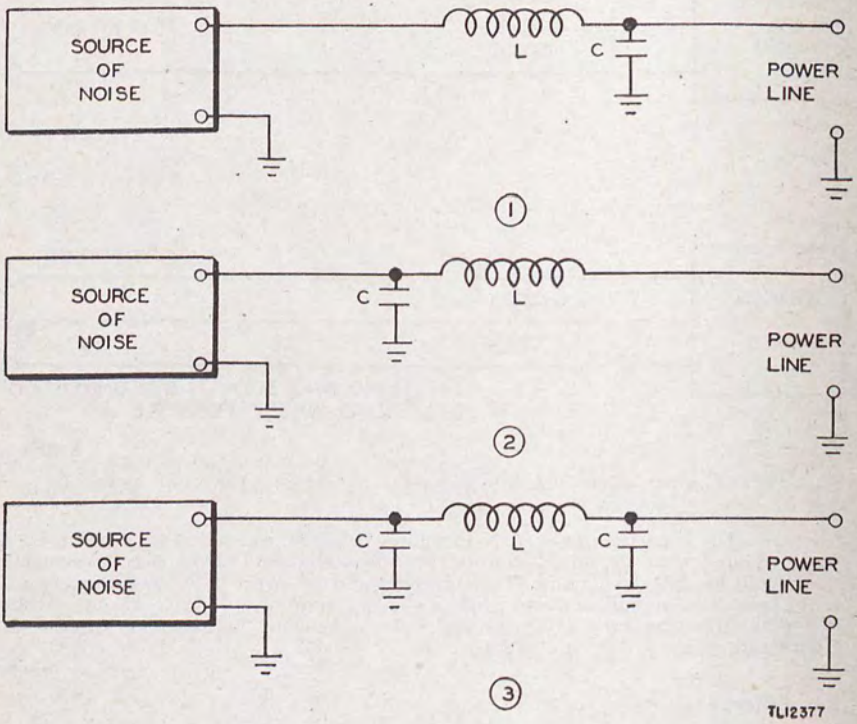


Figure 8. "L" type, "pi" type, and "T" type basic filter circuits.

equipment to be suppressed, and the degree of suppression required. Figures 9, 10, 11, 12, and 13 show how filters are applied for different types of power lines and equipment.



① *Capacitor on line side of choke.*
② *Capacitor on source side of choke.*
③ *Capacitor on each side of choke.*

Figure 9. Filters used with grounded line equipment.

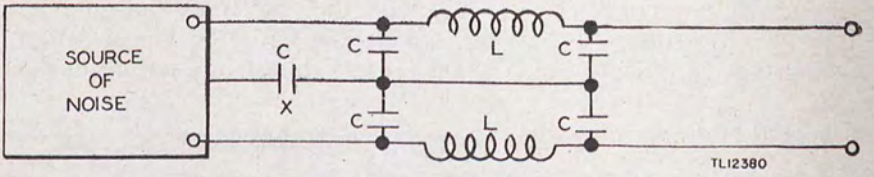
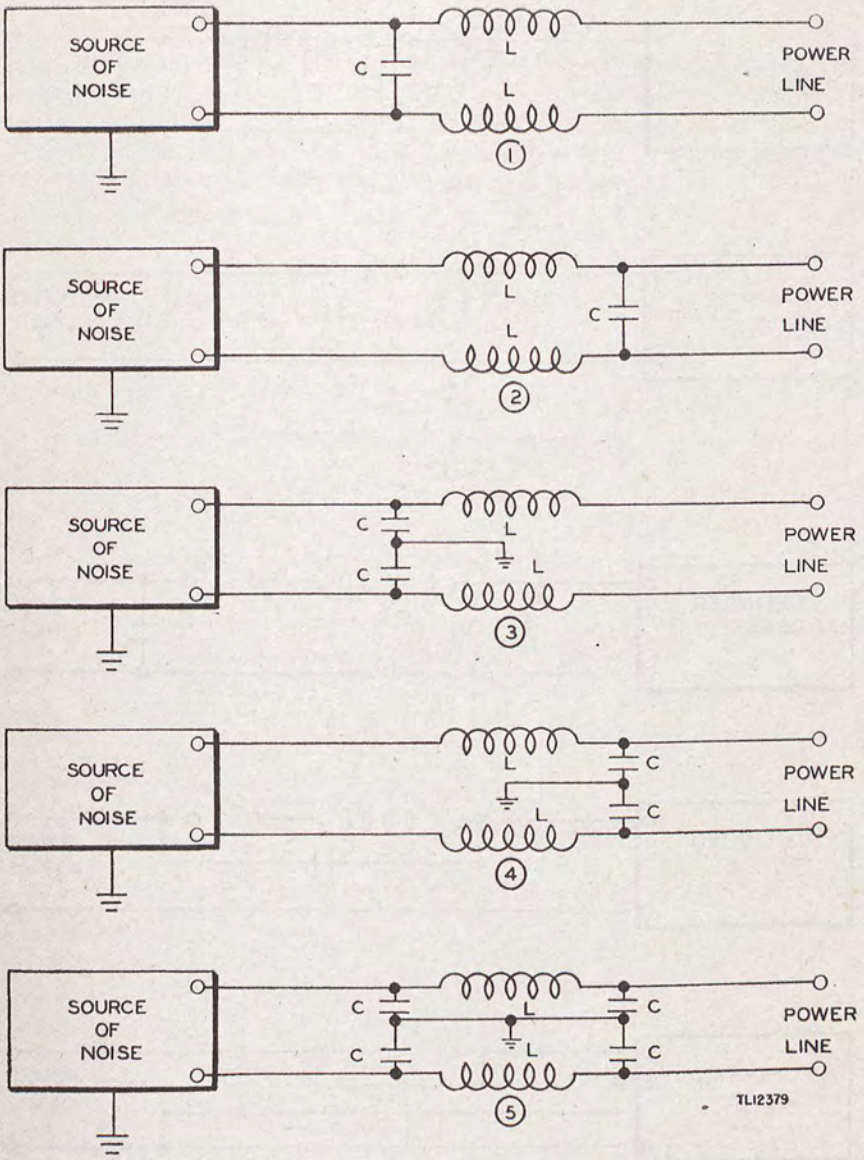


Figure 10. Filter used with ungrounded line and ungrounded frame equipment.



① *Capacitor on source side of chokes.*
② *Capacitor on line side of chokes.*
③ *Capacitors on source side of chokes with common connection grounded.*
④ *Capacitors on line side of chokes with common connection grounded.*
⑤ *Capacitors on each side of chokes with common connection grounded.*

Figure 11. Filters used with grounded frame equipment.

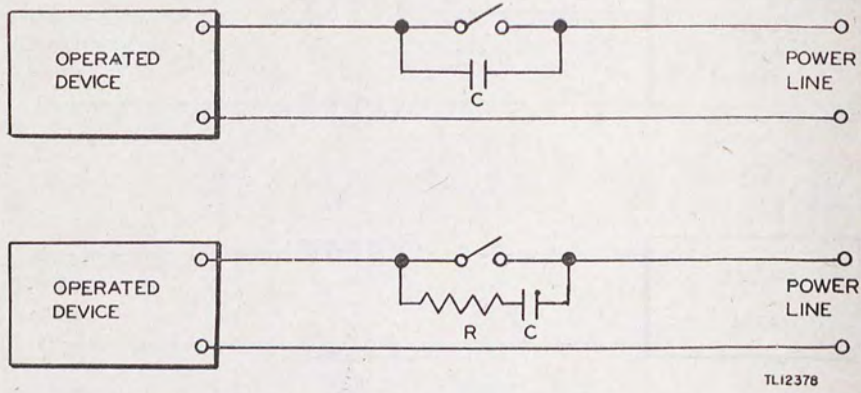


Figure 12. Filters used with vibrating contacts.

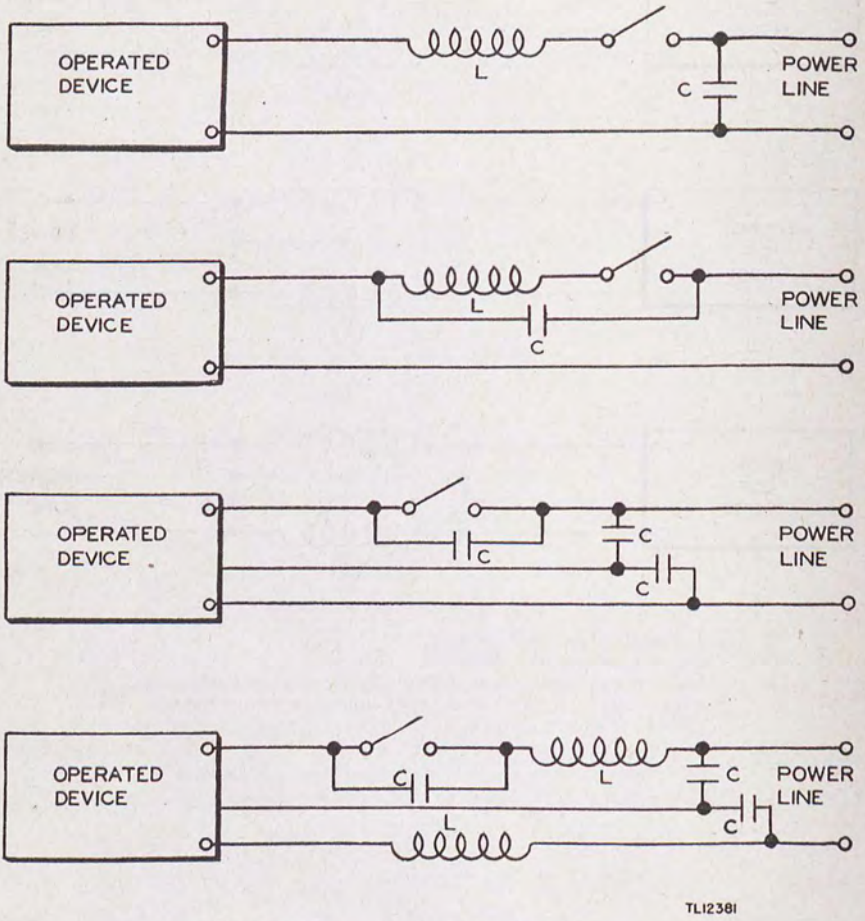


Figure 13. Filters used with make and break contacts.

