

PRACTICAL AUTO RADIO SERVICE & INSTALLATION

Jack Greenfield

\$4.60

*practical
auto
radio
service
and
installation*

*jack
greenfield*

GERNSBACK
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To the little women in my life

Laura Beth

Michelle Joy



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introduction

"FOR your own safety and the safety of other drivers, we strongly recommend that you use your automobile radio receiver only when the car is stationary. With road conditions the way they usually are, you should concentrate on driving, and you should not have your attention distracted by musical programs or talks while the car is in motion. . . ."

Before you challenge this statement, let us state immediately that this gem appeared in the Summer, 1930, issue of *Radio Design* as an "Important Notice" in a lead article describing an automobile radio of the day. Although the notice is an interesting bit of history, the topper was its last sentence:

. . . To prevent a wave of accidents, it is likely that state legislatures will make radioing-while-you-drive illegal.

The author is grateful that for this once the prophets were wrong.

Early auto radios were supplied in kit form (modern-day kit manufacturers take note) and were designed for installation on the running board (remember them?). The driver could operate the set from inside the car by means of flexible cables, but manufacturers (wary of impending trouble from the law) suggested the radio be used as a portable for picnics, etc.

The last three decades have witnessed auto radio development continue along the lines of a gigantic loop. The first 20 years produced changes that made the auto radio an integral part of the interior decor of the automobile. In the last 10 years, as a result of the revolution wrought by the transistor and miniaturization, the auto radio has gone back to designs that make it suitable for use outside the car (at picnics!). Thus, the modern auto

portable, offered as the last word in today's designs, is merely a refined version of a 30-year-old idea. Credit the prophets. This time they were right.

In preparing this text, I have been guided primarily by the thought of the practicing radio and television technician who is interested in expanding his field of interest to include auto radio servicing. In view of this, every effort has been made to provide as much *specialized* servicing information as possible. Very little space is devoted to repeating or reviewing material contained in texts covering general radio servicing. This type of presentation will appeal to serious electronics and auto hobbyists as well, who may be considering an interesting auto radio project.

The arrangement of the material reflects an individualized approach. The emphasis is always on new information. The text first covers the auto radio servicing field in general. This is followed by a survey treatment of installation techniques and then servicing techniques. Theory on tuners and power supplies is given as supplementary information. Also included is a discussion of interference problems and practical suppression techniques. Check lists and hints and kinks are used throughout wherever feasible.

Finally, we too have attempted to probe the future. The last chapter contains a discussion of present developments, and some possible trends. We hope that our gift of prophecy is better (or at least, no worse) than that of our predecessors.

The author wishes to acknowledge with thanks the following organizations who contributed valuable source material: Eico, Inc.; Robert Bosch Corp., Car Radio Div.; Hallett Manufacturing Co.; Motorola, Inc.; Paco Electronics Co., Div. of Precision Apparatus Co.; Pye Corp. of America; Seeley Electronics; Stromberg-Carlson Co., Div. of General Dynamics Corp.; Tobe Deutschmann Corp.

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Massapequa, N.Y.

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auto radio vs home radio

PEOPLE are emotional about their automobiles. They put lots of muscle, spit and polish into keeping them looking and running in top condition. This concern extends to the automobile radio as well. Take the fellow who is content to listen to his home radio with its cabinet crushed, the speaker cone held together with tape, and under the most fearsome conditions of interference. This same fellow will go to his service dealer and scream that his radio "goes out" when he drives under overpasses on the highway.

Because such attitudes are prevalent among auto owners, service operations geared to handle auto radios must be founded on providing quality work without compromise. To provide such service requires that the technician have a clear understanding of the principles underlying the operation of the auto radio, particularly with respect to those functions not found in the more familiar home receiver.

The auto radio differs from the average home set in that the auto radio must:

Operate from a low-voltage dc power supply;

Operate with nominal current drain;

Employ tuning units that will enable the driver to tune the set without distraction;

Provide good performance under conditions of severe radio interference;

Perform satisfactorily at high noise levels and under varying signal conditions when the car is in motion.

Notice that the differences call for designs that account for the special conditions under which the auto radio must operate. In

fact, except for the features that enable it to work in its special environment (Fig. 101), the auto radio is essentially a super-heterodyne receiver very much like the home radio.

Our discussion explains how and why the auto radio differs

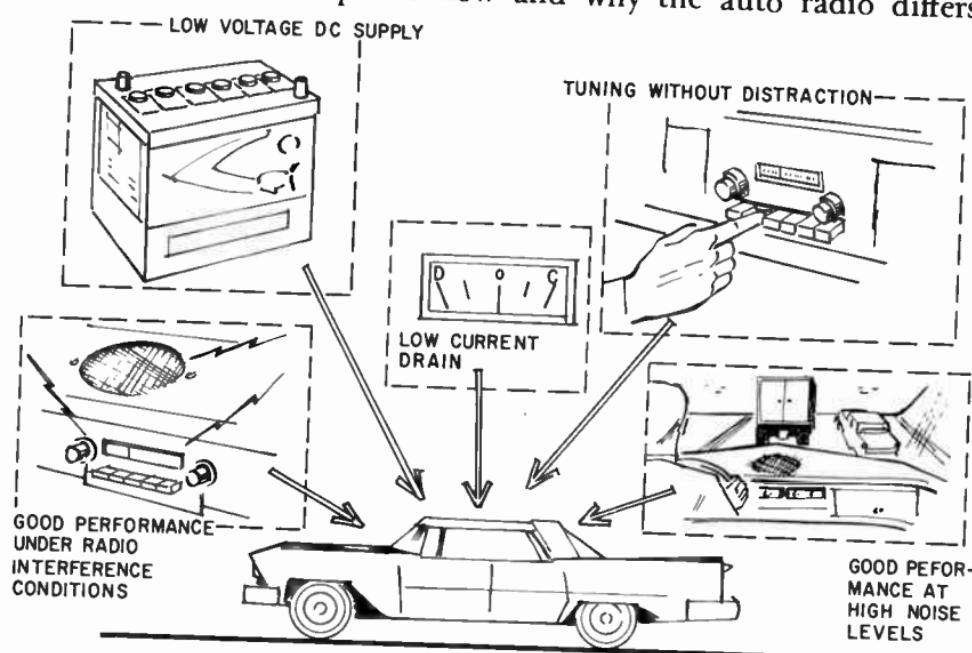


Fig. 101. *The auto radio must perform satisfactorily in a special environment.*

from the home radio. It provides an insight into exactly what auto radio servicing entails, and covers developments in each of the areas we have cited.

Low-voltage — low current requirements

Electrical power on the order of 115 volts up to 15 amperes is available for operating a home radio, while the auto radio is dependent on the low-voltage auto electrical system for its primary power. Available current drain for auto radio operation is generally a function of the number of accessory units being operated from the same supply generator (Fig. 102).

In auto sets using conventional tubes, heater and plate voltages must be supplied in normal operation. Heater voltage is usually obtained directly from the primary supply. Plate voltage (normally at high-level dc) is obtained by stepping up the primary supply voltage. The most common circuit used to perform this step-up function is the vibrator power supply. The vibrator, however, is an electromechanical device and is subject to early failure. One of the developments in transistor circuits has resulted in the

dc-to-dc converter — a longer lived, lower-noise-producing circuit which can replace the vibrator as a means of providing high-level plate voltage from a low-level dc source. Several enterprising manufacturers are producing a "universal" dc-to-dc converter that replaces many vibrators directly with no design changes required.

Moreover, some auto receivers employ tubes which operate with 12 volts on the plate. Sets using these tubes use the battery voltage directly to obtain the required plate voltage. An advanced form of low-plate-voltage tube radio is found in the hybrid set, which employs transistors in the audio stages. The operating voltages for these stages is obtained directly from the primary low-voltage supply.

As in the case of the home radio, most of the current required by the auto radio is for the tube heaters. Early sets all used tubes

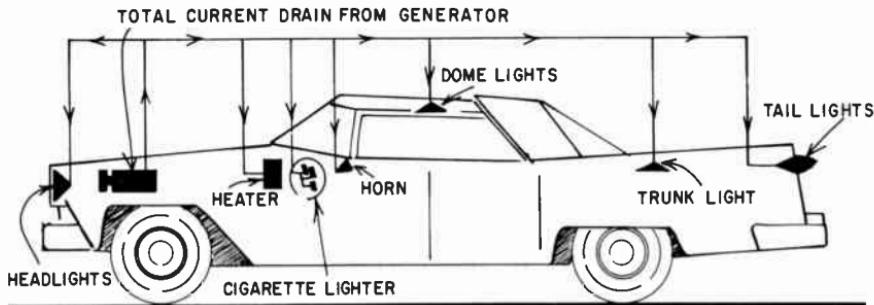


Fig. 102. For auto radio operation, available current drain is determined by the number of accessory units operated from the same generator.

that were developed for home radios and were very demanding on the auto electrical system. In recent years, tubes with low-drain heaters have been designed especially for auto radios. The advent of the hybrid set, in which transistors replaced the tubes in audio stages, has done much to further reduce current demands. With the all-transistor auto radio now a reality, current drain requirements have been reduced to almost negligible quantities.

Tuning without distraction

In the home radio, tuning of AM and FM sets is usually done by a ganged, continuously variable air capacitor. Some FM sets have ganged variable inductors to accomplish the same thing. Television sets use detent tuning, in which station selection is accomplished by switching from one set of tuned circuits to another.

The emphasis in tuning-system designs for use in autos has been

to put safety first. The gadgetry that is the current vogue in auto radio tuners is based on the principle that the man behind the wheel must be freed of the chore of making critical tuning while driving — and from the looks of the tuners and auto radio prices — add to this "at any cost." The simple requirement to produce

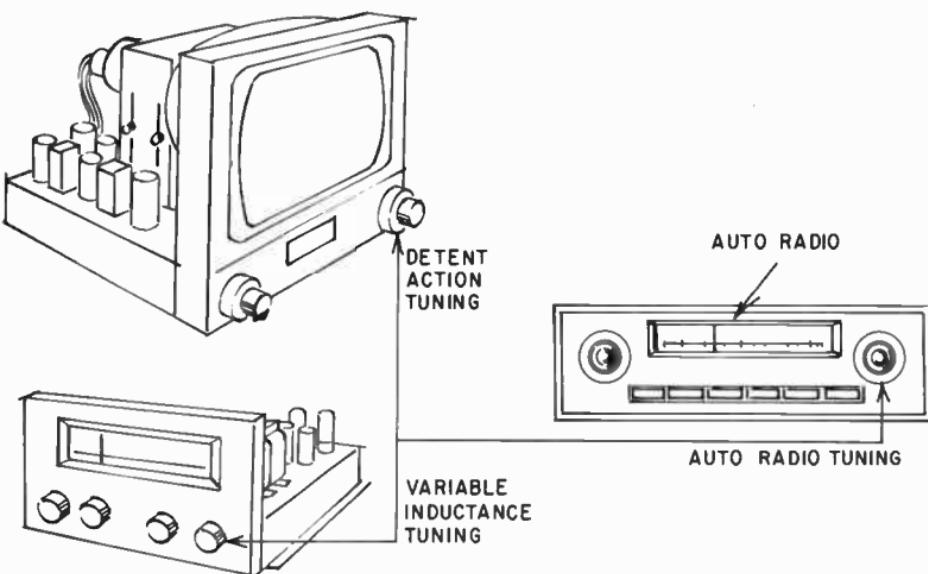


Fig. 103. *Auto radio tuners combine detent type action with variable-inductance tuning.*

auto radio tuners that may be operated without distraction has produced some of the most complicated clap-trap devices ever designed for breakdown and servicing. To date, auto radios have employed pushbuttons, push bars, toe bars — in fact, you name it, and next year it will be available as optional equipment.

Compared to domestic tuning systems, the auto radio tuner is closest in design to a combination of the variable inductor tuner and the detent tuner (Fig. 103). The detent action permits the driver to change stations in one simple operation while preventing detuning as a result of shock and vibration caused by a moving auto.

Interference

AM radios are especially sensitive to radio interference that generally appears at the output in the form of static or noise and results in poor performance. The interference of most concern to AM listeners is generated by a variety of everyday electrical devices. Among the most notorious offenders in the home are fluorescent fixtures, television sets and oil burners. In general,

appliances that produce sparks in their operation are interference generators.

Static-free operation requires that interference be suppressed. Experiment has shown that stopping it at its source is the most effective way of insuring its elimination (Fig. 104). Designers really have no direct control over a set with interference problems. Occasionally, radio designs incorporate line-filter capacitors

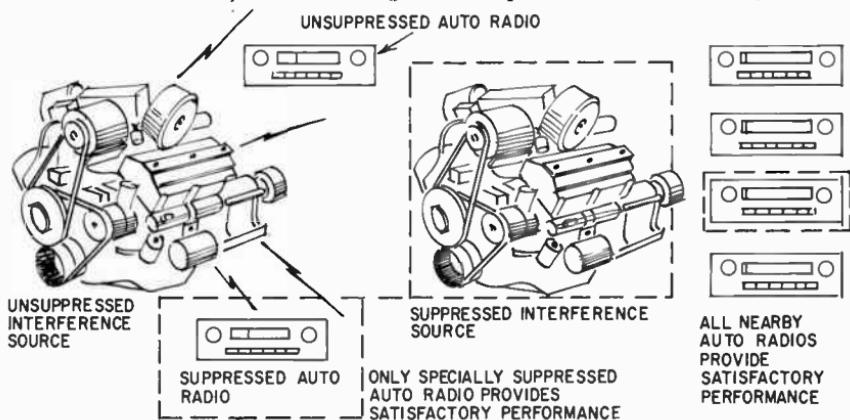


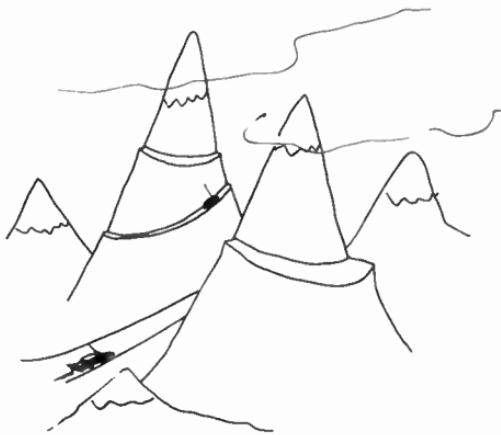
Fig. 104. *The most effective way of eliminating interference is by stopping it at its source.*

to eliminate interference carried by the power line. But true noise-free operation in the home is a function of the care that went into designing interference-free domestic electrical appliances.

The auto radio designer has what appears to be a monstrous interference problem on his hands since sparks and interference generation are a normal part of automobile operation. However, he has the advantage of being able to include in his design a suppression system for the interference-generating devices used in the car. Thus, he can specify the incorporation of interference suppression devices at the source. These include suppression capacitors installed at the generator and coil, and spark plugs or spark plug cables with built-in suppressor resistors. These special components in the automotive electrical system require that the service technician become familiar with suppression-system maintenance techniques.

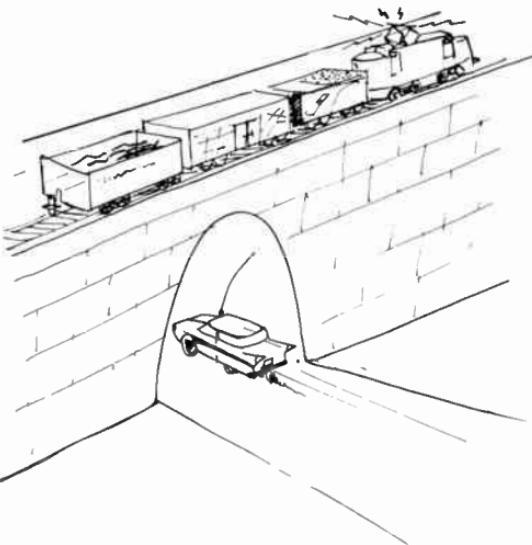
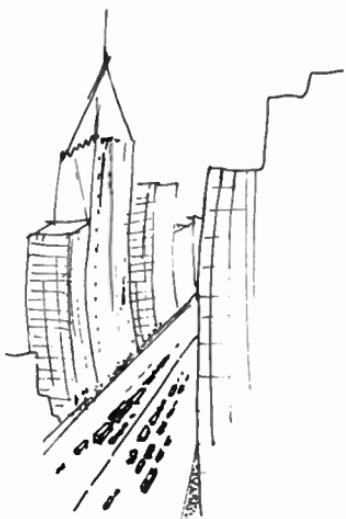
The problem of making a car radio static-free introduces still another problem to the service technician — component accessibility. The radio is packaged the way it is — completely encased in shielding — to minimize its susceptibility to radiated interfer-

Suspension and other bridges reduce the strength of the car radio's audio output signal so much as to make it practically inaudible. In addition to the weakened signal, radiated interference comes from other cars on the bridge and from the bridge lights at night.



Climbing mountains and driving through hills and valleys causes the signal to become progressively weaker and stronger, in addition to being totally lost at those times when the mountains completely prevent the signal from reaching the antenna.

Besides the static caused by other cars on the road, by street lights and telephone lines, tall buildings present a formidable obstacle in the path of the transmitted signal trying to enter the car radio antenna.



Radiated interference from passing electric railroads is a source of static in the car radio. Underpasses and tunnels cut signal strength.

Fig. 105. The auto radio must provide an adequate audio signal that remains relatively constant in strength under varying road conditions.

ence. Radiated interference comes from other cars on the road, from street lights and, inevitably, in spite of suppression devices, from the auto in which the radio is installed.

Performance under adverse conditions

The auto radio must be capable of producing a loud audio output signal at relatively low distortion levels in order to override successfully the high audible noise levels normally encountered in the moving automobile. In addition, the auto radio must provide an audio output signal that remains relatively constant under a wide variety of signal strength conditions encountered in the moving auto situation (Fig. 105). Auto radio audio sections and antenna systems are designed to help overcome the effects of the adverse conditions described.

Servicing differences

The basic differences between auto and home radios should lead one to the conclusion that there are bound to be some differences in servicing techniques as well. This conclusion is well founded. To haul the average home set to the shop involves unplugging, tucking under one's arm, and carting away. The auto radio presents no such easy solution. The set must be removed from its semi-permanent installation in the auto. To accomplish a removal usually involves a considerable number of electrical and mechanical disconnects, plus the necessity for keeping track of miscellaneous hardware. It also requires that the technician be somewhat of a contortionist particularly in the region of the neck. More often the removal operation, such as unfastening bolts and nuts, must be carried out by touch. Tools must be used in awkward, wrist-twisting positions. Because of the difficulties encountered in removing auto radios, this text advocates and details a program for in-place servicing which resorts to bench testing (that requires a prior removal), only as a last ditch measure to solve a trouble.

Once the auto radio is removed from the car a certain amount of special technical knowhow is involved in setting the radio up for bench servicing. The fact that the auto radio uses low voltage dc as its primary source of power makes it mandatory that such a source be available at the bench and that the technician simulate the polarities and other conditions found in the auto in his initial bench setup. Since the antenna is left at the auto for example, the technician must provide an antenna for the set at the bench. The case of the home radio is, of course, much simpler. Outside of a

special measure or two to ensure that he is not working on a hot chassis in the case of ac-dc home sets, the technician need only remove the home set from its case, plug into any ac convenience outlet and service. It is obvious that returning a set to service is considerably simpler in the case of the home set compared to the auto radio.

Bench testing

The detailed bench test procedures for isolating troubles in auto radios are essentially the same as for home sets. However, in the areas of front ends and power supplies the technician will encounter in the auto radio circuits and mechanical designs not found in the home receiver.

setting up shop

THE decision of an existing shop to expand servicing operations to include auto radios should be a simple one to make in light of the fact that the relative cost of getting into auto radio servicing will be very low. Stock will have to be expanded to include the tube and transistor types peculiar to car radios, several additional vibrator types, rear-speaker kits, some replacement antenna masts and a handful of interference-suppression components. The most important item of test equipment needed is a battery eliminator. Nevertheless, the auto radio field should be approached gradually. First, gear your operations to handle servicing jobs exclusively; then, expand to include sales and installation as well as servicing.

Stocking auto radios

The day will come when your auto radio servicing operation will have grown beyond early expectations. With a good income established, expansion to the sale and installation of auto radios can be sizable, and nothing rash should be attempted. Stick to putting in inventory only the 12-volt universal types adaptable to almost any car with a 12-volt electrical system. Arrange for a ready source of supply for custom types on order through a major distributor.

Car radios are available in an almost unlimited number of circuit arrangements. Unlike the standard four-tube superheterodyne ac-dc home radio, there is apparently no end to the variety of circuit arrangements available in auto radios (Fig. 201). The

deluxe models generally contain an rf stage, an if stage and a push-pull audio output stage. Intermediate models contain an rf stage, one if stage and a push-pull audio output. Utility models are the equivalent of the four-tube home radio containing a converter, one if, a detector and a single-ended audio output stage. Extras offered include pushbutton tuning, search tuning, rear speakers, stereo and portability features, among others.

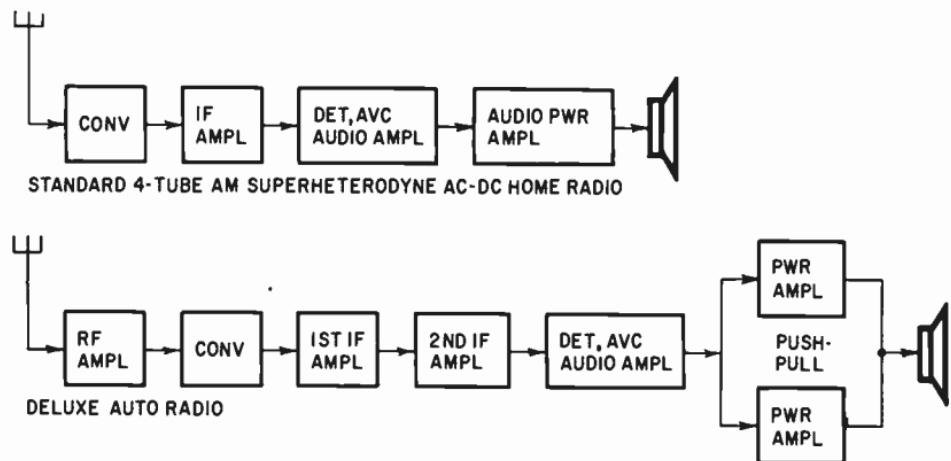


Fig. 201. (Top) Typical four-stage superheterodyne ac-dc home radio. (Bottom) Typical stages in a deluxe auto radio using push-pull output. Most vacuum-tube auto radios have just one if stage; transistor auto radios have two.

With the advent of the transistor and other new electronic components, the basic design of auto radios has undergone some radical changes in recent years. New ways of doing old things have resulted in the appearance of a rash of new and different types of auto radios. The information that follows is offered as a guide through the maze of receiver types available for installation in automobiles.

Vibrator-powered radios

Vibrator-powered car radios were dominant for several decades. The vibrator is the key component in converting the low dc voltage of the car's electrical system to the high dc voltage level required for the operation of the conventional tubes such as the 12BA6 and 12AQ5-A, used in these sets. A typical vibrator-powered auto radio showing the location of the vibrator is shown in Fig. 202. In modern installations, vibrator receivers have been completely displaced by the hybrid and all-transistor sets. The disadvantages of the vibrator-powered radio that have led to its displacement include its relatively high power drain (for tube filaments) and the relatively high failure rate of the vibrator. In

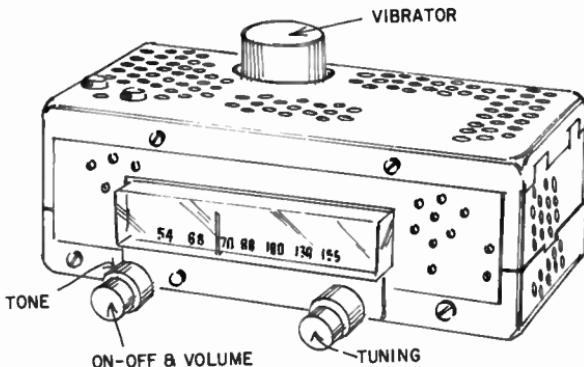


Fig. 202. Typical vibrator-powered auto radio showing location of vibrator.

general, vibrator-powered radios are among the low-to-medium-priced sets on the market.

Transistor-powered auto radios

The term transistor-powered has come to refer to two different things. On the one hand, some manufacturers apply the term to

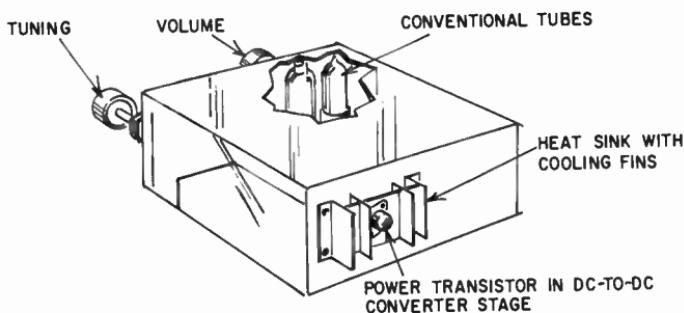


Fig. 203. Transistor-powered dc-to-dc converter auto radio (rear view) with cutaway showing conventional tubes.

auto radios in which the audio power output stage is transistorized. Alternatively, the term refers to the fact that a transistor dc-to-dc converter is used in place of a vibrator to furnish plate voltage for conventional electron tubes. Both approaches were interim stop-gaps that paved the way for the all-transistor set.

The transistor-powered audio output auto radio is none other than the so-called hybrid set, described in the next section.

The transistor-powered dc-to-dc converter auto radio (Fig. 203) uses the technological advantages of the transistor to make possible a tube radio with a failure rate much lower than that provided

by the vibrator-powered radio. Prices compare favorably with the generally low-to-medium range of the vibrator radio.

Hybrid radios

The hybrid was born when a new component, the low-plate voltage electron tube, was united in a single set with that other new component, the transistor, to permit the low-voltage automobile electrical system voltage to power the set directly. The hybrid employed these special low-voltage tubes in the rf and i

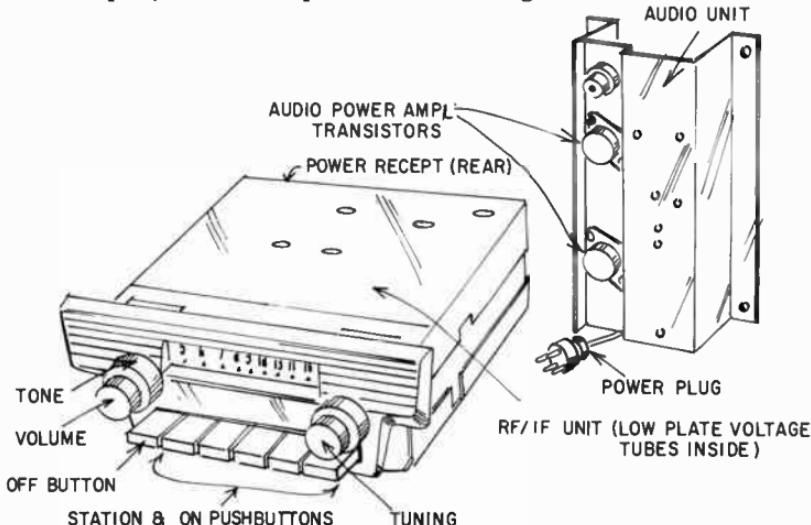


Fig. 204. Typical dual-chassis auto radio. Audio power amplifier transistors are shown on chassis at right.

stages, and used the transistor in the audio stages. A typical dual chassis hybrid auto radio is shown in Fig. 204.

At the time when the hybrid set was developed, three things held true: the transistor had not yet advanced to the point where it amplified efficiently in the rf and if ranges; it was too costly; and, auto manufacturers had decided to switch to 12-volt electrical systems for their autos (the new low-plate-voltage tubes could operate effectively at 12 volts). The hybrid set eliminated the need for a secondary dc supply, but still had the disadvantage of requiring power for its tube filaments. Hybrid sets have been offered in the entire gamut of price ranges.

All-transistor radios

Often described as the ultimate in auto radios, the all-transistor set employs semiconductor devices in each and every stage. These sets place an extremely low drain on the car's electrical system because they require no filament current. They operate efficiently

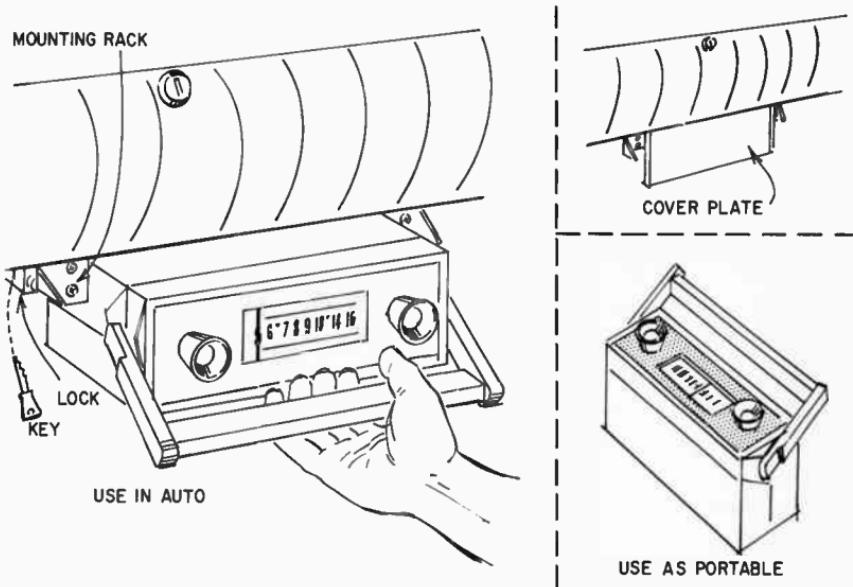


Fig. 205. Illustration showing versatility of typical auto portable radio. Left—used in the auto; right — removed and used as a portable.

at very low current drains in general, and have an extremely long mean time between failures compared to electron tube sets of any type. The all-transistor set undoubtedly will eventually replace all other sets in the auto radio field. The only deterrent, relatively high cost, is being overcome as the transistor comes more and more into demand. The reduced cost of all-transistor sets during the coming years is clearly predictable.

The auto portable

The auto portable, as the name implies, is a radio that is easily adapted for use as a portable unit outside the car. An illustration of a typical auto portable set indicating its capabilities is shown in Fig. 205. Although electron-tube designs can be modified to the auto-portable concept, it is the transistor that really turns the trick. Its efficiency permits the design of auto portables with extremely low power demands, and also makes them a powerful competitor of the conventional set. Prices of deluxe auto portables are generally competitive with the deluxe conventional auto radios of most manufacturers.

A typical deluxe auto portable comes equipped with a special rack to facilitate under-the-dash mounting, an external speaker and a special power supply unit to permit the set to be operated by the car's electrical system when used in the auto. When

removed from the auto, the portable becomes a battery-operated unit powered by a self-contained power pack. The auto portable may be used with an external speaker system installed in the dashboard or in the rear (or both), or with its own self-contained speaker. A conventional antenna is used with the portable in the car; outside, it has its own built-in antenna.

A utility model auto-portable — generally priced in line with standard (rather than deluxe) auto radios — excludes the power supply unit and the external speaker. The utility model is powered by a self-contained battery power pack when used in the auto, as well as when used outside. In addition, it uses its own built-in speaker when in the auto. The sound quality is apt to be poor, but the saving of not needing a speaker in the car may be worth it to the customer. The utility model should be especially attractive to anyone who expects to use the portable feature fairly often.

The question the theft-conscious customer might ask at this point can be answered this way: the auto portable comes equipped with a key-operated lock. The mounting rack is permanently secured to the dash, and the portable is actually locked into place in the rack. The radio can be removed only by unlocking the assembly with the key.

Playing the auto-portable concept for all its worth, manufacturers are marketing mounting racks which may be installed in second cars, boats, etc., to accommodate car portables. Thus, two-car families, or one-car — one-boat families need only one auto portable radio, and can install it where needed and when needed. In more instances than you would imagine, this proves a strong selling point. In general, the mounting rack is so arranged that an attractive cover plate drops into place when the set is removed.

Needless to say, the portability feature makes the auto portable a more serviceable set. In general, service fees asked for work performed on such sets should be in line with those charged for conventional portables, rather than auto radios. This factor should be another strong selling point.

Rear view mirror radios

The rear view mirror auto radio represents another step ahead toward taking full advantage of the many unusual features made possible through transistorization. In this case, a miniature all-transistor auto radio includes a mirror as an integral part of its case design. The set is scaled down to the size and shape of a rear view mirror and features a built-in non-directional ferrite antenna that requires no connection to an external antenna. To insure

years of service-free operation, the radio is designed to be operated from the auto's primary (12-volt) power supply. Needless to say, the power drain of this all-transistor set is extremely small.

To install this set, the auto's standard rear view mirror is removed and replaced by the radio as shown in Fig. 206. The

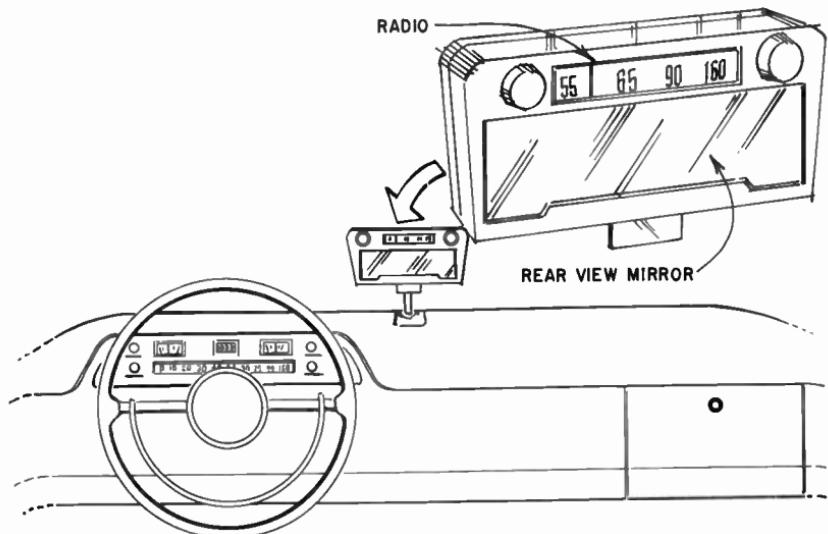


Fig. 206. *Rear view mirror auto radio. Note how mirror is built into the case of the radio.*

mirror built into the case then serves as the auto's rear view mirror. The radio's case acts as a shield, with the connection at the rear view mirror post serving as a bond to auto chassis ground. This arrangement insures interference-free operation. The radio is as easy to tune as adjusting a rear view mirror in an ordinary driving situation. Because of its novelty, the rear view mirror auto radio was initially priced rather high on its introduction to the market. The price should become stabilized in the middle price range as the set becomes more popular and as other similar-type units are introduced by competitive manufacturers.

FM auto radios

FM auto radios have been the subject of intensive advertising campaigns designed to make them a popular demand item. In line with the interest of the American public in hi-fi and the revival of FM broadcasting, the car FM radio should prove a commercial success. The pioneering sets were of European manufacture and the interest they inspired led American manufacturers to follow suit and offer competitive lines.

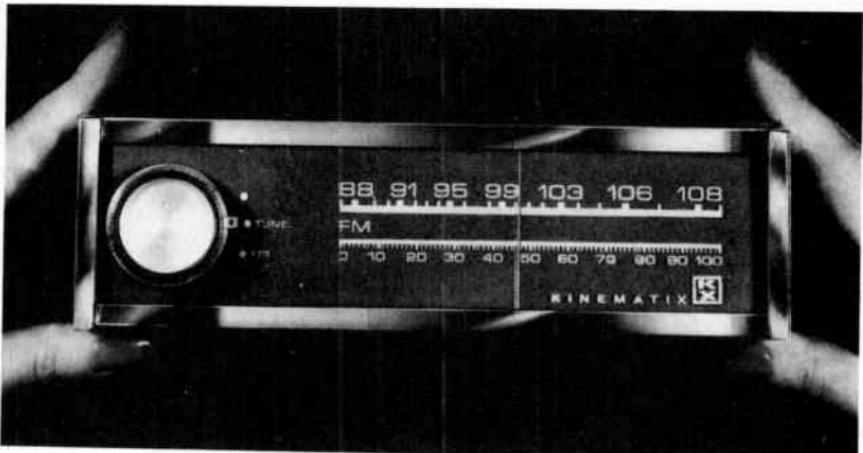


Fig. 207. FM tuner for use in autos with an existing AM radio system. (Kinematix, Inc.)

Hobbyists and serious research engineers who have conducted tests with such sets have all lauded the reception achieved. Fading is virtually nonexistent, and the problems of directionality at the FM frequencies (88.1 to 107.9 mc) is easily overcome through the use of a vertically-polarized antenna to receive (with excellent results) the horizontally-polarized FM signal.

FM - AM radios appeared in the early crop offered to the buying public, and were followed by FM-only sets, designed to meet the needs of the discriminating listener whose tastes could do without AM.

FM tuners and converters

FM tuners and converters have been introduced to meet the needs of those interested in updating their auto radio systems by including an FM program source. The car FM tuner (Fig. 207) is similar to the familiar FM tuner of the hi-fi system. The tuner consists of all the stages of a conventional FM receiver except the audio output stages. Essentially, the tuner output is taken from a single voltage amplifier stage that follows the discriminator or ratio detector stage. This is then fed to the audio output section of the AM radio already installed in the auto. The FM program is thus made audible over the existing speaker setup.

The FM converter (Fig. 208) represents a slight variation of the FM tuner. In the converter, the discriminator or ratio detector audio output signal is fed to an AM modulator stage, where the audio signal is used to modulate an rf signal in the AM broadcast band. The converted FM program signal is then applied to the

input section of the existing AM auto-radio, where it is handled just as an AM broadcast signal would be. The converter has the disadvantage of relying on the AM radio to provide audio output quality, whereas the tuner provides true FM quality directly. Commercially available converters (which generally have fewer if stages than tuners) can be adapted for use as tuners in strong FM signal areas.

Weatherproof auto radios

A weatherproof auto radio for use in open body vehicles has demonstrated itself to be in high demand, especially in rural areas where tractors and other types of farm machinery are in service for many hours a day. These radios, also suitable for installation in industrial vehicles such as steam rollers, derricks, etc., feature

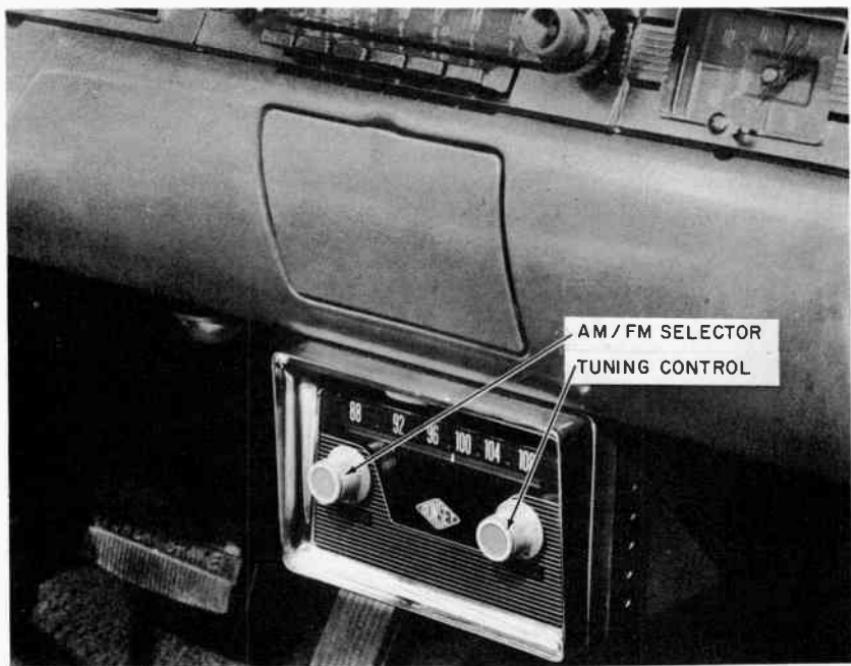


Fig. 208. *FM converter for use in autos with an existing AM radio system (Gonset Div., Young Spring & Wire Co.)*

universal mounting systems to expedite their installation in almost any location of a likely vehicle. To offset the relatively noisy environment in which they will operate, the sets contain a superior audio amplifier section and a large heavy duty speaker, a combination which can provide the required high volume with low distortion.

A typical weatherproof auto radio is shown in Fig. 209. The radio has a rust-resistant case with rubber sealed doors which, when properly secured, make the set weatherproof. A telescoping rod antenna is built into the case. Standard sets are available for use with 6- or 12-volt automotive power supply systems. Sets that operate on other voltages are available from manufacturers on special order.

Role of the automobile junkyard

The service technician expanding into the field of sales and installation may have an ace in the hole in a friendly automobile junk dealer, often a veritable gold mine of good used custom-model car radios. It is often possible to pick up sets in excellent condition from junked cars at a fraction of the cost of new radios. If you take care to overhaul these receivers as required, and back them up with your own written guarantee, they can provide a valuable source of income. Sometimes, junkyard dealers are unaware of the prices of new sets and, believing them to be *very* high, will place an utterly ridiculous price on their stock. If a previous customer had unwittingly paid his price, he would be a hard man to convince as to what a fair price really should be. Of course, junked radios, although in good condition, are not suitable for sale to just any customer who happens to walk in. Save them for your special customers who are "in the know" and can appreciate the value of a good offer when they see one.

Test equipment

The single item of test equipment that has been most publicized as *the* prerequisite to entering the auto radio servicing field — the battery eliminator — is not the best answer to powering modern auto radios on the service bench.

Battery eliminator

The battery eliminator, which was quite suitable for servicing the vibrator-powered tube radio, has proved unsuitable in its original form for servicing modern hybrid or all-transistor sets. The ripple level in the dc output of the eliminator designed to operate vibrator radios far exceeds the minimum tolerable ripple level for the transistor stages in the newer sets. As a result manufacturers have warned in their service notes that the use of battery eliminator with a radio containing transistors can damage the transistors and should absolutely not be used. The use of storage battery is recommended instead.

