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AUTOMOBILE RADIO AND SERVICING

A Complete Treatise on the Subject Covering All Phases from Installing to Servicing and Maintenance

by Louis Martin

A GERNSBACK PUBLICATION

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PREFACE

THE discussions and directions for installing and servicing automobile receivers contained in this book represent the practical findings of several years of experimental work in this subject carried out by the author and various commercial laboratories.

The purpose throughout has been to determine how to really install and service modern automobile receivers. The author has attempted to weed out all the non-essential details which have crept into the radio servicing profession. That the author has set for himself a rather large order, too large to be carried out to a final conclusion in many instances, will be realized by those who are familiar with, for instance, the transients set up in a line which is excited by a highly-damped spark discharge. However, in the treatment of each topic, the text is intended to contain a precise statement of the fundamental principle involved, and to insure the reader's clear understanding of this principle, without distracting his attention by the discussion of a multitude of details and mathematical expressions which usually tend to confuse rather than clarify a statement for the practical man.

In a word, this is a practical treatise for the radio Service Man who desires to enter the field of automobile radio and servicing.

L. M.

MAY 1932

Revised by J. T. Bernsley
March, 1934

CHAPTER I.

INTRODUCTION

Improvements in the design and general construction of auto-radio receivers in the past year have been so radical and tremendous that it has become necessary to revise and bring up to date the previous **Auto Radio and Servicing Manual.** While the use of auto-radio is, comparatively, not a new thing—since radio fans were installing portable sets in cars as early as 1920-21—all the progress in design, installation, and other features, previously made has been exceeded in the past twelve months.

To realize the progress in design, and what it indicates, let us go back to 1926, about which time the first commercial auto set was introduced. The manufacturer (a Long Island City concern) was also the distributor, dealer, installation, service and maintenance department. While chassis were built on a production basis, the changes afterwards necessary in the installation and car alterations made each individual job practically a "custom-built" affair. Since they were pioneering, none of the rules and information that we now have at our finger tips were either known or available at that time. The set was similar to most battery sets of that time—using '01A tubes for R.F. amplifiers and detector, and a '12A or '71A power tube in the final stage. Some of the sets used resistance coupling in the audio stages and, where that method of coupling was employed, the old 240 tube was used. The set was built within a metal box, mounted behind the instrument board, with controls protruding through. Each instrument board was first removed and the controls were rearranged on a new panel to make room for the set. The instrument panel, or "dash" as it is sometimes referred to, was made of bakelite; very pretty, but a handicap to the successful suppression of motor noises. "B" batteries, used for plate supply, were mounted within a metal housing placed either behind the rear seat or underslung through an opening in the rear floor-board. Since cars were not equipped at that time with antennas, the roof of each was cut open and copper screening installed.

For months this company labored to overcome ignition noises; finally evolving the present method of installing suppressors, shielding high and low-tension wires, etc., and attaining a state of perfection in car reception comparable to a present poor installation. Yet it seemed satisfactory, at that time when it was otherwise impossible, even with specially built portables, to receive any kind of broadcast within an auto without ignition noise to mar the reproduction.

From that time, until about 1930, few improvements were made, despite the fact that automobiles were in greater use for pleasure and the depression had not as yet been felt. Then came the remote-control tuning-dial arrangement, and the use of screen-grid tubes. Obviously, the higher amplification factor of the '24 or '22 tube (sets using each were designed) permitted far more satisfactory reception. Since the car antenna's pickup at best is exceedingly small, it can be realized how great a contributing factor to the progress of car-radios the higher "mu" tubes were.

Later refinements in chassis contruction, remote-control tuning devices, loud speakers, improvements in tube design, "B" battery substitutes, installation procedure, circuit design and, therefore, a considerable increase in overall efficiency—all brought the auto-radio to its present state of perfection and helped to enhance its popularity to such an extent that it is predicted that within a few years, practically every car will be equipped with radio.

What these newest refinements are, with an analysis of each—to facilitate servicing—is explained, and new servicing data with complete up-to-date installation information is given in this book. Advance information, about the auto sets of 1934-35, is also given, so that the auto-technician can be prepared for the set to come.