22. Resistor-suppressors

The only place resistor-suppressors are used is in the leads from the spark plugs to the distributor and in the lead from the distributor to the ignition coil or magneto. The preferred value of resistor is 10,000 ohms, although values between 8,500 and 18,000 ohms may be used without affecting the performance of the engine.

SECTION IV

NOISE SUPPRESSION OF POWER UNITS

23. General

The radio interference generated by a power unit must be suppressed at the source. Apply only sufficient suppression to permit satisfactory operation of associated or near-by radio equipment. Radio interference from power units is caused by unsteady or intermittent currents or voltages.

24. Sources of Interference

The following elements of a power unit will produce radio interference:

a. Driving engine.
b. Main generator.
c. Exciter.
d. Charging generator.
e. Voltage and current regulators.
f. Control panel and structural framework.
g. Since some power units do not contain one or more of the above items the suppression system must be fitted to the particular power unit at hand. In addition, certain power units have revolving permanent magnets to provide the necessary field flux. This method of excitation minimizes the problem of noise elimination, as no commutator ripple or brush sparking takes place within the exciter circuit. Again, some power units have voltage regulators which are inherently noise-free; other units may not have any voltage regulators.

25. Determination of Source of Interference

A power unit may be checked in several ways, depending on the facilities available, to determine the extent of the radio interference produced by it. A radio receiver can be used with its antenna placed as close to the power equipment as an antenna is likely to be installed. Wherever possible, this receiver should be operated from a separate power source. With the use of such a receiver the power equipment to be suppressed can be deactivated part by part until a single source of interference is located. In this way interfering sources may be suppressed separately. When a receiver that operates from a separate power supply is not available, the power unit cannot be deactivated. It will be necessary to locate the sources of interference by the trial-and-error method. Locate the probable source by a listening test, and apply suppressors to the source indicated. The following chart will aid in determining the source of noise.

Type of noise	Probable source
Clicks: Regular clicks that speed up when the engine speeds up and stop the second the switch is turned off.	Ignition system: Clicks are spark plugs firing or points opening.
Clicks: Irregular clicks that speed up when the engine speeds up and continue a moment after the switch is turned off.	Generator regulator: Clicks are contacts opening and closing.
Whine: Moaning sound that rises in pitch as the engine is speeded up and continues a moment after the switch is turned off.	Generator: Whine is coming from the make and break contact of brushes on the armature.

The accuracy of the diagnosis can be checked by listening before and after suppression components are applied.

26. Driving Engine

The principal source of radio interference produced by most internal combustion engines is the ignition system. Large power units with rated outputs of 10 kilowatts or greater often use Diesel engines to drive the generators. The Diesel engine generally does not incorporate an ignition system and therefore does not generate radio interference. Smaller power units and some of the larger ones are almost invariably driven by gasoline engines which have either battery or magneto ignition systems that must be suppressed.

27. Main Generator

Brush-sparking at the collector rings of the main generator of an alternator produces a type of radio interference called *hash*. This type of radio noise is sometimes confused with atmospheric noises, but can be distinguished by a careful listener. The main generator of a d-c power unit produces radio interference essentially the same as the exciter described in paragraph 28.

28. Exciter

The excitation for most power units is provided either from a separate exciter mounted on the engine shaft or from an auxiliary winding on the main generator armature. In either case the exciter output must be commutated before being applied to the main generator field. As a result, a steady hash or whine is heard in the receiver output. Commutator ripple is not as distinct as ignition noise, and generally no confusion arises concerning the source of such interference.

29. Charging Generator

With the exception of an additional whine in rhythm with the engine speed, the radio interference from a charging generator sounds like that from the main generator and exciter of the power unit. Only a careful listener can detect the difference.

30. Voltage and Current Regulators

The regulators applied to the charging generator which have vibrating contacts produce a distinct but intermittent clicking sound in the output of the receiver. This sound tends to be less steady than that from the ignition system. Regulators that do not have make and break contacts seldom cause radio interference.

31. Control Panel and Structural Framework

Any portion of the power unit may reradiate interference if it is not properly bonded to other portions of the unit. For this reason it is important that all components of the complete assembly be bonded together to be at the same potential. Meters, loose washers and bolts, loose fitting panels, exposed stopping switches, and many other seemingly unimportant items can be the cause of radio interference.

32. Methods of Treating Noise Sources

a. The most effective way to suppress radio interference from a power unit is to identify and locate each source and to apply a suppression component to each one in turn. Since suppression is applied to most power units at the time of manufacture, refer to the technical manual for the particular unit to determine where bonding, shielding, filters, etc. have been applied. Check these items and make sure they are in good order before attempting any further suppression measures. Tighten or replace loose bolts and washers. If contacting surfaces which should be bonded are insulated from each other by paint or rust, apply tooth-type lockwashers under convenient bolts. These lockwashers will cut through thin surface coatings and provide an adequate bond. If the surface coating appears to be too thick, clean it before the lockwasher is applied, and then paint it to protect it from rust. In particular make sure the engine block, main generator, and exciter frame are well bonded.

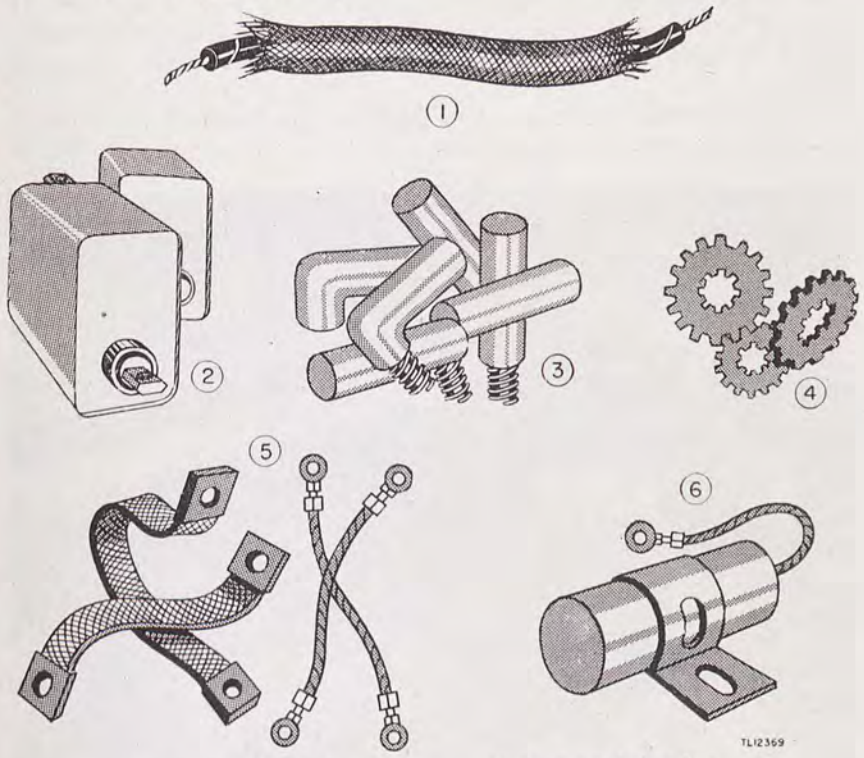
b. Methods of isolating disturbing elements of the power units will vary for different units, but a general procedure may be outlined. It will be supposed that a separately energized radio receiver is available and is used. However, if this is not the case and the power unit being suppressed is used to energize the receiver, the trial-and-error method must be used. The principles outlined will apply provided nothing is done which will remove or reduce the source of power. If either the charging generator or main generator is directly coupled to the driving engine, removal of either generator as an interfering source is easily accomplished by decoupling it from the engine. If the driving engine is directly coupled to the main generator, lifting the collector ring and exciter brushes will effectively eliminate radio interference from the main generator. The main generator voltage regulator can be removed from the exciter circuit (where it is customarily applied) with a control switch located on the control panel.

c. The following pages describe methods of treating each of the noise sources in turn. It should be emphasized that these are only

general methods and cannot possibly be effective in all cases. The need for ingenuity on the part of personnel applying suppression cannot be overestimated. If the suppression components described for a particular application are not available in the field, many substitutes may be devised. For example, where metal braid is suggested for bonding between elements of a power unit, strands of heavy copper wire can be used. Where tooth-type lockwashers (preferably internal-external tooth-type) are prescribed, ordinary spring lockwashers may be substituted, provided the contacting surfaces are well cleaned and all bolts and nuts are sufficiently tightened. Surfaces which are not in good electrical contact can be the cause of radio interference; therefore all bolts and nuts must be well tightened.

33. Suppression Components

a. The components used for the suppression of radio interference are bonds (bonding jumpers of metal braid, tooth-type lockwashers, or metal gaskets), capacitors, choke coils, filters, resistor-suppressors, and shielding (flexible metal hose, rigid metal conduit, or sheet metal boxes or partitions.)



① *Flexible metal shield.*
② *Inductor-capacitor filters.*
③ *Resistor-suppressors.*
④ *Tooth-type lockwashers.*
⑤ *Bonding jumpers.*
⑥ *Capacitor.*

Figure 14. Radio noise suppression components.

b. When a particular application calls for a capacitor, choose one with a voltage rating large enough for the application in question. In this regard, do not forget that the peak voltage of an alternator is 1.414 times the rated voltage. Metal-clad capacitors are recommended. In some cases, because of installation requirements, an insulated type of capacitor may be necessary.

c. The only value of resistor-suppressors shown in the following pages is 10,000 ohms, which is the preferred value, although resistances from 8,500 to 18,000 ohms may be used. Apply resistor-suppressors as close to the source of ignition interference as possible.

d. If choke coils are necessary, the type of radio-frequency chokes common in radio circuits will be satisfactory, provided current ratings are not exceeded.