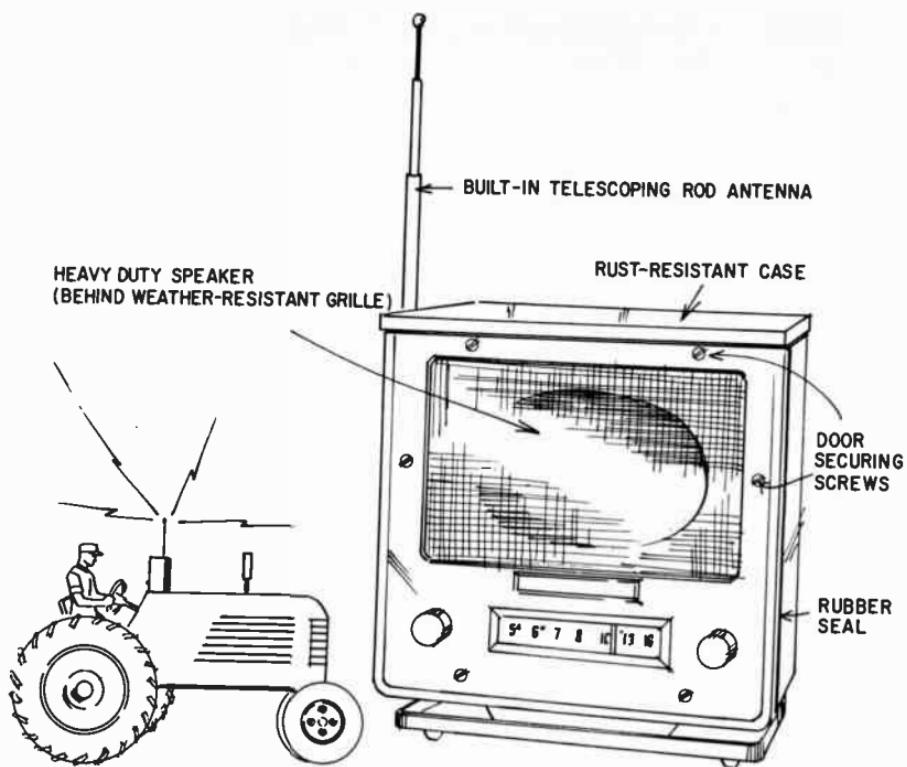


Fig. 209. Weatherproof auto radio for use in open vehicles has a rust-resistant case with rubber-sealed doors.

To meet the requirements of the transistor auto radio, battery-eliminator manufacturers have designed new units specially made for use with transistor models. In addition, manufacturers have brought out ripple-filter sets to be used with old battery-eliminator sets, to bring the old equipment up to the new standards.

Shops with high-ripple battery eliminators on hand might consider two possibilities: either acquire a ripple-filter set to bring the battery eliminator up to date; or acquire a storage battery and use the old battery eliminator to charge the storage battery between periods of use. A 12-volt battery made up of six 2-volt cells may be tapped to provide 6 or 12 volts to permit its use for all auto radios. In purchasing new equipment, be sure it meets the standards required by transistor radios.

Low-ripple battery eliminator

The low-ripple battery eliminator (Fig. 210) is a special-purpose dc power supply that facilitates the testing of auto radios and other devices requiring low-voltage dc at high current for their operation. Available commercial eliminators provide 6- and 12-volt outputs, with the ripple down to below 0.3% for current

drains encountered in hybrid and all-transistor sets. The battery eliminator includes a stepdown transformer, a solid-state rectifier, a filter circuit, and metering and switching facilities.



Fig. 210. Low-ripple battery eliminator. (Precision Apparatus Co.)

A simplified schematic diagram of a typical low-ripple battery eliminator circuit is shown in Fig. 211. Conventional ac power at 117 volts is applied to the primary of stepdown transformer T1. The stepped-down voltage is developed in the secondary, which has adjustable taps to permit varying the level of the voltage applied to the rectifier circuit. The rectifier output is taken across the bridge. With output-voltage selector switch S2 in the 12-volt position, the rectifier is a full-wave bridge rectifier. With the output-voltage selector switch in the 6-volt position, diodes D1 and D2 are out of the circuit and diodes D3 and D4 are arranged as a conventional full-wave rectifier circuit.

The rectifier positive output is taken at the tap of the secondary of the power transformer. Capacitors C1 and C2 and choke L1 form a pi-type filter to remove ripple from the dc output. The rectifier is returned to the negative side of the line through a circuit breaker (CB1) that protects the supply from overloads, and an ammeter (A) that indicates the drain on the supply during use. A voltmeter (V) is tied across the output terminals to indicate the value of the output voltage. The output voltage may be adjusted to precisely the required output level by varying the taps at the secondary of the power transformer.

The older battery eliminator was functionally similar to the low-ripple type, but usually contained a single high-capacitance

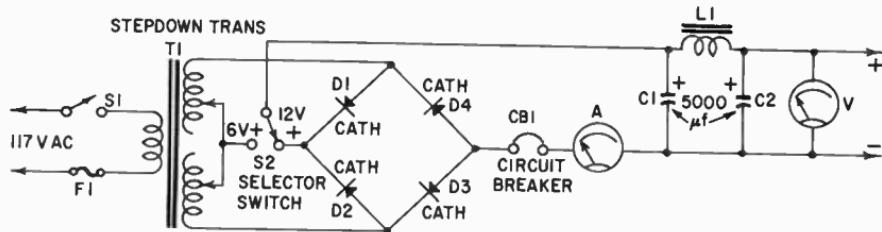


Fig. 211. Schematic diagram of a battery eliminator.

filter at the rectifier output. To update older models, manufacturers have issued L-C filter sets which convert the single capacitor filter to the low-ripple pi type. The L-C filter set is generally connected to the standard eliminator output terminals as shown in Fig. 212. The low-ripple output is taken from terminals provided on the L-C filter set.

Noise generator

Transistor equipment has placed a demand on servicing operations that did not exist during the peak popularity of the all-tube set. No longer is it feasible, for example, to check for voltage at key points by probing with a screwdriver and drawing sparks by shorting such key points to ground. Since power is often obtained directly from a battery supply, large currents can flow, resulting in voltage transients that can easily damage transistors and semiconductor diodes. Nor is it feasible any longer to check for intermittents by tapping the suspected components. The transistor has demonstrated itself to be extremely rugged and free from intermittent and microphonic troubles. On the other hand, many of the low-plate-voltage tubes used in hybrid sets are inherently somewhat microphonic when tapped sharply, due to the close construction of the tube elements.

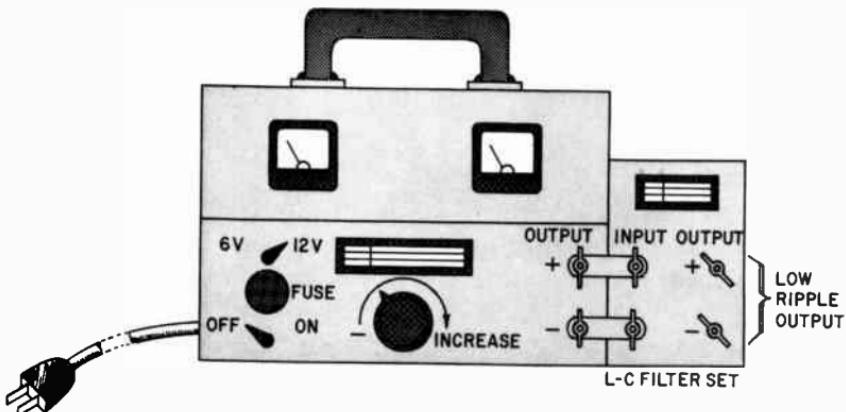


Fig. 212. Battery eliminator used with L-C filter.

As a result, a more formal approach to servicing transistor equipment is called for. A rapid, accurate and relatively safe method is afforded by the *signal-injection technique*. To implement this technique, in place of the conventional signal generator (which is cumbersome to use), a noise generator which provides a continuous audio, if and rf output is recommended. One particular form of the noise generator, a transistor multivibrator stage, has achieved a large measure of popularity.

The noise generator (Fig. 213) consists essentially of a battery-operated two-transistor multivibrator stage ($V_1 - V_2$) an output control (R_4), a traveling probe and a radiation loop. The traveling probe provides an output for direct insertion of a signal into circuits under test, while the radiation loop provides a radiated

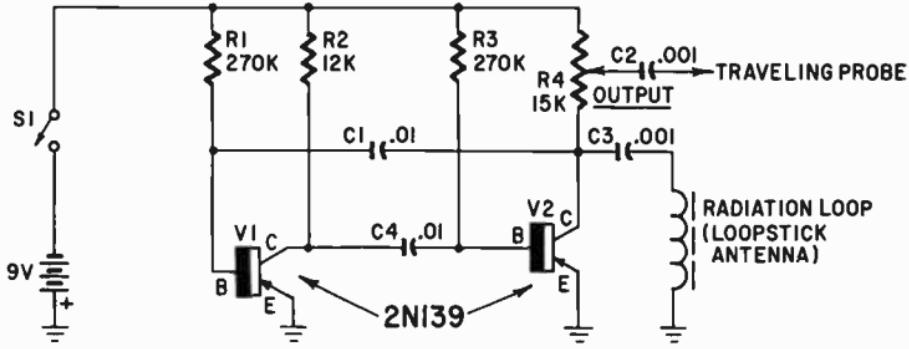


Fig. 213. Schematic diagram of a noise generator.

output useful in checking radio front ends. Although the multivibrator stage operates on a fundamental frequency in the audio range, the square-wave output is rich in usable harmonics up through the broadcast-band frequencies. Placement of components in the noise generator is not critical, and the entire unit can be assembled (according to the ingenuity of the individual technician) in relatively short order. A typical arrangement is shown in Fig. 214.

Signal tracer

The use of a noise generator would not be complete without a signal tracer as a companion piece. The signal tracer serves as a convenient means of detecting the presence of injected signals at various receiver stages. As such, the signal tracer replaces the oscilloscope as a go-no-go type signal detector. A simple signal tracer useful for detecting rf, if and af signals can be built into a probe to simplify its use. The device requires no external power.

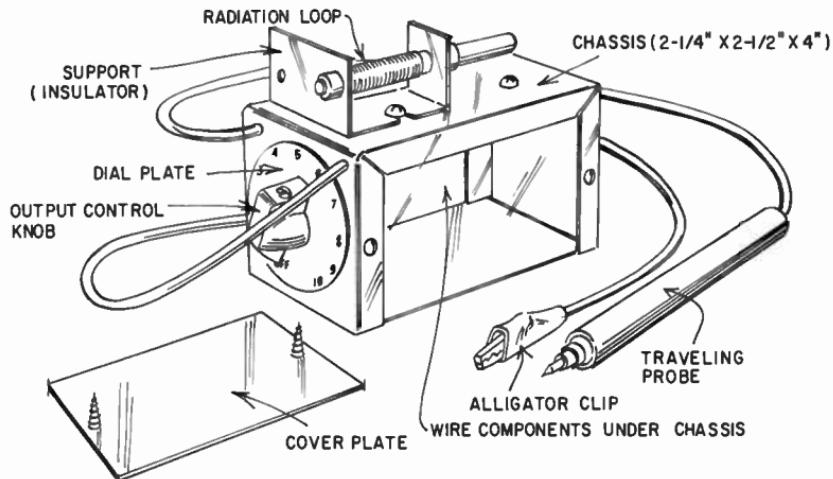


Fig. 214. Physical arrangement of components in the noise generator.
(Motorola, Inc.)

A schematic diagram of a signal tracer is shown in Fig. 215. The device consists of input capacitor C1, diode detector D1, RF/AF selector S1, volume control R1 and a high-impedance headset. In af operation, the diode detector D1 is bypassed by switch S1; the input signal is coupled through C1 and dropped across volume control R1. In rf operation, switch S1 is open and modulated signals probed at the input are demodulated through the action of the detector diode. Again, the audio signal is developed across R1. Either output can thus be heard through the high-impedance

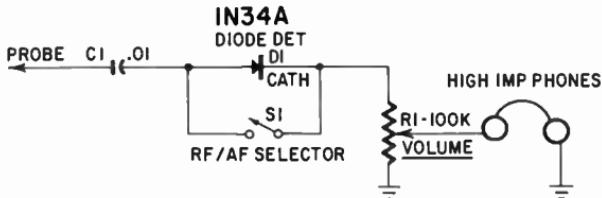


Fig. 215. Schematic diagram of a signal tracer.

headset. This type of device is sometimes referred to as a traveling probe, since it is moved from test point to test point in the normal course of its use. The associated noise generator is generally left connected at one particular tie point.

A suggested physical layout for the signal tracer probe is shown in Fig. 216 as a guide to its construction.

Special tools

A ratchet-type offset socket wrench set is a valuable investment

that will save many hours and bruised knuckles during removal and installation bouts. No other special tools will be required, assuming a set of standard tools (screwdrivers, assorted pliers, crescent wrenches, etc.) and a portable electric drill are available.

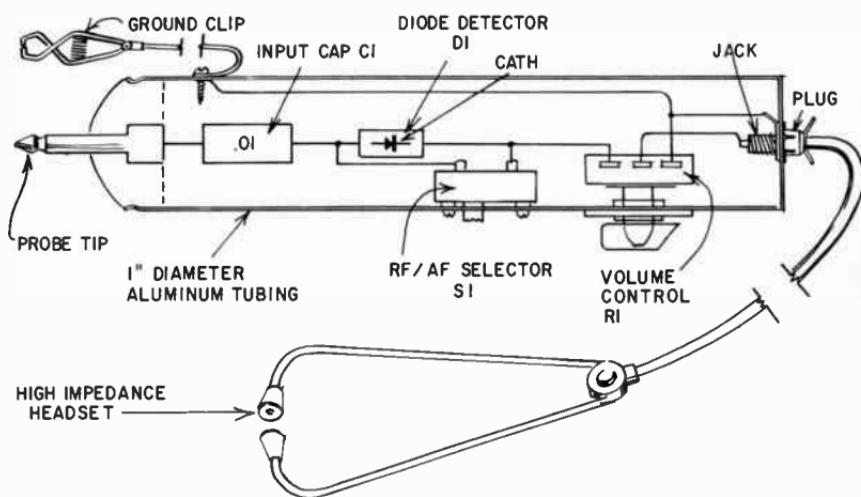


Fig. 216. Physical layout of the signal tracer probe.

Check list of special items to stock

The following check list is a good guide for the aspiring auto-radio service technician who wants to select intelligently the special items he will need in his new enterprise:

1. Universal vibrator replacements (6- and 12-volt).
2. Rear-speaker kits or individual components for rear-speaker installations.
3. Auto radio antenna kits (universal).
4. Antenna replacement masts.
5. Interference-suppression components:
 - a. Bypass capacitors,
 - b. Feed-through capacitors,
 - c. Resistor suppressors.
6. Automotive touchup paints (assorted colors).
7. Epoxy-resin body and fender compound.
8. Wing nuts (assorted).
9. Mounting brackets, bonding cables and straps.

Check list of tubes and transistors

The table lists the various tube and transistor types used in many makes and models of domestic and foreign auto radios. The items listed represent a basic stock for any shop geared for auto radio servicing operations.

FUNCTION					
	Rf, If Limiter	Converter (Mixer, Local Oscillator)	Detector, Af	Audio Power	Rectifier, Power Converter
Conventional Electron Tubes	6BD6	*ECC85	6BE6	6CR6 *EAA91	6AQ5-A
	12BD6		12BE6	12CR6	12AQ5
	6BJ6		6U8-A	6T8 *ECF83	6X4
	6BA6		*ECH81	6BF6	12X4
	12BA6			6AL5	
	12AT7	*EF89		12AX7	
	12AU7	*EBF89		12AL5	
Low-Plate-Voltage Electron Tube (Hybrid Applications)	12EG6		12AD6	12AE6-A	Search Tuner Trigger Tube
	12AF6			12DL8	
	12BL6			12F8	12AL8
	12EC8			12DV8	
	12EZ6			12EL6	
	*ECH83			12K5	
	*EBF83			*EF98	
Transistors	2N149		2N168-A	2N109	2N176
	2N439		2N140	2N270	2N443
	2N293			2N652	2N149
	2N169			2N573	2N257
	2N292			2N190	2N278
	2N247				*TF80/30
	2N139				*V30/20P
Diodes					*OC16/2N115
				1N295	
				1N60	
				1N34-A	

* Foreign Types

Foreign-to-domestic tube equivalent data

Equivalent data is given in the table below covering domestic tube types available to replace foreign types in use in auto radios of foreign manufacture. Most foreign tube types in use have exact replacement domestic equivalents. Exceptions are noted in the remarks column.

Foreign Tube Type	Domestic Equivalent	Remarks
EAA91	6AL5	Basing different
EBF83	6DR8	Exact replacement
EBF89	6DC8	Exact replacement
ECC85	6AQ8	Exact replacement
ECF83	None	
ECH81	6AJ8	Exact replacement
ECH83	6DS8	Exact replacement
EF89	6DA6	Exact replacement
EF98	6ET6	Exact replacement

installing and removing auto radios

THE Big Three auto manufacturers have come to recognize the importance of the small car. As evidence, they have shifted their regular lines to include, at the bottom, a "compact" car in the "low"-price range. Although most of the noise made prior to the introduction of these small cars ranted about size as a predominating factor, perhaps an even more dominating factor was price. People were not too willing to pay the price of a luxury car for one of the "most popular three." Instead, they were turning to more utilitarian foreign cars.

Naturally, the man who buys the luxury car or the man who buys the best model of the most popular three is the man who buys his wagon with the works included. However, the man attracted to the smaller car for reasons of economy will undoubtedly be economizing when it comes to purchasing accessories. These people generally think that the price they are asked to pay for the factory-installed auto radio is exorbitant. This was true at one time but the cost of such radios is definitely down from former high levels. Even so, there will always be some buyers, especially in the economy car class, who will seek the help of the service shop in obtaining and installing an auto radio.

Selling a radio installation to a new car owner will not be an easy job. Rarely can the installation be made to duplicate exactly the chromey "lost-in-the-maze" appearance of the factory-installed radio. In fact, the closer the resemblance to the factory-installed job, the greater the labor charge will probably have to be. The psychology of all service jobs must prevail — one must know his

customer before proceeding. Part of getting to know him is to educate him as to what he is buying in the way of an installation, and what he is paying for in the case of different installations.

Types of installations

To date, auto radios have been installed in the dash, duplicating the factory job (Fig. 301), under the dash (Fig. 302), in the glove compartment (Fig. 303) and on the floor (Fig. 304). (What with transistorization and miniaturization, the future promises auto

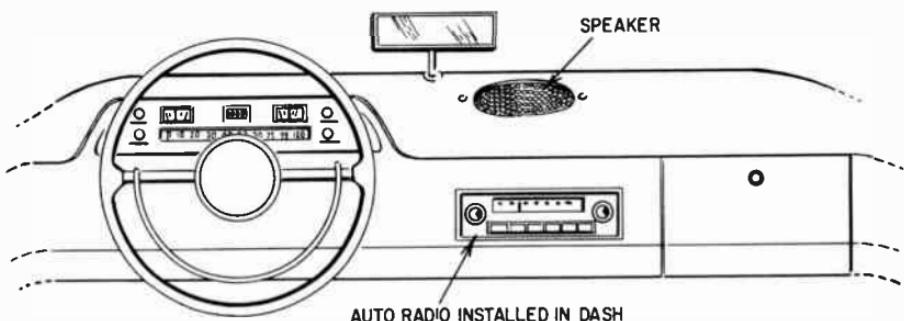


Fig. 301. Typical in-dash installation of an auto radio.

radios that, for example, can be secured to the top of the dash with a magnet in the same way as ash trays and coin holders). The complexity of an installation is strictly a function of the make and model of car and of the radio to be installed.

Most manufacturers produce a universal type of radio theoretically suitable for installation in all cars. It may be suited for in-dash installation in one make and model of auto and for under-dash installation in another car. Manufacturers' notes concerning the applicability of their universal model to the autos of various manufacture should form a part of the library of every service shop. When rushed with the business of the day, and provided the customer is not in a hurry, ask for a day to study his particular installation problem. Explain that it will be necessary to investigate the catalogs to find the best auto radio model for his particular need.

In-dash vs under-dash

Everyone is inevitably going to expect to get an in-dash installation. Naturally, if the customer really wants this, he will probably be satisfied with nothing short of it. When complaints arise about the cost of an in-dash installation, suggest the under-dash installation; mollify tempers by pointing out that future servicing of in-

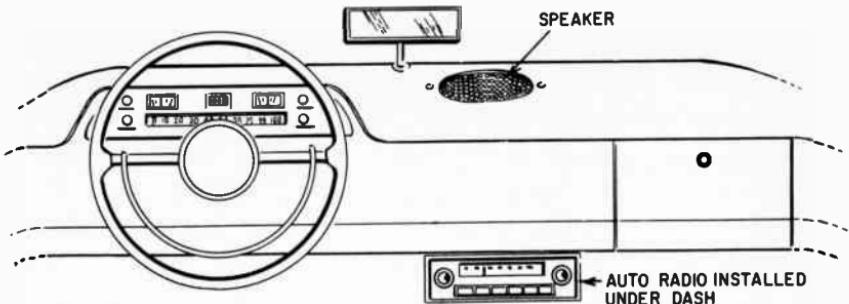


Fig. 302. Under-dash installation of an auto radio.

dash installations will cost more than servicing the more accessible under-dash sets. In most cases, you should be able to convince a die-hard after he recalls the price he paid for servicing the in-dash radio in his older-vintage auto.

Manufacturers provide accessory trim kits for their auto radio kits containing a variety of trim plates and escutcheons, with

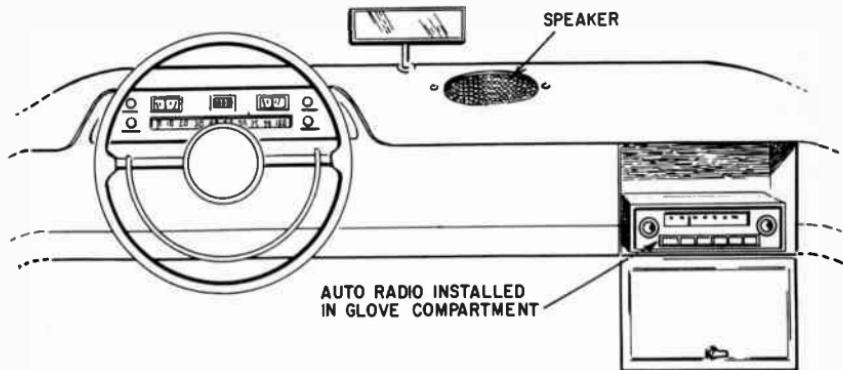


Fig. 303. Glove-compartment installation of an auto radio.

which the ingenious service technician can provide his customer with a superior and professional-looking installation. These cosmetic devices can often be employed to cover up major surgery that may have been required in an in-dash installation.

The glove-compartment installation

- A glove compartment installation will have to be resorted to:
1. When the customer wants to be different;
 2. When the customer owns a jazzy foreign or domestic sports or minicar and needs the room in and around the dash for his and her knees;
 3. For concealed installations of FM tuners.

At one time glove compartments were almost mandatory for auto phonograph installations (currently still popular with hobbyists who "do-it-themselves"). Several manufacturers, though, are making under-dash units.

The floor installation

Because of their miniature size, many sports cars (as well as other miniature cars not classed as sports cars) cannot accommodate the standard size auto radio designed for dashboard installation. Many auto radio manufacturers in the US and abroad

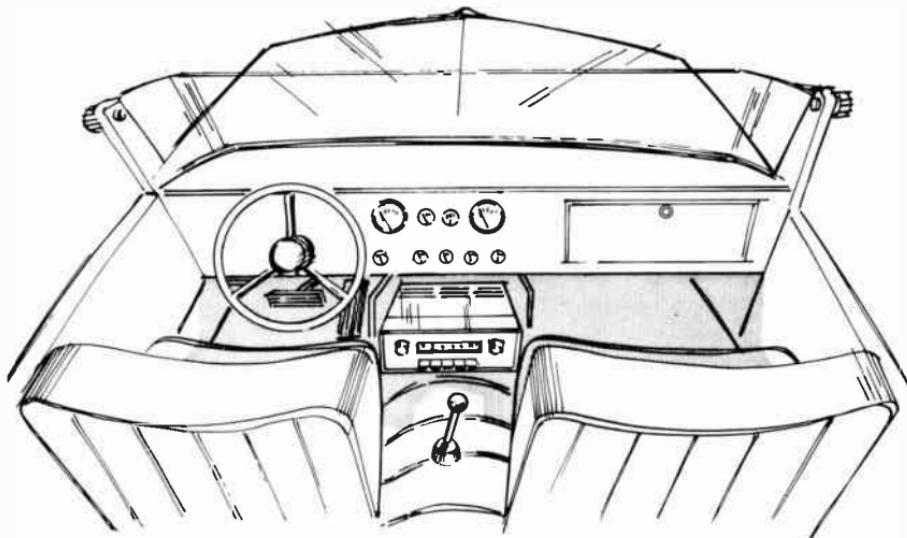


Fig. 304. Floor installation of an auto radio.

produce for what has come to be known as the American "family car." Many auto radio manufacturers in the US and abroad produce a line of compact-sized radios to meet the demands of the sports and minicar market. However, even the special compact size radios not designed specifically for a particular make or model sports or minicar often require special installation by the service technician. When dash and glove compartment installations are not feasible, it is often possible to install the radio on the floor. This is particularly desirable for the low-slung sports car with bucket seats where the driver is practically sitting on the floor in normal use.

Insuring quality of installation

When your installation job is over and the customer calls for his car, you (and the customer as well) will doubtlessly want to

switch the set on. When you do this, he will demand that the sound coming out of your blood, sweat and tears installation be faultless and compare favorably with what he thinks "hi-fi" should sound like . . . and it is possible that his taste will run to juke-box boom.

Your installation will not sound the way it should if you haven't taken the precaution of installing the speaker in the dash with the cone directed up or out (*never down*) to project sound to all corners of the car. This type of speaker installation is almost mandatory for good results no matter how the manufacturer has packaged his radio and speaker and no matter what type of installation you are selling. When estimating the cost of a job always take this factor into account, and tell the customer about it.

Installation check list

Installing an auto radio involves a series of steps which may be separated into operations for mechanically securing the radio and accessories, and operations for making the required electrical connections. In general, the steps include:

1. Determining power supply requirements;
2. Installing the antenna;
3. Installing the speaker;
4. Installing the radio chassis;
5. Connecting the antenna and speaker;
6. Connecting the power supply lead;
7. Adjusting the antenna trimmer;
8. Installing interference suppressors.

Power supply requirements

To date, American and foreign automobiles have been outfitted with either a 6- or 12-volt electrical system. Ignition systems, in turn, are designed to operate from the 6- or 12-volt systems. The primary source of power in either case is the storage battery, normally connected so that one pole is grounded while the other is live. Thus, auto electrical systems have come to be classified as either positive- or negative-ground systems. The choice of ground is the designer's and the auto manufacturer's. In either case, polarity problems in ignition-system design are accounted for early in the game. The auto radio, however, unless it is the type designed specifically for use in the make of one manufacturer for a given year, is not necessarily designed to be accepted in any auto. There are, however, universal types which are compatible and easily wired for acceptance in positive- or negative-ground cars.

The auto radio that employs the conventional interrupter vibrator power supply is universally compatible with car electrical

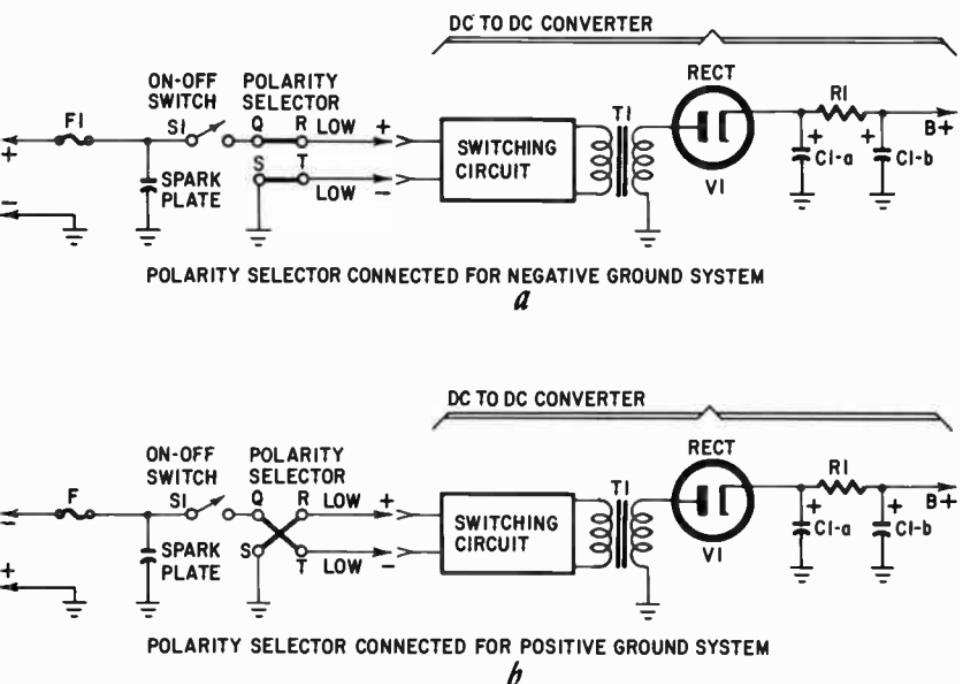


Fig. 305. Polarity-reversing circuits used in universal auto radios with transistorized dc-to-dc converters.

systems that employ positive or negative grounds. Auto radios that employ a synchronous vibrator or a transistor dc-to-dc converter as a secondary power supply, and hybrid and all-transistor sets that operate directly from the auto battery, require an applied voltage of proper polarity to assure operation and to avoid damage to components.

Polarity-reversing circuits

The polarity-reversing circuit of Fig. 305 makes the radio with a transistor dc-to-dc converter (and conventional tubes), compatible with positive- or negative-ground auto power supplies. In Fig. 305-a, the circuit is shown connected for use in an auto with a negative-ground power supply. Here, the polarity selector is connected so that Q is shorted to R and T is shorted to S, which is grounded. With the ON-OFF switch ON, the positive supply voltage is routed to the proper live point in the transistor dc-to-dc converter, while the ground line forms the negative return for the circuit, which is required for normal operation.

In Fig. 305-b the circuit is shown connected for use in an auto with a positive-ground power supply. Obviously, if the polarity selector were left connected as in Fig. 305-a, negative (reversed) voltages would be routed to the points that require positive voltages for normal operation (transistors would probably be damaged). Thus, the polarity-selector connections in the case of a positive-ground supply must be made as shown. Here, Q is shorted to T and R is shorted to S, which is grounded. The ground side of the line is positive in this case and forms the positive supply lead, while the negative line forms the return. Since the difference of potential between the lines and the polarity of the lines in both cases is the same (current flows through the converter in the *same* direction for either case), the operation of the converter circuit is identical for both.

For either circuit, Figs. 305-a or -b, the low-voltage battery lines feed a dc-to-dc converter switching stage whose output is transformer-coupled to a rectifier. This results in the production

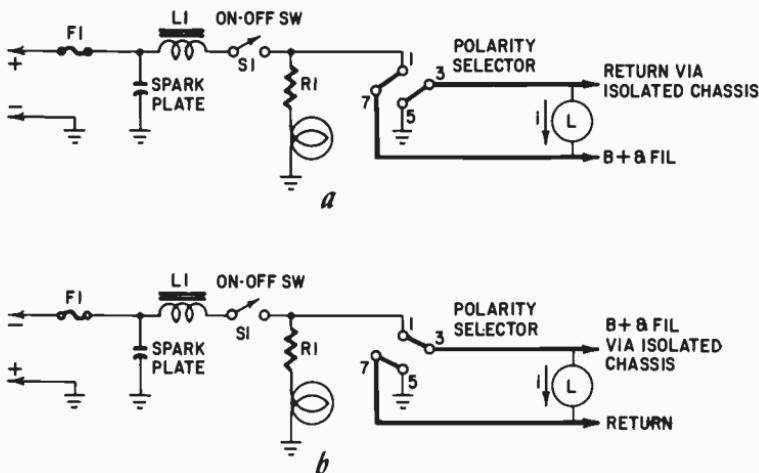


Fig. 306. Polarity-reversing circuits used in hybrid and all transistor universal auto radios.

of identical ac components at the rectifier input in the case of either polarity connection. The rectified and smoothed high-voltage dc output of the converter is therefore positive with respect to chassis ground whether the primary supply has a positive or negative ground.

Polarity-reversing circuits are also used in hybrid and all-transistor radios to make these sets suitable for use in autos with either positive or negative ground systems. A schematic diagram of a

typical circuit employed for this purpose is shown in Fig. 306. In this case, the common return for the radio is an isolated chassis

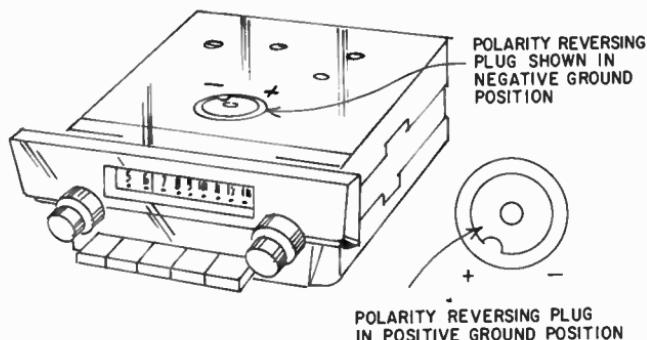


Fig. 307. *Polarity selector for universal auto radios with reversible shorting plug.*

separated from the outer auto ground chassis by a layer of plastic insulating tape. This chassis forms its own private return system,

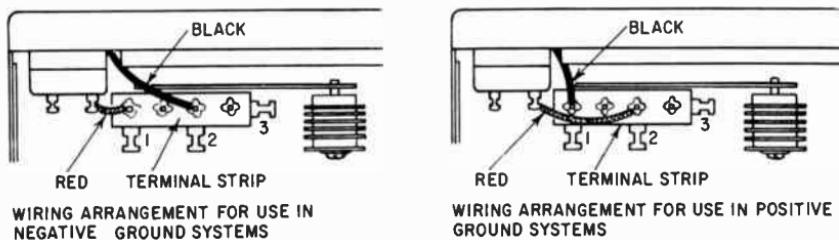


Fig. 308. *A polarity selector for universal auto radios in the form of a terminal strip that is wired per instructions.*

since it must often operate hot with respect to the car's chassis ground.

The polarity selector for the circuits described has been: either a reversible shorting plug that automatically makes the proper connections when inserted in its mating receptacle (Fig. 307); or a terminal trip (Fig. 308) that must be wired according to the manufacturer's directions (usually supplied with the set).

Installing the antenna

The average auto radio antenna designed for AM reception is a telescoping whip. Maximum sensitivity and best radio operation occur when the antenna is used fully extended. The telescoping design is necessary so the auto can be housed easily in low-roofed garages and can pass easily under low bridges. In the early days, antennas were installed under the car body or were concealed as a

special conducting section of the old tar roof, insulated by the tar from the auto body. Today, in this era of chrome and stainless steel, the auto antenna has become a desirable chrome accessory that takes its place alongside the less dashing doodads that find their place on the automobile.

Antennas have been designed for front and rear fender mounts, and for mounting above the windshield. Luxury autos feature mechanized systems to raise and lower the antenna that rival the submarine periscope system in ingenuity. Many autos feature

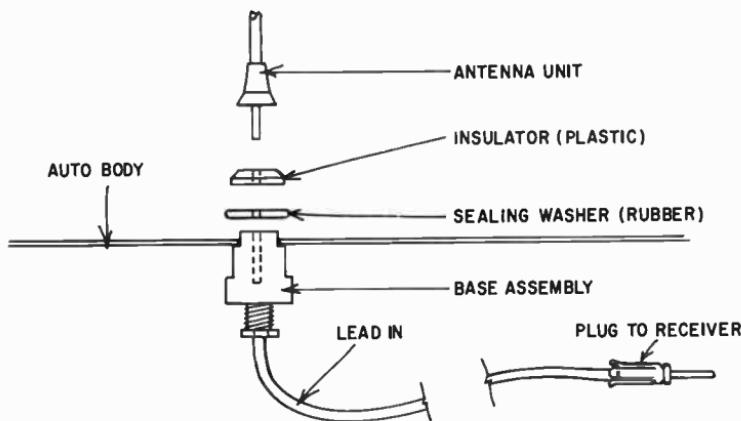


Fig. 309. Typical auto radio antenna assembly.

(according to the taste of their owners) two to four antennas for one radio. This author would like a nickel for every auto that sports an antenna that does not feed a radio. (Past surveys of homes with TV antennas have turned up the startling statistic that one out of six homes sporting a TV antenna on the outside had no TV set on the inside.)

New antenna installations

New antenna installations are generally easily accomplished with the complete instructions and hardware furnished in the antenna kit. The required body-fender operation is simplified through the use of power tools, and botch jobs are easily rectified with epoxy plastic body and fender mender (available from auto supply houses) and a dab of suitable touchup paint. In these days of unitized auto bodies, particularly tricky cases may require the services of a local garage.

To determine the best position at which to install the antenna, survey (if possible) a factory installation in a car of identical make

and model. Follow the directions provided with the antenna kit as to the size of the hole to be cut. Drill, or have a local body shop, burn a hole of proper size at the desired location. Install the antenna according to the instructions given in the kit. The assembly of a typical auto radio antenna is shown in Fig. 309. Remember, the antenna must be completely insulated from the auto

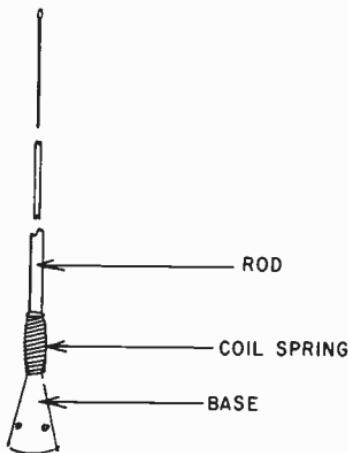


Fig. 310. *Anti-vandal antenna incorporating a powerful coil spring between base and rod.*

body. If insufficient lead cable is supplied with the kit, 53-ohm cable (such as RG-58U) of the proper length may be substituted.

Anti-vandal antennas

Auto radio antennas are not only popular with auto enthusiasts but also with vandals. To discourage destruction and to attract buyers who have been victims of vandals, some manufacturers are selling antennas that telescope almost completely into the fender of the auto. The author also recalls reading of an electrostatic shock-producing device that one hobbyist hooked up to his auto antenna to discourage someone's itchy fingers.

It is ironic that the most effective anti-vandal antenna sold is offered as a replacement antenna, for use after the fact rather than as original equipment. This antenna (Fig. 310), incorporates a powerful coil spring between the antenna rod and base. Any attempt to snap the staff from the base is discouraged by the action of the coil spring. The arrangement is also an aid in overcoming the possible damaging effects of driving under low bridges and through low garage doors with the antenna raised. Before installing an anti-vandal antenna, warn your customer of the dan-

gers that go with it. Such dangers arise when a frustrated vandal, thwarted by the trick antenna, turns his attention to some other ripe automotive ornament with vengeance in his heart.

The anti-vandal antenna may be installed without the necessity of replacing the entire antenna assembly. The unit is designed to fit over the stub of an existing antenna base assembly, and is

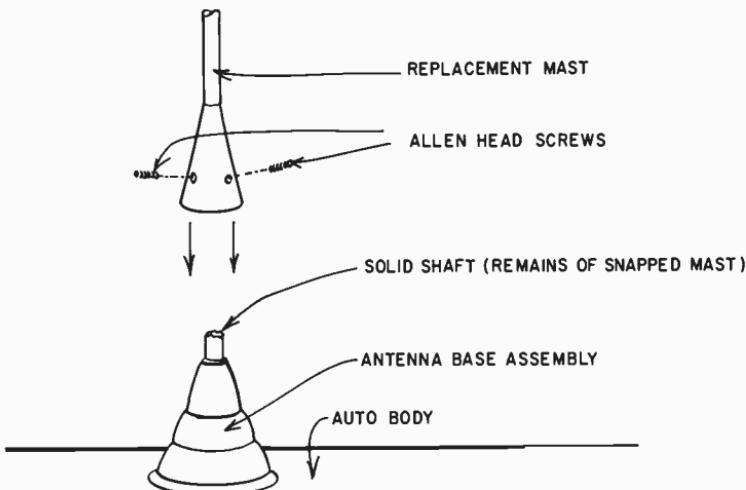


Fig. 311. *Installing a replacement mast.*

generally secured by means of screws as shown in Fig. 311. Replacement masts of the anti-vandal type are naturals for fastidious auto owners who might have invested in a good paint job but sport a twisted and tarnished antenna mast. The low price of such replacement masts will move them quickly. A word of advice: in general, do not permit the customer to watch the mast replacement operation since the quickest and easiest way to do the job is to snap off the old antenna. Many customers will not be too happy with this operation. Therefore, try to do it privately. If the customer wants to wait, be genteel — use a hacksaw.

FM antenna installations

There are two schools of thought that have cropped up concerning the best place to install an antenna intended for use with an FM (or AM/FM) auto radio. Both schools substantiate their arguments with proof in the form of experimental evidence gathered from trial runs under varying receiving conditions. The argument will surely become a classic and the trend from one to another will swing like a pendulum as did the triode-pentode con-

troversy in hi-fi. One school of thought believes that the FM auto radio antenna must be horizontally polarized to match the horizontally-polarized FM broadcast signal; the second school believes that adequate reception in FM areas can be achieved by using a wide band omni-directional vertically-polarized antenna.

A solution to the problem is an antenna with a flexible link incorporated that may be bent to enable the FM enthusiast to

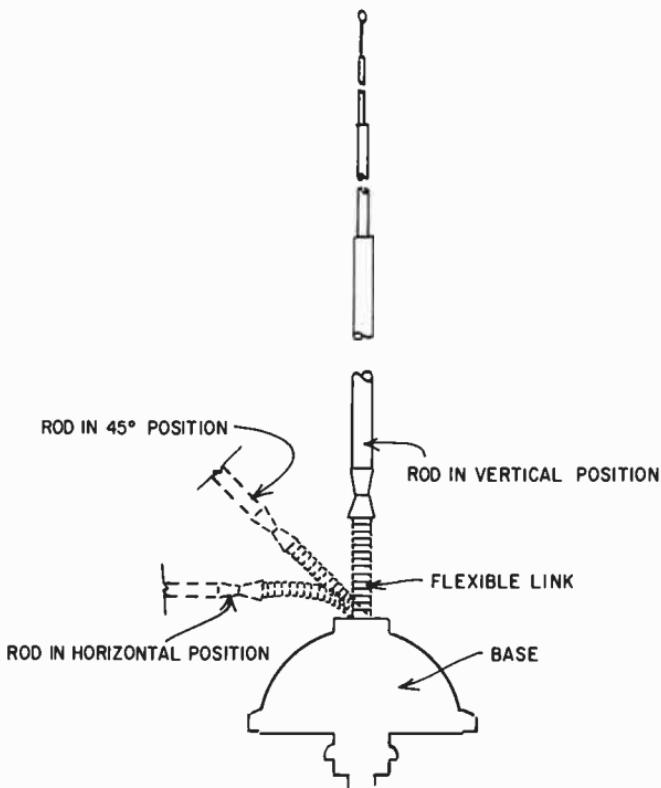


Fig. 312. Flexible link on this FM type antenna can be bent to various angles to provide desired polarization.

select his own antenna inclination angle (Fig. 312). Although a vertical installation presents no problem, and a horizontal installation (if carefully planned) presents just a little problem, a "changed my mind" vertical to horizontal installation can become a headache. Picture the situation in which a vertical installation can be converted to a horizontal installation by swinging the bending link section down to a point where the horizontal antenna interferes with opening the car door, etc. Perhaps the most conservative course to follow is to *always* install the antenna with horizontal use in mind, since switching to vertical is easily

accomplished without interfering with the use of doors, etc.