However, because of the number of earlier sets now in use, some information must be first given about their deficiencies and service troubles and the methods of bringing them as nearly up to date as possible.

Earlier Auto-Sets

In Fig. 1 we see a typical installation of a car radio, as it was made two or three years ago. A hole is cut out in the rear floor-board, and the "B" battery box suspended through it. The speaker is placed on one side, underneath the cowl, and the chassis on the other (generally on the extreme right). The tuning control, as depicted, is fastened to the instrument board to make it visible. In a good many cases, however, remote controls were mounted on the steering column. The antenna used may be in the roof of the car; but sometimes it is a capacitor plate fastened to the under side of the running board, as shown in Fig. 2, which is another view of a more complete installation. In some cases we might find a so-called "strap" antenna, which is a piece of copper screening, about 6" x 3 ft. 6", sewed into a canvas material for insulation purposes. This type of antenna is generally tied to some under part of the chassis—generally from the transmission housing to a bolt in chassis above the rear axle—as far back from the engine compartment as possible, and suspended loosely for best reception. The lead-in, soldered to the copper screen, is brought up through the front floor boards to the receiver chassis. This type of antenna, generally, does not survive over three months; since an obstruction in the road or a station ramp (when changing oil or grease) will almost always rip it off.

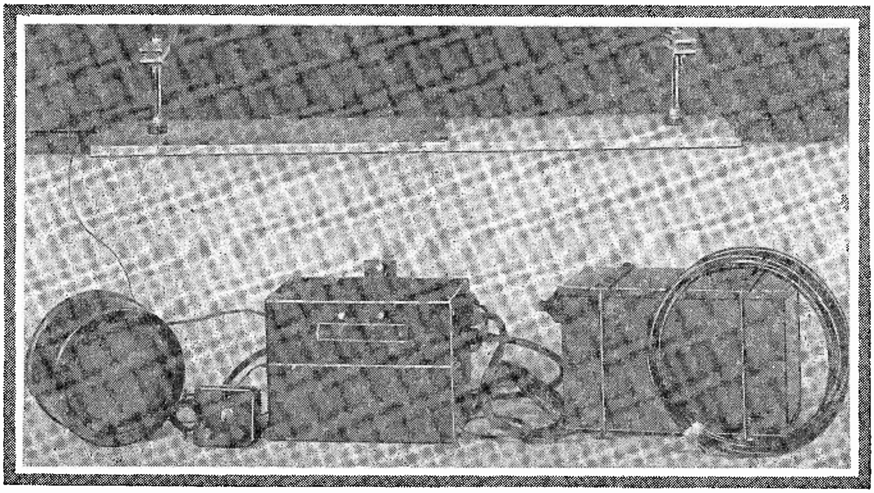


FIG. 1

Illustrating the various components of an earlier model auto set.

Fig. 3 is a schematic wiring diagram of the Crosley Model 92 receiver, an efficient receiver at the time of its manufacture, but now obsolete in comparison with present receivers employing higher-gain tubes. It employs two 36 type tubes in the R.F. stages; a 36 as an A.V.C. tube; one 36 as detector; a 37 as first audio; and a 71A in the final power stage. Three to four "B" batteries are necessary for a "B" supply.

Fig. 4 is a schematic diagram of a receiver incorporating some refinements over the one previously described. It employs the superheterodyne principle, a more advanced power tube for auto-use, and power detection in the second detector stage. While this set still