34. Methods of Application of Suppression Components

a. Before suppression components are applied to any circuit involving brushes, make sure the brushes are properly seated.

b. Apply all suppression components with proper lockwashers and/or necessary prepared spots to insure a good electrical contact and permanent bonding.

c. Make sure all electrical components of a power unit are at ground potential. Securely bond mechanical parts to the hull, frame, or bracket on which they are mounted by any of the following methods.

(1) By mating surfaces which are machine-finished and firmly fastened together. The surface must be free of paint and corrosion

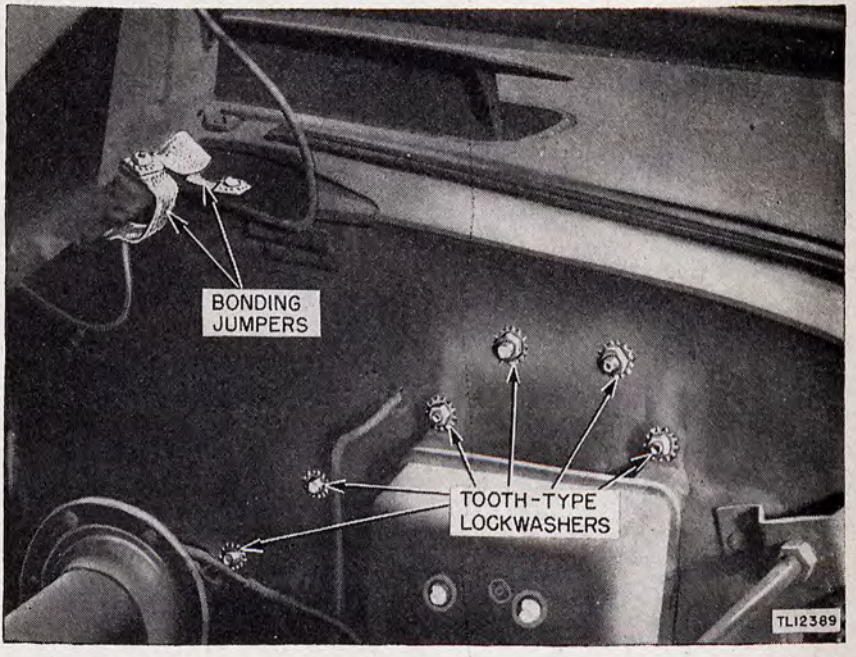


Figure 15. Tooth-type lockwashers and bonding jumpers in engine compartment.

and should not be treated in any manner which would reduce surface conductivity.

(2) By prepared spots or surfaces. The contact surfaces of the parts to be bonded are plated and firmly fastened together.

(3) By the use of tooth-type lockwashers, suitably plated to withstand corrosion, with good surface conductivity (fig. 15).

(4) By the use of a bonding jumper. Electrical components or mechanical parts which cannot be treated by any of the above methods may be joined by a bonding jumper.

d. In joining two parts, use tooth-type lockwashers to insure good conductivity.

e. In bonding a part with a cap screw, use a tooth-type lockwasher under the head of the screw. The threads with which the cap screw mates must be clean.

f. Remember that a bond should have an extremely low d-c resistance. In this use the word bond refers to the contact point at each end of the bonding jumper.

g. Terminate all electrical conduits, both flexible and rigid, with a good bond at each end. Whenever possible, bond these conduits at a maximum of 2-foot intervals throughout their length with bonding jumpers.

h. Bonding jumpers may be made of any resistance conductor which will withstand vibration and oxidization. They should be fitted with lug terminations.

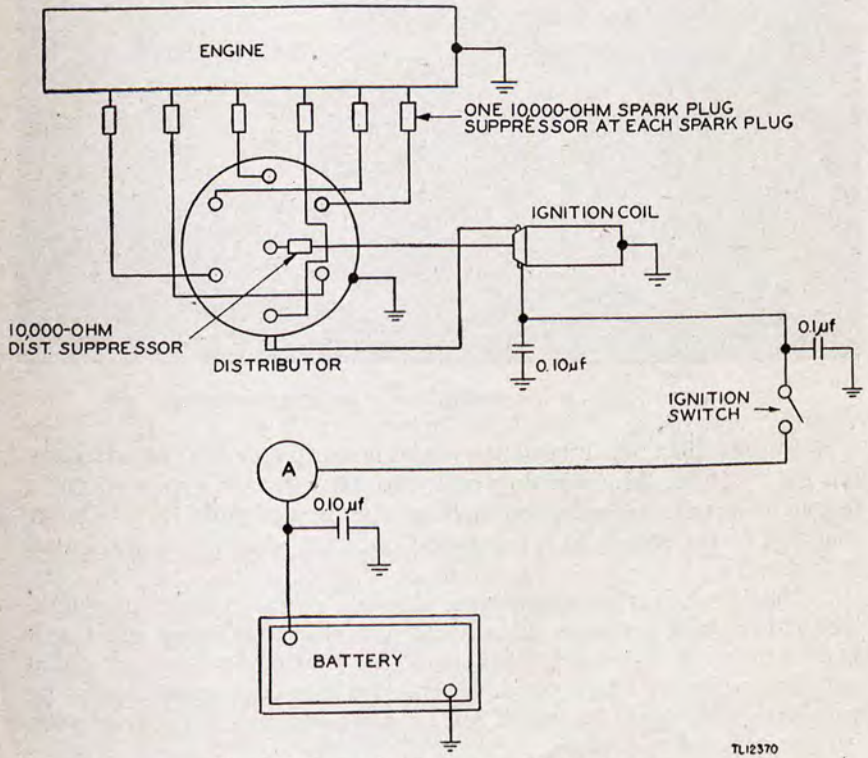


Figure 16. Battery ignition system, schematic diagram.

35. Suppressing Ignition System

a. If the power unit is driven by a gasoline engine or a Diesel engine using an ignition system, resistor-suppressors, bypass capacitors, and shielding may be necessary to eliminate radio interference. Figure 16 shows a schematic diagram of a battery ignition system and the recommended application of capacitors and resistor-suppressors. Table II at the end of section V lists, in the order of preference, the values for the suppression components indicated in figure 16.

b. Figure 17 shows a typical resistor-suppressor installation. Figures 18 and 19 give detailed views of suppression applications, and show further possible methods of shielding the elements of the ignition system. Remember that all joints must be clean and tight.

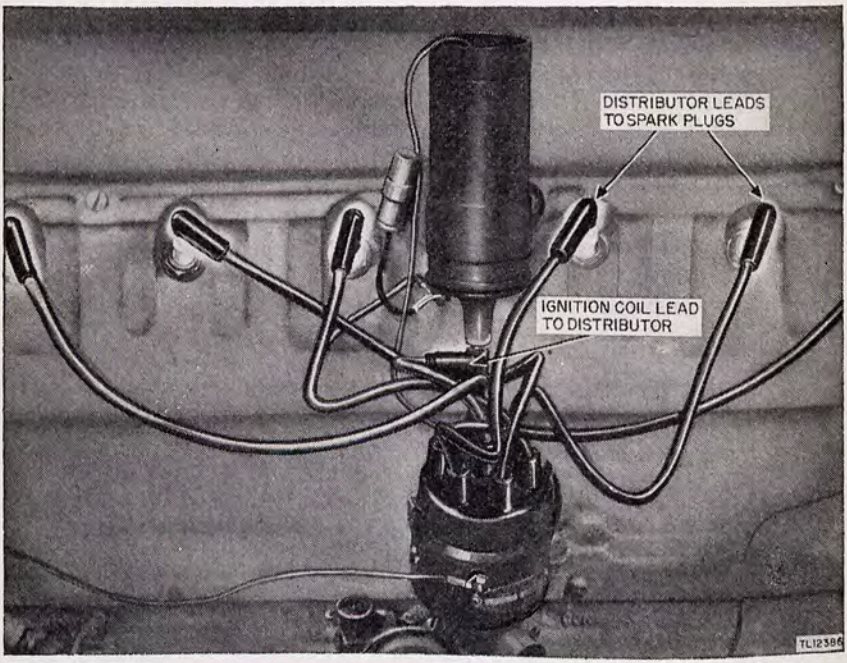


Figure 17. Resistor-suppressors installed in battery ignition system.

c. Suppression of a magnetic system is similar to that of a battery ignition system. The ignition coil and battery are replaced by a magneto which must be bonded to the power unit in a similar manner. If the magneto is not metal encased, shield it as indicated in figure 18.

d. Although it is unnecessary to shield a metal-encased magneto, when there is a cork gasket between the case and cover replace it with a metal-filled gasket. Make sure the mating surfaces are clean and all screws well tightened. In emergencies cork gaskets may be wrapped with strips of metal foil or copper screen to provide the necessary bond.