When an FM tuner is added to an existing auto radio system, it is often possible to hit a middle-of-the-road course with respect to the type of antenna to use, through the application of a specially-designed hoop antenna. The hoop antenna has been developed with an eye toward making fullest possible use of an existing vertical AM antenna, while providing flutter-free reception in

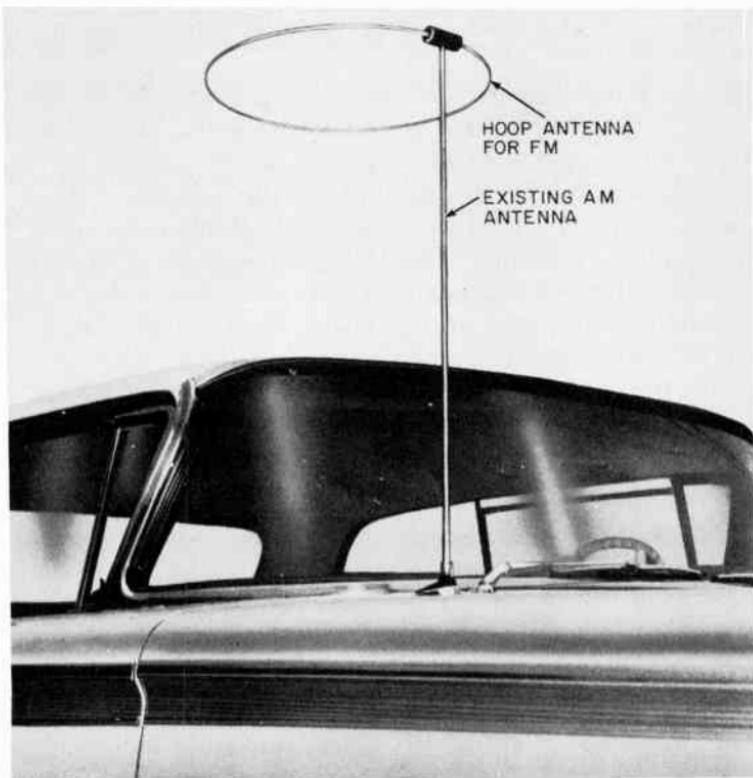


Fig. 313. Hoop antenna fits over existing AM antenna to provide improved FM reception.

weak FM signal areas. The hoop antenna fits over the existing standard AM antenna as shown in Fig. 313.

Whenever an antenna designed for AM use is applied to an FM reception situation, observe the following precautions:

1. Be sure that the lower telescoping section is completely withdrawn from the well in the auto fender, as the well may serve as a trap for FM signals;
2. Always extend the antenna from 30 to 42 inches.

Installing speakers

In general, the speaker will have to be installed before the radio itself. Always remove integral speakers from radio assemblies and install them separately to obtain best sound quality. Many cars without radios will have the speaker cutout in the dashboard, although this cutout may be enclosed by a cover plate or dust cover. In most instances, it will be necessary only to remove the cover and install the speaker using the existing hardware (Fig. 314).

Where it is necessary to provide a special cutout for the speaker, choose the location under the dash carefully and determine whether the speaker will fit. Plan to use the dash itself as the speaker grille. To do this, design a grille template which will enable you to form a suitable grille in the dash by merely drilling a large number of small ($\frac{1}{8}$ -inch) holes in a pattern of your own design. Depending on the size of the speaker, drill holes to accommodate bolts with fancy heads (visible on the dash) and secure such bolts with hex nuts and lockwashers to form studs on which to mount the speaker. Paint the bolt heads the color of the dash. When installing the speaker itself, use wing nuts to simplify the task.

Speaker size

The oval speaker is the most popular for auto radio installations. The 6 x 9-, 5 x 7- and 4 x 6-inch sizes are most in demand. (Round speakers of 5, 6, 7 and 8 inches have also been used in autos over the years). When a 6 x 9-inch speaker cannot possibly be used due to space limitations, a 5 x 7- or a 4 x 6-inch of good quality can successfully replace the 6 x 9-inch with totally satisfying results. In fact, this is so common that manufacturers provide reduction plates which mount on existing studs for a 6 x 9-inch speaker, for example, and provide auxiliary studs for mounting 5 x 7- or 4 x 6-inch speakers (Fig. 315).

Always use high-quality replacement speakers when making such changes, to avoid customer dissatisfaction. It is a good policy to swap evenly with the speaker provided, and not to charge the customer for the exchange.

In many cases, a situation such as this can be used as the starting point for promoting the sale of a rear-speaker installation, using the larger speaker supplied with the radio at the rear. Where an in-dash speaker installation is really too much of a problem, suggest a rear-speaker installation. It should not be too difficult

to sell the customer on this since most people by this time know the rear-speaker installation generally provides sound of top quality. It should also satisfy customers who are wary of a speaker swap and feel you are trying to get away with something when you

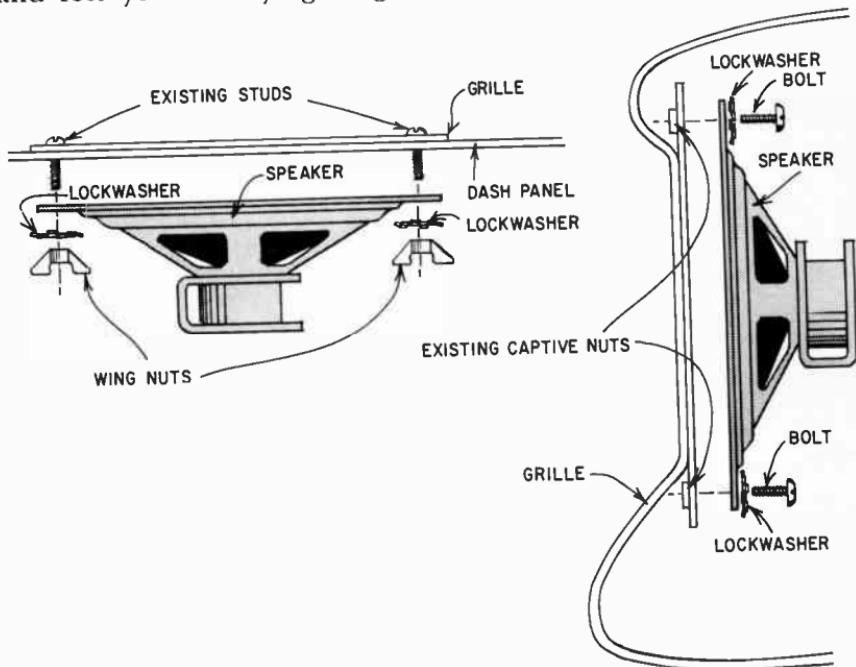


Fig. 314. *Installing speakers using existing hardware on dashboard panel.*

suggest it. Again, it is important to know your customer before deciding on your course of action.

In-dash installation — mechanical connections

The in-dash installation will require two basic mechanical connections: the tuning and volume-control shafts will be used to bolt the radio to the dash itself; and a supporting bracket will be used at the rear of the radio to bolt the radio to the fire wall at the rear of the dash (Fig. 316). The most common variation of this connection involves attaching the supporting bracket to a rigid member behind the dash instead of to the fire wall. Still another popular alternative involves the use of two supporting brackets, one on each side of the radio chassis, attached to two rigid members under the dash (Fig. 317).

Before attempting the in-dash installation, determine whether there is sufficient clearance behind the dash to accommodate the radio, mounting brackets and wiring. Of course, most impor-

tant of all, determine to your own satisfaction that you have sufficient working room to make the necessary connections, etc.

Most of the know-how in installing auto radios will come with time and the experience of several harrowing installations under your belt. Remember that your precious time and the customer's precious auto are involved. This author goes on record as recommending the easiest course in most cases, especially at the beginning.

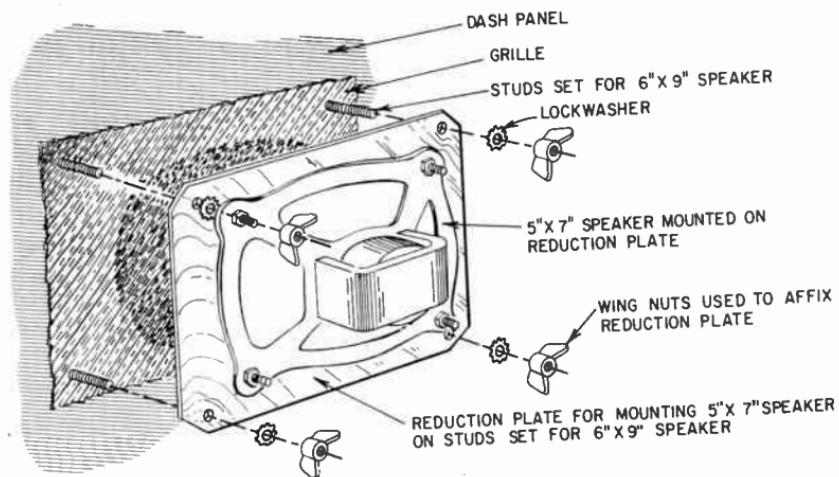


Fig. 315. Use of reduction plate for mounting 5 x 7-inch speaker on existing studs for 6 x 9-inch speaker.

The use of a wing nut in attaching the rear supporting bracket is highly desirable. Wing nuts eliminate the need to use a tool in the already inaccessible space behind the dash. If the radio installation kit is not supplied with them, obtain some locally and use them in place of the kit-supplied hex nuts. Wing nuts facilitate not only installations but removals as well, since the requirement for getting a tool into the limited space behind the dash is again eliminated. An important practice to follow is to substitute wing nuts for conventional hex nuts when returning a radio that has been previously removed for servicing in the shop. And don't forget lockwashers! They're very necessary in a car!

The installation diagrams of Figs. 318 and 319 provide details of typical in-dash arrangements.

Complications

Radios with pushbuttons (or bars) and slide-rule dials pose still another problem. In place of the simple drilled round holes

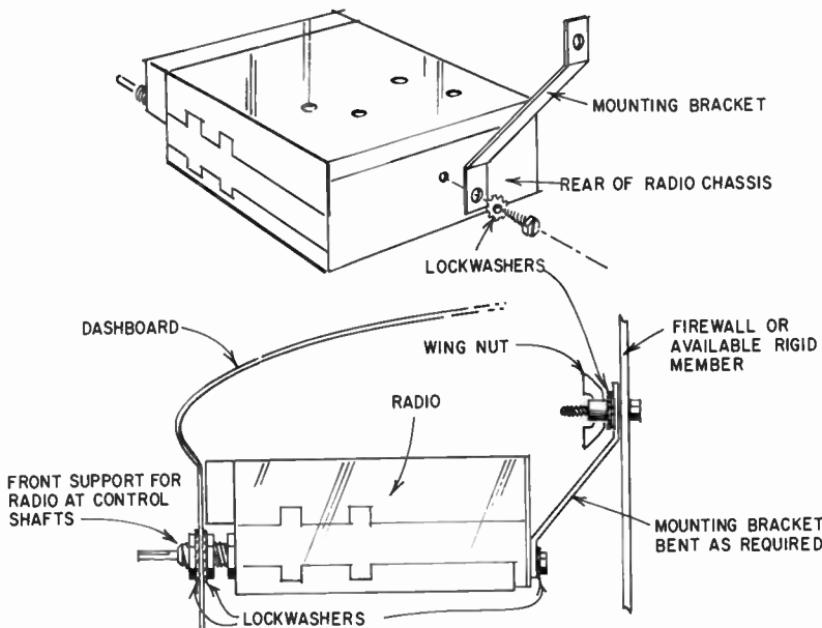


Fig. 316. Basic mechanical connections for in-dash installations.

required in the dash, these receivers call for complicated cutouts to accommodate the front panel containing the buttons, bars or slide-rule dial. Often, in the auto purchased without a radio, these cutouts already exist in the dash and may be covered with a grille or a simple cover plate. In these cases remove the cover and you have the required cutout for a radio designed for custom installation in that particular make and model auto. Of course, in an under-dash installation, the fancier radios may be used without difficulty. It is important to treat each case on an individual basis, and likewise, each customer. Unfortunately, no one rule applies to all cases.

Adjustable control shafts

In many universal-type auto radios, the positions of the tuning and volume-control shafts are adjustable. This facilitates in-dash installation of these radios in autos in which cutouts for a radio already exist in the dash panel. The front panel of a typical auto radio with adjustable control shafts is shown in Fig. 320. In the case illustrated, either control can be set in any one of three positions to account for nine arrangements.

In general, the procedure for adjusting the control shafts involves the following steps:

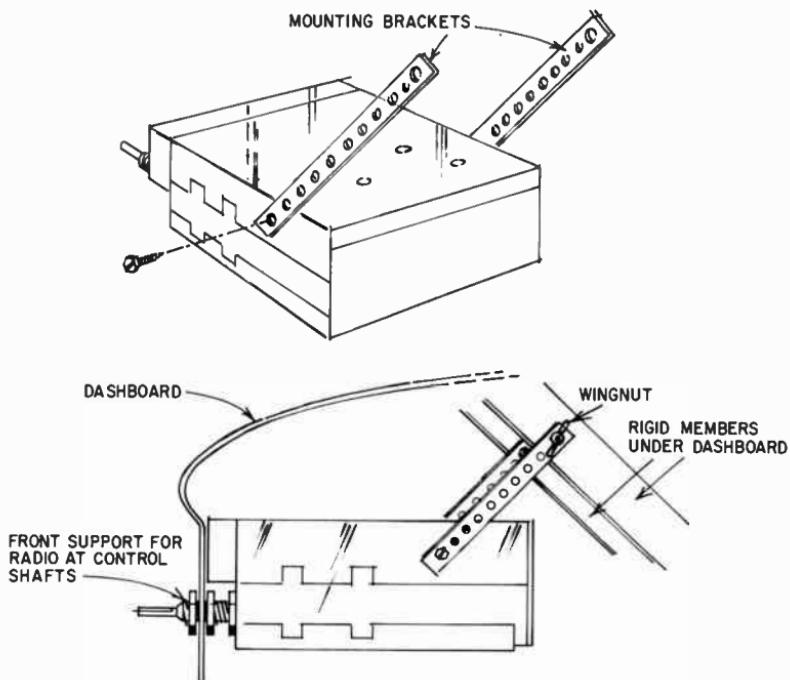


Fig. 817. The receiver can be held in place by means of a pair of mounting brackets. The brackets supply rear support for the radio, while the controls (going through the dashboard) give front support. The mounting brackets have holes punched in them. Select that pair of holes which will permit the receiver to be mounted in a horizontal position. If this isn't done, the control shafts will be tilted up or down.

1. Determine the distance between the shaft openings in the dash panel;
2. Loosen the bushings that secure the controls;
3. Move the controls to new positions as required;
4. Seat and set detent devices for the controls;
5. Tighten bushings;
6. Check that controls in new positions have not inadvertently short-circuited components in the radio.

Upside-down installations

Many universal-type radios are designed to be installed upside down as well as right side up. Manufacturers have allowed for this to meet the demands of installation situations in which the distance between the control shafts and the top of the radio is too great for the radio to be accommodated in the dash right side up. In these radios, the distance between the control shafts and

the bottom of the radio is often small enough to allow the radio to be installed successfully upside down. In such radios, tuning dials, trim and the like can be installed either in-phase or 180° out of phase to account for both installation situations.

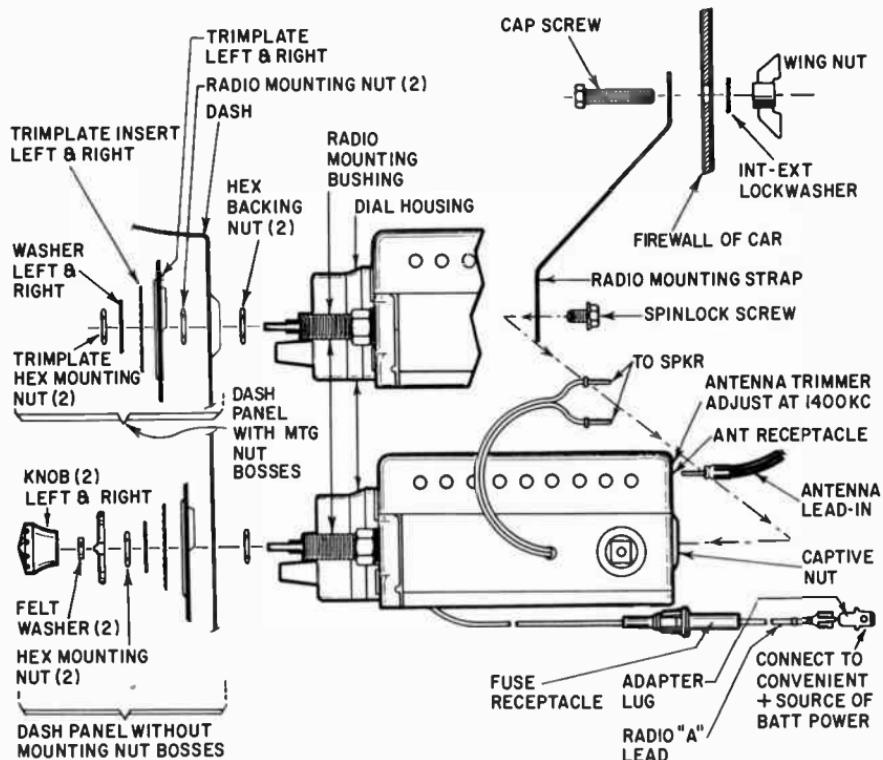


Fig. 318. Auto radio installation diagram for typical in-dash installation.

Under-dash installation — mechanical connections

The under-dash installation will also require two basic mechanical connections: the front of the radio must be supported at the lip of the dash; the rear of the radio must be supported at the rear of the dash. Often brackets are used to accomplish both. Refer to the under-dash installation diagrams of Figs. 321 and 322 for information on typical arrangements.

Glove-compartment installation — mechanical connections

The glove-compartment installation will probably prove to be the easiest of the installations discussed. Radios designed specifically for glove-compartment installation are often outfitted with

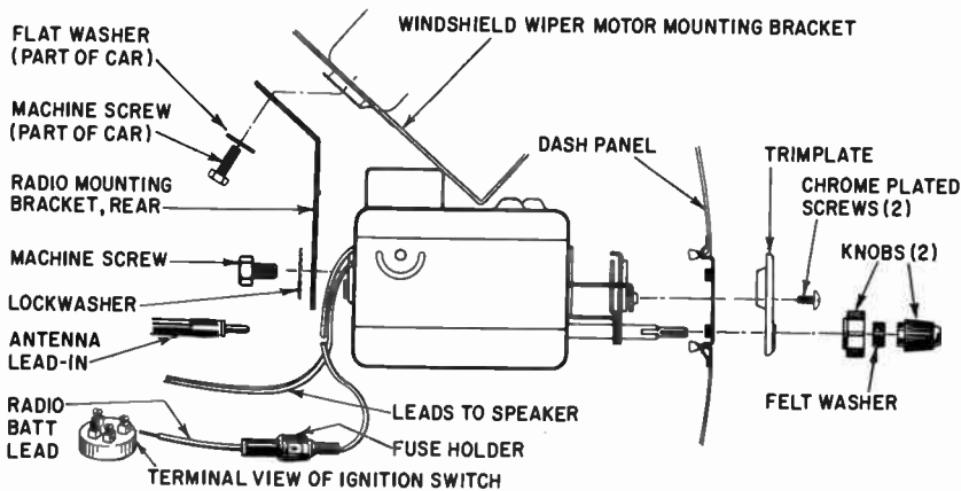
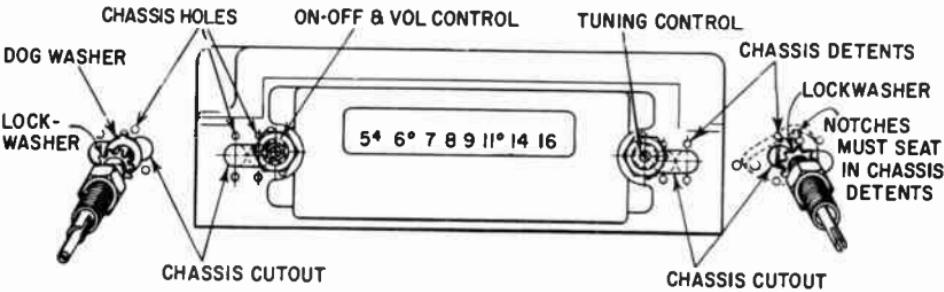


Fig. 319 (above). Auto radio installation diagram for alternate in-dash installation.

Fig. 320 (below). Adjustable control shafts employed in auto radios to facilitate installations in many cars.



a special front plate to facilitate mounting. The installation diagram of Fig. 323 is typical.

Floor installation — mechanical connections

The floor installation will require that the radio be secured by either of two mechanical connections. While supported by the hump in the floor under which the crankshaft passes, the set may be secured through the use of a suitable supporting bracket connected to the firewall. In other cases, the radio may be secured directly to the hump in the floor. When anchoring a set directly to the crankshaft hump, plan the installation around the use of self-tapping screws to eliminate the need for bolts and nuts which would require the technician to have access to the underside of the car.

Caution: When drilling through the floor of the car, be sure to

check clearances beneath the car to avoid drilling into vital auto components.

The installation diagram of Fig. 324 shows a typical floor installation.

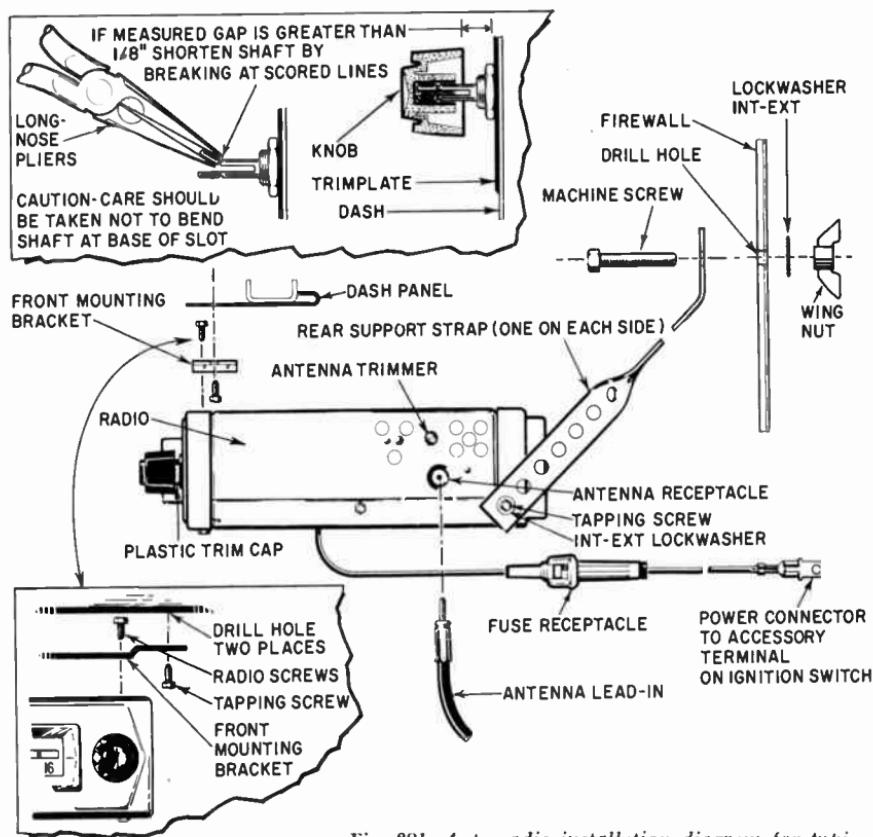


Fig. 321. Auto radio installation diagram for typical under-dash installation.

Electrical connections

Caution: Before making any electrical connections, be sure the radio is compatible with the car's electrical system. Do not use an auto radio designed for a 6-volt auto in a 12-volt one, and vice versa. Do not use a radio designed for use in an auto with a negative-ground system in an auto with a positive-ground system, and vice versa.

Be sure that polarity-reversing switches, plugs or terminal connections are connected correctly before attempting to connect the auto radio to the power source.

In general, the electrical connection is normally affixed to the radio at one end and to the power source at the other end, with a fuse holder in between. The fuse holder not only holds the fuse and provides a means for getting at it easily when replacement is required, but also provides a means for quick disconnect when the radio must be removed for servicing. When making the required electrical connection, disconnect the fuse holder and

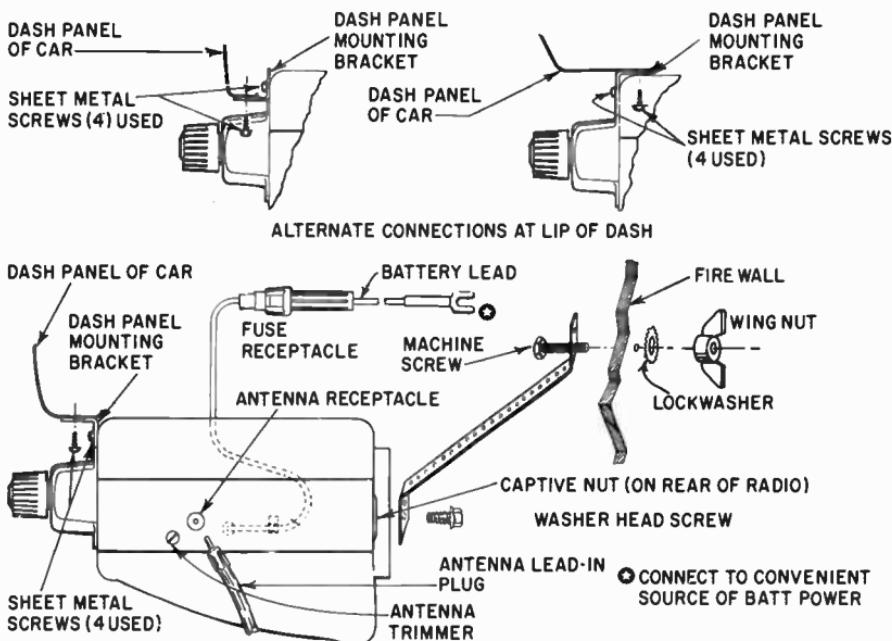


Fig. 322. Auto radio installation diagram for alternate under-dash installation.

install the lead wire alone to the source of power. In most modern autos, there is an accessory terminal in the electrical system at which power is available when the key is in either the ignition or accessory positions, but not in the off position. By hooking the power lead to the accessory terminal, it will be impossible to use the radio when the ignition switch is off. This is designed to prevent the use of the radio by unauthorized persons, with the subsequent running down of the battery. Thus, all the available current is diverted to the task of starting.

Physical connection is generally made to the accessory terminal at the rear of the ignition switch, or to the special terminal block installed on the firewall. In the case of the terminal block, the fuse will generally be mounted on the block. In case of the

ignition switch, the connection will generally be made to a stud, requiring the use of a connector and suitable hex nut, or to a screw post, which requires no additional hardware items (Fig. 325).

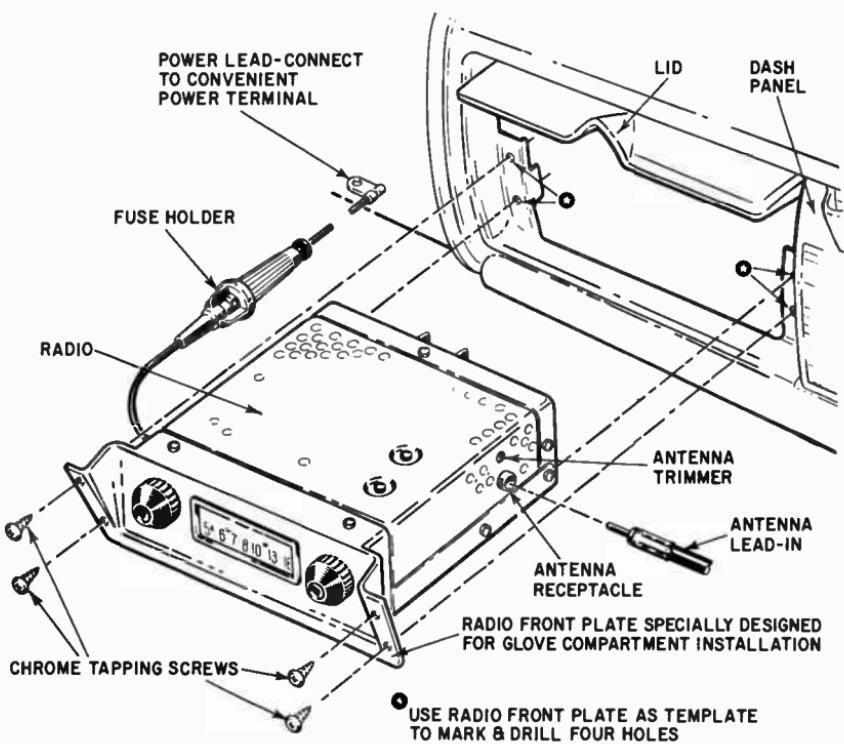


Fig. 323. Auto radio installation diagram for typical glove-compartment installation.

Check the electrical system of the auto in which the installation is to be made. The storage battery will provide the information needed. If the storage-battery terminal marked plus (+) is returned to the auto chassis, the system has a positive ground. If the terminal marked minus (—) is returned to the auto chassis, the system has a negative ground. In addition to the markings on the battery, the terminals can be distinguished by the fact that the live terminal will generally appear more encrusted with chemicals and corrosion. In cases of extreme doubt, check the polarity with a voltmeter.

Before investing in a radio for a customer, check his ammeter or generator moron meter (neon lamp) with the engine on. When

the engine is raced, the indicator should indicate charge. If the indicator indicates discharge, trouble exists in the electrical system (the battery may be reversed, generator may be dead, etc.).

Check out the electrical system in this manner before installing a radio, to prevent a callback during which accusations are made to the effect that "you ruined the car". Recommend a visit to a service station when a faulty electrical system is detected.

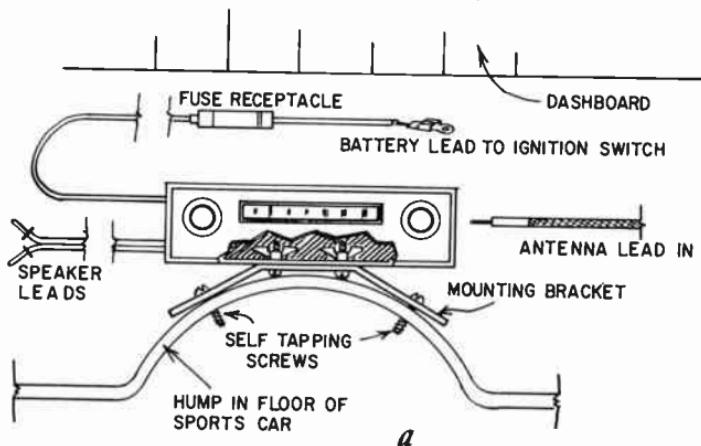
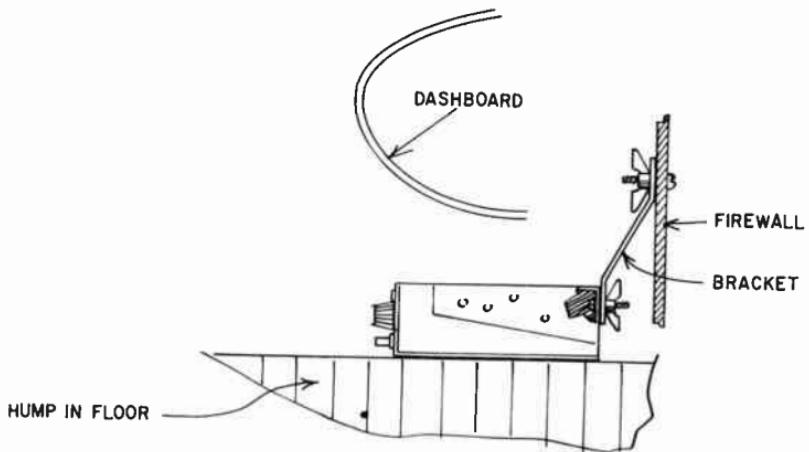


Fig. 324. Typical floor installation diagram. (a). Alternate floor plan showing radio secured to firewall (b).



b

Installation diagrams

The installation diagrams that accompany the previous discussions present a picture of the total auto radio installation, including details of all required mechanical and electrical connec-

tions. The diagrams should provide the enterprising service technician with a myriad of installation hints and kinks. Figs. 318 and 319 cover variations of the in-dash installation, while Figs. 321 and 322 cover variations of the under-dash installation. Fig. 323 shows a typical glove-compartment setup; Fig. 324, a typical floor installation. In all cases, hardware sizes will vary with the make and model of the radio.

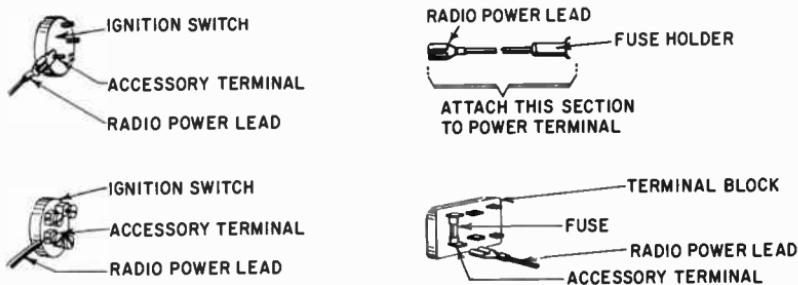


Fig. 325. Radio power-lead connecting points.

Adjusting the antenna trimmer

When the radio installation has been completed, the antenna trimmer control must be adjusted according to the following procedure if the radio is to operate satisfactorily:

1. Extend the antenna fully;
2. Tune in a weak station between the 1000-kc and 1400-kc points on the dial.
3. Advance the volume control to maximum output.
4. Using a fiber screwdriver, adjust the antenna trimmer control (Fig. 321) for maximum volume from the speaker. (In the absence of a signal, adjust for maximum background noise).

Installing interference suppressors

To assure interference-free quality audio from the new auto radio installation, various measures must be taken to suppress interference arising from operating the car. Included among these is the application of suppression devices such as capacitors at various points in the auto, including the generator armature, the coil, etc. The application of suppressors to quiet radio noise, and the general subject of interference, are covered in detail in Chapter 8.

Customer-relations check list

When the customer makes his appearance to look over your job, it is important for you to provide him with basic instructions regarding the operation of his newly-acquired auto radio. A few patient moments at this point will do much to improve relations.

Demonstrate the following features:

1. That the radio will not operate with the ignition key off; that it will operate with the key in either the accessory or ignition position.
2. That the volume of sound is lowered when the car is started (due to current drain by the starter motor).
3. The location and proper operation of all controls, including (as applicable):
 - a. on - off switch;
 - b. tuning control;
 - c. volume control;
 - d. tone control;
 - e. pushbutton tuning controls;
 - f. search tuning controls;
 - g. rear-speaker controls;
 - h. automatic antenna-elevating control.
4. Setting up pushbutton station selectors.

Removing auto radios

There is no better point at which to begin a discussion of auto radio removal than after an extended consideration of the principles underlying the installation of auto radios. For the secret behind accomplishing rapid and professional removal involves an unfaltering understanding of all the elements that play a part in the installation of the auto radio. Thus, with a knowledge of installation techniques the technician can approach a removal job with a trained eye. He will know what to look for and what to do regardless of the job with which he is particularly concerned.

The problem of auto radio removal will be considered here by first requesting that the reader familiarize himself with the installation principles set forth in this chapter. With this accomplished, apply the auto radio removal checklist that follows in performing almost any removal. Note that the checklist covers the task of removing auto radios from any of their common installation arrangements.

Auto radio removal check list

A. Electrical Disconnects Common to all Removals

1. Disconnect power lead to the auto electrical system ("A" lead).
2. Remove and check fuse. If good, set aside for reinstallation on reassembling.
3. Disconnect speaker leads.
4. Disconnect antenna lead.
5. Disconnect "B" supply leads, if any (multi-chassis radios).
6. Disconnect audio cables, if any (multi-chassis radios).
7. Disconnect ground wires between chassis, if any.
8. Prepare a simple sketch of the auto radio chassis indicating the location of electrical connecting points. (This step performed at this point will greatly assist in the reinstallation operation when the service job is completed.)

B. Mechanical Disconnects — In-Dash Installations

1. Remove control knobs.
2. Inspect the installation behind the dash to determine if any mechanical obstructions to removal are present.
3. Inspect the installation with an eye toward determining the precise techniques employed in securing the set.
4. Prepare a simple sketch indicating the basic mechanical assembly of the installation.
5. Remove or reposition any obstructions to removal that may have been detected. Repositioning is preferred to removing obstructions. (An obstruction may be repositioned by freeing it sufficiently to permit swinging it aside so that it no longer acts as a physical obstacle to the removal of the radio. The repositioned object should be secured in its new location.)
6. Loosen, uncouple and remove fastening devices such as wing nuts and bolts which secure the radio chassis or special structural members to the structures behind the dash.
7. Allow the chassis to tip back. Guide and control its fall behind the dash so as to bypass additional obstacles, and remove completely when free. Repeat for additional chassis.

8. Add to the sketch prepared for step 4 any details that will contribute to simplifying the reinstallation.

C. Mechanical Disconnects — Under Dash, Glove Compartment and Floor Installations

1. For most installations it is unnecessary to remove control knobs.
2. Loosen, uncouple and remove fastening devices as required.
3. Remove radio chassis as applicable.

installing rear speakers

THE trend toward greater luxury in American autos has brought with it a rash of gadgets as optional extras. Keen competition has succeeded in eliminating large variations in the basic price of autos, making it almost a necessity for dealers to offer and push the so-called optional extras. Among these optional extras, the rear speaker has become a sure-fire seller. Once the consumer hears one, he usually plans on an installation for his own car someday. For those who have not heard one, there is but one thing to say — they will and soon. The hi-fi rage probably has also had much to do with the promotion and sale of such installations.

Rear speakers are in demand, are relatively simple to install, and the cost of maintaining an adequate stock of different types should be within the financial reach of most serious service technicians. A typical rear-speaker installation includes the speaker (installed in the auto trunk so as to admit sound into the car through a grille on the deck at the back of the rear seat), an adequate wire run and a switching device installed in the dash within easy reach of the driver. A typical installation is shown in Fig. 401.

Guide to kits

Packaged commercial speaker kits generally include all the materials required for an average installation. Some offer only hardware and trim, less the speaker. The versatility of the rear-speaker installation is a function of the switch, and the purchase and selection of a kit should be made with an eye toward the type of switch offered. Ideally, the switch should allow for operating: the front speaker alone; the rear speaker alone; and the front and rear speakers together.

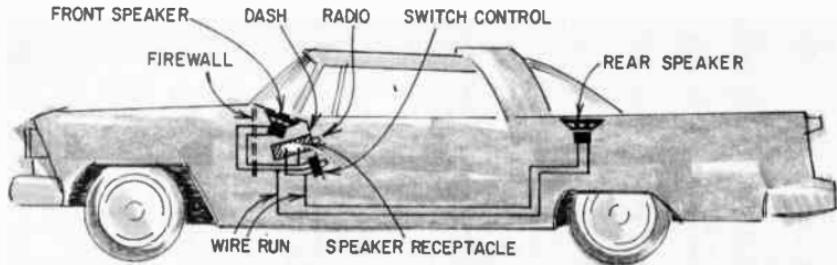


Fig. 401. Typical rear-speaker installation includes the speaker, a wire run and a switching device located in the dash.

Many packaged kits fall short of this requirement. The single-pole double-throw switch supplied in economy kits allows operation of either of the two speakers separately but not together. By

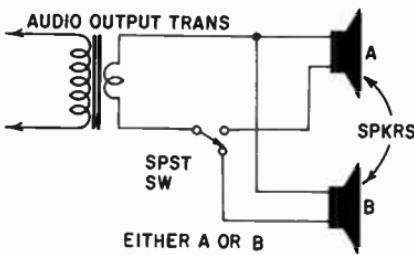


Fig. 402. Parallel-speaker arrangement whereby either A or B can be operated separately but not together.

the same token, many of the better commercial kits offer an extra not mentioned in the basic requirements above. These kits include a fader control in place of an actual mechanical switch. The fader control permits the driver to operate one speaker at a time or both at once and, in addition, permits the driver to control the fading out of one speaker in preference to the other. The fader was for many years the mark of the electronic hobbyist. It is only recently that the fader control has turned commercial.

Switching circuits

In any discussion of rear-speaker installations, it is interesting to analyze the various switching-circuit combinations that have been employed to accomplish the end result. One circuit involves

the use of a single-pole double-throw (spdt) switch installed in the common line of a parallel speaker arrangement. By this arrangement (Fig. 402), either speaker A or B may be operated but not both in combination. Another simple circuit uses parallel speakers with a single-pole single-throw (spst) switch installed

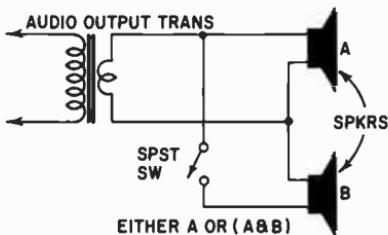


Fig. 403. In this parallel arrangement, A can be operated alone, A and B together, but B cannot be operated alone.

in the leg connected to the voice-coil terminal of one of the speakers. In this arrangement (Fig. 403), speaker A may be operated alone (when the switch is open), or speakers A and B may be operated together (when the switch is closed). Speaker B cannot be used alone.