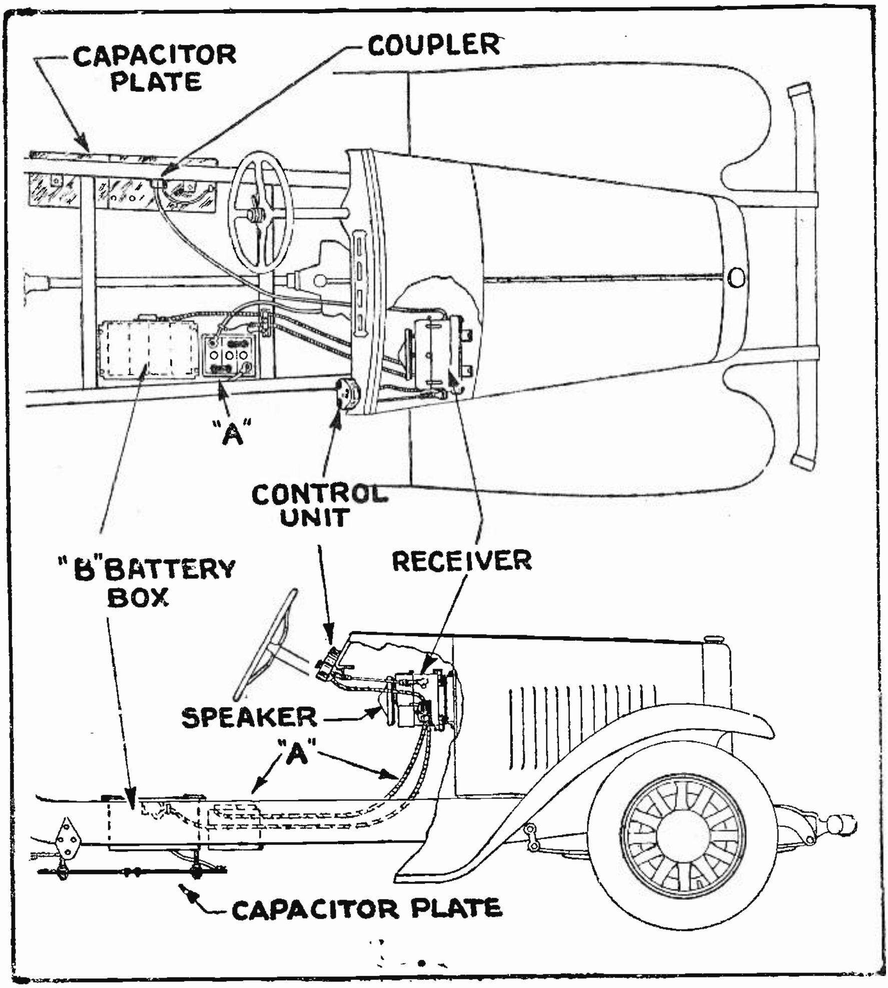


FIG. 2
Installation placement of the various "pieces" of the earlier set.

rates pretty high in efficiency, and it has many satisfied users, it is also behind present day auto-sets because of the improved tubes designed for this purpose, incorporated in the new sets. As will be noted from the diagram, three 45 volt "B" batteries are required; this presents the disadvantage of continual expense in replacing batteries every few months.

Improving Old Sets

As will be readily seen from reading the previous text, one of the major drawbacks of the old receiver is the use of "B" batteries. A considerable number of sets were made to work with four 45-volt blocks. This meant that, at the end of every three months, an expense of approximately ten dollars was necessary for replacing batteries. Forty dollars a year for this item alone would discourage most auto-set users. It is safe to say that motorists having radio sets of this type are

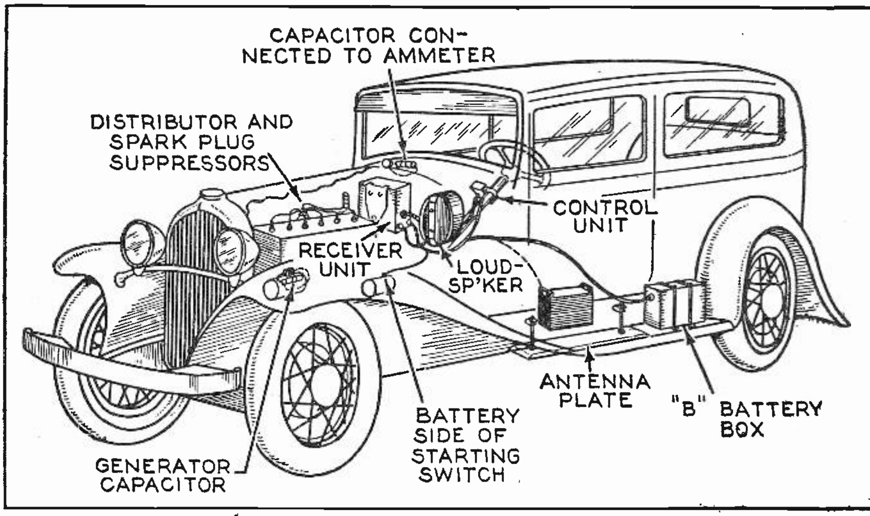


FIG. A

Perspective view of location of "B" battery box, receiver chassis, speaker, antenna plate, etc.