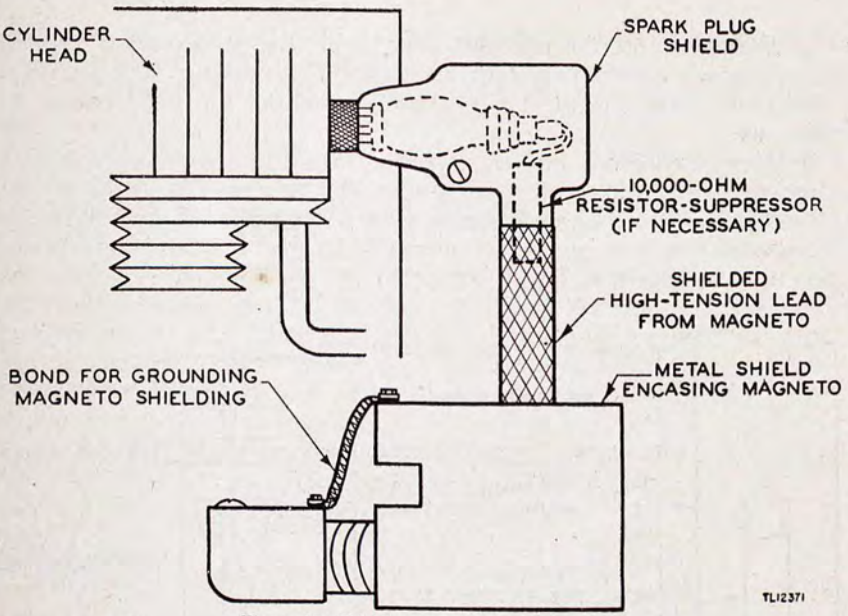
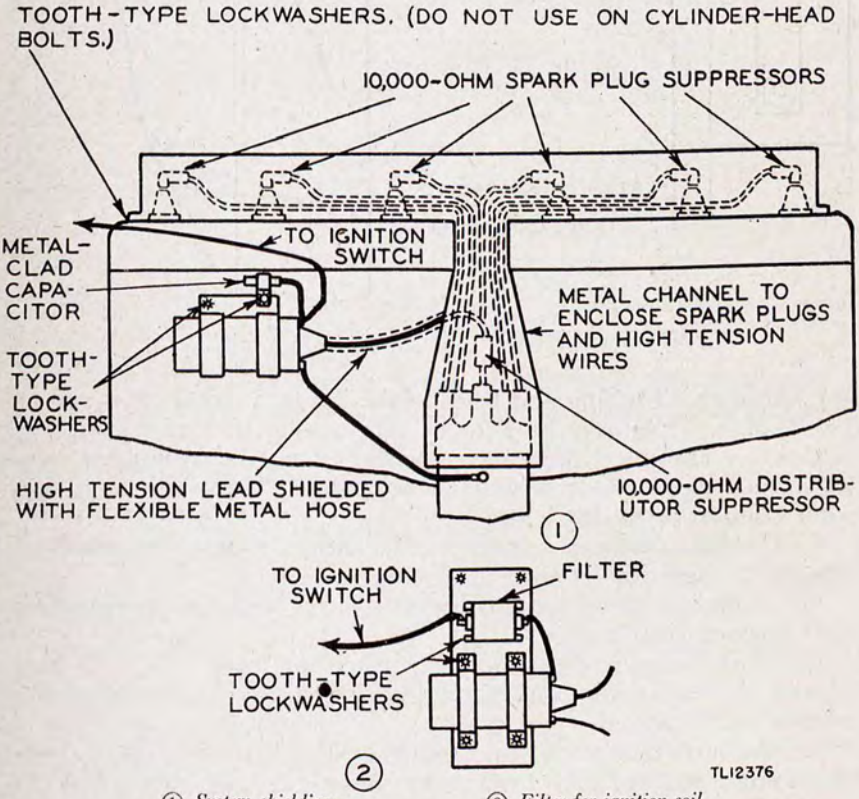


Figure 18. Shielding magneto ignition system.



① *System shielding.* ② *Filter for ignition coil.*

Figure 19. Shielding battery ignition system.

e. Suppress interference radiating from the stop switch circuit of a magneto ignition system by complete shielding and isolation of the stopping circuit. Do not use capacitors for suppression in this case.

f. If an exposed metal-tab type of stopping switch is mounted close to the ignition coil or magneto, the tab may have to be inclosed in a metal box. A simpler method of preventing such a tab from radiating is to reverse its operation so that the tab is at ground potential as shown in figure 20.

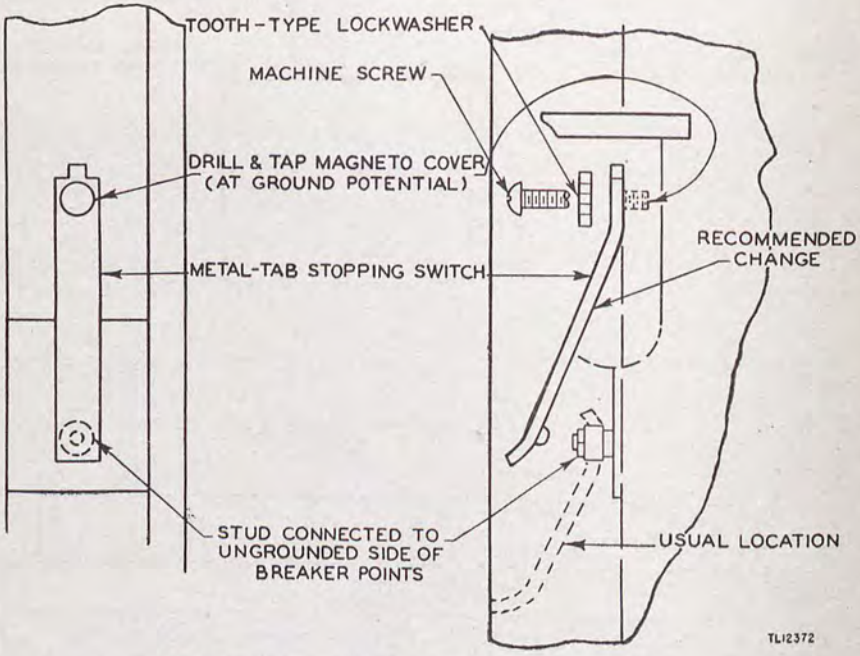


Figure 20. Recommended change for metal-tab stopping switch.

g. Shorten all wiring and leads of the ignition circuit as much as practicable. They may have to be rerouted to minimize coupling with other circuits. Radiating leads should not be assembled in a cable, nor should high- and low-tension leads be run through the same conduit or shield.

h. The following is a summary of suggested suppression applications to the ignition circuit:

(1) *Battery ignition system.* (*a*) Relocate leads to minimize coupling with various other circuits.

(*b*) Place resistor-suppressors in high-tension leads.

(*c*) Use combination of resistor-suppressors and shielding of the high-tension leads.

(*d*) Use a metal channel to completely shield the spark plugs, the distributor, and the high-tension wiring; use flexible metal hose to shield the high-tension lead from the coil to the distributor.

(2) *Magneto ignition system.* (*a*) Relocate leads to minimize coupling with various other circuits.

(*b*) Completely shield high-tension leads and use resistor-suppressors, if necessary.

(*c*) Use metal gasket between magneto cover and magneto housing.

(*d*) Encase nonmetallic-housed magneto within metal shield.

36. Suppressing Regulator and Battery-charging Generator

Battery-charging generators and regulators are normally used on larger power units. These generators and regulators are generally suppressed by flexible metal hose shielding the exposed leads and with bypass capacitors. Figures 21, 22, 23, and 24 illustrate typical methods of suppressing charging circuits. In addition, it may prove necessary to reroute leads in the charging circuit to reduce coupling with other circuits.

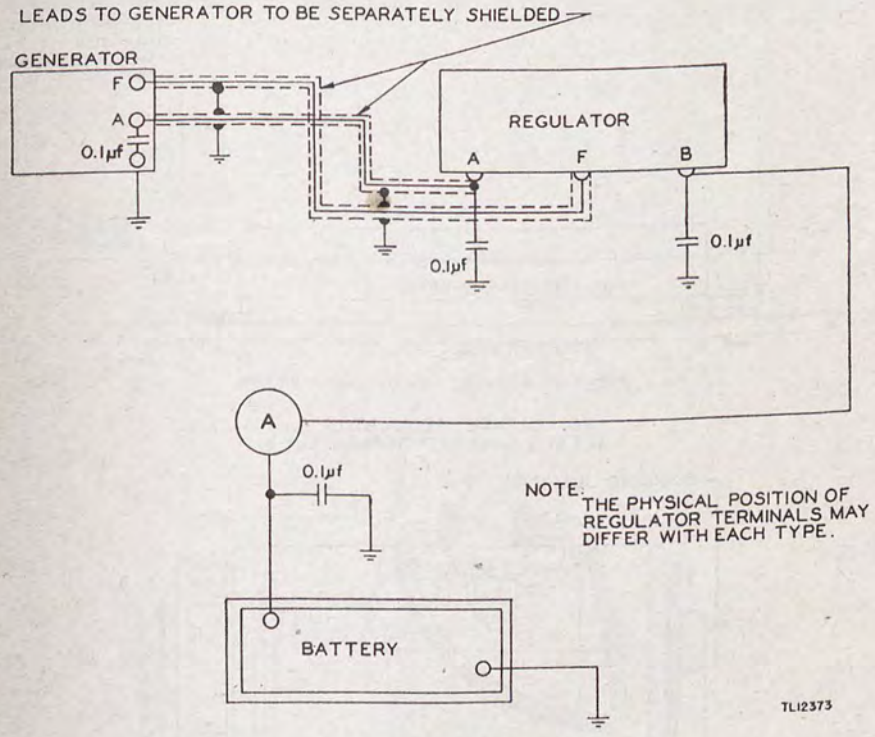


Figure 21. Battery-charging circuit showing suppression components schematic diagram.

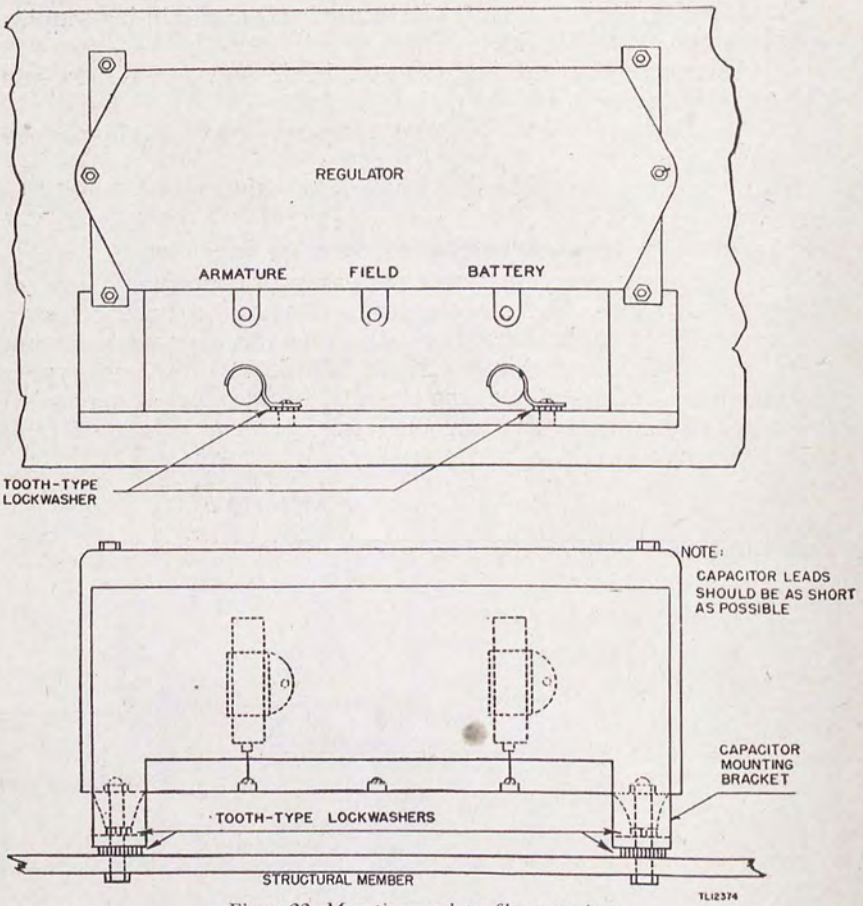


Figure 22. Mounting regulator filter capacitors.