Faders

Still simple, but a much better arrangement, is shown in Fig. 404. Here the switch is replaced by a variable resistor connected across the secondary of the audio output transformer. The speaker

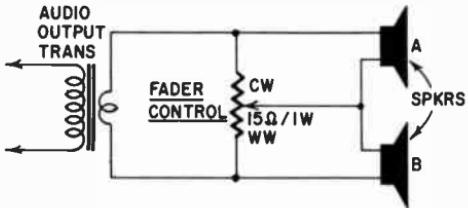


Fig. 404. Fader-control arrangement allows either A or B to be operated separately or both A and B simultaneously.

voice coils are connected in series, and the common voice-coil terminal is connected to the variable tap on the control. With the control advanced fully clockwise, the voice coil of speaker A is short-circuited, while the voice coil of speaker B is tied across the transformer secondary (and the control). Speaker B plays alone in this case while speaker A is off. With the control advanced fully counterclockwise, the reverse occurs. The voice coil of speak-

er B is short-circuited, while the voice coil of A is across the audio transformer secondary (and the control). This time, only speaker A plays while speaker B is off.

As the speaker control is rotated from one extreme to the other, both voice coils are in the transformer secondary circuit to some degree and the fader action takes place. When rotation takes place clockwise from the fully counterclockwise position, at first only speaker A plays; then speaker B begins to fade in. At the mid-point, both speakers are of equal intensity; past the midpoint, progressing clockwise, speaker A begins to fade out and speaker B gains in intensity. At the fully clockwise position, speaker A is off while speaker B is at full intensity. The same action occurs in reverse when the speaker control is advanced counterclockwise. In this case, the ideal arrangement of having *either* speaker A or B or *both* A and B operate has been met and surpassed.

In this situation, as in many others, a price must be paid. Some of the sound energy will be dissipated in the fader control. Where the car is operated sufficiently close to a broadcast station, this is of no consequence. At greater distances, the volume may drop to an unsatisfactory level. When this happens, extending the whip antenna to its full length will often bring the volume up adequately.

A somewhat more complex arrangement involving the use of a special fader control containing two variable taps is shown in Fig. 405. In this case, both speaker voice coils are in common at

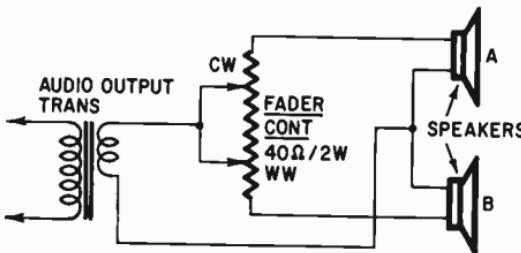


Fig. 405. More complex rear-speaker arrangement employs a special fader control having two variable taps.

one end and each are returned to a different end of the resistive speaker control. The two taps of the control are connected together and returned to the secondary of the audio output transformer. With the fader control advanced fully clockwise, the voice coil of speaker A is matched to the secondary of the audio transformer, while the voice coil of speaker B in series with the fader control

makes up a higher-impedance path. Speaker A plays at full volume while speaker B is effectively off.

As the fader is advanced counterclockwise, the overall impedance of voice coil B and the fader decreases while the overall impedance of voice coil A and the fader increases. The output

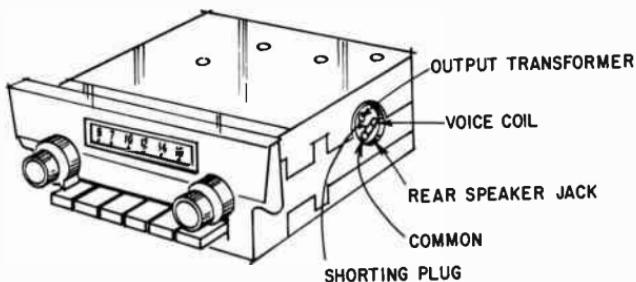


Fig. 406. Auto radio has built-in rear-speaker jack equipped with a shorting plug.

of B gains in intensity, while the output of A diminishes. At the fully counterclockwise position, the situation is the reverse of the fully clockwise condition. The impedance of voice coil B matches that of the transformer secondary and speaker B plays; while the combined impedance of the voice coil of A and the fader control is high, speaker A is effectively off.

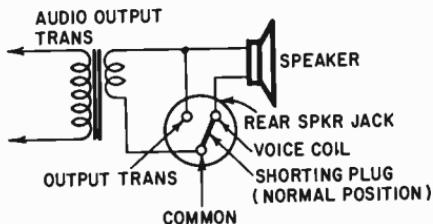


Fig. 407. Schematic diagram of audio output stage shows wiring of the rear-speaker jack and use of shorting plug.

The fader arrangements described are both recommended. The choice of one over the other should be dictated by cost factors. In general, the simpler control should cost less and would therefore be the preferable one. However, because of the popularity of rear-speaker setups, manufacturers are marketing kits containing the more complex fader control, plus a speaker and trim, at prices that often are lower than the cost of the simple control plus speaker bought individually.

Built-in facilities

In recognition of the growing demand for rear-speaker installations, auto radios in recent years have been outfitted with special

rear-speaker accessory jacks. One type of jack (Fig. 406) comes equipped with a shorting plug which must be kept in place when the radio is used without a rear speaker. When a rear speaker is installed, the shorting plug is removed and the jack alone is used to facilitate wiring the speaker and switching or fader control. A schematic diagram detailing wiring of the rear-speaker jack at the audio output stage, and the function of the shorting plug for the case described, is shown in Fig. 407. The switching

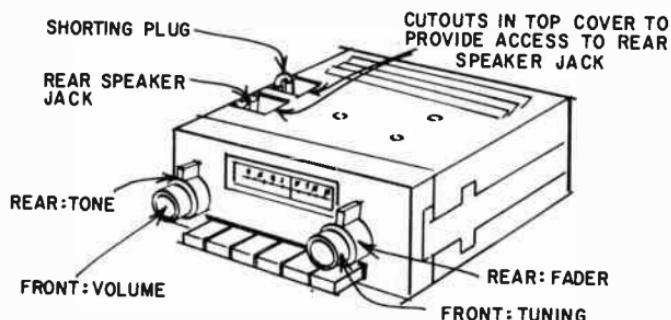


Fig. 408. *Typical radio with built-in fader control and rear-speaker jack with shorting plug.*

circuit diagrams of Figs. 402 through 405 should be used as guides to installing the rear-speaker system.

In deluxe auto radio models, in addition to a rear-speaker jack, a built-in fader control accessible at the front panel is provided. A typical radio with a built-in fader control and rear-speaker jack is shown in Fig. 408. In deluxe models with built-in faders, the rear-speaker shorting plug serves its most important function by simplifying the wiring needed for installation.

The circuit of a typical audio output section, showing the function of the shorting plug before the rear speaker is installed, is shown in Fig. 409-a. Note that the plug bypasses the built-in resistive fader control. With the plug removed and the fader turned fully counterclockwise, the speaker will operate normally. With the control advanced clockwise, the speaker operates normally at reduced volume. In effect, the shorting plug is being held in reserve for use when the second speaker is installed. At that time, the shorting plug is moved into the position shown in Fig. 409-b. The terminals that formerly held the shorting plug are now used as the tie points for the leads from the voice-coil terminals of the rear speaker. The shorting plug, in other words, ties the fader control into the circuit.

Before proceeding with a rear-speaker installation, inspect the

existing auto radio and, if possible, consult manufacturers' data to determine whether built-in facilities to accommodate a rear speaker exist. Don't overlook the possibility that they might. The customer who later discovers facilities *you* have overlooked may be a lost customer, as far as future business goes.

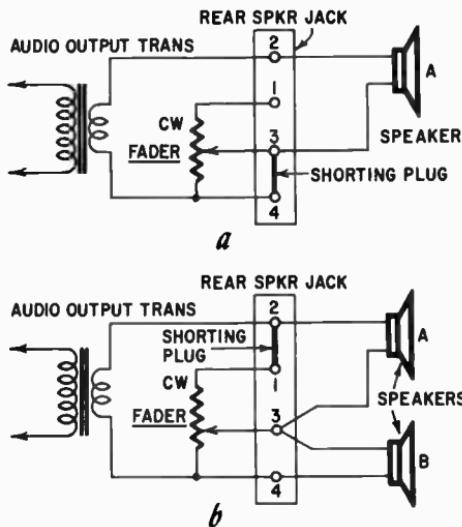


Fig. 409. (a) Audio output circuit shows function of shorting plug before rear speaker is installed. (b) Shorting plug is moved into position when rear speaker is installed.

Installation techniques

The job is relatively simple once the type of installation is decided upon. The rear-speaker kit generally comes equipped with various trim plates and grilles and other hardware to enable the technician to come up with a truly professional installation. The fader control or switch should be mounted in a suitable position on the dash within reach of the driver. When the radio is installed under the dash, the speaker control can often be attached to the radio itself. Frequently, a section of universal slotted bracket of the type used in securing the radio to the firewall can be employed successfully in mounting the speaker control.

As mentioned earlier, the speaker is generally installed in the trunk of the car. It is secured to the deck at the top rear of the trunk, so as to face into the auto cabin through the deck in back of the rear seat. Cutting into the deck can be a sloppy task, but excellent results can often be obtained by drilling a series of $\frac{1}{4}$ -inch holes in a regular pattern in the deck. If these holes are well

planned and neat, they can often substitute for a grille. Attach the speaker using trim as required. Run the required speaker lead wire under the floor covering to the front of the auto, make the required connections at the fader and front speaker, and solder.

Caution: When connecting rear speakers, never use the frame of the auto as one side of the line. Always use zip cord, lamp cord or other suitable twin lead to make an isolated connection to the speaker voice-coil terminals.

Also, when installing a rear-seat speaker, make sure that you have air pressure vent holes in the deck to prevent cone rupture when the trunk is closed.

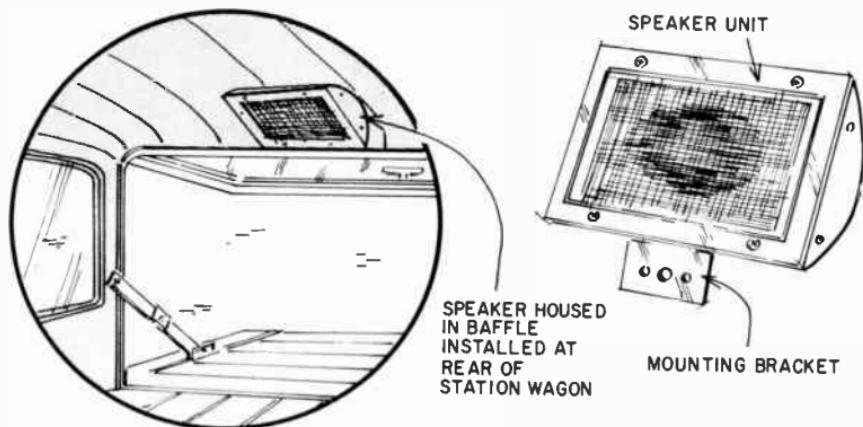


Fig. 410. The rear-speaker unit for a station wagon comes equipped with a mounting bracket.

Station wagon and truck rear-speaker installation

Special rear-speaker kits are available for station wagons. In general, the speaker in these kits is housed in a small baffle outfitted with a mounting bracket for installation at a convenient point at the rear of the wagon (Fig. 410). Placement will generally be determined by the tailgate design. Station-wagon speaker kits are easily applied in standard truck speaker installations, which often require the use of a separately-baffled speaker located outside the dash.

troubleshooting and repair

TIME is of the essence in servicing auto radios, perhaps more so than in other types of service operations. Only by keeping the time factor to a minimum can you expect to charge rates that will enable you to compete successfully in this field. In addition, quick servicing establishes customer confidence in you and your operation. Your best customers will, as usual, be those who were referred by people for whom you were able to provide effective rapid service in the past.

Rapid servicing can be accomplished only if problems brought to you are approached with a definite plan in mind. As in many other service operations, symptoms observed by the customer are often the starting point. In general, it will be best to verify the customer's story by checking to see if you observe or hear the same symptoms.

Thousands of words can be written on troubleshooting auto radios (and may yet be), but words are no substitute for clear thinking, good judgment and sound deductions made by the service technician. This text will therefore not attempt a cure-all but rather will offer a program to provide the technician with a logical basis for his servicing operations.

Servicing program

The servicing program advocated herein divides servicing into two parts — troubleshooting and repair. Troubleshooting includes those operations necessary to locate the exact fault causing trouble. Repair includes whatever is required to clear the trouble and return the equipment to normal operation.

The procedure to be presented requires a firm knowledge of radio fundamentals on the part of the technician. To fill any gaps

in this area, the paragraphs that follow discuss, on a block-diagram level, first, a typical AM superheterodyne auto radio receiver; then, the differences between AM and FM receivers.

The AM superheterodyne auto radio

Fig. 501 is a block diagram of a typical AM superheterodyne auto radio. The major sections include the radio frequency (rf), the intermediate frequency (if), the audio frequency (af) and the power functions. The stages that make up each of these include: antenna, rf amplifier, tuner and converter in the rf function; if amplifiers and detector-avc stage in the if function; first audio amplifier and speaker in the af function; and the primary and secondary power sources in the power function.

The component parts that make up the individual stages (not covered in this block-diagram discussion) include tubes, transistors, resistors, capacitors, transformers and other circuit building blocks, all of which are subject to failure.

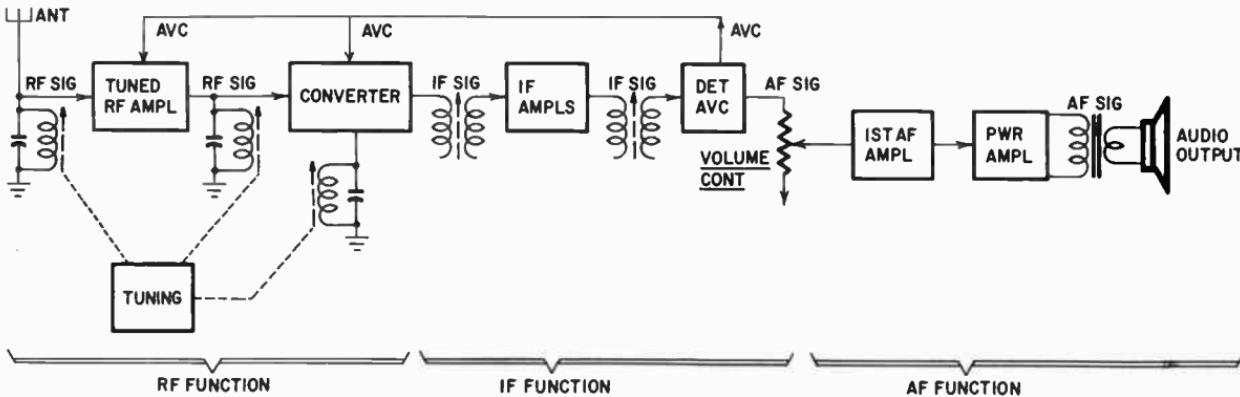
The broadcast signal consists of audio information or program material amplitude-modulated on a carrier in the frequency range from 540 to 1600 kilocycles. This desired signal is said to be at radio frequency and is often referred to as the rf signal. In AM broadcasting, it is vertically polarized. (In commercial FM and in television, the rf signal is horizontally polarized).

AM operation

The vertically-oriented auto radio antenna (usually adjustable) mounted where it is fairly free and clear of the metal auto body, picks up the small rf signal, whose power is on the order of microwatts. The antenna couples the signal to the first stage in the radio receiver, a tuned radio-frequency amplifier. The tuned circuit at this stage selects the narrow rf band assigned to a single station and rejects all other available bands. This action improves the overall selectivity of the receiver. The rf amplifier builds up the level of the selected signal and couples the signal via additional tuned circuits to the converter stage. The tuned circuits used in coupling again aid in improving receiver selectivity.

The converter, a single-stage local oscillator and mixer, converts the rf signal to an intermediate-frequency (if) signal. The program information remains unchanged during conversion and is amplitude-modulated on the if signal. The if signal is usually the difference frequency between the rf signal and the local oscillator signal (it can also be the sum frequency).

BROADCAST SIG INPUT



FROM AUTO ELECTRICAL SYSTEM LOW VOLTAGE DC (PRIMARY POWER) **DC-TO-DC CONVERTER** HIGH VOLTAGE DC TO CONVENTIONAL (SECONDARY POWER) TUBE STAGES

FROM AUTO ELECTRICAL SYSTEM LOW VOLTAGE DC (PRIMARY POWER) TO HYBRID TUBES & TRANSISTOR STAGES

PWR FUNCTION

Fig. 501. Block diagram of AM superheterodyne auto radio.

The local oscillator tank circuit is ganged to the tuned circuits that select the single broadcast station. The oscillator frequency is thus changed automatically as different stations are tuned. The object of this action is the underlying principle of the superheterodyne receiver: the if signal developed is always maintained at the same frequency even though each broadcast station is at a different frequency. In AM receivers, the if is usually set at 262 kilocycles.

Thus, the tuned circuits in the if amplifier stages that follow the converter need only be fixed-tuned to the intermediate frequency. The fixed-tuned circuits in the if stages make the major contribution to the selectivity of the receiver, since they can be critically peaked to pass only the narrow desired signal band. The if amplifiers build the desired signal to a still higher level. The output of the if amplifiers is fed to the detector stage, which demodulates the audio program information from the carrier.

The modulated if is rectified, filtered and fed back to the rf and if stages as an automatic volume-control (avc) signal. The avc signal controls the gain of the rf and if stages in an attempt to maintain the volume of the radio output constant under conditions where the received rf signal may be varying in strength. In addition, the avc signal succeeds somewhat in maintaining a constant volume out of the speaker for a given volume-control setting as the radio is tuned from station to station of different signal strength.

The audio frequency (af) signal separated at the detector stage is fed to the first af amplifier, where the audio signal is built up to drive the audio power output amplifiers. These amplifiers feed the audio output transformer, which matches the impedance of the amplifiers to the speaker voice coil for maximum power transfer. The speaker output level is controlled by the volume control at the first audio amplifier stage.

Primary power for the auto radio is generally supplied by the car's electrical system. In sets with conventional tubes, low-voltage primary power is stepped up to a usable value by a suitable dc-to-dc converter stage. In hybrid and all-transistor sets, the available low dc primary voltage is used to power the radio.

The FM superheterodyne auto radio

Fig. 502 is a simplified block diagram of a typical FM superheterodyne auto radio. The major sections duplicate those found in the AM radio of Fig. 501. The details of the if function are

notably different in the following respects: the FM set contains a limiter stage not found in the AM set; and a frequency discriminator is used in the FM set in place of the amplitude detector in the AM set.

FM operation

The FM broadcast signal is horizontally polarized and lies in the frequency band from 88.1 to 107.9 mc. As a result, the FM set requires a somewhat different antenna from the one suited for AM reception. In addition, separate local oscillator and mixer

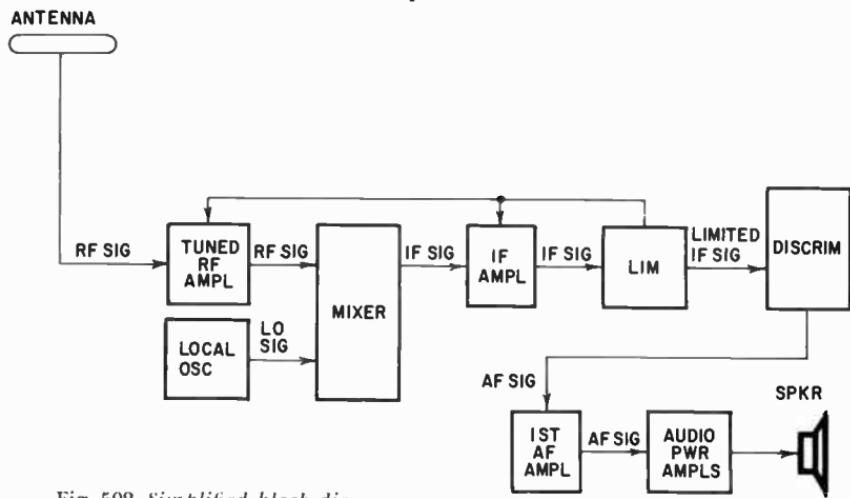


Fig. 502. Simplified block diagram of a superheterodyne FM auto radio.

stages are used in the FM receiver in place of the single converter stage of the AM set. Otherwise, reception, tuning and amplification up to and including the second if amplifier stage, are identical to the case of the AM set. The output of the second if amplifier in the FM set is fed to the limiter stage. The limiter is an overdriven amplifier (cutoff and saturation) which acts to reduce or eliminate amplitude variations in the FM signal. This action minimizes the effects of noise and fading in the signal appearing at the output of the discriminator. As such, the limiter is a very important stage in the FM auto radio, since the automotive environment is particularly offensive with respect to AM noise and fading. The output of the limiter is fed to the discriminator, a detector stage which demodulates the frequency varia-

ions in the received signal to yield the desired audio signal. In some sets, a ratio detector circuit is used in place of the discriminator to demodulate the received signal. The avc and audio amplifier stages of the FM set are identical in function to similar stages found in the AM receiver.

Troubleshooting

Troubleshooting has always been an art at which only the technician with a vast backlog of experience has been able to excel. Though there will always be room for the expert, and troubleshooting will remain an art, there is an approach to troubleshooting that attempts to employ a scientific method that enables even the inexperienced to locate faults. This approach casts aside the routine methods of locating troubles offered for the inexperienced technician and instead depends on his understanding of basic theory and his deductive powers to locate troubles rapidly.

The scientific method of troubleshooting, stated in its basic form, involves a discrete program for narrowing down the cause of trouble in a given equipment first to a major function, then to stage and finally to a faulty component. Of course, the last of the three procedures is the most important, since it is the individual component that is actually subject to failure. The scientific method *does not* require that all problems involve the application of all three operations.

The preferred approach instead involves isolating a faulty component as quickly as possible. Often, a cursory examination will lead immediately to the faulty component, as in the case of a burned resistor which may be detected by sight and smell. More often, trouble will not be as apparent, but with time and experience the technician can pinpoint many common faults by their symptoms with a high degree of accuracy. However, until the day experience can be brought to play in troubleshooting, the method to be prescribed should provide for the rapid location of most conventional troubles.

Program for auto radios

A two-part approach to troubleshooting auto radios is advocated as an aid to speeding up the process of isolating trouble: the in-place and at-the-bench programs. The in-place troubleshooting program offers the technician a systematic approach to checking out auto radios by isolating troubles to defective parts without removing the set from the auto. When trouble isolation cannot

be accomplished with the radio in-place, it must be removed and brought to the bench for servicing. The bench troubleshooting program picks up the problem at this point and offers the technician information on the bench servicing setup and provides a method for rapidly isolating troubles at the bench.

In-place troubleshooting

The following check list should be applied to all in-place troubleshooting operations:

1. Is the car's electrical system functioning properly?
 - a. Charge indicator (lamp or meter) should indicate "charge" with engine racing and all electrical accessories off.
2. Is the trouble in the primary power-distribution system?
 - a. Headlights, taillights, cigarette lighter and other accessories should be operating properly.
3. Is power getting to the auto radio?
 - a. Check connection of the hot lead at the ignition switch.
 - b. Check the fuse in the line between the ignition switch and the power input plug to the radio.
 - c. Dial indicator lamp must light.
 - d. Tubes (if any) must light or heat.
 - e. Check whether power transistors (if any) heat (normal).
 - f. Check whether voltage amplifier transistors (if any) heat up (abnormal).
 - g. In dual-chassis sets, check that all interchassis connections are secure.
4. Is the antenna functioning properly?
 - a. Check the connections of the antenna lead-in at the radio chassis.
 - b. Check condition of the mechanical connection of the antenna unit to the auto body. If evidence of damage by wear or corrosion is present, disconnect the existing antenna and replace with a substitute test antenna and again try the radio.
5. Is (are) the speaker (s) functioning properly?
 - a. Check the connection to the speaker.
 - b. Check connections to rear speaker (if any).
 - c. Check connections at rear-speaker switch or fader controls.

6. Is vibrator buzz audible at characteristic low level (vibrator powered radios only)?
 - a. Check accessibility of vibrator. (Since the vibrator has an extremely high failure rate, most manufacturers take this into account and design their sets to make the vibrator easy to get at and replace.)
 - b. Replace vibrator with a unit known to be in good working order. *CAUTION:* A defective buffer capacitor in the power supply will cause premature failure of the new vibrator. If the customer says he has had trouble recently with the vibrator, the buffer capacitor will probably have to be replaced. If vibrator trouble is occurring for first time, it should be possible to replace vibrator unit without replacing the buffer capacitor, without endangering new vibrator. In older radios with a history of vibrator failure, a new buffer capacitor must be installed before vibrator replacement is attempted. *NOTE:* the capacitance and working voltage value of the buffer capacitor is critical. Always install an identically rated replacement unit.
7. Are all accessible tubes operating properly?
 - a. Remove one tube with power off and replace with a known good tube. Reapply power. Check set for normal operation. Repeat this procedure one tube at a time until all tubes are accounted for, or until a faulty tube is found and trouble is cleared. Return all original tubes to their sockets at completion of each separate test operation.
8. Are interference suppressors functioning properly?
 - a. Check for presence of suppressor components at generator, coil, voltage regulator, etc.
 - b. Check connections of suppressor components.

Bench troubleshooting

When trouble in the auto radio cannot be isolated with the set in place, the radio must be removed from the car and brought to the bench for further troubleshooting. For removal hints and kinks refer to Chapter 3, which covers installations. In general, removals may be accomplished by reversing the installation procedure.

The bench troubleshooting procedure recommended consists of a planned systematic program designed first to localize trouble

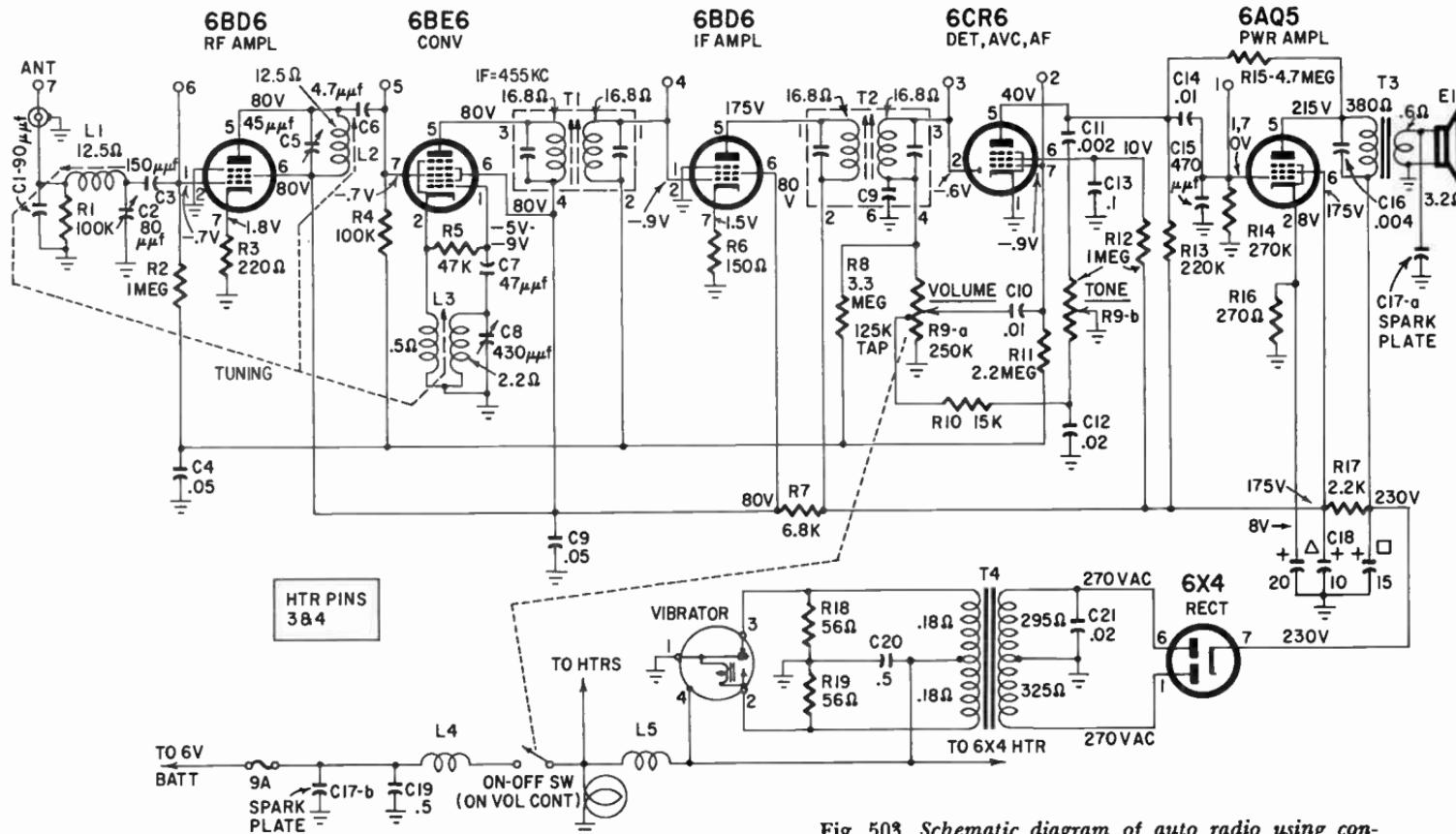


Fig. 503. Schematic diagram of auto radio using conventional tubes and vibrator power supply.

to a stage, and finally to isolate trouble to a defective component. In general, the program advocates using the signal-injection technique for localizing trouble, measuring voltage and resistance at all key points for isolating trouble.

To implement the bench troubleshooting program, schematic diagrams (Figs. 503 through 509) covering the gamut of auto radios, have been incorporated into this text. These schematics should be of great help in the majority of situations the technician will find himself faced with in actual practice. However, for the tough sets that defy the techniques described here, it will be necessary to obtain the service manual covering the specific make and model of the radio being tackled. Often a manufacturer comes up with a novel way of doing things that can be understood only by studying the special service notes that usually accompany the introduction of new circuits. In addition, the manufacturer's service manual is almost a must in cases where wiring and interconnections cannot be followed in the set because printed wiring and other specialized construction is used.

Bench servicing setup

The bench servicing setup for auto radios is shown in Fig. 510. It is important that each of the items in the check list that follow be accomplished before proceeding.

1. Determine the operating voltage requirements of the radio to be worked on, and adjust the battery eliminator for either 6 or 12 volts. (If a storage battery is used, set up the battery leads to provide required output). *Caution*—Use only a low-ripple battery eliminator with hybrid and all-transistor radios.
2. Determine whether the radio's ground is to be returned to the positive or negative power supply terminal. If there is any doubt, recheck the auto from which the radio was taken. If there is a schematic for the set in the shop file, check that. In an event, guessing is not good enough. You *must* know before proceeding.
3. When setting up universal radios containing a polarity-reversing device, adjust the device to place the isolated inner chassis at common or ground potential with respect to the bench setup (Remember to readjust the polarity-reversing device, if necessary, before reinstalling the set in the auto).
4. Install a common or ground return lead from the radio chassis to the positive or negative terminal, as determined, of the battery eliminator or battery. Remember that in the car, except for

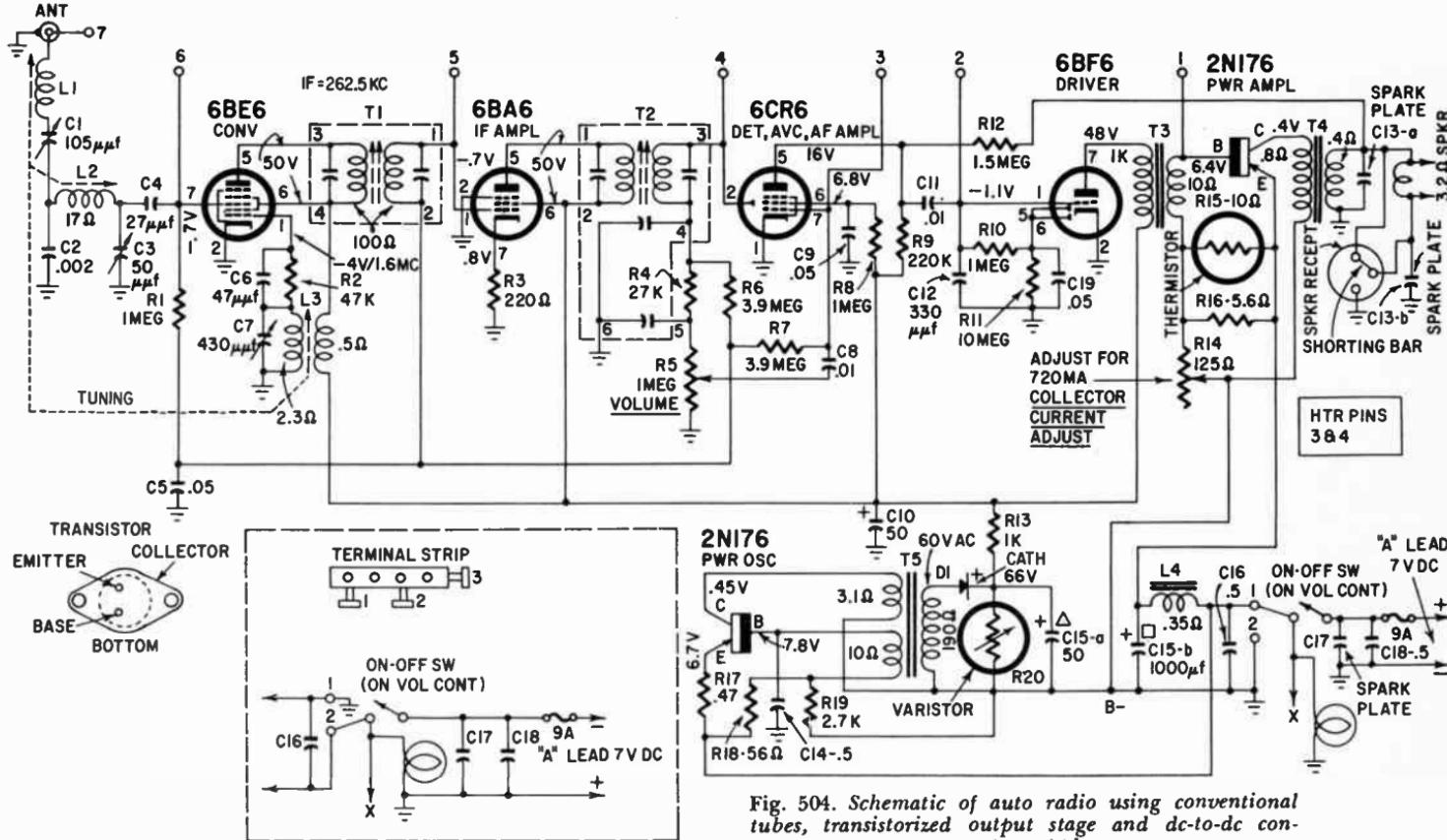
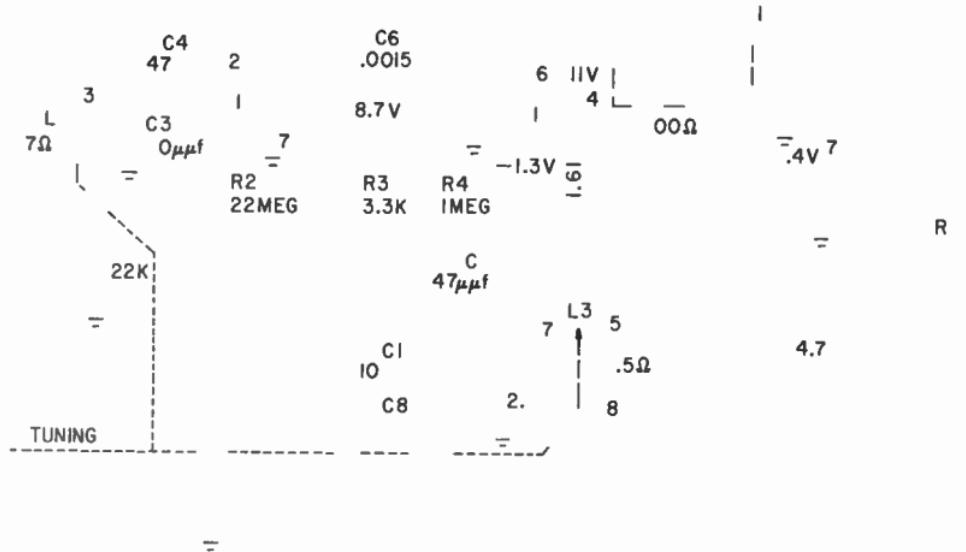


Fig. 504. Schematic of auto radio using conventional tubes, transistorized output stage and dc-to-dc converter supply.



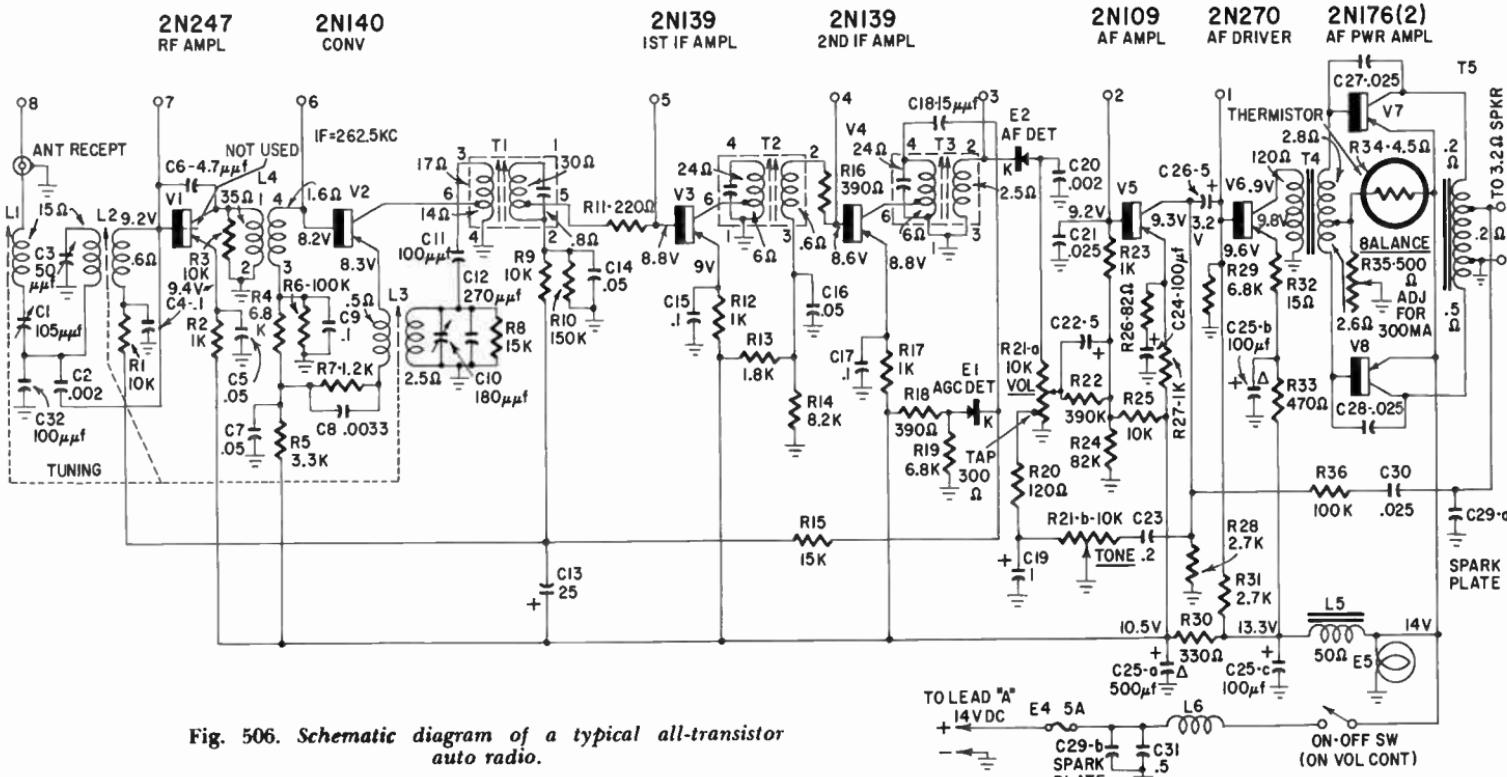


Fig. 506. Schematic diagram of a typical all-transistor auto radio.