not getting full satisfaction from their receiver, for the simple reason that they are disinclined to make this expenditure so frequently. Operating the set on weak or rundown "B" batteries simply detracts so much from the range and quality of the receiver.

Here then, is one of the greatest fields for money making for the auto-radio technician. On the basis of the information presented above, it should be easy to sell a "B" eliminator to a customer who is otherwise satisfied with his set. Types of eliminators or

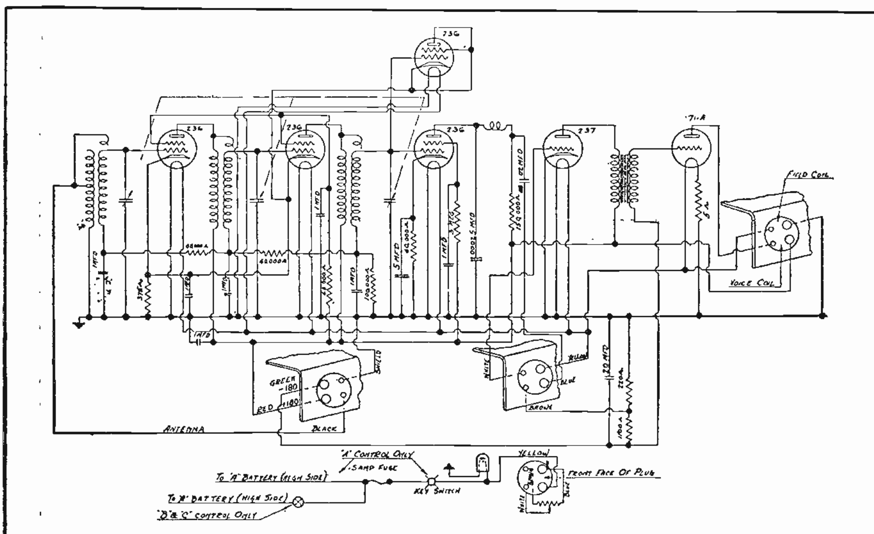


FIG. 3

Schematic diagram of an early model auto set. Analysis of this diagram will indicate where changes for improvement may be made.