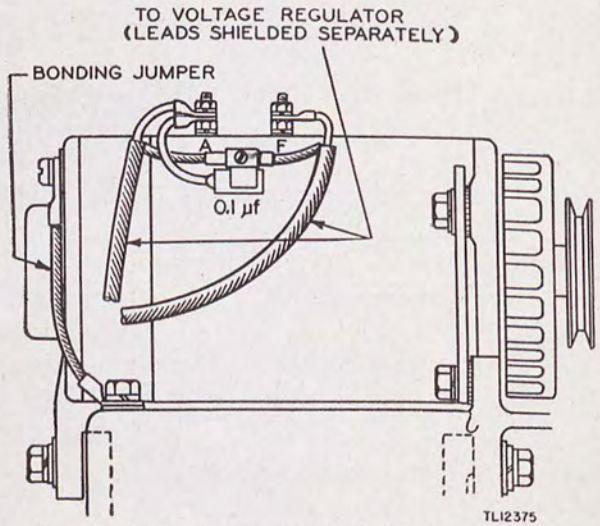


Figure 23. Suppression components applied to charging generator.

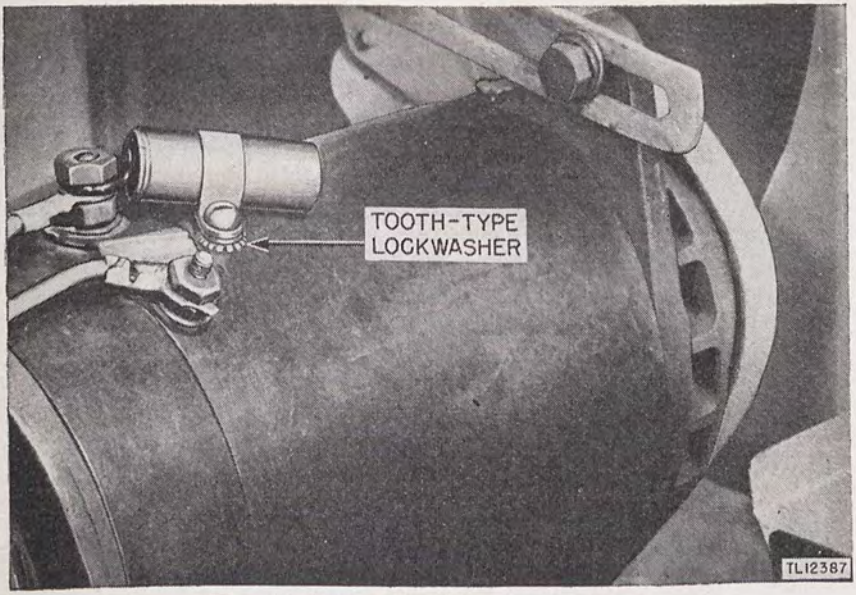
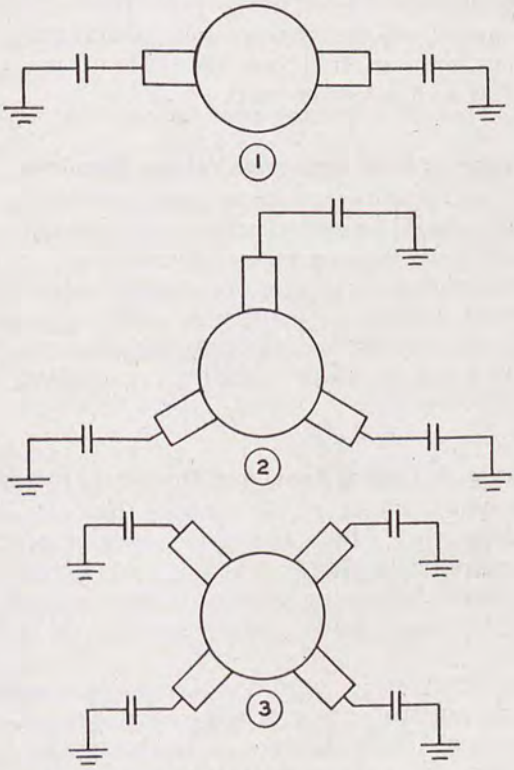


Figure 24. Capacitor installed on charging generator.



NOTE: ALL GROUNDS SHOWN ARE FRAME OF MOTOR OR GENERATOR.

TL12383

① *Two brushes.* ② *Three brushes.* ③ *Four brushes.*

Figure 25. Capacitors applied to motor or generator brushes, schematic diagram.

37. Suppression of Main Generator and Exciter

a. Usually it will be sufficient to use bypass capacitors on brushes to eliminate commutator interference. It may also be necessary to shield all exposed leads of the exciter circuit. Another effective application is to put a grounded wiping contact or brush on the shaft to bypass noise currents generated within the unit. Be careful in applying such a wiping contact as one which will damage the unit should not be used. If a brush is required, it is recommended that it be made from a carbon (or other self-lubricating) commutator brush and holder. If a holder is not available, one can be improvised with a strip of phosphor bronze or spring steel properly bent and bolted to the carbon brush. If these applications are not successful, it may be helpful to put a radio-frequency choke coil or a filter in series with the exciter output.

b. If the main generator has a revolving field, it may also be necessary to apply capacitors at the slip ring brushes. This application is essentially the same for commutator, slip ring, and collector ring brushes (fig. 25). Generally, 0.1 microfarad capacitors are used.

c. The output of a revolving armature alternator is generally bypassed with a capacitor at the collector ring brushes, as described in *b* above. Three-phase units usually require identical suppression components applied to each of the three phases.

d. The output of the power unit is generally bypassed with capacitors at the terminal box. A 0.01 microfarad capacitor is recommended for a-c power units.

38. Suppression of Main Generator Voltage Regulator

a. Since additional capacitance may result in damage to the contact, none should be added across vibrating contacts of a voltage regulator when suppressing radio interference.

b. Where additional suppression is needed, shielding and bonding will be helpful. However, if sufficient shielding, etc. is impractical in the field, satisfactory radio communication may be maintained by transferring the regulator to manual operation during necessary periods.

39. Suppression of Control Panel and Structural Framework

a. It is important that all elements of the complete assembly be at an equal potential. To achieve this, bond together when necessary, the control panel, side panels, gas tanks, driving engines, main generator, exciter, charging generator, and all other components.

b. Fasten the control panel and the side panels to the main framework.

c. Bypass voltmeters, ammeters, frequency meters, and other electrical instruments with capacitors if they radiate interference. Mount these capacitors as close as possible to the instrument they are bypassing, and reduce lead lengths as much as practicable (fig. 26). Methods of mounting these capacitors follow those illustrated in figures 22 and 23.

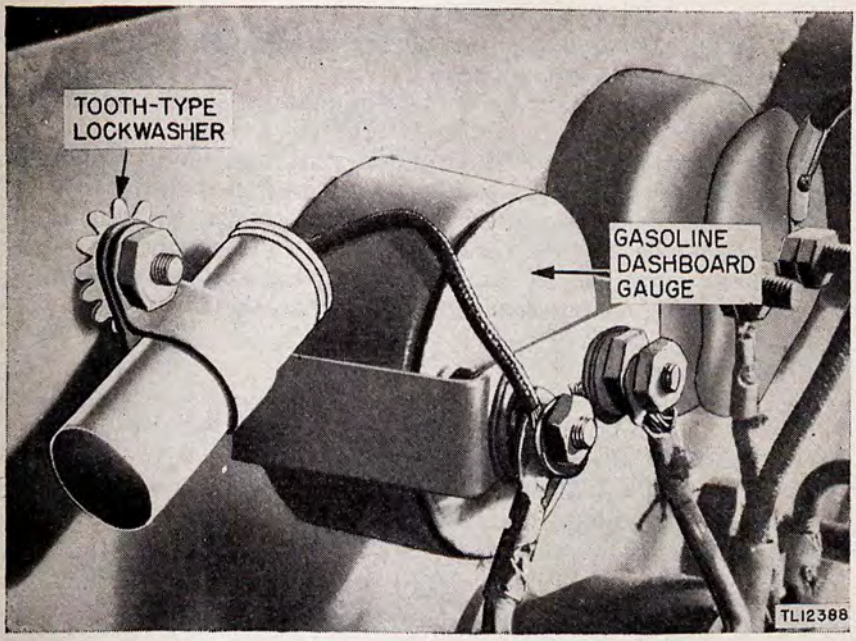


Figure 26. Capacitor installed on gasoline gauge.

40. Unusual Sources of Interference and Suggested Methods of Treatment

Unusual sources of radio interference frequently appear in power units. The following examples may aid in their location.

a. Small power units which have little mass have limited capacitance to ground for bypassing noise currents. Consequently, after every effort to reduce the entire unit to an equal potential has failed to eliminate noise radiation, it may be necessary to bond the unit to a rod which is driven into the ground.

b. If the power unit is mounted in a vehicle, it must be securely bonded to the vehicle.