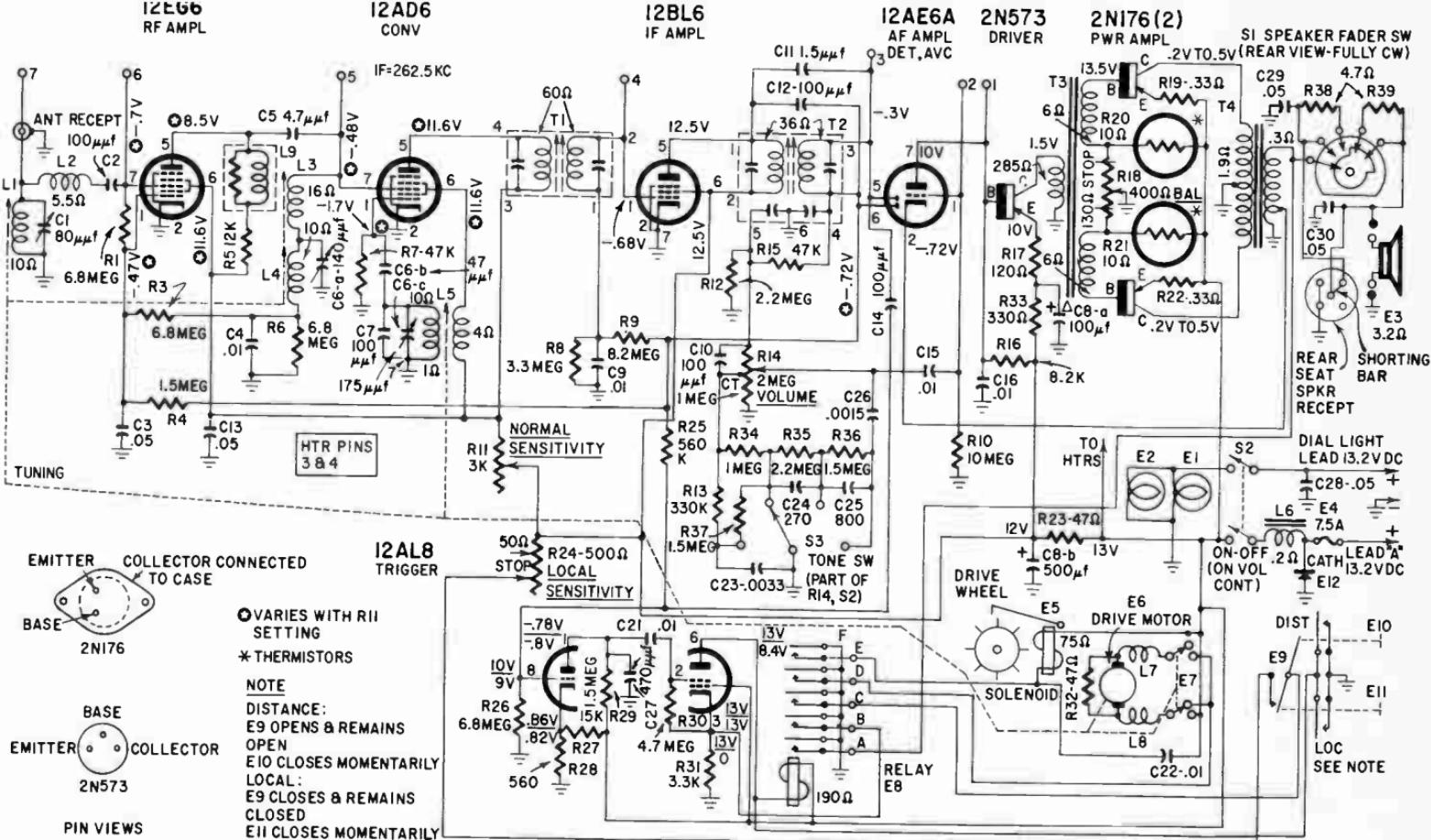
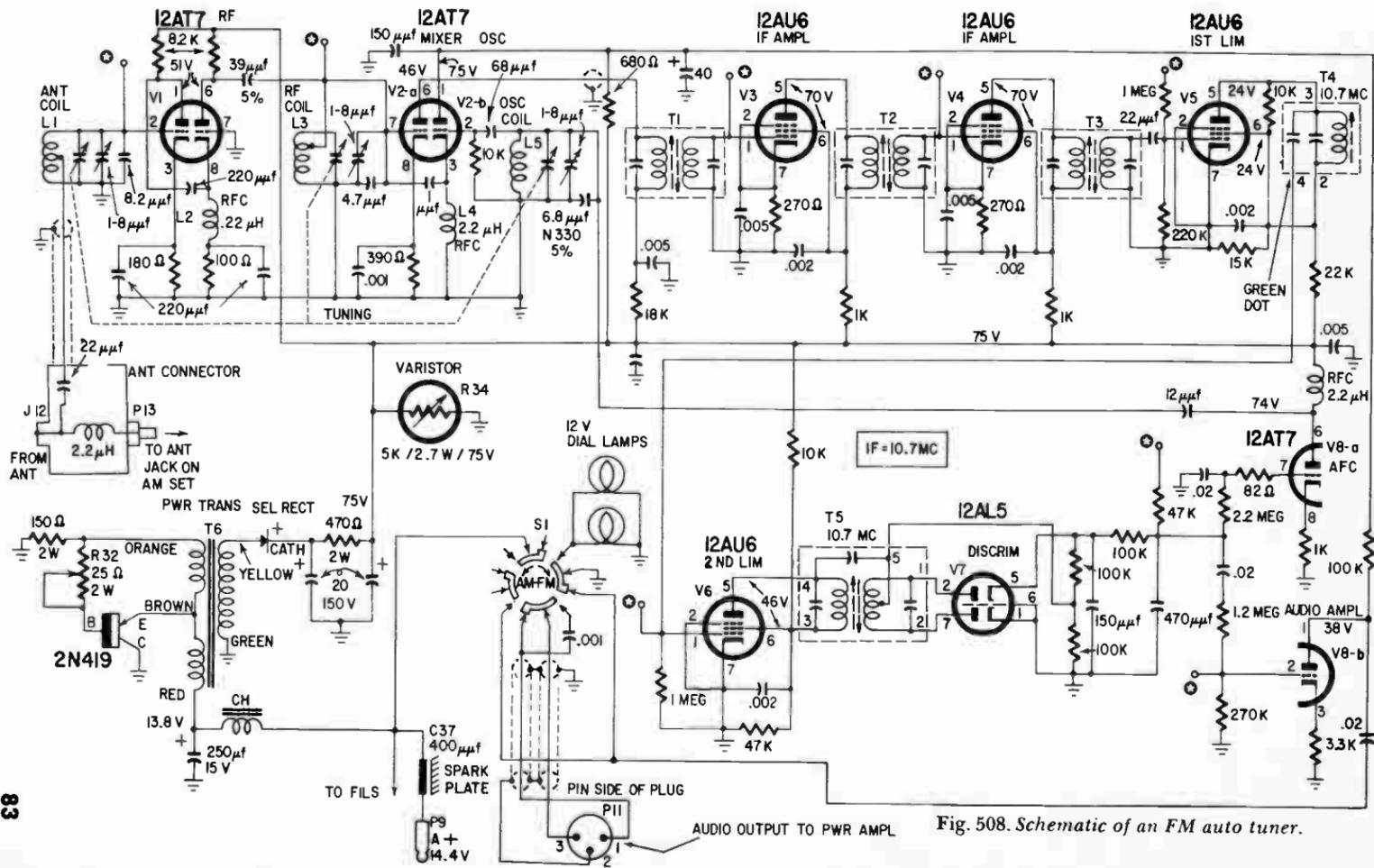


Fig. 507. Schematic diagram of a hybrid auto radio having a search tuner and push-pull output stage.



universal models with isolated common chassis, this ground return was provided by the mechanical connections between the radio and the auto chassis.

5. Install a ground lead between the chassis of ac-operated test equipment (a vtv) to be used and the radio chassis.

6. Connect a matching speaker to the speaker output terminals. Adjust rear-speaker shorting plugs, if any, to account for operation with one speaker. Adjust built-in fader controls accordingly.

7. Connect an antenna or dummy antenna (see Fig. 510) to the antenna input terminal.

8. In two-chassis sets, be sure to cable the chassis as required. Add an external ground wire to connect the two chassis.

9. Check that the ON-OFF control is off. Then connect the power lead to the selected side of the battery eliminator or battery. Do not forget to install the fuse in series with this line. This fuse should be the same size used in the auto.

Localizing trouble to a defective stage

Use the signal injection method in localizing troubles to a defective stage. In hybrid and all-transistor sets, the noise generator, in conjunction with the signal tracer described in Chapter 2, are recommended as a signal source and indicator. They are portable and considerably less complicated to use than the average signal generator and oscilloscope combination. In tube sets, signal injection may be accomplished by pulling a tube from its socket while power is applied and then replacing the tube. This action produces an arc as power circuits are broken. The arc introduces a signal into the radio circuits which acts exactly like a noise signal that is introduced by other means.

Caution: Transistors used in auto radios are vulnerable to the shock that can be incurred by large voltage transients. Although the "pull-to-arc" method of localizing trouble has been recommended for certain industrial and military equipment employing advanced transistor types, avoid this method when troubleshooting auto radios.

Localization should consist of a checkout of the receiver using the signal injection technique, until the defective stage is pinpointed. Recommended test points for signal insertion are called out on the servicing schematic diagrams (Figs. 503 through 509). In general, the trouble will be in the stage associated with or immediately following the check point where the injected signal is lost. On some occasions, particularly in the case of shorted

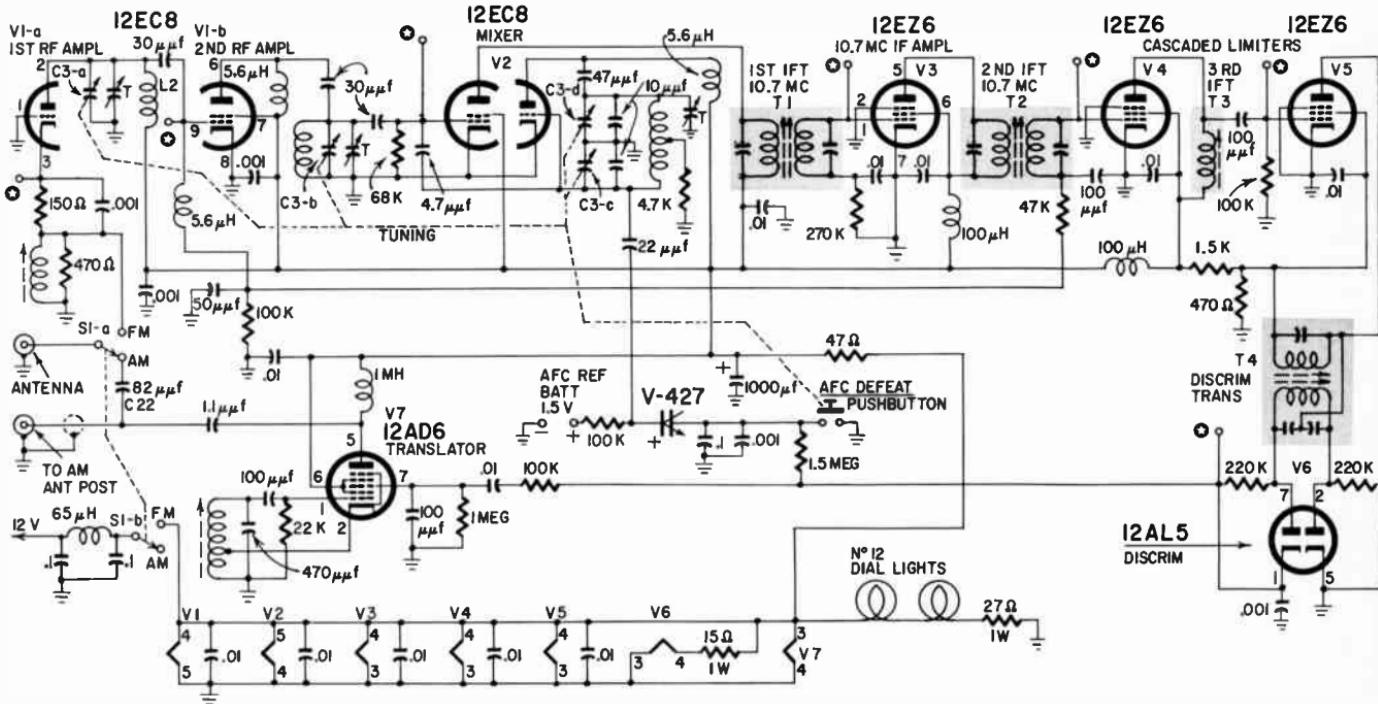


Fig. 509. Schematic of FM converter
for use with an AM auto radio.

components, the trouble will be found in the stage immediately preceding the test point where the signal is being lost.

Detailed localization procedure

A detailed localization procedure for the classic generalized case of a dead receiver is given in Table 5-1. Since actual practice has demonstrated that in transistor auto radios, the dead set is a very common symptom, the generalized case actually becomes the specific for a majority of troubles arising in these receivers.

The procedure is predicated on use of the noise generator and signal tracer to localize trouble to a single defective stage. Multiple troubles may be solved by applying the table, but the intent is

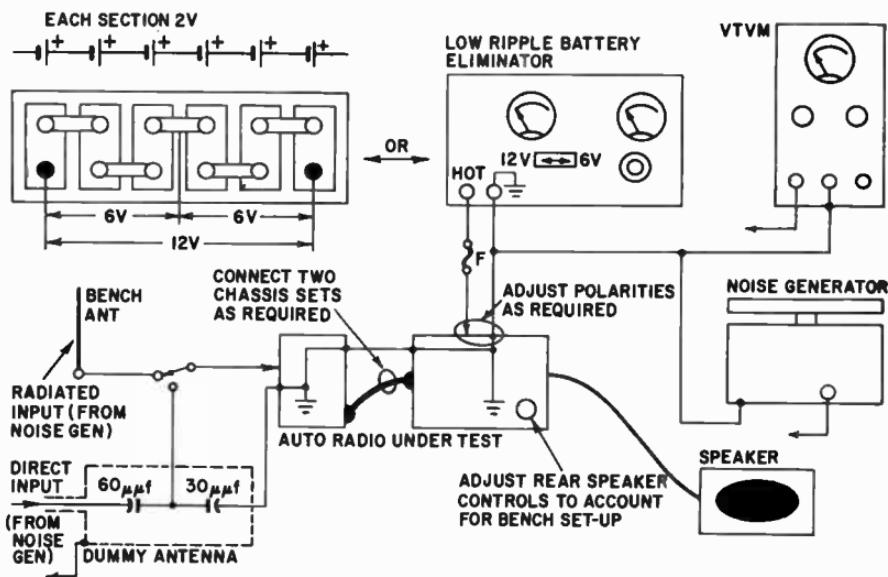


Fig. 510. Bench setup for servicing auto radios.

the solution of single failure trouble. In general, a stage begins at one input point and ends at the input point of the next stage. All parts that fall between these limits are considered part of the same stage.

Before Table 5-1 can be brought into play, check the power supply for normal operation with the aid of a voltmeter, since power supply troubles common to several stages are *not* covered by the table.

The table is designed to help the technician localize trouble using a minimum number of steps. Toward this end, trouble is

Table 5—1. LOCALIZING TROUBLE TO A DEFECTIVE STAGE IN A DEAD AUTO RADIO

Step	Symptom	Probable Cause of Trouble	Remedy
1.	With high-level noise generator signal radiating in vicinity of radio's antenna, no signal at input of 1st audio amplifier (driver)	Antenna Rf amplifier Converter 1st if amplifier 2nd if amplifier Detector	Check input to 1st if amplifier. (refer to steps 3 and 4).
2.	Signal present at input of 1st audio amplifier	1st audio amplifier Audio power amplifier Speaker	Check input to audio power amplifier. (refer to steps 5 and 6).
3.	No signal at input of 1st if amplifier	Antenna Rf amplifier Converter	Apply low-level noise generator signal directly to rf amplifier input and recheck input to 1st if amplifier. (refer to steps 9 and 10).
4.	Signal present at input of 1st if amplifier	1st if amplifier 2nd if amplifier Detector	Check input to detector. (refer to steps 13 and 14).
5.	No signal at input of audio power amplifier	1st audio amplifier	Isolate trouble to defective part in 1st audio amplifier stage by performing voltage and resistance measurements.
6.	Signal present at input of audio power amplifier	Audio power amplifier Speaker	Check output of audio power amplifier. (refer to steps 7 and 8).
7.	No signal at output of audio power amplifier	Audio power amplifier	Isolate trouble to a defective part in the audio power amplifier stage by performing voltage and resistance measurements.
8.	Signal present at output of audio power amplifier	Speaker	Check wiring and speaker voice coil. Repair wiring or replace speaker, as required.
9.	Still no signal present at input of 1st if amplifier	Rf amplifier Converter	Return noise generator to radiated output condition and check signal input to converter. (refer to steps 11 and 12).
10.	Signal present at input of 1st if amplifier	Antenna	Check antenna and associated wiring. Repair wiring or replace antenna as required.
11.	No signal at signal input terminal of converter	Rf amplifier	Isolate trouble to a defective part in the rf amplifier stage by performing voltage and resistance measurements.
12.	Signal present at signal input terminal of converter	Converter	Isolate trouble to a defective part in the converter stage by performing voltage and resistance measurements.
13.	No signal at input of detector	1st if amplifier 2nd if amplifier	Check input to 2nd if amplifier (refer to steps 15 and 16).

14.	Signal present at input of detector	Detector	Isolate trouble to a defective part in the detector stage by performing voltage and resistance measurements.
15.	No signal at input of 2nd if amplifier	1st if amplifier	Isolate trouble to a defective part in the 1st if amplifier stage by performing voltage and resistance measurements.
16.	Signal present at input of 2nd if amplifier	2nd if amplifier	Isolate trouble to a defective part in the 2nd if amplifier stage by performing voltage and resistance measurements.

first sectionalized to either the rf, if or af section, (see the block diagrams of Figs. 501 and 502), and then localized to a stage within a particular section.

The generalized procedure is applicable to the case of the FM receiver, even though the table as shown applies directly to the AM set. In troubleshooting FM sets, assume the limiter stage to be an additional if stage.

Isolating trouble to a defective component

Once trouble has been localized to a particular stage, isolation of a component can be accomplished through voltage and resistance measurements made at key points in the stage. Specifically, check voltages in divider networks that establish critical bias and other potentials for key points. Follow voltage measurements with resistance measurements (power off!) as required.

Detailed isolation procedure: voltage measurements

Make all voltage measurements with a high-impedance vacuum-tube voltmeter to minimize circuit loading by the meter. Circuit loading is the condition in which a relatively low-impedance meter draws current from the circuit under test to produce a meter reading that is lower than the actual voltage in the circuit under test. In the relatively low voltages and currents encountered in hybrid and all-transistor radios, circuit loading is a special nuisance.

When measuring voltages in universal auto radios designed for use with positive- or negative-ground power supplies, be sure to connect the voltmeter between the point at which voltage is to be measured and the true reference point for that voltage. In many cases, the true reference will be the isolated chassis or bus wire rather than the outside chassis.

Use extra care when checking voltages in hybrid and transistor sets to avoid accidentally shorting voltage points to ground.

Transistors are vulnerable to the voltage transients formed by the arc generated under these conditions. In addition, such short circuits often result in the temporary removal of protective biases (in transistor power circuits especially), causing excessive current to flow through the transistors and driving them to premature failure. Wrap the conducting tip of the voltmeter (and other) test prods with insulating tape so as to expose only the shortest tip necessary when probing in transistor circuits.

Voltage measurement in transistor circuits

In servicing tube circuits, every technician is aware of the polarity of the voltage to be expected at key points. For example, in conventional amplifier circuits, the voltage at the cathode that is returned to ground through a resistor is positive with respect to ground, as is the plate voltage. The technician even has an idea as to the value of the plate voltage to expect, since he has probably read the B-plus voltage applied to the stage in question. He then reasons that if the stage is cut off, he should read full B-plus at the plate; if the stage is conducting, he should read some positive value below B-plus. By the same token, he knows that operating bias for amplifier stages, for example, is of negative polarity of a relatively low-voltage value.

Since transistor circuits are new, and there are two distinct types of transistors that are the opposite of each other in terms of voltage polarities required for operation, some transistor servicing data will be detailed here to aid the technician meeting transistors for the first time in his experience with auto radios.

Transistors are either p-n-p or n-p-n. N and P refer to the electrical character of the semiconductor material used in their makeup. (This discussion applies only to junction transistors. Point-contact transistors have found no application in auto radio circuits). The transistor used in auto radio circuits is almost always a three element device, containing an emitter, base and collector (roughly analogous to the cathode, grid and plate of the triode electron tube). N-p-n transistors are complementary to p-n-p transistors and actually require voltages of exactly the opposite polarity for their operation. The actual polarities to be found in normal operation of p-n-p and n-p-n transistors are detailed in Fig. 511.

Locating and identifying transistor electrodes

In checking voltages at tube pins, the technician must often

refer to a tube basing diagram to locate the various elements. Or he can trace the circuit in the set to determine the pin numbers for the elements of interest. In checking voltages at transistor elements, the technician will have to check in a suitable transistor data chart the transistor type: (n-p-n or p-n-p),

	PNP			NPN		
POLARITY WITH RESPECT TO:	E	B	C	E	B	C
EMITTER	+	+		-	-	
BASE	-	+	+		-	
COLLECTOR	-	-		+	+	

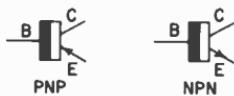


Fig. 511. Electrode polarities encountered in normal operation of p-n-p and n-p-n transistors.

and the identity of the leads or pins. Since the transistor is a relatively simple device, manufacturers have standardized lead placement to aid in rapid identification of the transistor elements. In transistors whose three leads lie in one plane and are unequally spaced as shown in Fig. 512, the base is always the center lead, while the lead farthest from the base is the collector and the lead close to the base is the emitter.

In transistors whose leads are spaced so each is at the apex of an equilateral triangle, there will be a colored dot (generally red) on the body of the transistor (Fig. 512). The lead closest to the dot is the collector. Viewing the bottom of the transistor and reading counter-clockwise as in reading tube pins, the emitter and base may be identified in that order.

Common-electrode voltage

The transistor is referred to as a current-operated device, as compared to the electron tube which is considered to be voltage-operated. In evaluating electron-tube circuits, the technician is interested in such factors as bias (grid-to-cathode voltage) and plate voltage (plate-to-cathode voltage). In transistor work, the base, emitter and collector currents are the equivalent items of interest. Measuring current in service operations has always been a problem because a circuit must be opened to accommodate the required ammeter. To offset this difficulty, Ohm's law has come to the rescue. By reading the desired transistor currents as a voltage across a resistor in series with the path of the currents, the entire operation can be performed with a voltmeter without the necessity of opening circuits.

Of three basic transistor circuit configurations in general use,

the most popular in radio circuits is the common-emitter circuit, in which the input signal is applied between base and emitter and the output signal is taken between collector and emitter. Since the

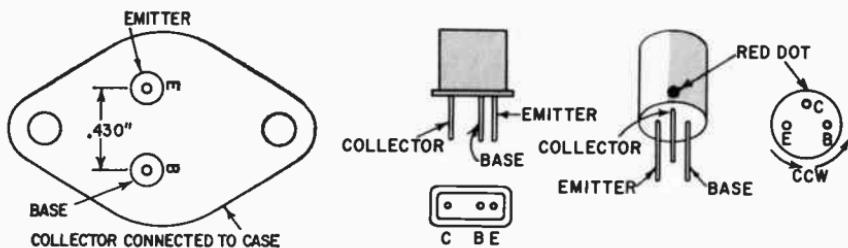


Fig. 512. How to locate and identify transistor electrodes.

emitter in this case is common to the input and output circuits, there is a definite mathematical relationship between the current flowing in the input and output circuits and that flowing in the common-emitter circuit. As a result, the voltage dropped by the resistor in the emitter circuit is, by Ohm's law, directly proportional to the total current flowing in the transistor.

This concept is illustrated in the schematic diagram of Fig. 513. The value of the voltage drop across the emitter resistor in this case (or the common-electrode resistor in the general case) becomes an important piece of troubleshooting information. Recognizing this, manufacturers include the normal value of this voltage in their service-manual schematic diagrams. When variations from the normal are measured, the service technician can expect to find trouble with the transistor or associated components. In general, a voltage across the emitter resistor approaching the power supply voltage is an indication of a shorted transistor or an associated parallel component. A voltage drop at or near zero across the emitter resistor indicates an open circuit in the emitter or collector junctions or associated series components.

Detailed isolation procedure: resistance measurements

Switch off power and discharge all power supply filter capacitors before attempting to make resistance measurements.

Ohmmeters containing battery packs with potentials greater than $4\frac{1}{2}$ volts are not recommended for use in checking resistance in hybrid or all-transistor auto radios.

When checking resistance, remember that the shunting effect of components in parallel with the part being tested will result

in a lower than actual resistance reading. To obtain a true reading for an individual part, it will often be necessary to disconnect one terminal of that part before making the resistance measurement.

A common trouble with resistors is a change of value with a change of ambient operating temperature. A typical symptom in an auto radio containing this type of faulty component can be described as a drift from normal operation to faulty operation over a short period of time. To check for this, measure resistance when the suspected component is cold, allow the equipment to operate for a short period and recheck the resistance.

Nearly all electronic component parts can be checked by making resistance measurements with a suitable ohmmeter. The versatility of the ohmmeter enables one to detect open and short circuits in all components and directly measure the dc resistance values associated with all coils, resistors, semiconductor diodes and transistors. The ohmmeter also provides a positive test for the detection of shorted or extremely leaky capacitors. In addition, it supplies a positive test for checking for open circuits in large-value electrolytic capacitors. With the ohmmeter connected to match the polarity of the electrolytic capacitor, an infinite reading indicates an open capacitor. If the capacitor is good, the meter needle will rise to peak as the capacitor charges and will fall slowly as the capacitor approaches complete charge.

Since capacitors often indicate they are good when simply checked with an ohmmeter and fail only when under stress in actual equipment operation, the most conclusive check of a suspected faulty capacitor consists of disconnecting one end of the capacitor, shunting a known good capacitor across it in the circuit and checking operation.

Transistor junction resistance

The comparative resistances of the transistor's junctions in the forward and reverse directions provide a good indication of the absolute condition of the transistor. Such resistance measurements may be made with an ohmmeter that contains a battery pack whose maximum available potential is either 3 or 4½ volts. The junction-resistance test gives no indication of performance of a given transistor. It does provide positive results in the sense that a transistor failing the junction-resistance test may be considered to have failed, and replacement is indicated.

Use of a simple battery-powered ohmmeter is mandatory in checking junction resistance.

The junction-resistance test consists of taking resistance readings between the base and emitter and between the base and collector in both the forward and reverse directions, with respect to the voltage source in the ohmmeter. The manner of connection and the normal indications expected in such a test for both p-n-p and n-p-n transistors are shown in Fig. 514. To perform this test,

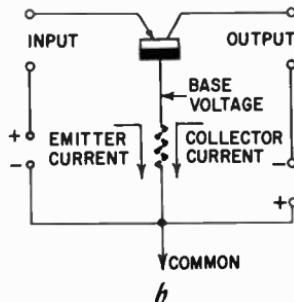
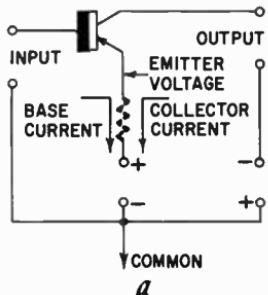
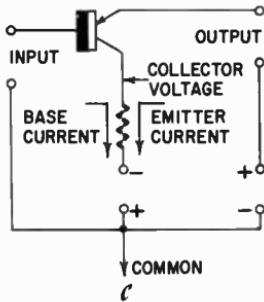


Fig. 513. Common electrode voltage is proportional to total current flowing in a transistor.



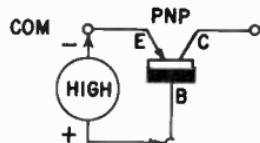
equipment will have to be off and transistors will have to be unplugged from sockets. If transistors are soldered in, and provided the battery-powered ohmmeter is used, it will be necessary to open only the base circuit to check the required junction resistances. This need not necessarily be done at the base lead itself; it can be done at any point in series with the base-return circuit.

Caution: Do not attempt this test with an ohmmeter that is part of an ac powered device (a vtv, for example), as ac leakage from such devices can destroy a transistor.

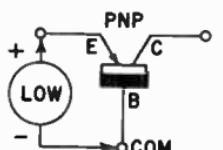
Repair, replacement, adjustment

When trouble has been isolated, the troubleshooting operation ends and the next step is to effect a repair that will restore the

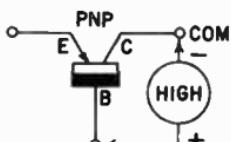
auto radio to normal operation. Often, repair involves something as simple as replacing a tube. Sometimes, it means replacing a soldered-in component. Generally, repairs can restore normal operation directly, but often adjustment is required after the repair procedure to restore normal operation.



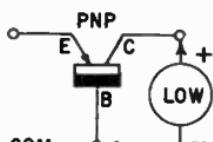
BASE TO Emitter
REVERSE RESISTANCE
a



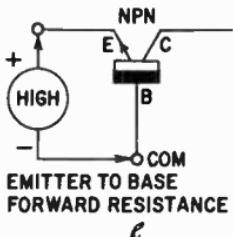
EMITTER TO BASE
FORWARD RESISTANCE
b



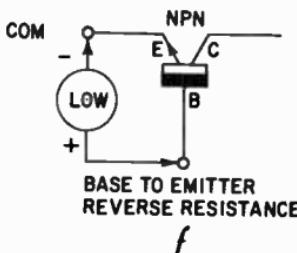
BASE TO COLLECTOR
REVERSE RESISTANCE
c



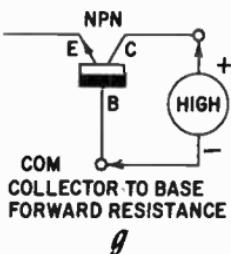
COLLECTOR TO BASE
FORWARD RESISTANCE
d



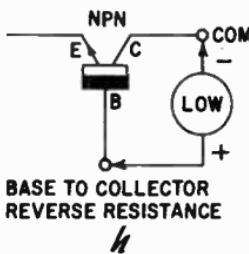
EMITTER TO BASE
FORWARD RESISTANCE
e



BASE TO Emitter
REVERSE RESISTANCE
f



COLLECTOR TO BASE
FORWARD RESISTANCE
g



BASE TO COLLECTOR
REVERSE RESISTANCE
h

Fig. 514. Forward and reverse junction resistances for p-n-p and n-p-n transistors.

This text assumes the reader has a more than adequate knowledge of general repair techniques. The information presented herefore covers only those techniques probably less familiar to the average technician. These are related to the repair and ad-

justment of auto radios employing transistors and printed-circuit construction.

Replacing transistors

The transistor is a peculiar device. Witness the manner in which these units are manufactured and typed. Often the slabs of semiconductor material are joined with an eye toward production of one particular type. When the processing is complete and the units are checked to see if they meet the specifications set up for the type aimed for, the makers are disappointed. Only a restricted group meets the required specs. Are the rest discarded, thrown out? No! Instead they receive new type numbers, specifications are written for them and we have a new transistor type. A glance at the current lists of available transistor types will bear this out.

Unfortunately (for us), the transistor with the "high-falutin" specifications is the one that goes into military and industrial equipment. The byproducts are for home entertainment instruments. This is not to say that the transistors for home equipment are inferior. Rather, the specs for these transistor types are relaxed, and one finds units with a wide range of values for a given parameter. Thus, when used in rather critical circuits where a particular operating parameter must be within a very narrow range of values, of two transistors having the same type number, one may work while the other may not. Because of this replacement of a known faulty transistor does not always effect a repair. It will therefore often be necessary, especially in critical circuits (converter stages for example), to try several transistors of the same type number before a substitute will be found that works properly.

Transistor replacement techniques

The physical act of replacing transistors is not as simple as the replacement of tubes. Transistors used as voltage amplifiers may be either soldered in place or plugged into sockets. Transistors used as power amplifiers are generally bolted to the radio chassis, which forms a heat sink for the power dissipated in operation.

Plug-in transistors

Plug-in transistors are not as easy to replace as plug-in electron tubes. Part of the problem lies in the fact that the sockets of transistors in which the leads are at the corners of an equilateral triangle are not keyed. This makes it possible to insert the new transistor in any one of three ways, only one of which is correct.

A colored dot on the transistor helps differentiate between the electrodes; however, the equivalent of this dot does not appear on the transistor socket. As a result, it is possible to insert the transistor incorrectly, unless the special precaution is taken to mark the socket appropriately before the faulty transistor is removed. This mark will then facilitate the correct replacement of the new unit. The unequal arrangement of the leads in transistors in which the three leads are in the same plane is, in effect, a built-in keying device which eliminates the necessity of marking the socket. (Other transistor lead arrangements are shown in Fig. 512.)

Replacing soldered-in transistors

Transistors are soldered into circuits in the manner of resistors and capacitors to decrease the possibility of a poor connection between the thin electrode lead and the transistor socket.

The transistor is *very sensitive to heat* in any form. Inadequate ventilation in hybrid radios, for example, will first adversely affect transistor operation and will soon lead to eventual transistor failure. By the same token, a soldering operation which subjects a transistor to excessive heat for even a short period of time may cause irreparable damage to the transistor. For this reason, special precautions must be taken when soldering transistors into circuits during replacement. The following techniques, when properly applied, will assure a replacement that does not damage the transistor.

Use a 35- to 50-watt high-quality soldering iron. Use of higher-wattage irons is not recommended because the larger amount of heat dissipated endangers even the life of neighboring transistors. Use of lower-wattage irons is not recommended because of the increased time required in the soldering operation. As a result of their ultra-high-speed high-heat operation, gun type soldering irons are not recommended, because of their tendency to cause cold solder joints.

Use rosin core 60/40 high-quality solder. The 60/40 composition solder melts quickly at a lower temperature and tends to solidify all at once. By comparison, the more common 40/60 composition solder requires a higher temperature to melt and solidifies over a range of temperatures, increasing the tendency to form cold-solder joints.

Use some form of heat-sink device between the point being soldered or unsoldered and the body of the transistor. The use of a long-nosed pliers as a heat sink in this application is recommended (Fig. 515).

Replacing power transistors

Power transistors are used in audio output stages and in transistor dc-to-dc converter stages of auto radios. In both of these applications, the power transistor, unlike the voltage amplifier transistor, generates a large amount of heat in the course of normal operation. This heat must be quickly and effectively dissipated or

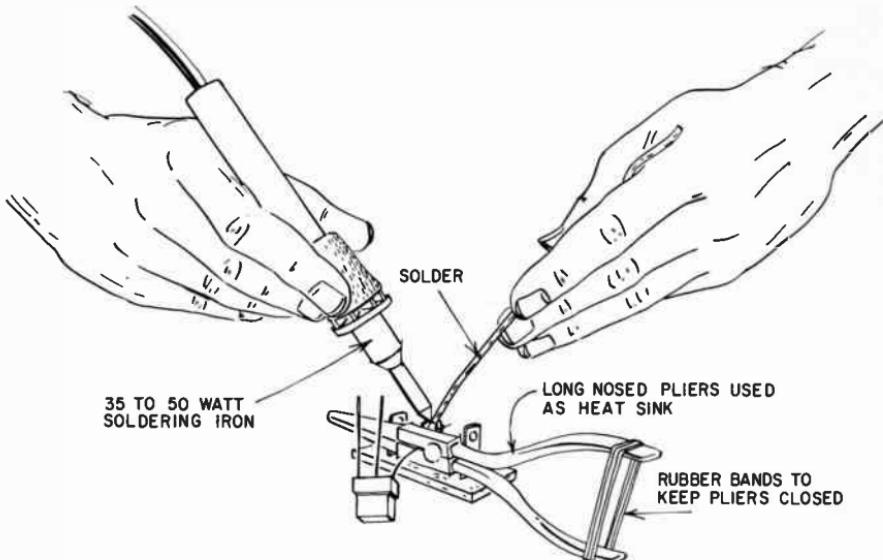


Fig. 515. Using long-nose pliers as heat sink in replacing soldered-in transistor.

it will damage the transistor. The most effective method of dissipating heat generated by power transistors is through the use of a heat sink. In practice, the auto radio chassis is used as the heat sink. To facilitate the use of the chassis as a heat sink, power-transistor designers have arranged things so that the collector electrode of the power transistor is tied to the metal case of the unit. This improves heat dissipation by allowing rapid conduction of heat from the collector junction, to the transistor body and to the chassis heat sink.

Since the collector is often operated at a potential above or below chassis ground potential, it is necessary to isolate the body of the transistor electrically from the chassis, while maintaining intimate heat-conductive physical contact. This is accomplished through the use of a mica washer that is coated with a thermally-conductive silicone grease. The mica washer electrically isolates the case from the chassis while the silicone grease assures adequate thermal conduction (Fig. 516).

When a power transistor is being replaced, check the following points:

Has the mica washer been completely coated with a film of the proper silicone grease?

Has the transistor been bolted down with adequate force?

Adjusting audio output power-transistor circuits

Push-pull and single-ended transistor audio output stages are operated class B to obtain maximum power efficiency. However, the class-B transistor amplifier can be biased for either zero collector voltage or for collector-current cutoff. In the zero-collector-voltage condition, heavy collector current can flow in the absence of a signal (an undesirable condition in auto radios). Therefore, car radio power output stages employ collector-current cutoff bias in which collector current flows only during the half-cycle of input

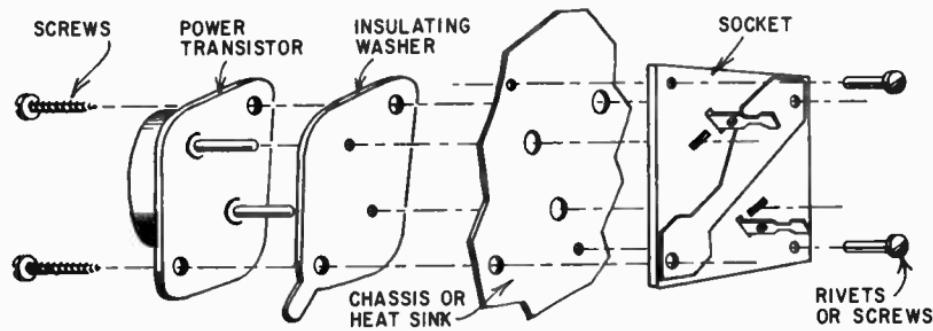


Fig. 516. Exploded view of power transistor mounting. Mica washer coated with silicone grease electrically isolates transistor case from chassis.

signal. Due to the different characteristics of transistors of the same type number, it is necessary to readjust the stage bias each time a power output transistor is replaced. The bias is adjusted to produce the proper collector current cutoff value, which varies depending on the transistor used and the circuit design.

Manufacturer's service notes generally contain a complete procedure covering this adjustment, for which a control is generally incorporated into the circuit design. Where service notes are not available, collector-current cutoff (I_{CO}) values for a given transistor at the circuit operating voltage can be obtained from a transistor data handbook.

Repairing printed circuits

Printed circuits used in auto radios (and home entertainment instruments in general) include printed-wiring boards used in conjunction with conventional component parts (resistors, capa-

citors, etc.). The printed-wiring board begins as a conductor (copper) laminated insulator (plastic) board. The wiring design is transferred to the conductor surface by silk-screening with a chemical agent known as a "resist." The copper surface is then treated with an etching solution which attacks the free copper, leaving the resist-treated pattern to become the wiring of the printed-circuit board.

Conventional component parts are used to bridge gaps in the wiring to make up the intended circuit. These components are secured to the board either through the use of plated holes into which the part leads are inserted or through the use of eyelets which make electrical contact with the printed wiring at the surface of the board. Often, printed wiring is used on both surfaces of the board. In this case, plated holes or eyelets are again used to establish electrical contact between the board surfaces.

Emphasis is being given here to the manner in which parts or wiring on different surfaces are connected, since experience has indicated that the connections in printed circuitry are the weakest link. Connection points are more subject to failure than component parts. Troubleshooting and repair operations should proceed with this point clearly in mind.

Repair hints and kinks

Since printed wiring is, actually, nothing more than metal foil bonded to a plastic conductor, repair of printed circuits is likely to be a delicate procedure. Both the removal and installation of component parts of printed-circuit boards can, if improperly executed, cause damage to the sensitive printed wiring. The hints and kinks listed below should arm service technicians with a foreknowledge of printed-circuit repair techniques.

Many printed-circuit boards are coated with a protective plastic substance which maintains a hermetic seal to protect the wiring from exposure to air. Remove any such protective coatings by scraping the circuit board in the area to be repaired. If cold scraping does not work, gently heat the area with a hot soldering iron to soften the plastic before scraping.

Caution: Never use solvents to remove protective plastic coatings. Solvents may dissolve the adhesive bond between the printed wiring and the circuit board.

Always use a small 35- to 50-watt soldering iron of high quality when making printed-circuit repairs. The key to effective soldering is the application of relatively high heat to a small area to

sure the melting and flow of solder in the shortest possible time. Bargain irons often do not fulfill their promise to deliver high heat. High-wattage irons (100 to 150 watts) are often large and have a tendency to heat too large an area to too high a temperature. Soldering guns, unless specially designed for printed circuit work, rarely meet the requirement for adequate solder flow during repair operation.

Always use 60/40 (tin-lead) rosin core solder of the highest quality, preferably a commercial solder recommended for printed circuit use. When in doubt, use fluxless 60/40 solder and a flux solution made of rosin dissolved in alcohol. Always use alcohol to remove excess flux after a soldering operation.

Caution: The use of corrosive fluxes in soldering printed circuits can cause serious damage to printed wiring at connection points in a very short time.

Wherever possible, replace component parts by allowing the original connections (the wiring) to the printed circuit board to remain intact. Cut the body of the faulty component away. Form loops at the ends of the leads of the new component and the remaining leads of the old component, secure the loops together with solder. This technique is illustrated in Fig. 517. Where the leads of the defective component are too short, greater lead length may sometimes be obtained by breaking apart the old component. If this fails to provide long enough leads, the component will have to be removed from the board. Proceed according to the hints and kinks given below.

Always apply the soldering iron to the pigtail lead of a component part being removed — *never to the printed-wiring foil at the joint*. Work rapidly but carefully. Remove the iron the instant the solder has melted.

When installing new components after a complete removal operation, be sure to provide sufficient lead length to allow for subsequent replacement to be made by the more conservative technique previously described. Cinch pigtail leads to the foil to obtain a secure mechanical connection wherever possible. Again, heat the lead rather than the foil. Remove the iron as soon as solder has had a chance to flow adequately into the joint.

When excess solder remains in a plated or eyelet hole after component removal, do not attempt to clean the hole by applying heat. Instead, drill the solder out carefully, using a drill size slightly larger than the size of the lead to be inserted in the hole. It is best to start drilling from one side. Stop when partway

through, turn the board over and drill from the opposite side until the hole is completed.

Do not attempt to repair broken foil by using conductive paint, as this method does not produce reliable results. The best means for repairing a broken foil is the use of a wire bridge. In this technique (Fig. 518), a piece of thin tinned copper wire is bent into the shape of a staple and is used to span the section of broken foil. The ends of the wire are secured to the points at the junction

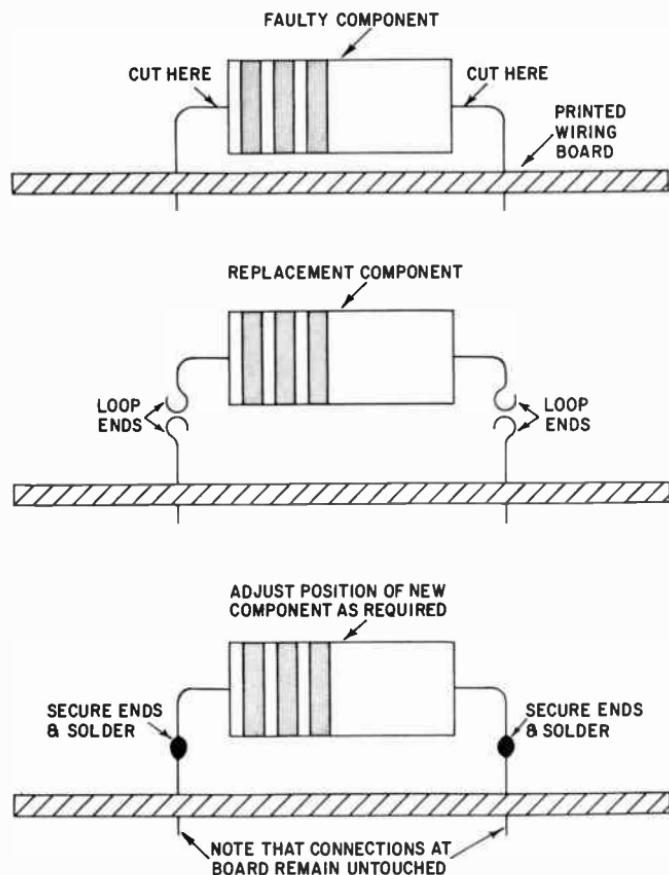


Fig. 517. Three steps in replacing a defective component mounted on a printed-circuit board.

of convenient components at the ends of the broken section of foil.