41. Preventive Maintenance

Preventive maintenance of the suppression system should be performed at the same time as the scheduled equipment maintenance. This applies equally well to all units whether suppressed at the factory or in the field. Follow, not necessarily in the sequence shown, the procedure below.

a. CAPACITORS. Check the mounting and connections of each capacitor when the unit on which it is mounted is inspected. Thus, when inspecting the brushes and commutator of the generator or exciter, make certain the suppression capacitors are securely mounted and connected to the brush holders. Do not take it for granted that such connections are tight; *make sure by trying them with a wrench or screw driver.* In the same manner, check the suppression capacitors on other components of the power unit.

b. FILTERS. Follow the procedure in *a* above.

c. RESISTOR-SUPPRESSORS. Inspect resistor-suppressors when the high-tension circuits are checked. Replace those that are scorched or cracked. Make certain by actual trial that all leads are firmly fastened to the body of the resistor-suppressor.

d. BONDS AND SHIELDING. Make certain that each bond is mounted securely. Do not take it for granted that the bolts are tight; *use a wrench.* Replace any worn bonds. Establish a routine by starting at one point and checking each bond in succession. Check the couplings or ground connections of shielding on wiring and the mounting bolts of shielding covers. Keep them clean and tight.

42. Trouble Shooting

If excessive interference is experienced, the source can be determined by following the procedure in paragraph 25. When the circuit causing the noise has been found, an examination of the components will usually disclose the cause. The following chart will aid in determining the cause of the noise.

Type of noise	*Probable cause*
Ignition	Poor adjustment or poor condition of breaker points or spark plugs, loose connections, loose bond straps, broken resistor-suppressors, loose shielding, or defective filter or capacitor.
Regulator	Loose connections, loose mounting bolts or screws, loose shielding, or defective filter or capacitor.
Generator or exciter	Loose connections, worn brushes or commutator, loose bond straps or shielding, or defective filter or capacitor.

a. The remedy for any of the above conditions is fairly obvious. Connections should be clean and tight. Worn bonds and defective filters and capacitors should be replaced. Numerous points are bonded by tooth-type lockwashers which bite through paint and grease to the metal. When any suppression component is replaced. a tooth-type lockwasher should be placed under the head of the bolt.

b. Common sense must be used when shooting trouble on a noise suppression system. It should not be expected that the interference can be reduced to a point where it cannot be heard on a radio receiver with the volume control full on and no signal coming in; rather, the interference should be reduced so that it does not interfere with the weakest signal that can be received above the background noise of the receiver.

c. The one most important point to remember in connection with a suppression system is to *keep all connections and mountings clean and tight.*

SECTION V

APPLICATION OF SUPPRESSION TO AUTOMOTIVE VEHICLES

43. General

The radio interference generated by automotive ignition and electrical systems is very similar to that produced by power units. In most cases, however, more complete suppression is required than for power units because radio equipment is installed in the vehicle. Since the engine is generally inclosed, the radio interference radiated directly from its electrical system reaches the antenna by reradiation from metal parts surrounding the engine or from wiring leading from the engine compartment.

44. Sources of Interference

Radio interference originates in automotive vehicles from high tension wiring, charging generators, voltage and current regulators, and other electrical controls and switches. While these are the originating sources of interference, all metal parts or wiring not properly bonded or filtered may pick up and reradiate it.

45. Locating Source

a. Before attempting to locate the source of noise, place the vehicle in a location as free from external noises as possible, either in a screen room or at some point at least 100 feet from power lines or other installations which produce interference.

b. With the engine stopped and all other equipment off, turn on the receiver and check the amount of noise present.

c. Check the antenna and ground connections of the set.

d. Start the engine and listen for the noise.

e. Disconnect the antenna and connect the antenna terminal to ground. If the noise stops or is greatly reduced, it is being picked up by the antenna; if the noise does not stop or is only slightly reduced, it is entering the set through its power circuit.

f. Determine from the type of noise heard the component most likely to be at fault (pars. 25, 26, and 29).

46. Methods of Suppression

The methods of suppression for automotive vehicles are essentially the same as those for power units covered in paragraphs 34, 35, 36, 38, and 39. Figures 27, 28, and 29 show typical applications of bonding. Most military vehicles are suppressed at the time of manufacture; therefore, all suppression components should be thoroughly checked before any additional suppression is applied. Always refer to the technical manual for the vehicle requiring suppression.

Table II lists recommended values for suppression components to be applied to various points of the vehicle and its electrical system. Approved suppression components with stock numbers are listed in the appendix.

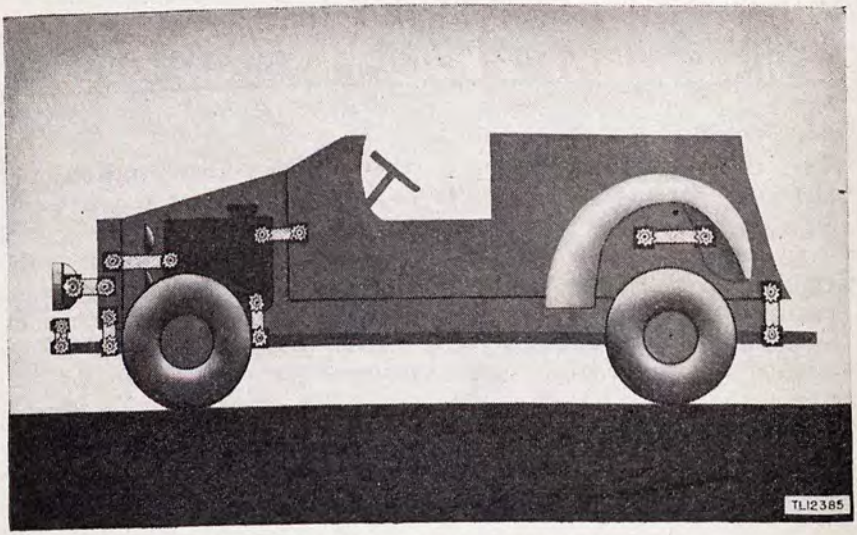


Figure 27. Typical application of bonding jumpers to vehicle.

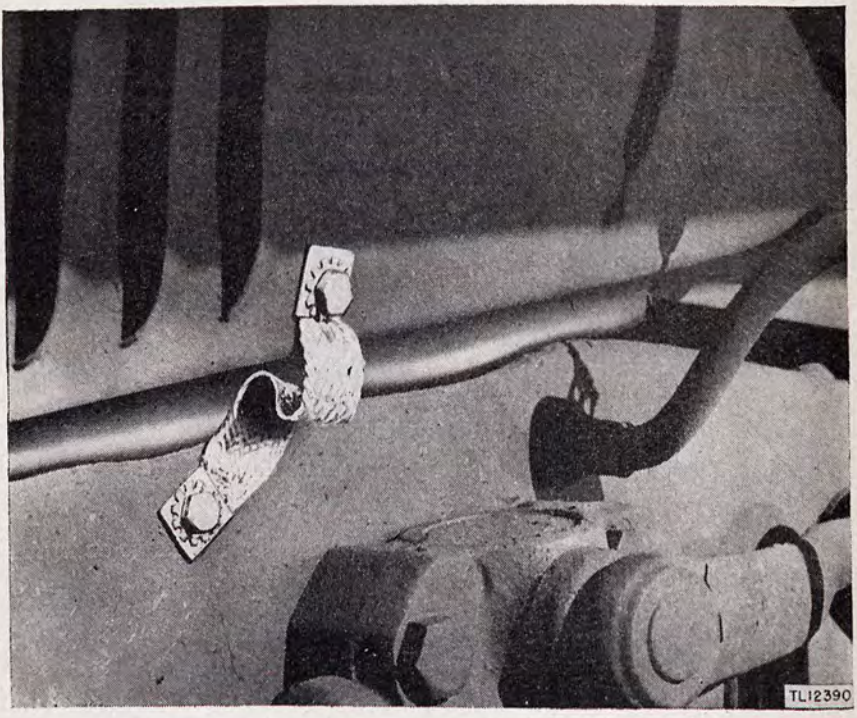


Figure 28. Bonding jumper, fender to frame.

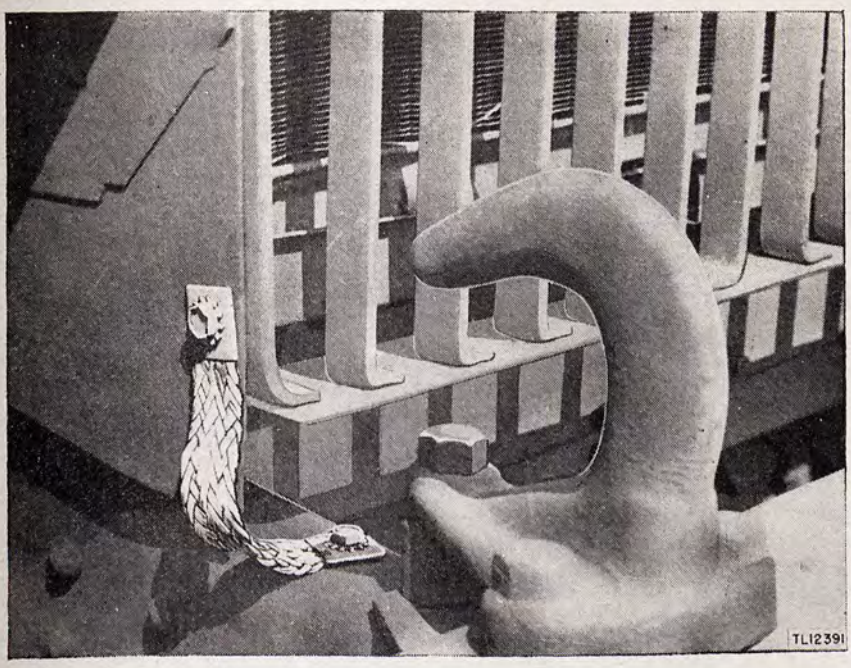


Figure 29. Bonding jumper, radiator grille to frame.

47. Preventive Maintenance and Trouble Shooting

As the maintenance of a vehicle is the responsibility of the Ordnance Department, trouble-shooting and replacement of defective components of the suppression system can be done by Ordnance personnel. When a suppression system is faulty, although components are apparently in good condition, Signal Corps personnel may be called upon to assist in detecting and correcting the defect. The information in paragraphs 41 and 42 applies equally well to vehicles. The procedure outlined should be followed when it is necessary for communication men to assist the Ordnance mechanic to eliminate radio interference from a vehicle. Usually, it will be possible to use the radio equipment installed in the vehicle as a test instrument for determining the source of the noise and the effect of the changes made.