When excess heat causes the foil to become unbonded from the board, and the foil is otherwise intact, it may be cemented back to the board. Use a high-quality commercial nonconductive cement recommended for this purpose.

All newly-soldered joints on printed-circuit boards should be cleaned with alcohol and then coated with a protective plastic finish. Polystyrene "dope," available commercially, is recommended for this application.

Aligning transistor auto radios, hints and kinks

Transistor auto radios may be aligned according to the generalized procedures for aligning conventional radios. The following additional guides should be of assistance:

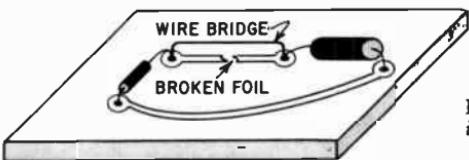


Fig. 518. Preferred method of repairing broken printed wiring foil through the use of a wire bridge.

Maintain the input signal from the noise- or signal-generating device at the lowest possible level by coupling the signal to the set through a radiating loop. (Such a radiating loop is incorporated into the recommended noise generator described in Chapter 2).

Never attempt to touch up or peak an individual stage without regard to the rest of the set. Since transistor stages are not isolated from each other, adjustments in one stage affect the adjustment of all others. Always make it a practice to align the entire set when alignment is called for.

When performing the if alignment, first peak each transformer, starting with the last and ending with the first. Then reverse the procedure, this time starting at the first transformer and ending at the last.

theory of auto radio tuners

FUNCTIONALLY, tuning an auto radio involves a process almost identical to tuning a conventional home radio. This chapter develops the theory of auto radio tuners, emphasizing those aspects that make them different from their home radio counterparts. The chapter goes on to detail theory of operation of typical auto radio tuning systems.

The nature of tuning

The extremely weak signal (measured in microvolts) of the desired station picked up by the antenna must be separated in the receiver from adjacent station signals and built up to a usable level. This separation for the most part takes place in coupling circuits used between various stages in the receiver. A maximum amount of energy at the desired frequency is coupled between stages when the coupling circuits are tuned to resonance at the desired frequency. Unwanted signals are rejected in the process. Tuned circuits are required in the rf and if sections of the radio receiver.

Since the if signal is at the same frequency for every station selected, the tuned circuits in the if section are fixed-tuned to the pre-established intermediate frequency (455 kc for home radios, 262 kc for most auto AM radios and 10.7 mc for FM sets). In the rf section of the receiver, however, the tuned circuits must be variable to enable these circuits to select the stations operating at different frequencies in the broadcast band.

The rf stage

In the average home radio, the signal picked up by the antenna is fed directly to a converter stage where the intermediate frequency is formed. In the average car radio, however, the converter stage is preceded by a radio-frequency amplifier stage. The rf amplifier isolates the antenna from the converter to suppress unwanted back radiation, improves the selectivity and sensitivity of the receiver, suppresses image interference (more of a problem with a 262 kc if) and improves the overall gain of the receiver. These assets gained from the use of an rf stage in the mobile car radio outweigh the liabilities of additional complexity and cost. As a result, only the very low-priced economy models are without this feature.

Among the complexities introduced by the rf stage is the need for one additional tuned circuit. In the radio without an rf stage, the input circuit to the converter and the local oscillator tank of the converter require retuning as the radio is switched from station to station. Since the output of the converter is at the if for each station, the coupling circuit used is fixed tuned, as previously described. In the radio employing an rf stage, an additional tuned circuit must be incorporated between the rf stage and the converter since the frequency to be coupled will be different for each station selected.

Tracking

In all radios, tuning consists essentially of adjusting both the resonant frequencies of the tuned coupling circuits that handle the rf signal before it is converted to an equivalent if signal, and the frequency of the local oscillator or converter oscillator tank circuit. The oscillator frequency must always be separated from the selected rf signal by a frequency equal numerically to the intermediate frequency. The tuning elements in coupling and oscillator circuits are generally ganged mechanically, to insure proper tracking. Tracking, then, is the process in which all tuned circuits are simultaneously adjusted to the correct resonant frequency over the entire band of frequencies being tuned.

Tuned circuits

Tuned (or tank) circuits at the broadcast frequencies are made up of capacitors and inductors. Either the capacitive or the inductive component may be varied to act as the actual tuning element. The ganged air-dielectric capacitor used in the home radio is an example of a variable capacitive tuning element used

for simultaneously adjusting rf coupling circuits and the converter oscillator. The variable capacitor has proved to be a poor component for use in auto radios since it does not remain stable under the shock and vibration encountered.

In the car radio, variable inductive tuning elements are employed because of their inherent mechanical stability. The most common method of varying inductance is by positioning a brass or powdered-iron slug within the core of a coil. This type of tuning is referred to as slug tuning and is used for adjusting the fixed-tuned frequency of the if coupling stages as well. Powdered-iron (a magnetic material) slugs concentrate the magnetic lines of force in the core of the coil to increase its effective inductance. Increasing the inductance decreases the resonant frequency of the associated tuned circuit. With nonmagnetic conductors (such as brass), the opposite effect is obtained. As the brass slug is inserted in the core of the inductor, the resonant frequency of the associated tuned circuit is increased. The use of different slug materials accounts for the differences in direction of insertion, and the subsequent results obtained from tuners of different manufacturers. The tuning slugs are mechanically ganged to provide the necessary tracking action required in radio tuning.

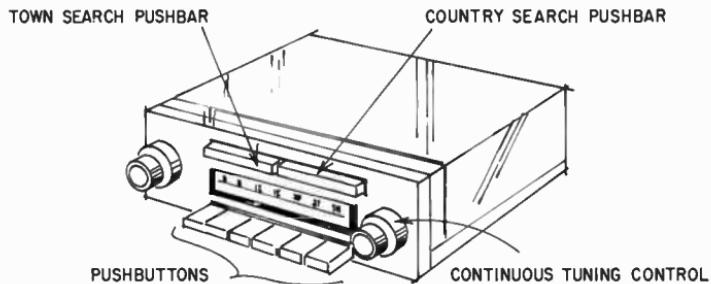


Fig. 601. Typical deluxe auto radio with continuous, search and push-button tuning controls.

Auto radio tuner

Auto radio tuners consist essentially of a mechanical unit designed to position tuning slugs or cores automatically and simultaneously in the coils associated with the tuned coupling circuits of the rf and converter oscillator sections. These ganged tuning slugs may be operated by the continuous tuning control accessible to the user on the front panel of the radio, or by push-buttons which facilitate the selection of one of a number of preset stations. Deluxe models incorporate elaborate search-tuning mechanisms controlled by the listener which are designed to seek

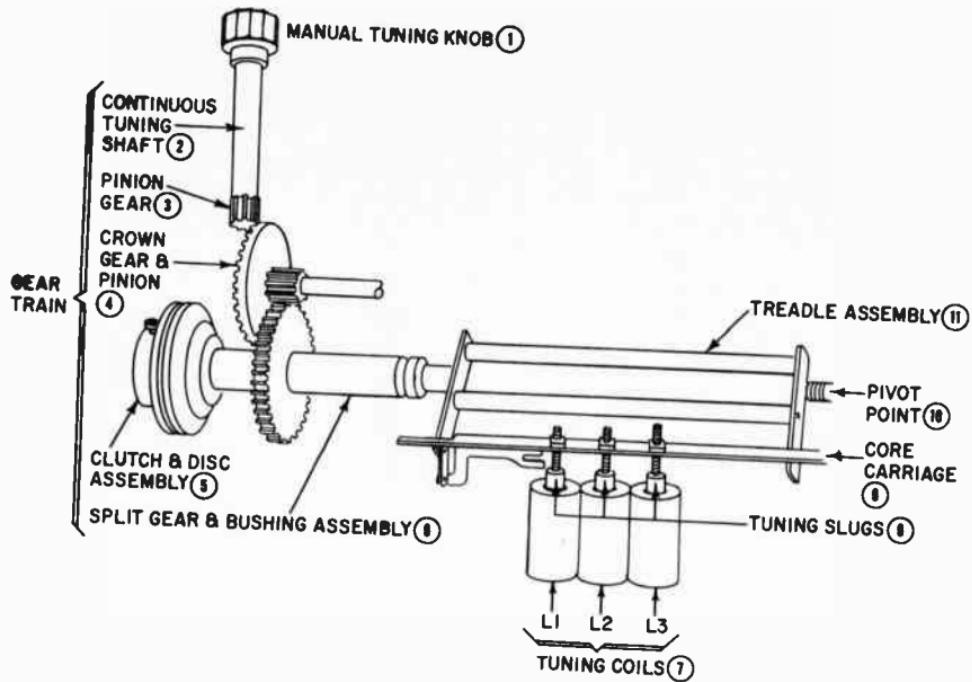


Fig. 602. Typical manually operated continuous tuning unit section of a deluxe auto radio tuner. Pushbutton and search tuning are included.

strong stations in a given area one at a time in sequence until a desirable program is found. A typical deluxe radio that incorporates all the tuning devices described is shown in Fig. 601.

Manual continuous tuning

In manual continuous tuning, the user turns a tuning knob to effect a change in the position of the tuning slugs in the tuning coils associated with the tuned circuits in the radio. A typical manually-operated continuous-tuning unit is shown in Fig. 602. The unit illustrated is the manual continuous-tuning section of a deluxe tuner that also includes pushbutton and search tuning. The continuous-tuning unit consists of tuning coils (7) in which tuning slugs (8) are positioned through the action of a treadle assembly (11). The operation is controlled by a manual tuning knob (1). Motion is transferred from the manual tuning knob to the treadle assembly through a gear train (2,3,4,5 and 6).

When the manual tuning knob is rotated, the continuous tuning shaft (2), through the action of its pinion gear (3), rotates the crown gear and pinion (4), which in turn rotates the split gear and bushing (6). The split gear and bushing assembly is frictionally coupled to the clutch and disc assembly (5) to which the

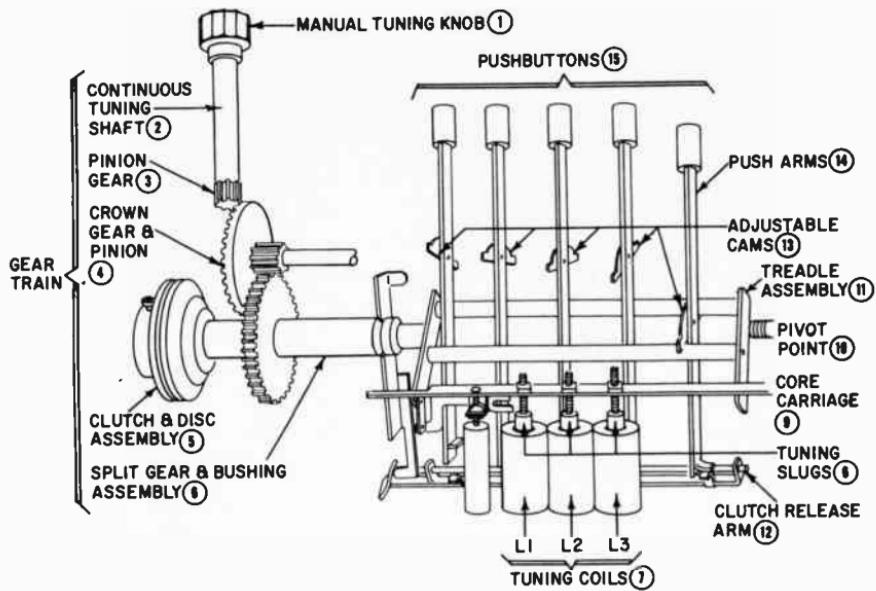


Fig. 603. Deluxe auto radio pushbutton tuning unit incorporating manual and search tuning systems.

treadle assembly (11) is attached. Rotation of the split gear and bushing assembly can operate the treadle assembly only through the action of the clutch and disc assembly.

The tuning slugs (8) are ganged together by the slug carriage (9). When the treadle assembly is rotated on its pivot point (10), the ganged tuning slugs are moved in or out of their associated tuning coils (7), depending on the direction of rotation. The angles at which the treadle assembly is positioned corresponds to the different frequencies of the stations to which the radio is tuned.

Pushbutton tuning

In pushbutton tuning, the user manually operates a pushbutton station selector to position the tuning slugs associated with the tuned circuits in the radio. In this case, the tuning slugs are shifted to various preset positions as the pushbuttons are operated. The preselected frequencies are set up by the user so that each of the pushbuttons tunes a different desirable station in the area.

A typical pushbutton tuning unit is shown in Fig. 603. The unit illustrated is the pushbutton tuning section of a deluxe tuner that normally includes manual and search tuning controls as

well. The pushbutton tuning section consists of pushbutton- (15) operated push arms (14), which operate the tuning-unit treadle assembly (11) by an adjustable cam (13) associated with each push arm. The cams are normally adjusted to different angles with respect to the push arms.

Detailed operation

When a pushbutton (15) is pressed, the push arm operates the clutch release arm (12) to disengage the clutch and disc assembly (5). This in turn isolates the split gear and bushing assembly (6) and the entire gear train to the manual tuning knob (1). This prevents the manual tuning system from rotating when a pushbutton is operated. As the push arm moves in, the adjustable cam, which is locked at this time, pushes against the treadle assembly, which rotates on its pivot point (10). The treadle assembly stops when it assumes the angle determined by the locked cam. Through this action, the tuning slugs (8) that are ganged to the core carriage (9) are simultaneously positioned in their associated tuning coils to select the desired station. The action on the ganged tuning slugs of cams adjusted at three different angles is illustrated in Fig. 604. When the pushbutton is released, the clutch release arm (12, Fig. 603) engages the clutch and disc assembly, which again ties the continuous tuning gear train to the treadle assembly. This action locks the tuner on station.

Setting up pushbuttons

To preset pushbuttons to the desired stations, the radio is first tuned manually to the first station to set the treadle assembly (11, Fig. 603) to the angle that corresponds to the desired station. The pushbutton is then unlocked (by pulling it out or by unscrewing it several turns) to release the adjustable cam on the pusharm. When the pushbutton is depressed, or depressed and screwed in, the adjustable cam is locked in the angular position determined by the setting of the treadle assembly.

Each pushbutton is adjusted in a similar manner. Once set, depressing a pushbutton will return the treadle assembly to the preselected angular position, thus positioning the tuning slugs to select the desired station.

Search tuning

Search tuning could logically be called automatic continuous tuning. In search tuning, the user operates a search pushbutton or bar. The search-tuning system operates the tuner automatically until the next strong station on the dial in the particular area is

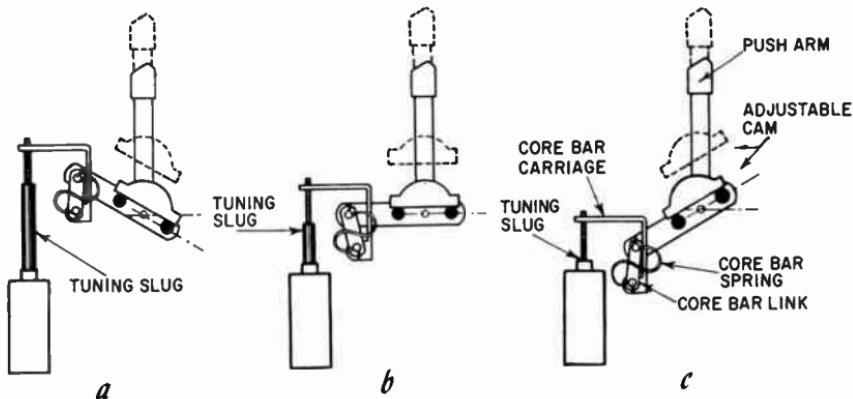


Fig. 604. Three different angles of cam action in pushbutton tuning.

reached. The system then stops and locks the tuner on station. Signal-seeking tuning is another name applied to search tuning.

Functional block diagram

A functional block diagram of a typical auto radio incorporating a search tuning system is shown in Fig. 605. In addition to the superheterodyne receiver stages, this contains country and town search pushbuttons S1 and S2, a search relay RY1, a trigger tube

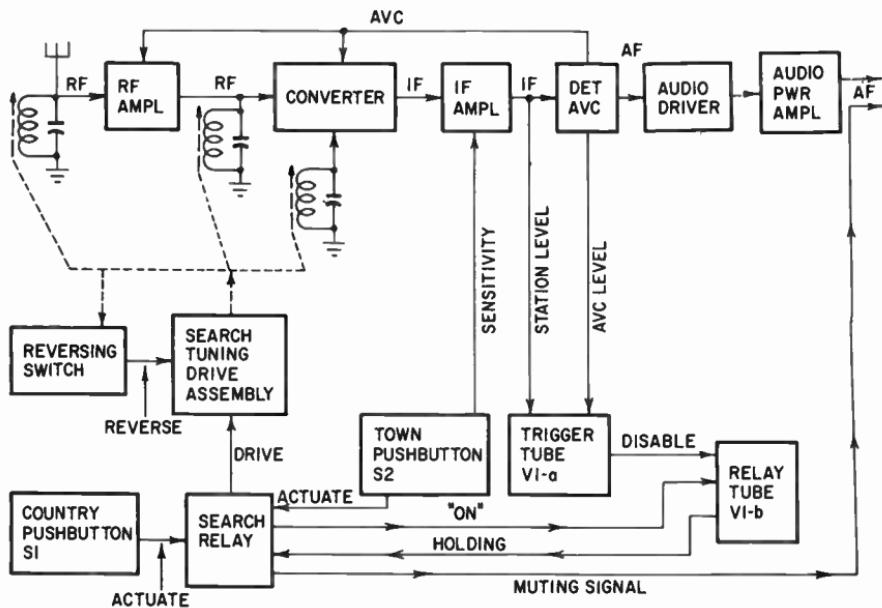


Fig. 605. Block diagram of a typical deluxe auto radio search tuning system.

VI-a, a relay tube VI-b, a search-tuning drive assembly and a reversing switch.

In search tuning, either the town or the country pushbuttons can actuate the search system. In town, where the stations are strong, the town pushbutton permits the search system to operate with the receiver sensitivity reduced somewhat below normal. In the country, where stations are generally weak, the receiver may be operated at normal sensitivity by depressing the country pushbutton.

Operation of either the town or country pushbuttons momentarily actuates search relay RY1, which sends an on signal to relay tube VI-b. The relay tube conducts and feeds a holding signal back to search relay RY1 to keep it energized after the town or country pushbuttons are released. Search relay RY1 also routes a muting signal to the speaker to switch sound off during the search-tuning operation. The search relay supplies the voltages required to operate the search-tuning drive assembly, which automatically positions the ganged tuning slugs in their associated tuning coils and thereby tunes the radio through the broadcast band.

During the tuning operation, a station-level signal from the second if amplifier and an avc-level signal from the detector avc stage are fed back and added at the input of trigger tube VI-a. When the first relatively strong station is reached, the combined level signals at the input of the trigger tube VI-a drive this stage into conduction. Tube VI-a sends a disabling signal to cut off relay tube VI-b. The search relay is thereby de-energized, the search-tuning drive assembly is stopped at the strong station and the speaker is switched back into operation. Again, depressing either town or country pushbuttons repeats the process so that the radio tunes to the next strong station on the dial. When the search-tuning drive assembly reaches the end of the dial, the reversing switch is mechanically actuated and tuning takes place in the reverse direction. Reversal occurs at each end of the dial.

Detailed functional analysis

The electronics section of the search tuner includes the circuits that control and operate the tuner drive motor. The electronics section is actuated when a new station is tuned, operates the tuning motor, reverses the tuning motor and switches the motor off when a strong station is reached. A simplified schematic diagram of the electronics section of a typical search-tuning system is shown in Fig. 606. (The circuit is typical of such circuits used in

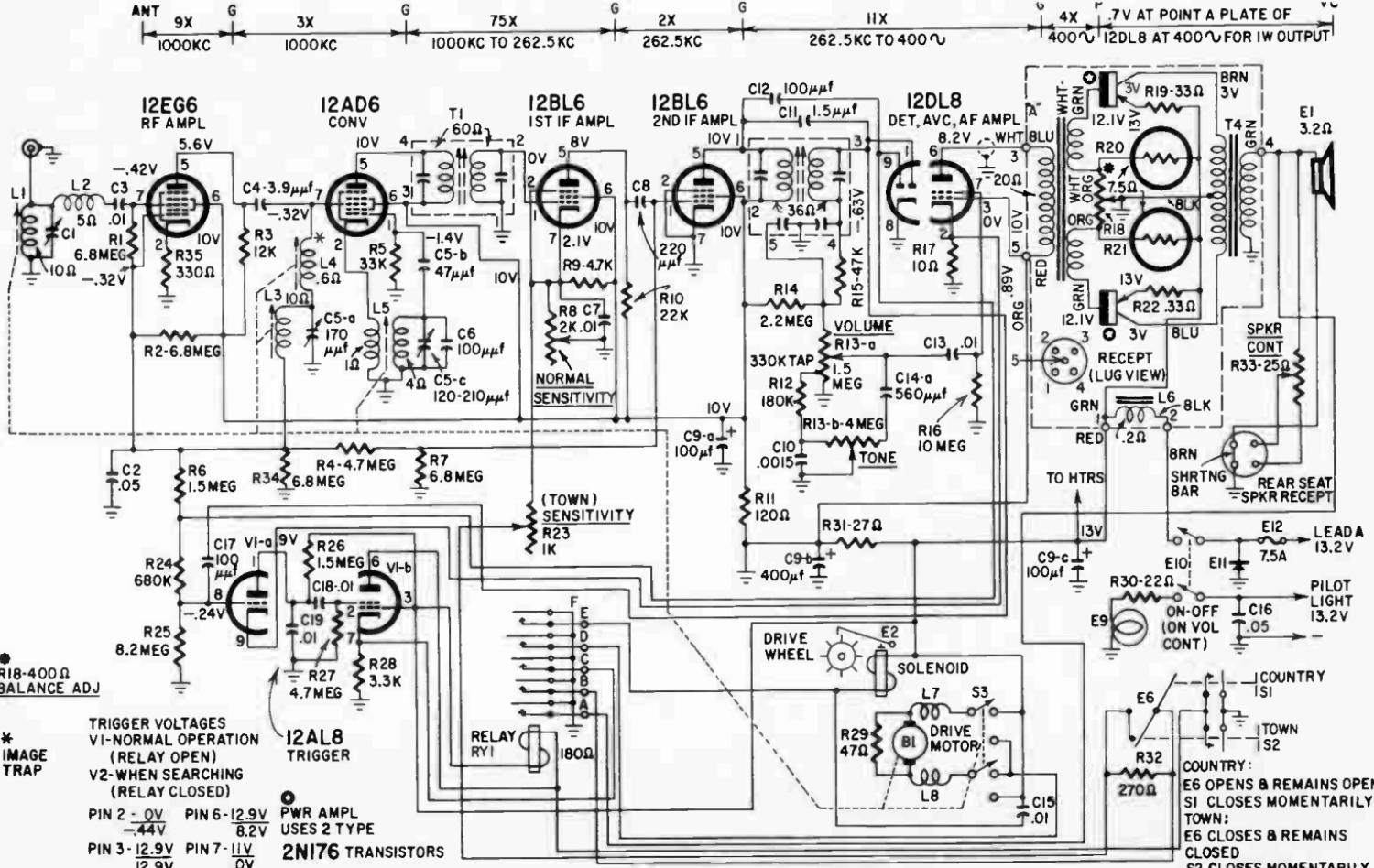


Fig. 606. Hybrid receiver using a search tuning system.

hybrid auto radios). This typical electronics section includes trigger tube V1-a, relay tube V1-b, search relay RY1, country pushbutton S1, town pushbutton S2, drive motor B1 and reversing switch S3. The circuit also shows the radio's first and second if stages, and the detector-avc-first audio stage. These stages provide the lock-in control signal for the search-tuner electronics section.

Depressing either the town or country pushbuttons grounds one side of the search relay and energizes the relay. The relay contacts all close momentarily, applying ground through F to the external circuits connected to contacts A through E. Contact B grounds the cathode of relay tube V1-b, removing bias for this stage and driving the stage into full conduction. The conduction of the relay tube in series with the search relay holds the relay energized after the momentary town or country pushbutton is released.

When the country pushbutton is depressed, switch E6 opens and the suppressor of the first if is returned to a higher B-plus point. Under these conditions, the radio operates at maximum sensitivity to insure pulling in even weak signals in the country. When the town pushbutton is depressed and switch E6 is closed, the radio is set up for operation under conditions of reduced sensitivity to account for the relatively stronger city radio-station signals. When the search relay is energized while E6 is closed, closing of contact B returns the suppressor grid of the first if tube to ground through R23, the town sensitivity control. The radio operates at reduced sensitivity during the search operation in this condition. Normal operation is restored when the search relay is de-energized on reaching the next strong station on the dial.

With the search relay energized, the speaker voice coil is grounded through contact A to silence the speaker during tuning. Power is applied to drive motor B1 through contacts D and E. When reversing switch S3 is operated, the direction of current flow through drive motor B1 is reversed and motor B1 turns in the opposite direction.

Drive motor B1 operates the search-tuning drive assembly which positions the tuning slugs and tunes the radio to the next station on the dial. When the new station is approached, a station-level signal from the output of the second if amplifier and an avc-level signal from the avc section of the detector-avc-first audio stage are fed back and combined at the input of trigger tube V1-a. V1-a couples the resultant signal to the grid of relay tube V1-b to cut off the relay tube when a station has been reached. Since the

drive motor and search-tuning drive assembly have a tendency to coast after the relay tube is de-energized, the system is set up so that the relay tube cuts off before the station is tuned perfectly. The coasting action is then used to bring the radio exactly on station. The station-level and avc-level signals are used in combination to control the trigger tube, since the added levels of these signals will remain constant for stations of relatively equal signal levels. (Where the signal level is slightly weaker, avc will be high to compensate for it; where signal level is strong, avc will be low). The combined system insures that the trigger tube will react the same way to all qualified stations.

The combined voltage applied to the control grid of trigger tube V1-a is amplified by V1-a. The resultant pulse (negative) is coupled from the plate of V1-a to the control grid of relay tube V1-b. Tube V1-b is cut off by the negative pulse de-energizing relay RY1 which removes power from the drive motor. The motor coasts to a stop, positioning the search-tuning drive assembly and associated slugs at precisely the center frequency of the desired station. With the search relay de-energized, the speaker voice coil is switched back to the audio output circuit.

Detailed mechanical analysis

When power is applied to the search-tuner drive motor (16), the tuning slugs (5) are positioned in the coils (6) of the tuned circuits according to the following detailed analysis (refer to Fig. 607). The search-tuning drive motor runs the drive gear (10) which operates the planetary gear (11). The planetary gear in turn operates the pinion gear (13) which operates the power transfer gear (9). The power transfer gear drives the power takeoff gear (8) and the tuner drive shaft (15), which is clutch-coupled to the pinion gear (2). The pinion gear applies power to the tuning gear (1), which operates the treadle assembly (4) in a manner similar to the action of the power transfer in manual tuning. The clutch coupling (3) between the tuner drive shaft and the pinion gear prevents damage to the search-tuning drive motor, in case the tuning mechanism jams during automatic tuning.

When the treadle assembly has moved to the end position in either direction, the reversing switch (7) is actuated, changing the direction of the search-tuning drive motor. The search tuner is able to search for stations in either direction as a result of this arrangement.

The control clutch (12) actuated by the solenoid (14) operates on the planetary-gear assembly only during search tuning to per-

mit the transfer of motor power to the manual-tuning shaft. During manual tuning, the control clutch locks the planetary gears, to prevent the search-tuning drive motor from being turned when the manual control system is in use.

Not all search tuners use an electric motor. Some have a spring-wound clock-like motor which unwinds from the low frequency end of the dial to the high-frequency end. At the high-frequency end a contact closes, actuating a solenoid, winding the clock motor, and returning the dial to the low-frequency end. At this point the solenoid releases and the motor unwinds slowly, moving the dial (and the tuner) toward the high-frequency end again.

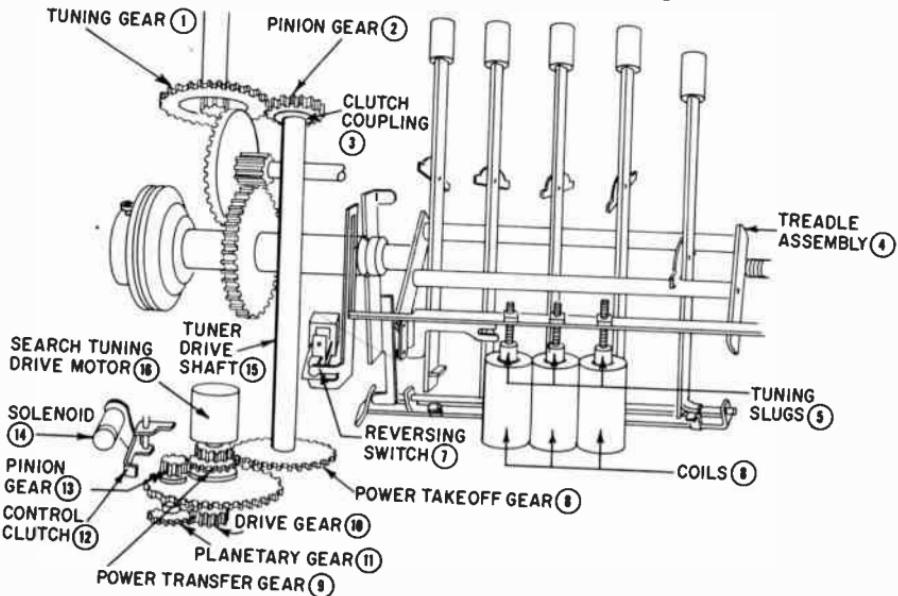


Fig. 607. Detailed mechanical analysis of a search tuning system.

power supplies

AUTO radio power supplies have come and gone. In the early days, an A battery supplied heater power, while special B and C batteries provided plate and other operating potentials. Modern all-transistor auto radios require no heater power or special supplies since they use the auto electrical system as their source of all required operating potentials. In between these two developments, there appeared a variety of devices designed to meet efficiently the power requirements of the auto radio.

The auto's electrical system has always been the source of heater power for radios employing tubes. However, several variations of the means to obtain the required plate voltage have been developed and used over the years. All of these variations have been one or another form of dc-to-dc converter secondary power supply. In dc-to-dc conversion, a low-voltage dc potential is converted to a high-voltage dc potential through electrical, electromechanical or electronic means. One of the first dc-to-dc converters used was the dynamotor, a generator-converter rotary machine that still finds application in military and civilian mobile communications systems. The most popular dc-to-dc converter over the years has been the vibrator power supply, which dominated the auto radio field for many years. It took the transistor to unseat it. The transistor dc-to-dc converter is the latest and most efficient dc-to-dc converter device developed.

In hybrid auto radios, the B-supply for tube stages is obtained directly from the electrical system primary supply. The supply in this case must deliver 12 volts, as hybrid sets use low-voltage tubes

that require 12 volts on the plate. The transistor audio stages of the hybrid set also obtain their operating voltages directly from the primary supply. Power supply requirements of the various auto radios are summarized in Table 7-1.

Table 7-1.
AUTO RADIO POWER SOURCES

Type of Auto Radio	Primary (Auto Electrical System) Supply	A (Heater) Supply	B (Plate) Supply	C (Bias) Supply
All tube set	6 or 12 volts	From primary supply	Dc-to-dc converter secondary supply: 1. Vibrator 2. Transistor dc-to-dc converter	
Hybrid set	12 volts	Tubes: primary supply Transistors: not required	Tubes: primary supply Transistors: primary supply or divider across primary supply	Divider across primary supply
All transistor set	12 volt (6 volts, foreign makes)	Not required	Primary supply or divider across primary supply	Divider across primary supply

The vibrator

The vibrator (Fig. 701) consists of a vibrating mechanism sealed in a plug-in unit, with a suitable vibration-damping material. The plug-in construction assures easy replacement. The vibrating mechanism includes a frame, an electromagnetic coil and associated magnetic core, a flexible reed with an armature and associated set of movable contacts, and a set of fixed contacts.

Operation of the vibrator can be initiated either by a positive- or negative-drive voltage. The polarity determines only the direction in which the vibrator armature will swing first in response to a drive voltage. The case for both polarities of applied voltage is illustrated in Fig. 702. This discussion will treat the case where 6 volts is applied (as in autos with negative-ground electrical systems) as representative of both.

Before power is applied, the flexible reed is in the neutral position and both sets of vibrator contacts are open. On applying power (6 volts), the electromagnetic coil is energized and a magnetic field built up around the coil. The polarity of the field causes the armature to swing in a direction that closes contacts 1 and 2, placing a direct short across the coil. The coil de-energizes, with a resultant collapse in magnetic field which causes

the armature to swing back toward neutral, breaking contacts 1 and 2. With contacts 1 and 2 open, the coil again energizes. The spring action of the flexible reed, however, carries the armature past neutral and on to the point where contacts 1 and 3 close. Contacts 1 and 3 again place a short across the coil that de-energizes it. The armature swings back toward neutral, breaking contacts 1 and 3 and again energizing the coil. The magnetic field builds up and pulls in the armature again to make contacts 1 and 2, and the entire action is repeated. Vibrator action is carried out at a rate of 60 to 250 cycles per second in common commercially-available vibrators.

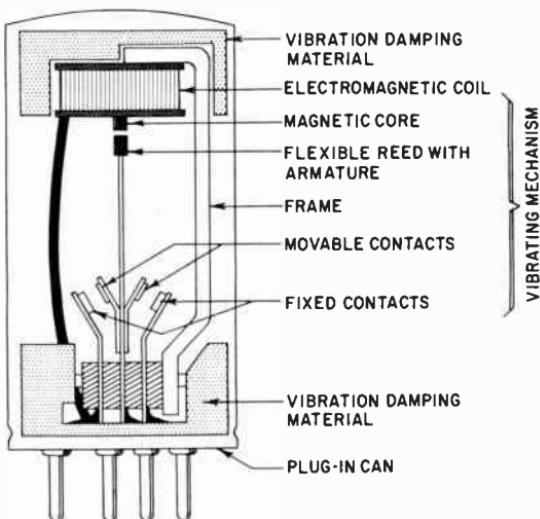


Fig. 701. Internal construction of a non-synchronous vibrator.

Vibrator power supply circuit

A simplified schematic diagram of a typical vibrator power supply circuit is shown in Fig. 703. The circuit consists of an interrupter-type vibrator K1, a special stepup transformer T1, rectifier V1, a pi-type filter circuit composed of capacitors C4-a, C4-b and resistor R3, and miscellaneous hash-filtering components. The circuit is typical of vibrator power supplies in current use in auto radios.

When ON-OFF switch S1 is closed, drive voltage is applied to vibrator K1 at the center-tap (pin 5) of the primary of transformer T1. The electromagnetic coil is energized by the current that flows from the battery through fuse F1, choke L1, switch S1, choke L2,

from lug 5 to lug 6 of the primary of T1, to fixed contact 2 and through the electromagnetic coil to ground. The flow of current from lug 5 to pin 6 of T1 induces a stepped-up voltage swing in the secondary of T1. When the vibrator armature swings down (contact 1 makes 2), the coil is shorted and the current through T1's primary reaches a maximum. As the coil de-energizes (impeding the flow of current in a new direction), the armature swings past neutral to the point where contact 1 makes 3. At this point, current ceases to flow from lug 5 to lug 6 of T1, and instead flows from lug 5 through the primary to lug 4, through closed contacts 1 and 3 to the ground. The flow of current from lug 5 to lug 4 of T1 induces a new stepped-up voltage swing in the secondary of T1 of an opposite polarity to that of the previous swing. An

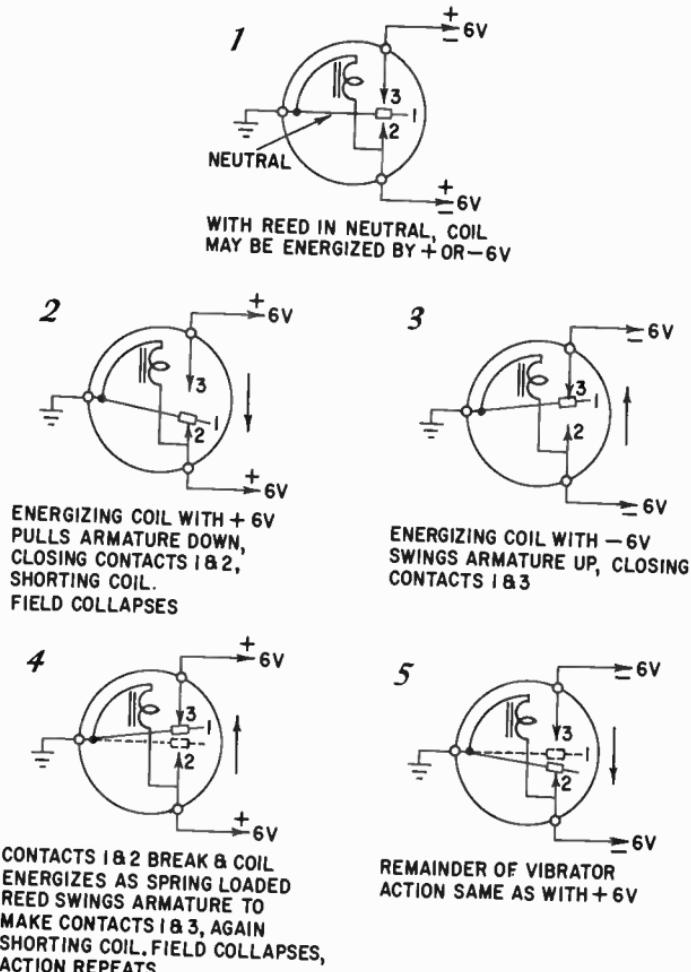


Fig. 702. Typical vibrator operation.

idealized waveform of the resultant alternating-current cycle developed at the secondary of T1 is shown in Fig. 704.

The high-voltage ac component developed at the secondary of stepup transformer T1 is rectified by V1 and filtered by the pi filter consisting of R3, C4-a and C4-b, to yield a relatively high-voltage dc used as B-plus for the auto radio electron-tube stages.

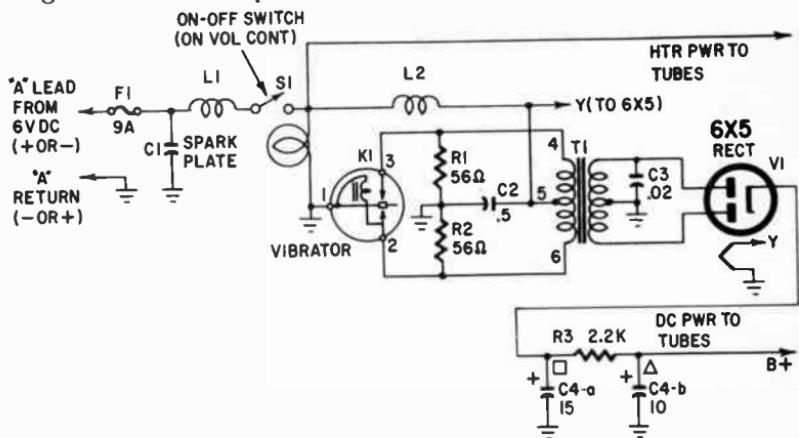


Fig. 703. Simplified schematic diagram of a conventional vibrator power supply.

Capacitor C3, connected from one side of the secondary of T1 to ground, is known as a buffer capacitor. The buffer capacitor absorbs voltage surges that develop in the secondary as a result of interrupting current flow in the primary. In this manner, the buffer capacitor suppresses sparking at the vibrator contacts and contributes to extending the life of the vibrator. Buffer action is

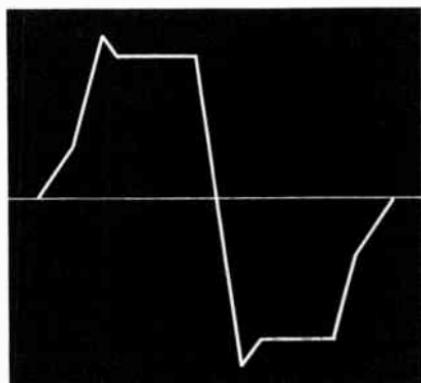


Fig. 704. Idealized waveform of the ac cycle developed at the secondary of vibrator transformer T1 (Fig. 703).

dependent on a resonant circuit formed by the buffer capacitor and the inductance of the transformer. For this reason, the value of the buffer capacitor is extremely critical. (Typical values run from between .02 and .005 μ f rated at 1,600 to 2,000 volts). A 5,000-ohm resistor is often connected in series with the buffer capacitor to limit the secondary current in cases where the buffer capacitor develops a short. In many power supplies, the buffer capacitor is tied across the entire transformer secondary.

Resistors R1 and R2 are hash suppressors used to reduce sparking at the vibrator contacts. Choke L2 and capacitor C2 make up a hash filter: the choke keeps rf interference from entering the A supply leads; the capacitor bypasses this interference to ground.

At the power input circuit, spark plate capacitor C1 and choke L1 prevent ignition interference carried in on the A supply lead from getting into the tube heater circuits. The choke blocks these interfering currents, while the spark plate capacitor bypasses them to ground.

Synchronous or self-rectifying vibrator

The synchronous or self-rectifying vibrator, as the name implies, is a device that accomplishes automatic rectification (conversion to dc), without the aid of an external rectifier tube. A simplified schematic diagram of a typical self-rectifying vibrator is shown in Fig. 705. It contains an extra pair of rectifying contacts (3 and 4) in addition to the elements found in the conventional interrupter vibrator. In practice, these contacts are connected across the secondary of the vibrator stepup transformer. In operation, with ON-OFF switch S1 closed, contacts 1 and 2 of the vibrator perform the normal interrupter vibrator function and produce the characteristic vibrator ac waveform at the primary of stepup transformer T1.

However, when the vibrator coil is energized and the armature is activated to make contact 1, contact 3 is also made. Under these conditions, contact 3 grounds the bottom leg of the secondary of T1. Current thus flows through the load, through chokes L3 and L2, to the center tap of T1 and returns to ground through the bottom leg of T1 and grounded contact 3. (Note that current flows from the load to the center tap of T1).