Table II. Suppression components for ignition and electrical systems of power units and vehicles

Note. All capacitor values given in microfarads.

Circuit	Point of application	Suppression component	Preference				
			1	2	3	4	5
Ignition coil to distributor lead	Distributor	Resistor-suppressor	10,000-ohm				
Distributor to spark plug lead	Each spark plug	Resistor-suppressor	10,000-ohm				
Ignition coil to ignition switch	Ignition coil, switch side	Capacitor	0.1	0.25	0.01	0.5	
	Ignition switch	Capacitor	None	0.1	0.25	0.01	
Generator armature	Generator armature terminal	Capacitor	0.1	0.25	0.01	0.5	
Generator armature to regulator	Regulator armature terminal	Capacitor*	0.1	0.25	0.01	0.5	Filter FL-19†
Generator field to regulator	Regulator field terminal	‡					
Regulator battery terminal to ammeter	Regulator battery terminal	Capacitor	0.1	0.25	0.01	0.5	Filter FL-19†
Ammeter to hot battery terminal	Battery terminal	Capacitor	None	0.1	0.25	0.5	
	Ammeter terminal	Capacitor	None	0.1	0.25	0.5	
	Terminal strip	Capacitor	0.1	0.25	0.5	0.01	
Battery to starter switch	Starter solenoid	Capacitor	None	0.1	0.25	0.01	
	Starter switch	Capacitor	None	0.1	0.25	0.01	
Ignition switch to gas gauge	Gas gauge	Capacitor	None	0.1	0.25	0.01	
Ignition switch to temperature gauge	Temperature gauge	Capacitor	None	0.1	0.25	0.01	
Ignition switch to oil gauge	Oil gauge	Capacitor	None	0.1	0.25	0.01	
Lighting	Lights or terminal strip	Capacitor	None	0.1	0.25	0.5	
Ammeter to windshield wiper	Windshield wiper	Capacitor**	0.1	0.25	0.01	0.5	
	Windshield wiper switch	Capacitor	None	0.1	0.25	0.5	
Battery to radio terminal box	Radio terminal box	Capacitor	0.1	0.25	0.5	0.01	
Ammeter terminal to fuel pump, motor type	Switch	Capacitor	None	0.1	0.25	0.5	
	Terminal	Capacitor	0.1	0.25	0.01	0.5	
Ammeter terminal to ventilator fan	Ventilator fan	Capacitor	0.1	0.25	0.01	0.5	
Ammeter terminal to heater fan motor	Heater fan motor	Capacitor	0.1	0.25	0.01	0.5	
Ammeter to defroster fan motor	Defroster fan motor	Capacitor	0.1	0.25	0.01	0.5	
Power switch to electric oil pump motor	Load side of switch	Capacitor	0.5	0.25	0.1	None	
Traversing motors	Each ungrounded brush	Capacitor	0.1				
Gyro stabilizer supply	In gyro motor control box	Capacitor	0.1				
Gyro oil pump motor	Each ungrounded brush	Capacitor	0.1				
Main switch to steering motor	Steering motor terminal	Capacitor	0.1	0.25	0.01	0.5	
Main switch to accessory receptacle	Accessory receptacle	Capacitor	0.1	0.25	0.01	0.5	

* It may be necessary to add shielding to inclose the generator armature to regulator armature terminal lead if satisfactory suppression cannot be attained with the components suggested.

† In all circuits where a filter is required to carry: 55 amperes or less use Filter FL-19. 100 amperes or less use Filter FL-16. 150 amperes or less use Filter FL-36.

‡ The following is the suggested treatment of the generator regulator field circuit in the order of preference:

1. No application. In many cases no suppression component is needed.
2. Tinned metal braid shielding over the generator-regulator field lead grounded at each end and at intermediate points determined by test.
3. Shielding outlined above plus an 0.01 microfarad capacitor at the regulator field terminal.
4. Shielding as outlined above plus a Filter FL-13 at the regulator field terminal.

** It may be necessary to add *shielding to inclose the windshield wiper supply lead if satisfactory suppression cannot be attained with the components suggested.*

SECTION VI

SUPPRESSION OF HETERODYNE NOISE

48. Interunit Heterodyne

a. Superheterodyne receivers can interfere with one another when they are operated near each other. The signal produced by the high-frequency oscillator may be directly radiated or conducted through the power leads to reach the antenna of the other receiver or receivers.

b. To prevent the signal from being conducted through the power leads, use bypass capacitors as shown in figures 5, 6, and 7, or one of the filters shown in figures 8, 10, and 11. Install these capacitors or filters inside the chassis at the point the power leads enter.

c. To suppress the signal directly radiated, shield the high-frequency oscillator stage when it is not shielded, or use additional bonding for existing shields.

SECTION VII

SUPPRESSION OF NOISE FROM MAKE AND BREAK CONTACTS

49. General

a. The same method of suppression is used for most types of make and break contacts. The amount of suppression needed will depend upon the intensity of the spark which results from the opening and closing of contacts. Low-voltage circuits may be suppressed with capacitor filters only; while high voltage circuits may require the more complex filters using inductors or resistors and capacitors (par. 21 and figs. 12 and 13).

b. Typical equipments using make and break contacts in the form of relays, keys, or switches are code machines, teletypewriters, telephone switchboards, and thermostatic controls.

50. Teletypewriters

a. Teletypewriters and printers contain a number of switches and relays which can cause interference. Suppression components are installed in most machines at the time of manufacture. When interference is produced, check the filters according to the technical manual for the particular equipment.

b. The most common cause of interference by these machines is the absence of a good ground connection. The frame of the machine should be connected through a heavy wire to a good ground. To be effective, this ground lead must be as short and as direct as possible. It should connect to a driven ground rod, to water pipes, or to the steel frame of a building. Do not connect to electrical outlet boxes or conduit; they seldom provide a good ground and will result in more rather than less interference. Wherever possible, use a separate grounding point for the interfering equipment than the one used for the radio receiver. When both the teletype machines and the radio receiver operate from a-c power lines, connect them to different circuits when they are available. When it is necessary to have the radio receiver located near teletype machines, shielding the signal circuits to the teletype will also reduce interference. Do not attempt to install filters of any type on contacts or relays unless the exact size and type are recommended by the technical manual for the equipment. The wrong type of filter may stop the noise, *but it may also stop the equipment from functioning properly.*

51. Code Machines

Automatic code machines and recorders, generally used in conjunction with a radio receiver, are equipped with suppression

filters. A good ground is essential for quiet operation. Replace the filter provided in the units if interference develops and cannot be eliminated by proper grounding.

52. Telephone Switchboards

The switches and relays of telephone switchboards are provided with filters and usually do not create interference. A good ground is important and should be carefully made.

53. Thermostatic Controls

Thermostatic controls which create interference can be suppressed by using filters such as those shown in figure 13.

54. Electric Shavers

Electric shavers which have make and break contacts create a great amount of radio interference. They can, however, be completely silenced if a lead from the metal frame can be brought out and used as a return for filters of the type shown in figures 7 and 10.

SECTION VIII

SUPPRESSION OF NOISE FROM RADIATING DEVICES

55. Medical Apparatus

a. DIATHERMY MACHINES. The diathermy machines used by doctors are in effect short-wave transmitters. There are two principal types; one uses a self-rectifying oscillator, and the other uses a conventional oscillator and a d-c power supply. The type which operates from a d-c power supply will only cause interference at its fundamental frequency. The self-rectifying oscillator type generates a great amount of interference as the frequency is unstable and in addition is modulated as twice the supply frequency. The only effective remedy for either type is to place it in a screen room and install filters in the power-supply line.

b. X-RAY MACHINES. Modern X-ray machines cause very little interference and can be suppressed by the addition of a filter to the power line. The only effective way to suppress the older type, which uses a mechanical rectifier is to place it in a screen room and install line filters.

c. DENTAL EQUIPMENT. Dentists drills use small, high-speed brush-type motors which create violent interference. They are easily silenced by installing capacitors from the brushes to the frame of the equipment. Install the capacitors inside the end cap of the motor if there is room. If there is not enough room inside the cap, connect them to the power cord as close to where it enters the motor as possible. When the motor wiring is run inside the pedestal, the filter may be installed in the base where the a-c line enters.

56. Fluorescent and Neon Lighting Equipment

a. FLUORESCENT. Fluorescent lighting fixtures are not very bad noisemakers and are quite easily silenced. A capacitor connected to either side of the a-c line and grounded to the metal fixture frame will usually be sufficient. In bad cases use a complex filter.

b. NEON. Neon signs and lights may create interference by direct radiation from the tubing or by reradiation from the power line. A neon fixture may cause interference even though it is in good working condition. Interference can also result from a defective transformer.

Caution: Neon transformers produce voltages which are dangerous to life. Do not attempt to check any connections with voltage applied to the primary of the transformer.

To determine if the transformer is at fault, remove the leads to the tubing and turn the power on. If the noise is still present, the transformer is defective and should be replaced. A flickering light indicates the transformer is not supplying enough voltage, and the

tubing should be repumped and refilled with gas. At points where the tubing makes a loop and crosses itself, a leak may occur through the glass. Such leaks can be located by placing a sheet of paper where the tube crosses. A rustling sound indicates a leak is breaking through the paper. This defect may sometimes be corrected by placing a piece of glass between the turns. When this does not effect a cure, the tubing should be reformed to provide a space of at least ½-inch between turns. Grounding the case of the transformer may eliminate the noise and will be all the suppression that is required. Moving the radio set a few feet to a new location will sometimes reduce the interference considerably.

57. Other High-frequency Apparatus

Another source of interference is induction heating apparatus used by many manufacturing plants. Since these devices are essentially short-wave transmitters, they can be suppressed only by inclosing them in a screen room.

SECTION IX

SUPPRESSION OF FRICTION STATIC

58. Friction Static

Friction static may be caused in several ways. Leather or rubber belts used to drive various types of machinery and vehicle tires and the tracks of track-laying vehicles are the most common sources of friction static.

a. Belt Static. Belt static can be eliminated by installing a grounded idler pulley or by using a number of sharp-pointed wires grounded and mounted so they are close to the surface of the belt.

b. Tire and Track Static. (1) Tire static is usually not severe enough to interfere with reception and will not be considered further.

(2) Track static produced by track-laying vehicles may be very severe under certain conditions of terrain, atmosphere, and track. There is very little that can be done to eliminate this condition in the field. Bonding of the trunnion pins to the metal sections that form part of the treads is accomplished by spring clips which occasionally break after a short period of use. When these clips break, bonding is no longer effective and the static charge accumulated on the individual treads discharges to adjacent metal sections thus creating the interference.

SECTION X

SUPPRESSION OF NOISE CARRIED BY POWER-SUPPLY LINES

59. Power-Supply Lines

Power-supply lines often reradiate a great amount of interference caused by electrical devices of many types. Since it is usually impractical to locate and suppress each source of noise, only the means of reducing its effect at the receiving point will be discussed.

a. If the noise is being picked up by the antenna, the use of a shielded lead-in or a balanced transmission line will be effective. Always locate the antenna as far from the power line and as near a right angle to it as possible.

b. Further reduction can be had by installing filters of the type shown in figures 9 and 11 in the power line. These filters are most effective when installed at the fuse box or at some point near where the power line enters the building. The installation of the filters will also reduce any noise which might be conducted into the receiver through its power supply.

APPENDIX

APPROVED LIST OF SUPPRESSION COMPONENTS WITH SIGNAL CORPS STOCK NUMBERS

When adding suppression to equipment which was suppressed when issued, requisition additional or replacement suppression components from the arm or service issuing the equipment. Consult the technical manual for the equipment concerned.

When adding suppression to equipment which has not been suppressed, requisition the necessary suppression components through channels from: Installation and Supply Section, Supply Branch, Storage and Issue Agency, 128 North Broad Street, Philadelphia 2, Pennsylvania.

Tables III and IV below list approved and available suppression components with Signal Corps stock numbers. Figure 30 illustrates the components listed in table III. Requisition by stock number, name, and description.

Table III

Item (fig. 31)	Signal Corps stock No.	Name of part and description	Unit of issue
1	2Z9054–6.....	SUPPRESSOR: spark plug or distributor; elbow-type; 10,000-ohm; type L-7-VR-10 ME, or equal.	ea.
2	2Z9054.....	SUPPRESSOR: spark plug; elbow-type; 10,000-ohm; type L-4-VR-10 ME, or equal.	ea.
3	2Z9054–1.....	SUPPRESSOR: distributor; straight; 10,000-ohm; type S-5-VR-10 ME, or equal.	ea.
4	2Z9054–3.....	SUPPRESSOR: spark plug; elbow-type; 10,000-ohm; type SPK-VR, or equal.	ea.
5	2Z9054–2.....	SUPPRESSOR: spark plug; straight; with rajah clip; 10,000-ohm; type S-26-A, or equal.	ea.
6	3DA100–143..	CAPACITOR: 0.1-mf; 200-v d-c; with 5″ lead; mounting bracket hole for 1/4″ screw; type JX-131, J34, or equal.	ea.
7	3DA10–164...	CAPACITOR: 0.01-mf; 200-v d-c; with 5″ lead; mounting bracket hole for 1/4″ screw; type JX-131, J32, or equal.	ea.
8	3Z12035–9.12.	TERMINAL LUG: ring-type; for capacitor lead; hole for 3/8″ screw.	ea.
9	3Z12031–3....	TERMINAL LUG: side-type; for capacitor lead; hole for 5/16″ screw.	ea.
10	3Z12031–2....	TERMINAL LUG: side-type; for capacitor lead; hole for 1/4″ screw.	ea.
11	3Z12031–1....	TERMINAL LUG: side-type; for capacitor lead; hole for No. 10 screw.	ea.
12	2Z1242.....	BRACKET: for mounting capacitor on voltage regulator; per SCD-8082-D, group 2.	ea.
13	2Z1243.....	BRACKET: for mounting capacitor on ignition coil; per SCD-8082-D, group 1.	ea.
14	1F6B1–2.....	WIRE: flat braid; copper; tinned; 25/32″ wide.	ft.
15	6Z3817.....	FERRULE: copper; tinned; for use with 3/4″ braid.	ea.
16	1F6C1–8.....	WIRE: flat braid; copper; tinned; 1/2″ wide.	ft.
17	6Z3815.....	FERRULE: copper; tinned; for use with 1/2″ braid.	ea.
18	6L52028.....	WASHER: lock; steel, cadmium-plated; internal-external teeth; for 1/2″ screw.	ea.

Table III—Continued

Item (fig. 31)	Signal Corps stock No.	Name of part and description	Unit of issue
19	6L72220–1....	WASHER: lock; steel; cadmium-plated; internal-external teeth; for 3/8″ screw.	ea.
20	6L71005–4C..	WASHER: lock; steel; cadmium-plated; internal-external teeth; for 5/16″ screw.	doz.
21	6L2214–20....	WASHER: lock; steel; cadmium-plated; internal-external teeth; for 1/4″ screw.	ea.
22	6L7221C–14..	WASHER: lock; steel; cadmium-plated; internal-external teeth; for No. 10 screw.	ea.
23	6L7950–12....	SCREW: sheet metal; roundhead; cadmium-plated; self-tapping; No. 10 x 3/4″.	doz.
24	6L7032–8,1S..	SCREW: machine; steel; roundhead; cadmium-plated; No. 10–32 x 1/2″.	doz.
25	6L7032–16.1S.	SCREW: machine; steel; roundhead; cadmium-plated; No. 10–32 x 1″.	doz.
26	6L4904–16E...	SCREW: machine; steel; cadmium-plated; hex; 1/4″–20 x 1″.	doz.
27	6L3110–32S...	NUT: machine; steel; cadmium-plated; hex; No. 10–32.	ea.
28	6L3504–20S...	NUT: machine; steel, cadmium-plated; hex; 1/4″–20.	doz.

Table IV

Signal Corps stock No.	Name of part and description	Unit of issue
3Z1890–12.....	FILTER FL-12: 55-amp; 30-v; (replaced by Filter FL-19).	ea.
3Z1890–13.....	FILTER RL-13: 10-amp; 30-v.....	ea.
3Z1890–14.....	FILTER RL-14: 10-amp; 30-v; (replaced by Filter FL-19).	ea.
3Z1890–15.....	FILTER FL-15: 10-amp; 30-v.....	ea.
3Z1890–16.....	FILTER FL-16: 100-amp; 30-v.....	ea.
3Z1890–19.....	FILTER FL-19: 55-amp; 30-v.....	ea.
3Z1890–23.....	FILTER FL-23: 10-amp; 30-v.....	ea.
2Z1250.5.....	BRACKET: (for mounting Filter FL-19 on generator).	ea.
2Z1250.7.....	BRACKET: (for mounting Filter FL-19 on firewall).	ea.
3Z820.....	BRACKET: (for mounting Filter FL-16 on firewall).	ea.
3Z820–3.....	BRACKET: (for mounting Filter FL-13 on firewall).	ea.

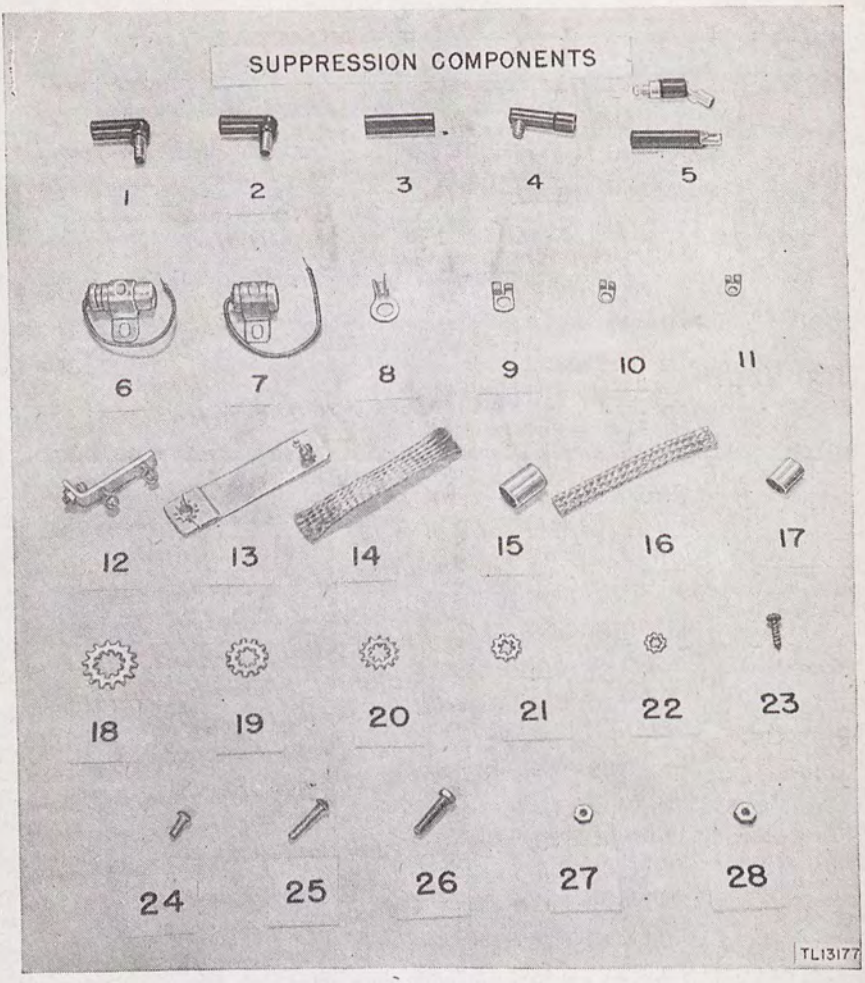


Figure 30. Approved suppression components.

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