After the vibrator de-energizes, the armature springs back and makes contacts 2 and 4. This time, the top leg of the secondary of T1 is returned to ground, and current flows through the load, through chokes L3 and L2, to the center tap of T1, through the top leg of the secondary of T1, and on to ground through closed

contact 4. In the case of this alternation, current again flows through the load to the center tap of T1's secondary. Since the current through the load always flows in the same direction, the action described is obviously rectification. A positive rectified dc voltage is obtained at the center tap of the secondary of T1.

The synchronous vibrator will produce a positive voltage at the secondary-winding center tap only if the storage battery is connected with a negative ground as shown in Fig. 705. If it is connected to have a positive ground, a B-minus voltage will be developed and the radio will not operate. To use a synchronous vibrator in an auto radio connected in a positive-ground system, it is necessary to reverse connections at the primary or secondary of the stepup transformer (reversing the polarity) to permit normal operation.

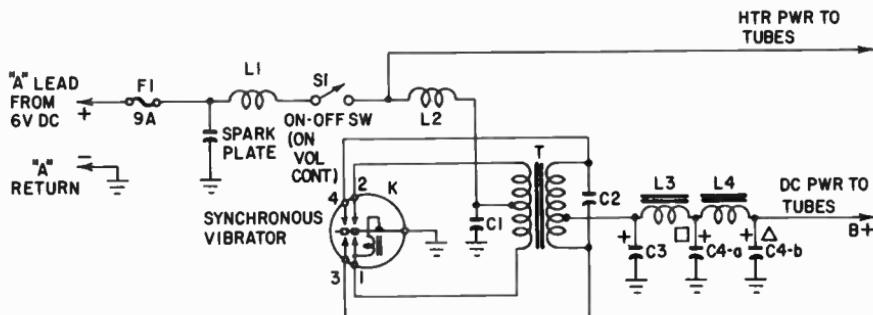


Fig. 705. Simplified schematic diagram of the synchronous or self-rectifying vibrator power supply.

Transistor dc-to-dc converters

The discussion so far should indicate to you that to make high-voltage dc from low-voltage dc, you need only find a means of switching and reversing the low-voltage dc, applying the resultant ac voltage to a suitable stepup transformer and rectifying. The vibrator has proved to be an effective method of accomplishing this conversion. However, the vibrator has several inherent disadvantages that have kept mobile-equipment designers on their toes looking for a better device.

High failure rate and noisiness are the most serious shortcomings. The basic reason for them is the fact that the vibrator is a mechanical device. What was sought as a replacement was a relatively passive all-electronic switching device, of proper size, that could handle the power. The answer was found in the transistor.

Transistors were developed that could be switched, could reverse signal polarity and could handle the power. However, the same component (the transistor) at the same time made obsolete the need for transforming low-voltage dc to high-voltage dc. It offered designers a means of achieving at low operating voltages the amplification standard tubes could only obtain at high operating voltages. Nevertheless, transistor dc-to-dc converters were developed, in many cases, not for new equipment designs but to replace vibrators in existing equipment. Many auto radios employing conventional electron-tube stages and circuit designs to meet the demand for sets at all price levels, are abandoning the vibrator as a means of obtaining high-voltage dc for tube operation. These radios are employing instead one or another form of the transistor dc-to-dc converter.

In essence, two basic types of transistor dc-to-dc converters have emerged. One generally employs two transistors in a multivibrator type switching circuit to generate the required ac waveform. A second method uses a power transistor in a blocking oscillator circuit to convert the low-level dc to a suitable pulsed signal. In both cases, the transistor switch is used in conjunction with a stepup transformer and a stage of rectification. The transformer in the case of the two-transistor switching circuit is apt to be of complex design and thus expensive; the transformer used with the blocking-oscillator transistor can generally be of simpler design and consequently is currently held in greater favor by auto radio manufacturers.

Multivibrator power converter: circuit analysis

The dc-to-dc converter power supply (Fig. 706) includes power transistors V1 and V2 (each a type 2N443 p-n-p power transistor or equivalent), bias networks R1, R2, R3 and R4, desparking capacitors C1 and C2, saturable reactor transformer T1, and full-wave rectifier D1, D2 and associated filter network R5, C5-b and C5-c. In brief, circuit operation depends on the multivibrator-like action of the transistors wherein one is driven to saturation while the other is held near cutoff. The saturable reactor transformer controls the state of the transistors in a manner similar to the control effected in a conventional multivibrator by R-C networks. The control action is in the form of positive feedback from the collector circuit to the base circuit. Note that the transformer primary is in the collector circuit while the transformer feedback winding is returned to the base.

When analyzing transistor switching circuits of this type, remember that the transistor does not function as a perfect switch; that is, cutoff does not signify a completely open system as in electron-tube switches but rather a state of extremely low conduction, or a high-resistance state as in the case of a crystal diode that is cut off. When power is applied to the circuit of Fig. 706, slight differences in the properties of the two transistors causes one to conduct sooner or more heavily than the other.

Assume that V1 conducts first. The conduction of V1 increases collector current flow through the top section of the center-tapped primary of T1. This action induces a voltage of opposite polarity into the feedback winding which causes the base to drive V1 into increased conduction. At the same time, the lower section of the

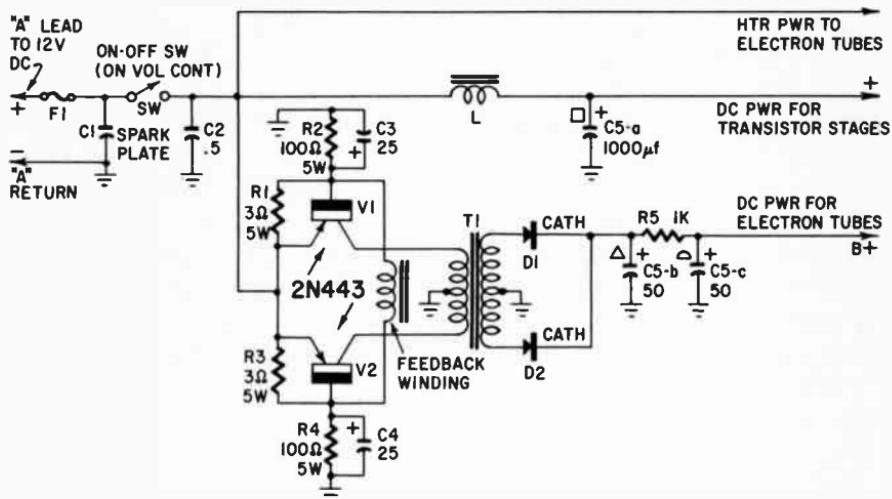


Fig. 706. Secondary power supply for a 12-volt negative-ground electron tube auto using a transistorized dc-to-dc converter in multivibrator configuration.

center-tapped primary of T1 and the feedback winding apply voltages to transistor V2 that drive it toward cutoff. After a prescribed interval, the core of saturable reactor transformer T1 saturates and the rate of change of flux in the windings rapidly drops to zero. Because the transistor cannot meet the demands for current placed on it when the transformer core saturates, the voltage across the primary begins to drop in response to the rapid drop in flux. The decreasing voltage diminishes the base driving voltage, producing a corresponding decrease in collector current. As V1 is brought toward cutoff, the flux in the windings of T1 begins

to build up in the opposite direction. A voltage of opposite polarity is built up in the various windings, driving transistor V2 into conduction. The saturable reactor transformer repeats the previous action in the case of V2. The cycles are repeated until power is removed.

The characteristic square waveform of the converter is induced into the secondary of T1, where it is stepped up and applied to the full-wave rectifier. Since an almost perfect square wave results, the rectified signal is almost perfect dc and requires very little filtering. The dc output is applied as B-plus to the plate and screen circuits.

Blocking-oscillator power converter: circuit analysis

The power supply circuit of Fig. 707 includes a transistor blocking-oscillator stage and a rectifier stage. The blocking oscillator circuit consists of transistor V1 (a 2N176 p-n-p power transistor), blocking-oscillator transformer T1, resistors R1 and R2 and network R3, C4. The rectifier stage is a conventional half-wave type made up of silicon diode D, varistor R5 and filter circuit R4, C3-b and C3-c.

When power is first applied, the base-emitter junction of V1 is forward-biased and current flows in the collector circuit. The collector-circuit transformer winding induces a negative voltage in the transformer winding at the base of V1, causing the collector current to increase. A positive feedback action is set up that drives the transistor to saturation. At saturation, the collector current reaches a constant value and a voltage is no longer induced in the transformer winding at the base. The collapsing field around the winding in the base circuit applies a positive voltage to the base, driving the transistor into cutoff. Capacitor C4 charges to the positive potential induced at the base to hold the transistor cut off. The collapsing field in the base winding induces a reverse voltage in the collector-circuit winding that applies a negative voltage to the collector. The base and collector currents are thereby reduced to zero, as are the fields around the transformer windings. With the collapse of the fields, capacitor C4 begins discharging through resistor R3. Transistor V1 is cut off until capacitor C4, discharging through R3, drops the base voltage to the point at which V1 is once again forward-biased. At this point, conduction begins again and the blocking-oscillator action is repeated until power is removed. The oscillator output is applied to the half-wave rectifier circuit, where it is rectified and filtered to yield the required dc output.

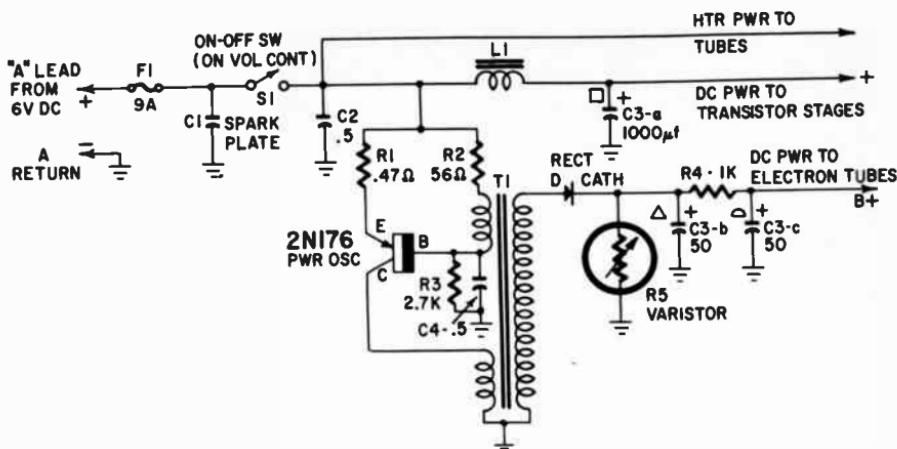


Fig. 707. Secondary power supply for a 6-volt negative-ground electron tube auto radio using a transistorized dc-to-dc converter in blocking oscillator configuration.

In the blocking-oscillator power-converter circuit, the output voltage is dependent on the free-running pulse repetition frequency of the oscillator. This in turn is regulated by the time constant of network R₃, C₄. Aging or other factors which might tend to decrease the time constant of R₃, C₄, will increase the repetition frequency, causing a corresponding increase in output voltage. The output voltage of the circuit must be regulated in some manner, to prevent serious damage to components that may result if the voltage is permitted to rise to dangerous levels. Regulation is accomplished in this circuit through the application of a varistor.

The resistance of varistor R₅, (a voltage-sensitive resistor connected across the rectifier output) varies inversely with the applied voltage. As the output voltage tends to increase, the resistance of the varistor decreases. It begins to draw current, and the output voltage decreases to nearly its original value. Similar regulation is also accomplished through the use of Zener (reverse-voltage breakdown) diodes. When the output voltage increases to a dangerous level, the Zener diode breaks down, conducts and reduces the output voltage to nearly the original level.

Future Trends

Auto radio power supply designers have already demonstrated their interest in moving their designs in the direction of semiconductor components. Witness the rapid introduction of the transistorized dc-to-dc converter in place of the electromechanical

vibrator. The same thinking will drive the dc-to-dc converter into limbo as all-transistor auto radios that operate on a trickle of electrical power come into their own. The current trend also seems to be in the direction of the auto portable in which the auto radio is liberated from its exclusive automobile environment and becomes the entertainment instrument taken to the beach or picnic area.

With things as they are, the stage seems to be set for the cutting of the umbilical cord between the auto radio and the automobile electrical system. An intermediate development, the introduction of an auto radio that is powered by a self-contained battery pack is sure to come about. Particularly in the field of FM auto radios this is a logical method of solving the interference problem sets powered directly from the noisy auto electrical system. The ultimate development will be the introduction of the auto radio powered by the semiconductor solar battery.

The solar battery powered auto radio would simplify servicing operations outside the auto, since a battery or battery eliminator device would no longer be required for bench operations. The solar battery set could be of a design similar to the rear view mirror auto radio, or might be installed in the roof of the auto immediately above the windshield so as to make the operating controls easy to reach from the driver's seat. For night listening, a trickle of power from the auto electrical system could be used to energize a luminescent light panel to supply light energy for the solar cell. An alternate night system could employ a rechargeable secondary battery to power the set at night while the solar cell was used to recharge the battery during day operations (the manner in which present day solar battery systems are being applied commercially).

interference suppression

INTERFERENCE in radios exhibits itself either as noise (static) or as fading. Both conditions upset normal operation by interfering with the audio output program. In auto radios, interference that exhibits itself as static most often originates in the automotive system. Interference may also arise from within the set (internal set noise) and from sources outside the automotive system (power stations, lines, etc.) Interference that causes fading arises from atmospheric disturbances that affect radio transmission.

This chapter is concerned with the suppression of interference resulting from the normal operation of the automotive system. Since the service technician has little or no control over interference from external sources (including atmospherics and fading), these subjects have been intentionally omitted.

Nature of interference

Radio interference is created by electrical devices which spark in the course of their operation. The spark transmits a random pulse of radio-frequency energy rich in harmonics which can be picked up by a radio receiver, amplified and detected along with the desired signal to produce static in the audio output. Since sparking is an inherent part of the operation of an automotive system, the generation of interference is a natural byproduct of auto operation.

Auto ignition system: chief source of interference

The ignition system is the site of most of the radio interference generated in the automotive system. A functional schematic di-

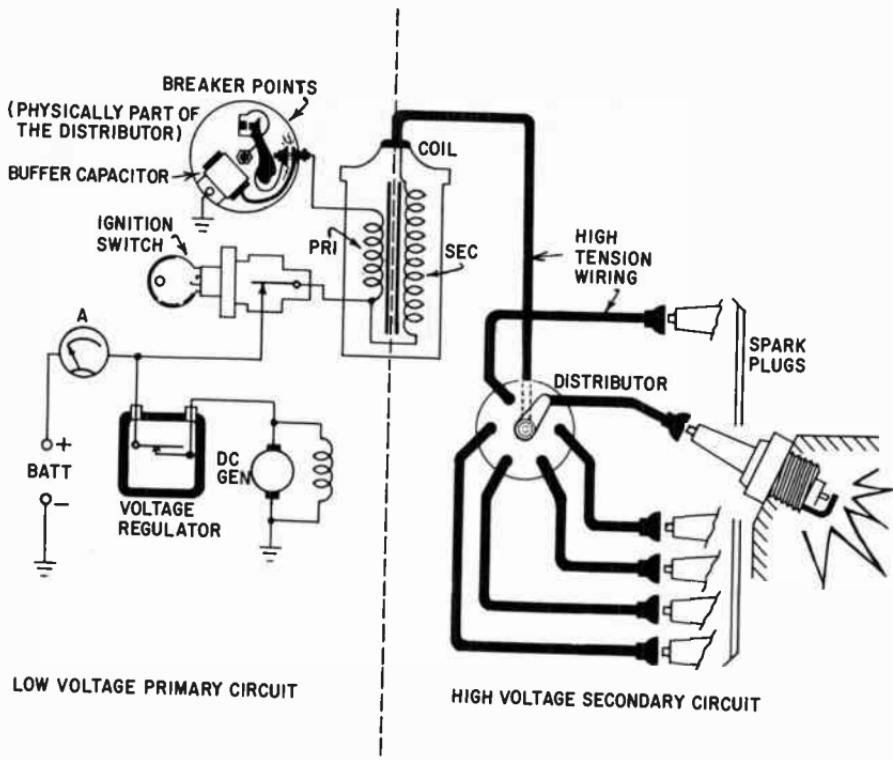


Fig. 801. Functional diagram of a typical ignition system, site of most of the radio interference generated in the auto.

agram of a typical automobile ignition system is shown in Fig. 801. It includes a low-voltage primary circuit consisting of the battery, generator, voltage regulator, ammeter, ignition switch, breaker points and coil primary, and a high-voltage secondary circuit consisting of the coil secondary, distributor and the spark plugs.

Basic electric power

The battery and generator supply the basic electric power for ignition. The battery is required for starting, but the load is switched to the generator by the regulator once the engine is running. The ammeter provides a visual indication as to whether the generator or the battery is carrying the load. An ammeter reading *charge* when the engine is running indicates the generator is carrying the load and is charging the battery. The ignition switch permits the motorist to open the ignition circuit to stop the engine. The breaker points (physically, part of the distributor) are operated mechanically from the engine camshaft to provide a

timed, interrupted low-voltage current for the primary circuit of the ignition coil. The coil is an autotransformer which steps up the interrupted low-voltage dc in the primary circuit to a pulsating high voltage in the secondary circuit. The distributor, timed from the engine camshaft, directs the high-voltage pulses to the proper spark plugs to fire the fuel-air mixture in the cylinders in correct sequence to sustain engine operation.

In the operation of the ignition system, sparks are generated at the plugs and at all make-and-break contacts, including the distributor, breaker points and voltage regulator. In addition, sparks are created in the operation of the dc generator as the brushes sweep over the segmented commutator. To aggravate the situation, the offending components are connected by wires which act as antennas to transmit the interference created. In this manner, interference can be picked up by the auto radio antenna. Moreover, interference can be introduced into the auto radio by direct conduction through the power leads from the generator.

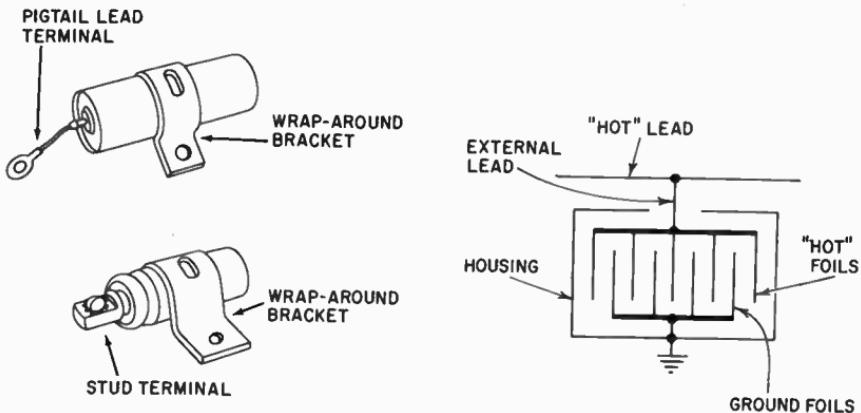


Fig. 802. Construction of a bypass capacitor, and some typical bypass capacitors for suppression applications.

Suppression techniques

The interference that fouls radio reception by appearing as static in the output is in the same frequency band as the desired signal at the receiver input. As a result, the radio can do little to discriminate between desired signal and interference. For this reason, the receiver is not a logical place to suppress interference. The most logical and best place to suppress it is at the source.

Interference can be suppressed by preventing it from being radiated or conducted. This is normally accomplished by provid-

ing an easy path to ground for interference currents, by attenuating the interference where it is created or by containing it. In autos, capacitors are used to bypass interference, resistors to attenuate it and shields to contain it once it has been radiated. The effectiveness of capacitors and shields is dependent on the technique of bonding which establishes and insures a low-impedance path to ground for the interference currents. In modern auto radio installations, all of these techniques and devices are used to keep the level of interference low.

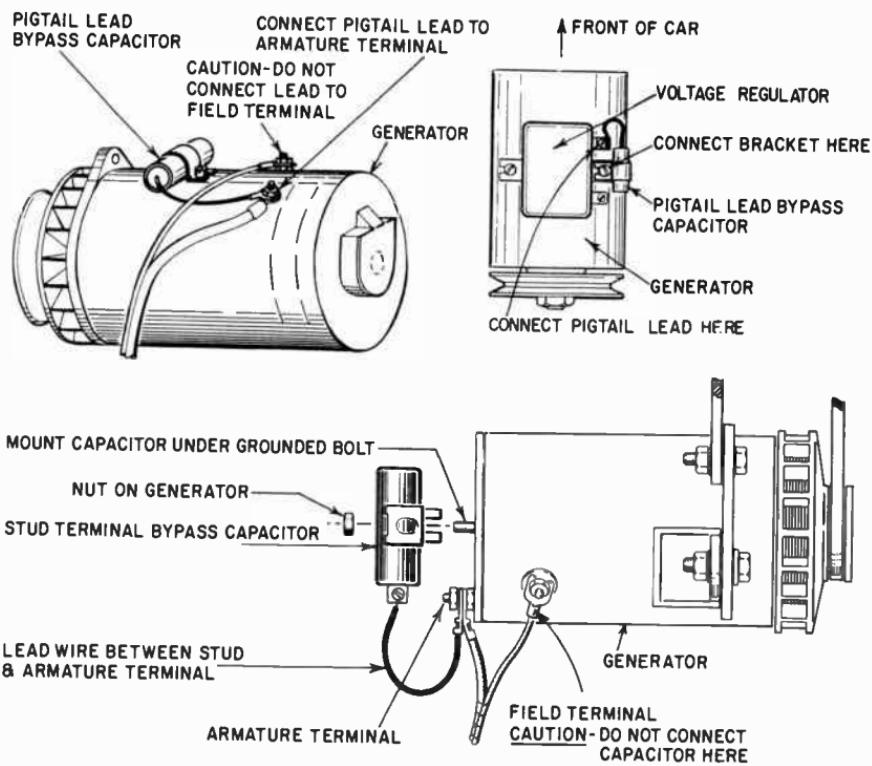


Fig. 803. Typical installation of bypass capacitors at automobile generators.

Bypass capacitor

The bypass capacitor is a relatively simple, low-cost component used for bypassing interference in the frequency range up to 10 mc (broadcast-frequency band 540-1600 kc). The construction of a bypass capacitor is shown in Fig. 802. Typical bypass capacitors are shown in the same figure. The bypass capacitor has a bracketed metal body for one conductor and a pigtalead or a stud for the second. The stud-type bypass capacitor is preferred because of its greater effective frequency range.

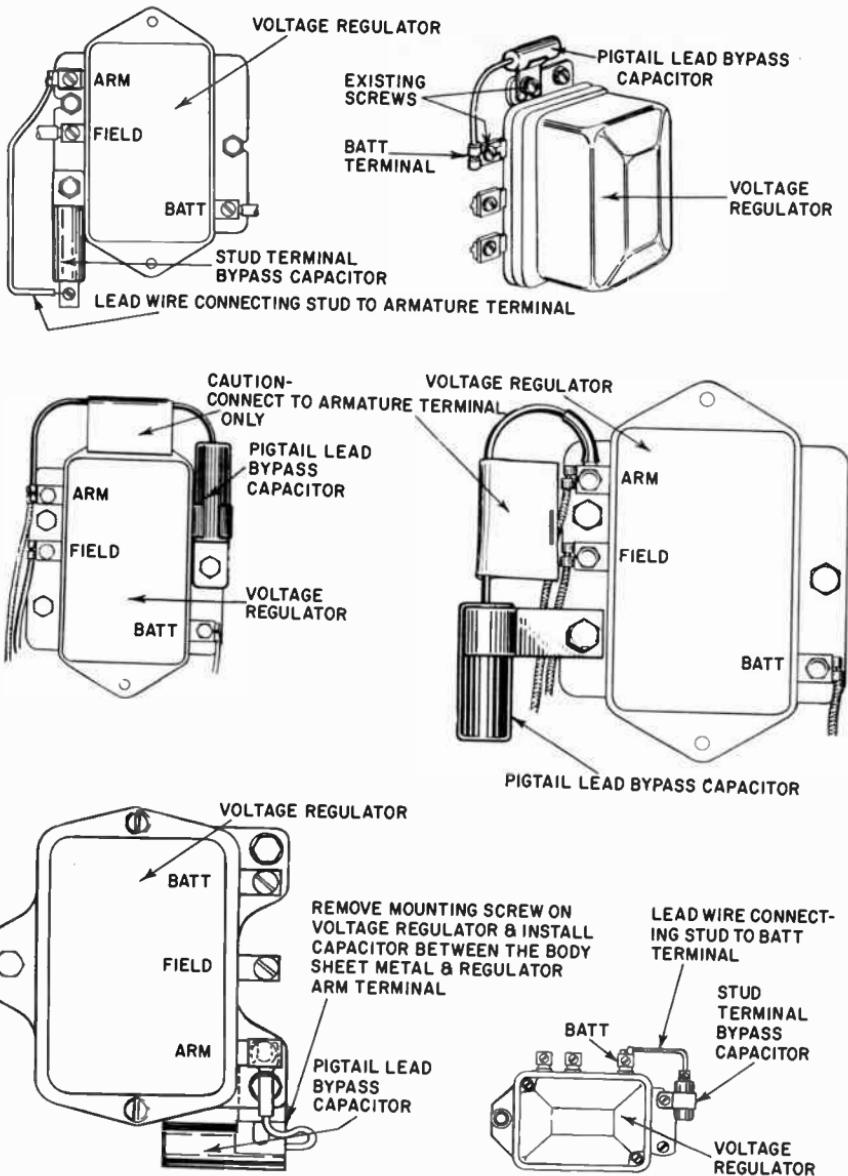


Fig. 804. Installation of bypass capacitors at voltage regulators.

In a typical installation, the bracket is bonded to ground and the pigtail lead or stud is bonded to a convenient "hot" point on the component to be suppressed. The bypass capacitor is used to suppress interference at the generator, voltage regulator and primary circuit of the ignition coil.

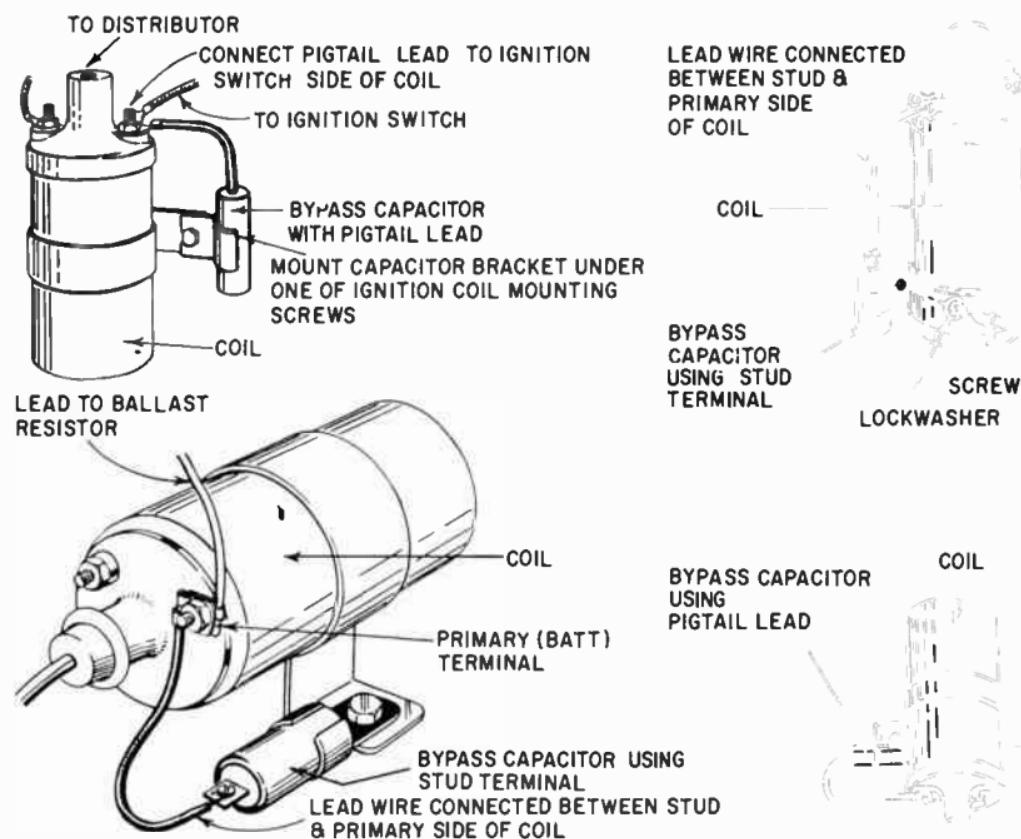


Fig. 805. Installation of bypass capacitors at ignition coils.

Typical installations for generators are shown in Fig. 803 and for voltage regulators in Fig. 804. Coil installations are shown in Fig. 805. Note that the bypass capacitor is always installed at the

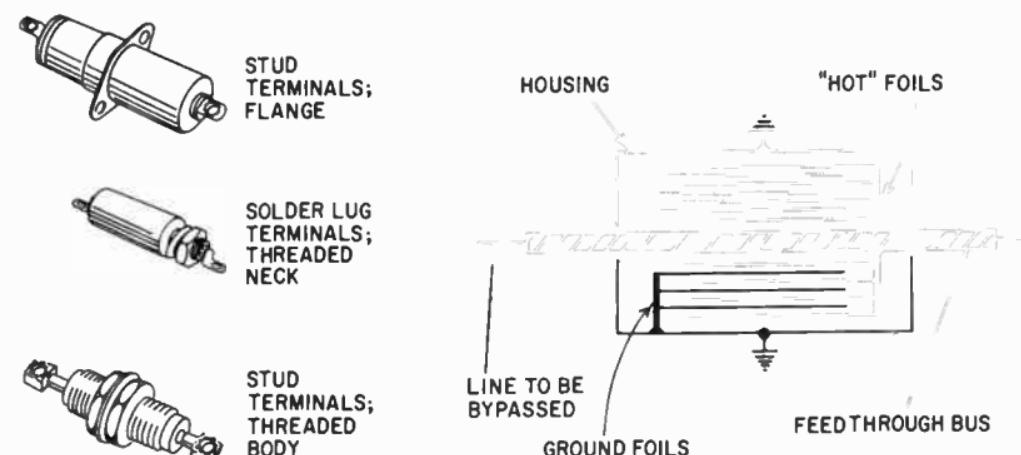


Fig. 806. The construction of a feedthrough capacitor, and some typical feedthrough capacitors for interference suppression applications.

generator armature close to the actual source of interference never in the field circuit. Note also that the bypass capacitor is

installed at the battery or armature terminal of the voltage regulator and at the ignition switch side of the coil circuit.

Feedthrough capacitor

In recent years, a better component, the feedthrough capacitor, has been developed that is effective in the frequency range to

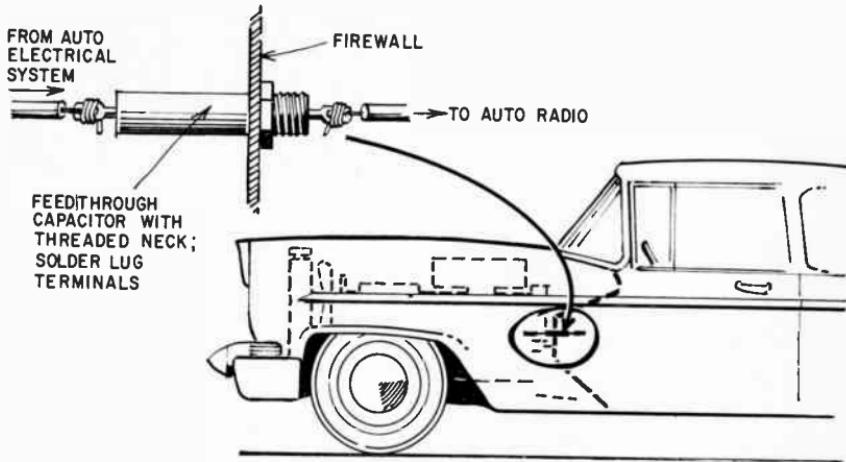


Fig. 807. Feedthrough capacitor installed in the firewall.

above 100 mc (FM band 88.1 to 107.9 mc). The feedthrough capacitor resembles a piece of coaxial cable in that the live conduc-

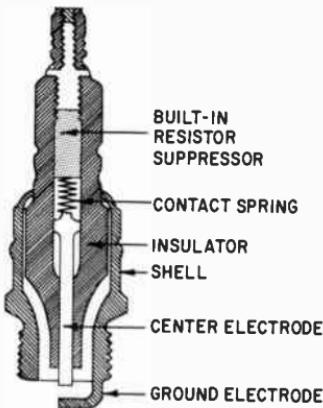


Fig. 808. Cutaway view of a resistor spark plug.

tor is surrounded by the second conductor, which acts as the ground terminal. The construction of a feedthrough capacitor is shown in Fig. 806. Typical units are shown in the same figure.

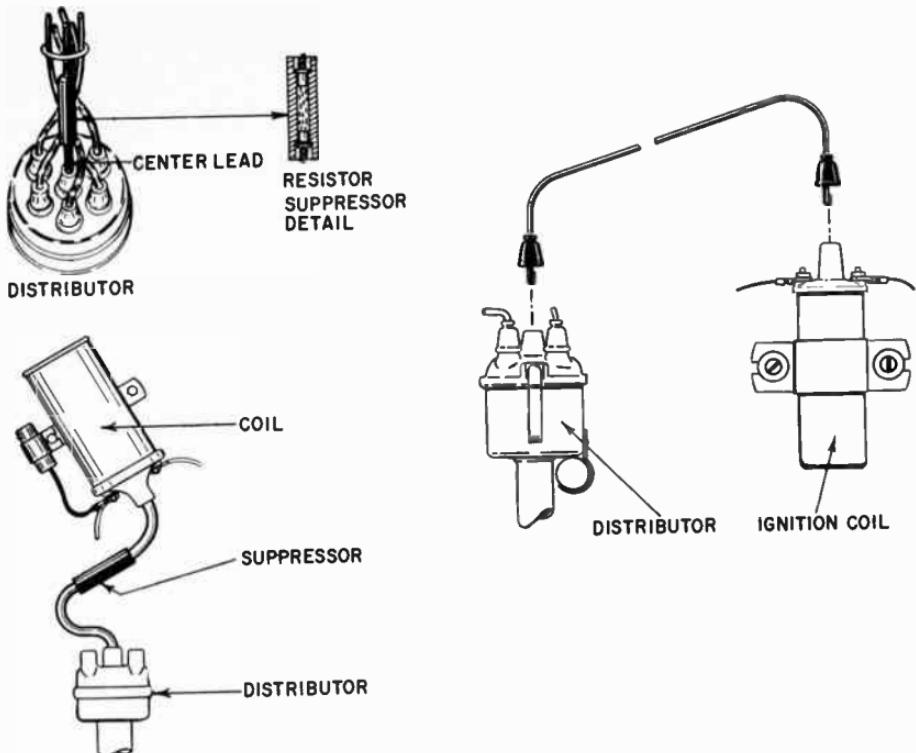


Fig. 809. Typical installation of suppressor resistors at the distributor. Caution: some cars have an ignition interference suppressor built into the distributor cap or ignition leads. Do not install a second suppressor as high resistance affects engine performance. To put in a suppressor, cut the center distributor lead and screw the suppressor resistor in series with the two pieces of wire.

The feedthrough capacitor can be used most effectively when installed in the firewall between the compartment where the motor is located and the dash containing the auto radio installation. All lines (conductors) carrying operating power for the automobile radio can thus be cleared of interference by installing a feedthrough capacitor in their path. A method for doing this is illustrated in Fig. 807. Connections to the feedthrough capacitor should have no excess wire dangling from the capacitor terminals, should be mechanically secure (wrap the wire) and well soldered. This applies to both sides of the capacitor.

Resistor suppressors

Resistor suppressors are often an integral part of the component with which they are used. The best example of this is the resistor spark plug. A cutaway view of a typical one is illustrated in Fig. 808. Resistor suppressors are also used at the distributor (Fig. 809). In this case, the resistor suppressor is often a separate ex-

ternal component, although built-in suppressors are also used. Resistor suppressors are placed in series with the circuit load to act to attenuate interference currents independent of frequency.

Since the effectiveness of bypass capacitors is restricted to frequencies below 10 mc and feedthrough capacitors are restricted in application, short-wave sets and FM auto radios (frequencies to 107.9 mc) place a greater importance on resistor suppressors. There is a good deal of controversy as to the effect their use at plugs and distributor has on engine performance. Reason would seem to be on the side of negligible effect, since the spark plug represents a device that draws no current until its full firing potential is reached and then, on firing, draws maximum current which the series suppressor resistors should not limit. Practice has shown that, at least in some reported instances, engine performance was affected adversely by the use of very-high-resistance values. Since the reputation and standing of a radio service technician are at stake in this

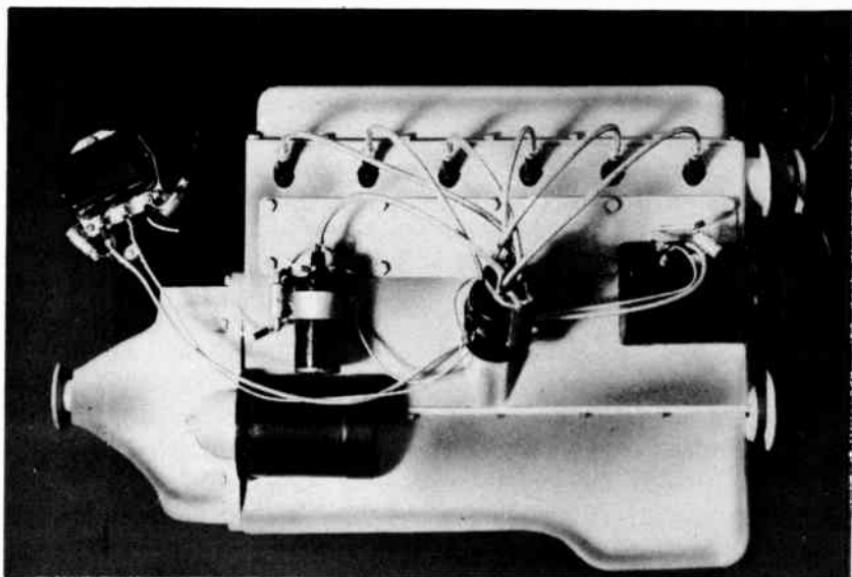


Fig. 810. Ignition system showing the use of shielded ignition wiring. (Hallett Manufacturing Co.)

controversy, this text recommends preserving the status quo. Do not attempt anything contrary to the auto manufacturer's recommendations for the engine, regardless of what may suggest itself regarding a suppression installation.

Resistor cable

In some cars special resistor cables are used instead of resistor

plugs or separate resistor suppressors. The resistor cable is 7 millimeter cable in which the conductor is non-metallic. The conductor is a cord impregnated with a graphite (carbon) compound. Both the resistivity and the conductivity are accounted for by this construction. The graphite particles represent the conductive portion and their spacing provides the resistivity.

For short wires the resistivity is 9,000 to 12,000 ohms per foot. For longer wires (say, 2 feet) a resistivity of 3,000 to 6,000 ohms per foot is used.

The rest of the cable is finished like ordinary, conventional 7 millimeter cable, having a jacket of rubber covered with neoprene.

Shielding

Radio-frequency energy radiated by high-tension wiring in the automotive system can be suppressed through shielding. Shielding keeps radiated radio interference contained within a specific region to prevent its entering a sensitive region. Where higher frequencies are met, as in short-wave sets and in FM auto radios, shielding becomes more important as a suppression measure.

Many auto manufacturers, recognizing the importance of adequate ignition-wiring shielding, have designed their ignition wiring into a duct which serves to contain radiated interference. The installation of such ducts is beyond the scope of operations of the average radio service technician. However, effective results may be obtained through the application of special shielded ignition wiring available from auto supply houses. A typical shielded-wiring installation is shown in Fig. 810.

Bonding

Bonding is the term applied to the method of connecting two metallic units to provide a low-impedance path for rf currents. As such, bonding is the key to achieving good results in applying suppression components. Capacitors and shields must be bonded at all connection points to the auto chassis and ignition components. Failure of a bond can destroy the effectiveness of a suppression measure. Often, interference troubles can be traced to failure of a bond rather than to component failure.

The following techniques will help assure a good bond.

1. Abrade all surfaces involved in a bond to bare metal.
2. Use tooth type lockwashers (preferably internally and externally toothed) when nuts and bolts are used to make the connection in a bond. Tighten connections so that the teeth bite into metal surfaces being bonded.

Troubleshooting ignition-system interference

In general, ignition-system interference problems are best approached through a four-part troubleshooting procedure:

1. Establish that the trouble is caused by the ignition system.
2. Try to identify the type of interference.
3. Locate the source of interference.
4. Correct the faulty condition to reduce or eliminate the interference.

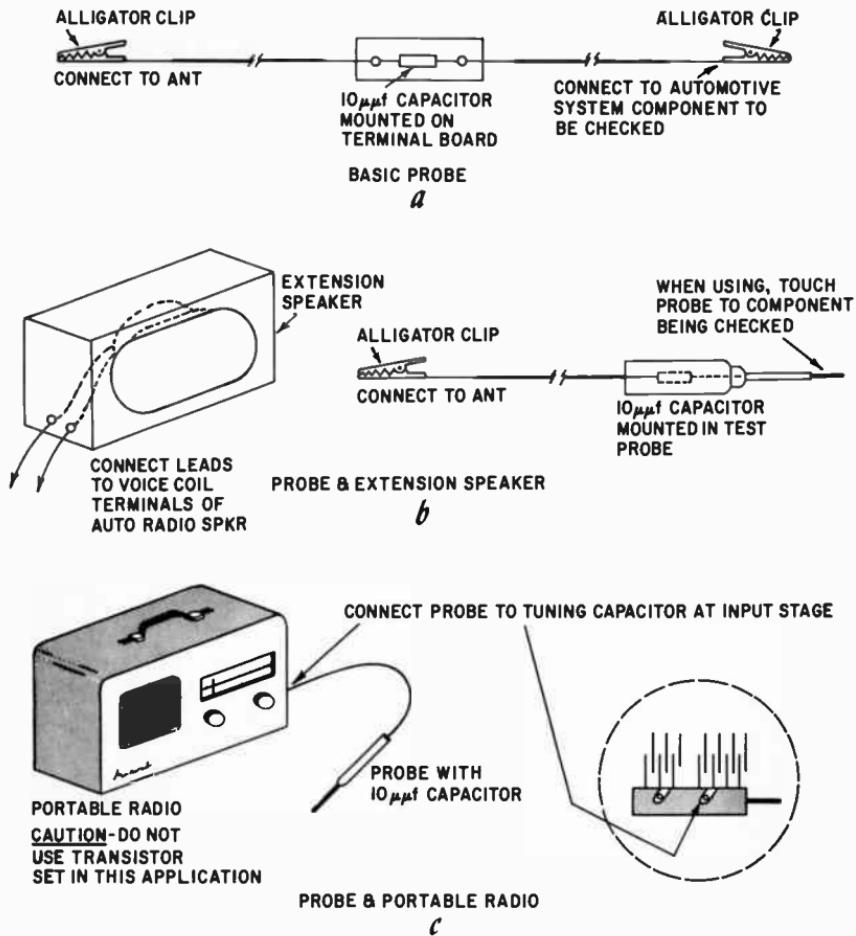


Fig. 811. Equipment recommended for investigating the sound character of interference from different ignition components.

Establishing the cause of trouble

As in other troubleshooting situations, the customer will state

the case when he wheels his vehicle up to the front door of the service shop: "The radio plays beautifully when I'm outside taking it easy waiting for my wife, but when she shows up and I start the engine, you can hardly hear the music because of static". Part 1 of the troubleshooting procedure has been accomplished. At this point, impress upon this customer the fact that he has an interference problem that will involve checking the entire automotive system, as well as the radio.

Identifying the type of interference

One way of classifying interference is by the way it is spread. Radiated and conducted interference get their names from this system. Radiated interference is transmitted from the source of interference, is picked up by the antenna or antenna lead-in and is fed to the receiver front end along with the desired signal. Conducted interference is directed into the receiver through the power leads.

With the engine running and the radio operating at high volume, short the antenna to a suitable ground point on the auto. If signal and static are attenuated equally, the interference is being radiated. If the signal is strongly attenuated but the static is only slightly attenuated, the trouble is being caused by conducted interference.

Locating the source of interference

Just as the keen mechanic can evaluate the condition of an auto engine by listening to it purr, so can the trained auto radio troubleshooter learn to identify and locate the source of interference by its aural characteristics. Through this approach, the time required to perform many interference troubleshooting jobs can be reduced considerably. The trick is to listen with a discerning ear to the effects of interference at the speaker, and the best time to listen and learn is during off hours.

Caution: Do not use a transistor radio for the procedure to be outlined.

Any one of several methods may be employed to learn what interference from different interference-generating components in the automotive system sounds like. The simplest involves the use of the radio itself and a probe consisting of two lengths of lead wire, a 10- μf capacitor and two alligator clips as shown in Fig. 811-a. Attach one alligator clip to the antenna and the second clip to the automotive system component to be checked. Disable the suppression component at the point under test. Start the engine,

tune the radio between any two stations and listen to and mark the characteristic sound of the interference. Repeat the check at every interference-generating point, including the plugs, coil, distributor, voltage regulator, and generator armature. The basic aural character of the interference from these points is given in Table 8-1. Other methods of accomplishing this checkout involve

Table 8-1. SOUNDS PRODUCED IN THE SPEAKER BY THE IGNITION SYSTEM

Component	Sound Character	Detailed Description
Spark plugs	Popping, crashing	Occurs at regular intervals, speeds with increase in engine speed. Stops when engine is stopped.
Distributor, Coil	Popping	Similar to popping caused by spark plugs.
Voltage regulator	Clicking, crackling	Rapid and irregular. Speeds with increase in engine speed. Continues for a moment after engine is stopped.
Generator	Whining	Rises in pitch as the engine is speeded.

the use of a portable extension speaker and a probe (Fig. 811-b), or the use of a portable radio and a probe (Fig. 811-c).

The portable radio and probe technique is also recommended for localizing interference to a faulty part in actual servicing opera-

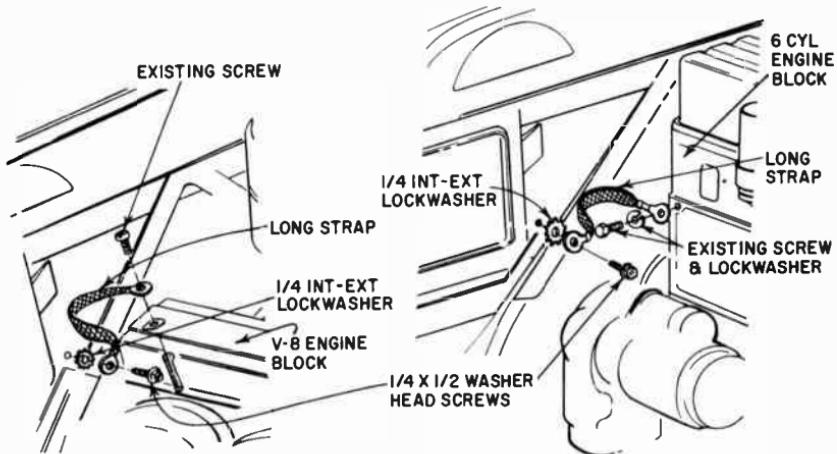


Fig. 812. Installation of bonding straps from engine blocks to auto frames.

tions, although this step can be eliminated once the aural character of interference from different parts becomes easily discernible through practice.

There is one final, but most important step in localizing the source of interference. Run the engine at a good speed and turn the ignition switch to the accessory position. This will kill ignition noise (if any) but generator and regulator noise will continue until the engine stops turning.

Correcting the faulty condition

Generally, the source of interference will turn out to be a part that was never suppressed, was improperly suppressed or is no longer suppressed due to failure of the suppression component or associated bond. To clear the trouble, install or restore suppression components as required:

Bypass capacitors: Install at generator armature terminal, in primary circuit of the coil, at regulator.

Resistor suppressors: Install in the distributor circuit; install resistor spark plugs.

Shielding: Install specially-shielded ignition wiring.

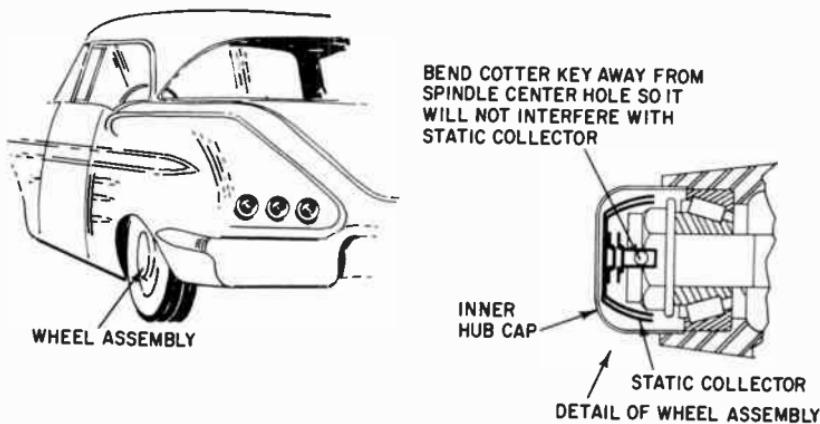


Fig. 813. Typical wheel-assembly static-collector installation.

Bonding: When installing suppression devices, bond all connections to insure good electrical continuity.

Body noises

Loose parts of the auto body produce a form of radio interference known as body noise. It is caused by the chafing of loose metal sections that results in static electricity buildup and resultant discharge. These discharges are accompanied by sparks and the transmission of radio interference. The static charges generally build up on poorly grounded sections of the auto body and discharge to well grounded ones.

Body noise can be distinguished from other forms of inter-

ference in that it manifests itself when the auto is in motion and for a very short period after the auto is stopped. Interference from this source is almost always accompanied by telltale mechanical squeaks and rattles. These are an aid to pinpointing the site of trouble.

A body-noise problem can be confirmed by rocking the auto (as in checking shock absorbers) while listening to the radio with the engine off. Frying, snapping, or scratching sounds at the speaker produced by this test confirm a body-noise problem.

To clear such interference, apply bonding straps in conjunction with internal-external tooth type lockwashers at the site of trouble.

Typical installations of bonding straps from engine blocks to auto frames (a common trouble spot) are shown in Fig. 812.

Tire static

Tire static is a special form of body noise in which interference is generated by the discharge of static electricity from the wheel assembly to the axle. Tire static appears as a periodic popping sound in the speaker. It can be reduced or eliminated by applying static-collector springs to the wheel assembly. These springs are installed beneath the axle locknut dust cap, and serve to ground the wheel assembly to the axle. A typical static-collector installation is shown in Fig. 813. As an added measure, dusting graphite powder into the inner tube of the tire helps reduce static buildup.

A kit that includes all components required to reduce tire-static interference is available from most auto supply stores.

Interference problems in FM auto radios

The average consumer knows from his experience with home hi-fi systems that the FM set should provide wide-band audio sound in a static-free background. Imagine what happens when he hears background noise and gobbled sound issuing from his auto radio receiver. Such noise is commonly associated with FM auto radios which are installed in cars whose ignition systems are not effectively suppressed.

In normal operation, an automobile ignition system is a notorious generator of wide-band random interference pulses. Such pulses, when introduced into the tuned circuits of FM receivers, mix with the carrier signal in such nonlinear stages as the limiter, to produce static in the audio output. Through effective suppression techniques, including the application of feed-through capaci-

tors, it is possible to achieve noise-free FM reception, in areas of good signal strength.

Another noise problem in FM auto radios is encountered in weak signal areas. Here the interference introduced from neighboring vehicles often overcomes desired signals. The limiter stage in the FM set is unable to eliminate completely this AM type of noise in the presence of a weak program signal. Static in the audio output is the result. There is no simple solution to this problem. Some customer education on the subject of auto FM radio limitations vs home radio FM may be in order.

Importance of ground points

Eliminating the final, last little bit of interference, sometimes depends on unusual, and often unknown, details. In one instance an auto radio was mounted on the firewall and a shielded battery cable brought through the firewall to the receiver. To make sure the shield was grounded, it was attached to the car chassis with a length of shield braid. However, noise pickup was traced to the cable. The grounding braid was unsoldered from the cable and moved back and forth along its length. A point was found at which noise disappeared. The braid was then soldered to the battery cable shield at this point.

In some makes of autos, the hood is supplied with grounding points, making grounding contact with the car frame when the hood is closed. The positioning of the grounding points is extremely precise, another indication that ground location can be critical.

An in-dash installation may presuppose automatic grounding since the case of the receiver becomes part of the car frame. But, especially in the case of vibrator-powered receivers, circulating currents in the metal case of the receiver can induce noise voltages. Probe the case with shield braid (the other end of which is securely fastened to the car frame) to learn if an additional ground is needed.

While this test is awkward to do in some installations, it isn't practical to postpone it for bench servicing. On the bench the receiver isn't subjected to the interference it receives when in the car, with the car operating.

miscellaneous developments

THE electronics industry is constantly developing new products, improving old ones, and adapting them to new uses. The

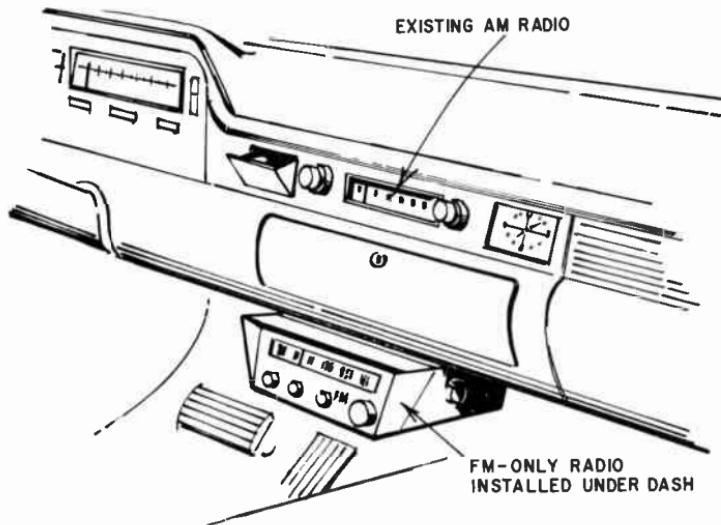


Fig. 901. An FM-only auto radio installed under the dash of a car that has an AM set installed in the dash.

auto radio is an excellent example. Manufacturers are continually adapting existing products for use in the American family car.

FM-only auto radio

An interesting development is the FM-only set (Fig. 901). The remarkable thing about this radio, compared to FM models available for some years now, is that it is self-contained — it has a

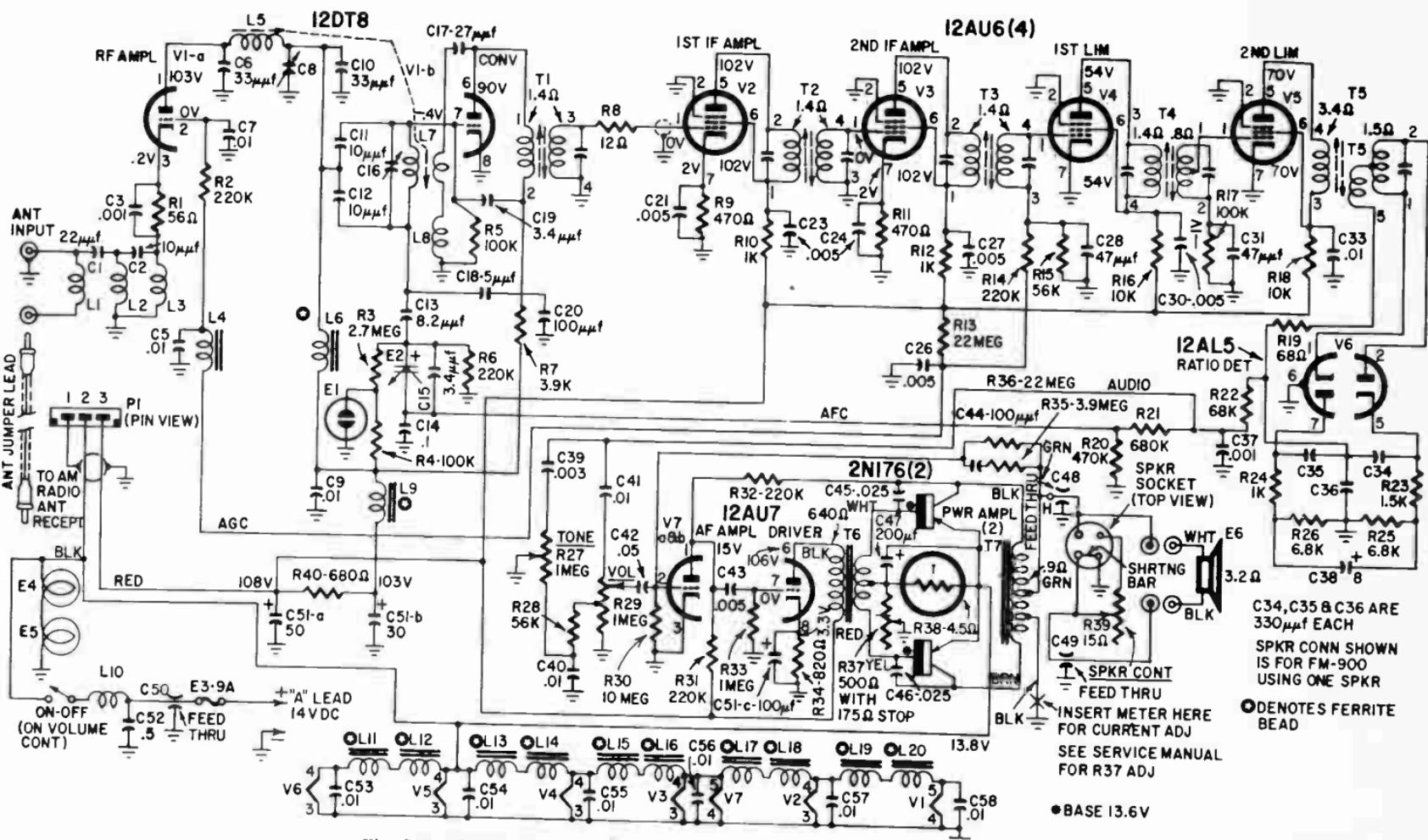


Fig. 902. Circuit diagram of the FM-only auto-radio receiver.

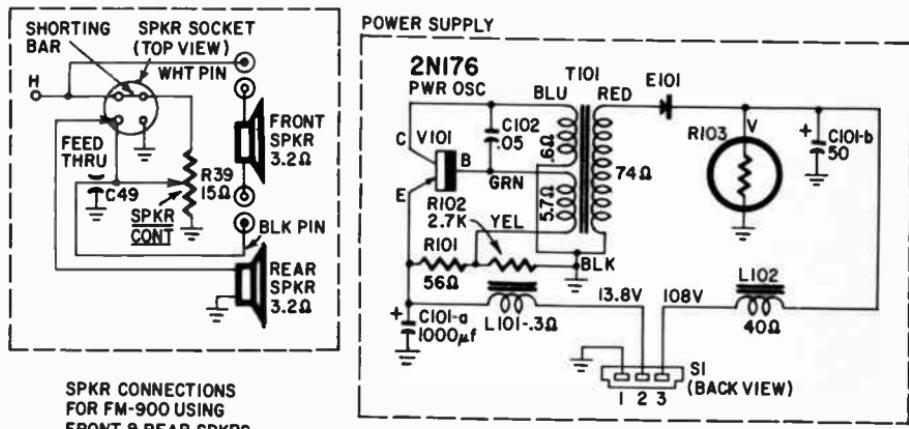
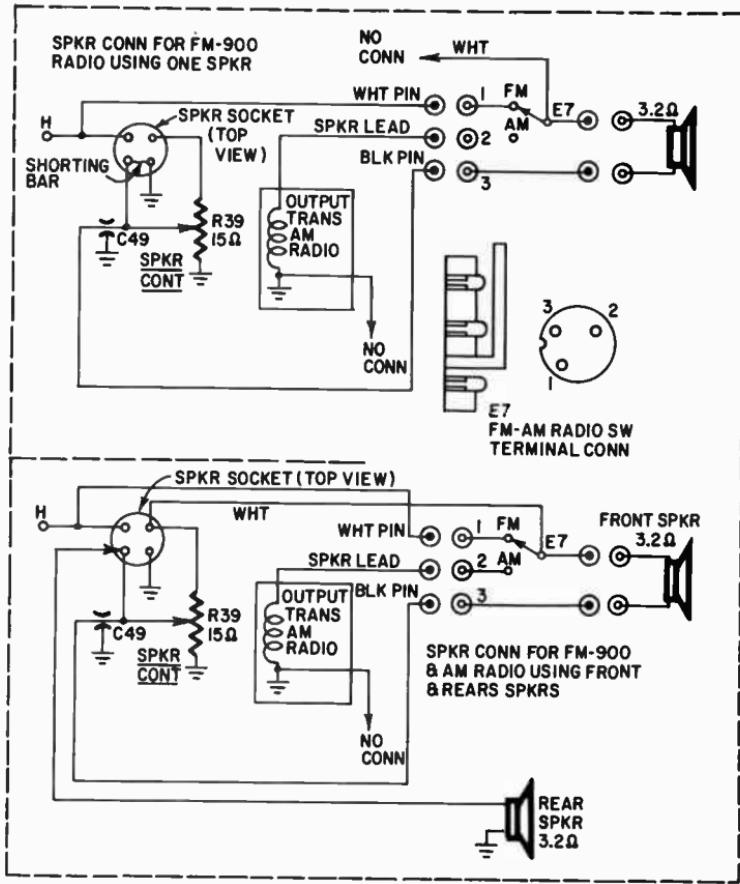


Fig. 902 (continued). Additional circuit components of the FM-only auto-radio receiver.

complete audio amplifier section that enables it to drive its own speaker. Fig. 902 is the schematic diagram of the unit.

Previously, all available FM auto radios were either tuners or converters that had to be used with an AM radio or a separate external audio amplifier and speaker system to function properly. The natural implication was that the FM tuner or converter could play "through" an existing AM auto radio system. The FM tuner and converter were unattractive to a buying public aware that their existing AM auto radio could not offer the quality sound approaching their packaged "hi-fi's" at home. (Many probably reasoned that as FM listeners at home, they seldom if ever listened to AM, and that the purchase of an FM tuner would do little more than render their existing AM auto radio obsolete). Psychologically, nobody likes to admit that the auto radio that cost nearly \$100 is good for nothing more than its audio amplifier section. Years ago, it may have been possible to build a convincing case around this point, but an enlightened public has become a somewhat more sophisticated buying group. The differences

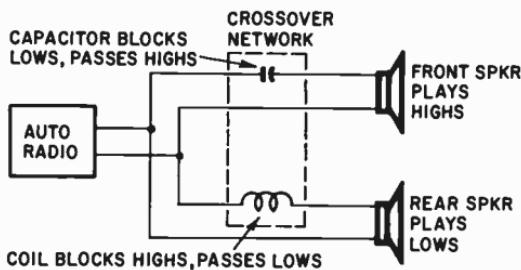


Fig. 903. A simulated stereophonic system for auto radios. The operation of the system is based on the use of a crossover network.

between and the purposes of a tuner and an audio amplifier are no longer so mysterious.

Stereo

True stereophonic listening involves the reception of multi-channel program material picked up and transmitted via a multi-channel system. To date, in commercial broadcasting, two and three channels have been used, with two channels via radio being the most common. (A number of three-channel stereo broadcasts were transmitted using AM, FM and TV sound facilities in the stereo flurry that followed the introduction of the stereophonic phonograph record). Commercial broadcasting of binaural and

stereophonic programs from both live and magnetic tape sources has been a common practice since about 1952.

The standard approach to stereo radio broadcasting has dictated the use of the AM source as one channel and the FM source as the second. Several special systems of FM multiplex have been devised which permit the simultaneous transmission of two channels multiplexed (or scrambled) together within the frequency band normally assigned to a single FM channel. Experimental broadcasts employing FM multiplexing have been made. Many regard FM multiplex as the straw that will break the AM strangle hold on stereo broadcasting and will usher FM-only stations into the stereo fold.

Attempts made in the past to adapt the auto radio to stereo reception always have been variations of the twin-speaker - single-program-source theme. This absence of at least two channels immediately removed such systems from qualifying as true stereo systems. Stereo systems based on a single program source generally were a "sooped-up" or glorified version of the fader-controlled front- and rear-speaker system. The gimmick that produced the stereophonic effects was an audio crossover network that per-

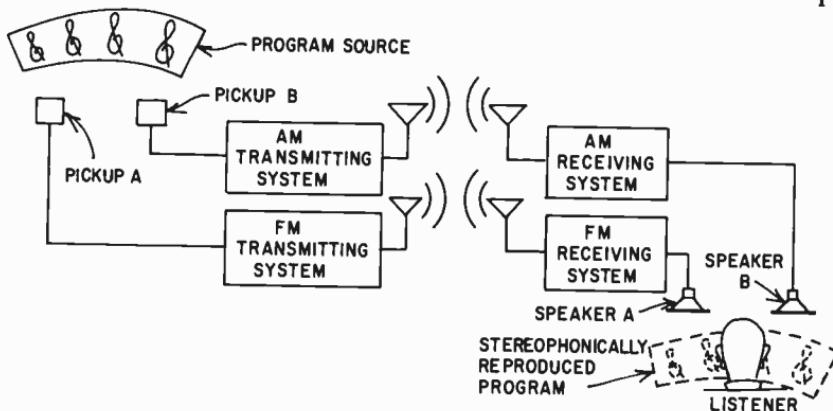


Fig. 904. Typical two-channel stereophonic broadcasting system employing AM and FM radio systems.

mitted the high frequencies to come from one of the speakers (usually the front) while the low frequencies were shunted to the other speaker (the rear), which was installed in the trunk — a sort of baffle (Fig. 903). Surprisingly enough, this technique helps produce an illusion of listening in depth to true stereo. The effectiveness of the phenomenon probably can be explained as a psychological one in which the brain automatically fills in the sound gap between the highs coming from the front and the lows coming

from the rear, thus creating for the individual the impression of space-spanning sound.

With the self-contained FM auto radio a commercial reality, true stereophonic reception and listening while motoring is immediately feasible. The FM auto radio is a compact unit which may be easily mounted under the dash, in the glove compartment or on the floor (of sports or minicars), following the procedures covered in Chapter 3.

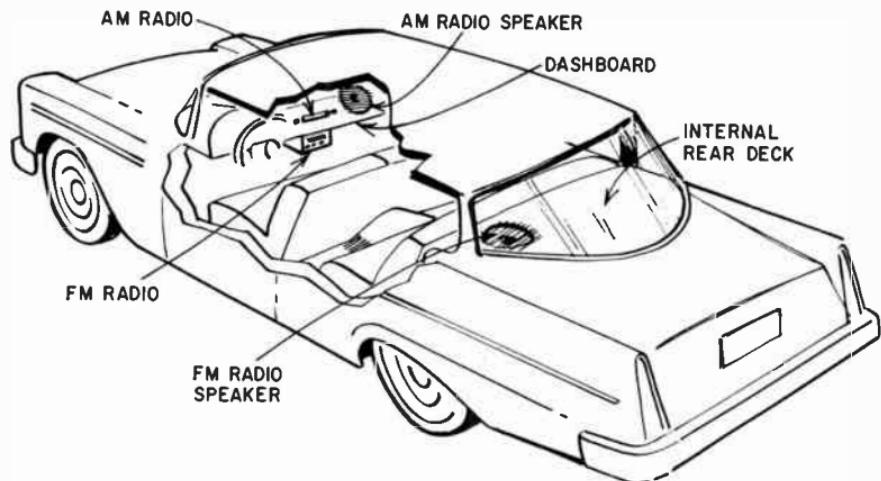


Fig. 905. Recommended speaker placement for front-to-back auto radio stereo system.

While the installation of the radio chassis itself presents a minor problem, the more immediate and major difficulty is speaker placement. Generally, commercial stereo broadcasts have standardized their transmissions so that the left spatial channel is broadcast over the FM source while the right is broadcast over the AM source. To re-create the stereo effect on the receiving end, it is necessary to arrange the speakers so that they are to the left (FM source) and to the right (AM source) of the listener to duplicate the original program source (Fig. 904). One of the critical adjustments in stereo is the achievement of proper speaker balance to afford the true stereo effect. In the auto, it is obviously more difficult to effect a speaker placement which will assure the desired balance than it is in the home.

Remember that the stereo effect in sound is psychological just as the stereoptic effect in seeing is achieved when the brain successfully combines two independent images it receives from the eyes. Thus, it is possible to throw the separated stereo sound "images" at the brain and have it combine them to provide the

effect of stereo listening. The effect may be achieved, moreover, through a front-to-back placement of speakers as well as by a side-to-side placement with respect to the listener. The effect of front-to-back stereo may be likened to that of a listener sitting with the performers of a symphony orchestra or jazz band as opposed to sitting as an audience in front of the performers.

The "sitting-in-the-orchestra" effect is exactly what made the Kostelanetz sound of pre-hi-fi days so different from all other recordings. Kostelanetz utilized a technique in which he placed the pickup microphones at key points among his players to capture that special sound quality. This technique has been adapted for use in modern high-fidelity recordings. The first time it was employed on a major musical scale was to record the Philadelphia Orchestra under Ormandy performing Tchaikovsky's Sixth Symphony. To this day, listening to this recording is startling since the effect achieved is that of an orchestra in motion. The multiple

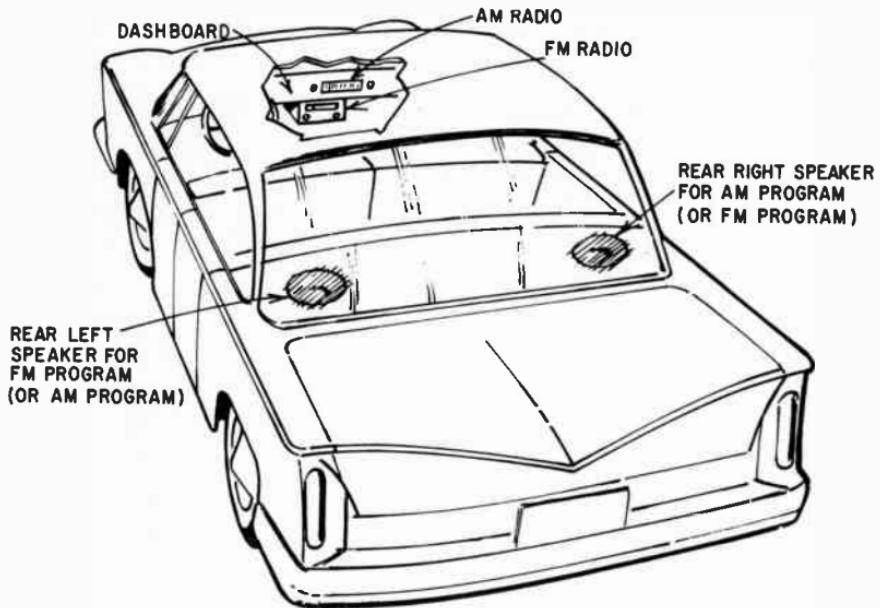


Fig. 906. *Alternate method of speaker placement for stereophonic reproduction.*

microphones in the orchestra emphasize everything (which may be a distortion of what Tchaikovsky planned for the listener), but no one can deny that a new insight into the music is to be obtained from the technique.

Jazz, of course, is recorded often using this technique since the mood is more intimate and is played often for the jazzmen seated

among the players, as opposed to being played for an audience out front. The same holds true for chamber works. Solo songs, show tunes and choral works obviously are suited to the front-to-rear speaker placement, since the listener will hear solos either

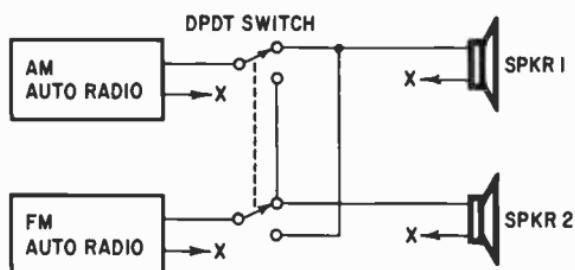


Fig. 907. Dpdt switching circuit used to obtain choice of speaker arrangements in two-rear-speaker stereo system.

from one or the other speaker and will hear choruses as if he were among the choral group.

In a front-to-back auto-radio stereo system, it is best to place the rear speaker in the rear left-hand corner of the back deck,



Fig. 908. Phonograph designed for use in an auto (CBS Labs).

with respect to the driver (Fig. 905). This speaker should handle the FM output channel to follow the broadcasting convention of having the FM channel carry the program material generated at the left side of the studio.

Note that, as far as the driver's position goes, this places him spatially in the orchestra, facing the audience. However, for sedan passengers sitting in the front-right and rear-right positions

(facing in slightly), the program will be a normal stereo show heard as though they were seated in the audience. (The passenger in the rear-left corner must take pot luck. With six passengers,



Fig. 909. Initiating a play on the "Highway Hi-Fi" automobile phonograph.

there will probably be enough conversation in the average situation to kill all chances of adequate stereo listening anyway).

An alternate method of placing speakers for stereo reception

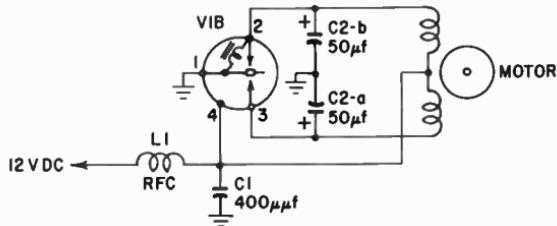


Fig. 910. Vibrator power supply for ac induction motor used in "Highway Hi-Fi" automobile phonograph.

involves the installation of two speakers at the rear deck, as shown in Fig. 906. In this case, the AM and FM sources may be tied to either speaker as desired. The acoustics in the auto will dictate the best arrangement. With the FM program beaming in from

the rear left and the AM program from the rear right, the driver and passengers may get the illusion that they are sitting in the

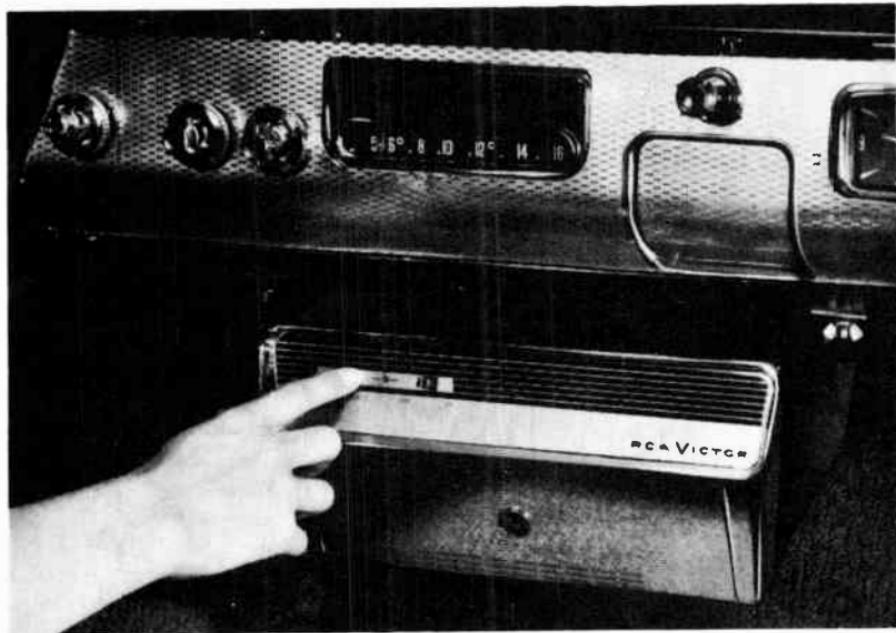


Fig. 911. The 45-rpm record changer automobile phonograph.

orchestra facing the audience. In the reverse configuration, if the acoustics are right, the driver and passengers may get the illusion of sitting in the orchestra. To provide a customer with a choice of arrangements, outfit an installation with a switch connected as shown in Fig. 907.

Auto phonographs

In 1955, one of America's major auto manufacturers introduced the first "Highway Hi-Fi" set — a phonograph designed especially for use in that firm's 1956 model autos (Fig. 908). Highway Hi-Fi was an oddity. After the 45 - $33\frac{1}{3}$ - 78-rpm confusion of 1948, along came the $16\frac{2}{3}$ -rpm unit to add to the jumble. Oddity is especially appropriate when one considers that the music this phonograph was to play was on a special 7-inch disc with a standard center hole (not 45-rpm size) and cut 550 grooves to the inch (twice that of a conventional $33\frac{1}{3}$ -rpm LP record). It required a super-special 0.25-mil stylus (today's stereo styli are available from 0.5 to 0.7 mil) at a stylus pressure of 2 grams.

The Highway Hi-Fi unit cost almost \$200 and generally was available only as an accessory through an authorized automobile distributor. This tended to keep its distribution and use exclusive

In addition, the special records this unit played were not the type available in the neighborhood record store. Nor could these records, once bought, be used inside on the conventional home phonograph. When an owner disposed of his auto, he inevitably



Fig. 912. Loading the auto "Victrola". (RCA)

had to turn over his record collection with it, unless he took the Highway Hi-Fi set with him (in which case installation in his new car became a problem).

To complicate matters further, Highway Hi-Fi was not an automatic changer but a manual record player. To be sure, the special records it played provided a full 45 minutes to 1 hour of listening per side. At the end of each play, however, it was necessary to pull the unit partially out of its case to gain access to the record, reinsert a new side and manually operate the tone-arm mechanism to switch the turntable on and to engage the stylus in the record groove (in the manner indicated in Fig. 909). In addition to all this, Highway Hi-Fi utilized an ac induction motor, incorporating a vibrator power supply into its design to convert the auto dc power to a suitable ac operating power (Fig. 910). (The reader will recall that the electromechanical vibrator is a notorious noise producer, and perhaps has the highest failure rate of all the components used in auto radios.) The owners of Highway Hi-Fi were determined to be a small exclusive minority, and like all small exclusive minorities, they were destined to fade away.

Undaunted by the failure of its original Highway Hi-Fi, its promoter cooperated with one of America's leading electronics

firms in a project involving the application of a more conventional phonograph to automobiles. The new phonograph is a 45-rpm automatic record changer of special design (Fig. 911) to enable it to be used in the family car.

The unit is normally installed under the dashboard. Two features that differentiate auto radios from home radios are found

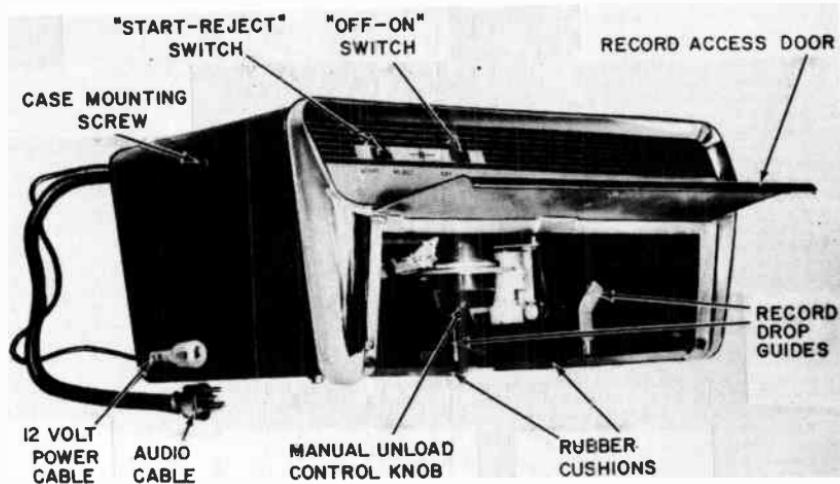


Fig. 913. Internal view of the 45-rpm automobile phonograph.

in the design of this phonograph. It is intended to be operated with a minimum of distraction and is specially compensated for shock and vibration to enable it to operate in a moving auto. Cost is about a fourth the cost of the original Highway Hi-Fi.

The phonograph plays up to 14 extended-play 45-rpm records for a total playing time of up to 2½ hours. Loading 14 records is accomplished easily and with a minimum of distraction, as shown in Fig. 912. Once inserted, the records are played automatically at the flip of switch on the case of the unit (Fig. 911). The operator need never position the tone arm in the record groove. A record can be replayed instead of rejected at the end of its play by operating a switch on the front-panel control. Operation is directly off the automobile's 12-volt dc supply.

An internal view is shown in Fig. 913. The device is actually an upside-down version of a conventional 45-rpm changer. It is similar in operation to many commercial 45-rpm jukeboxes in that the pickup is held by spring tension against the underside of the record being played. Tracking pressure is high compared to conventional 45-rpm units. Sapphire and diamond replacement

styls are available and should be stocked in the shop in anticipation of a service call.

The 45-rpm phonograph originally was developed for use with

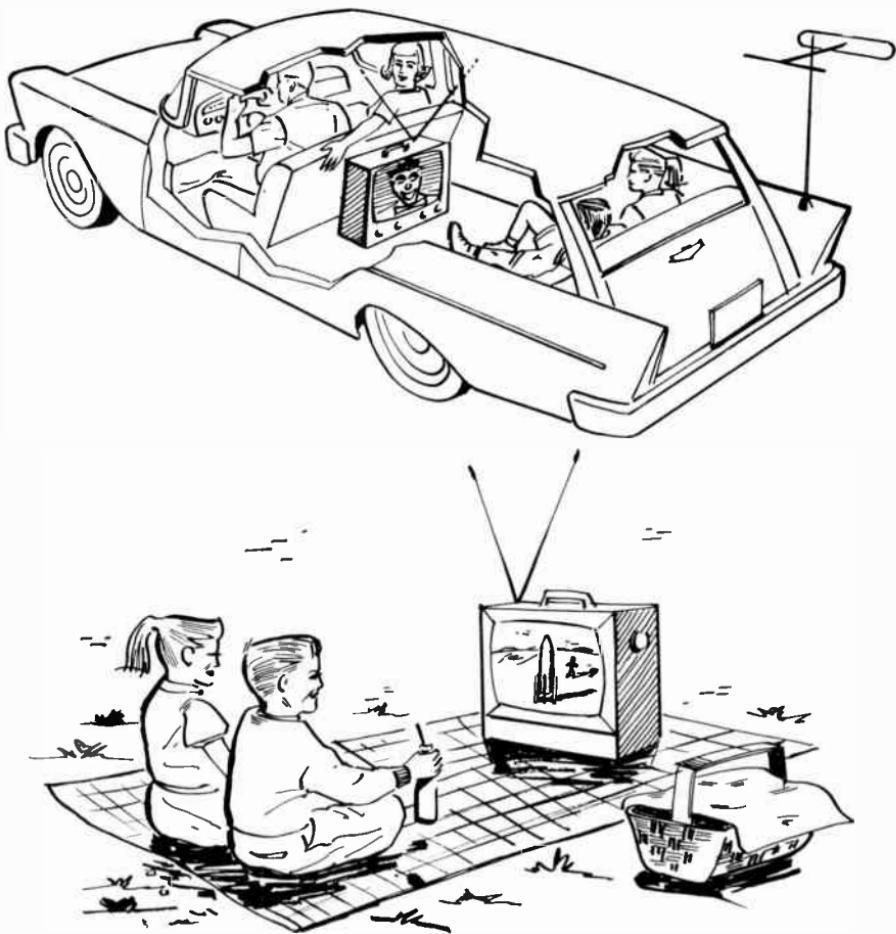


Fig. 914. Transistor portable TV sets hold some intriguing possibilities.

two specific models of cars. The auto radios that came with these cars had a special phono jack to accommodate the phono's audio cable plug. The phonograph is available now for use in any car. As such, the unit represents an interesting repair to the service technician who must provide a suitable phono jack for the auto radio with which it is to be used. In most cases, the phono-jack installation will be conventional. It should be tied between the

hot side of the auto radio's volume control (the input of the first audio stage) and ground (chassis or bus, depending on the radio).

Television and the automobile

In their early days, auto radios were designed and recommended for use outside the automobile. The radio was carted along on an outing and was hooked up to the auto electrical system when the picnic grounds were reached to provide musical and other broadcast entertainment for the day. Following this pattern we can visualize a day in the country with the automobile-portable television (Fig. 914). The day begins with television inside the auto entertaining the kids in the back seat or in the rear of the station wagon. Power is provided by a special receptacle at the rear designed especially for this purpose. At the journey's end, the set is removed from the auto and powered by its own portable wet-cell battery on the picnic grounds. During the ride home, the set again is powered by the auto's electrical system, which recharges the wet-cell battery at the same time.

There seems to be little doubt that portable TV sets will favor transistors. Sets are available featuring 12-volt dc operation and supplied with a rechargeable lightweight wet cell of special design to match the set. The 12-volt operation feature, plus the fact that the set is equipped with its own built-in rabbit ears antenna, makes it a logical choice for the auto owner who demands the ultimate in accessories.

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