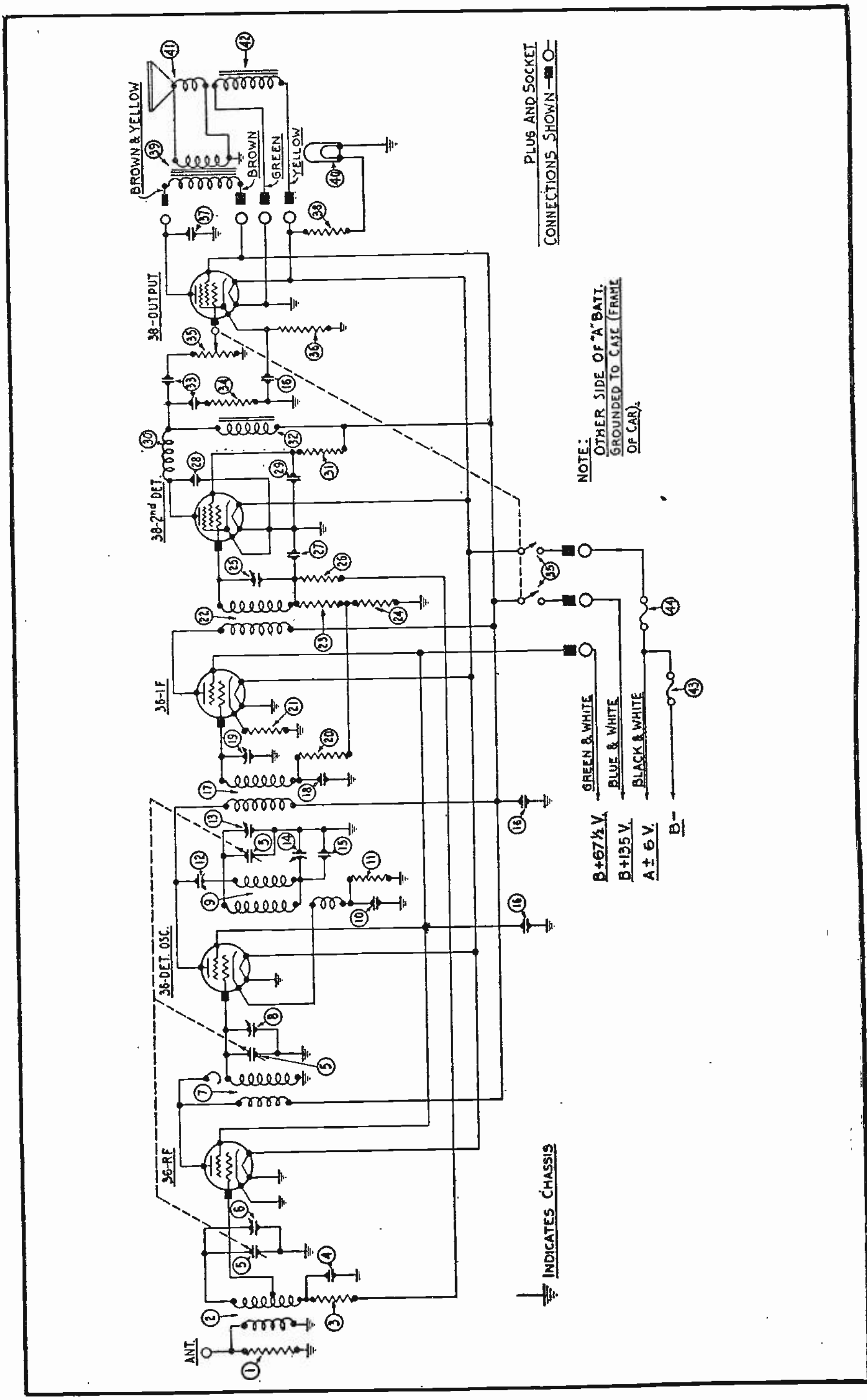


FIG. 4
Schematic wiring diagram of the superheterodyne auto set, the features of which could be incorporated in that shown in Fig. 3. See text.

power-supply units, and their installation, are discussed in another chapter.

Concerning those sets whose "gain" or amplification is not sufficient for satisfactory reception — because of either the circuit design or low "mu" tubes—a circuit for rewiring is suggested and illustrated in Fig. 5 and 6. One is of the standard T.R.F. type, employing all of the latest type tubes, and which with high-gain coils will perform almost as satisfactorily as present-day sets. New sockets will undoubtedly be necessary to accommodate these tubes; yet this item, with other miscellaneous resistors, condensers, etc., but excluding labor, will not run over five or six dollars. Fig. 6 illustrates a superheterodyne circuit employing the latest in tubes. This schematic may be adapted only where the original receiver operates on a similar principle. This would save the cost of special coils, gang condensers, and intermediate-frequency transformer, which would run into a considerable sum of money. Where the set is already of superhet design, only new sockets, resistors, and by-pass condensers are necessary plus, of course, the labor cost for rewiring.

Servicing Older Model Sets

The procedure for servicing the auto-set is the same as for any radio set, with possibly a few exceptions. To gain access to the tubes, remove the front plate or, in some models, the top or side plate. Naturally enough, the first move is to check all tubes for emission. From the continuous vibration in a car, tubes will very often go bad in an auto set. An up-to-date analyzer is, of course, a pre-requisite, and with this instrument a defective tube can be readily discovered.

Sometimes, the antenna lead-in becomes grounded; either against the shielding or against some sharp corner of the car chassis, around which it is secured. By trying another short external antenna secured to the length of lead-in coming from the set, the efficiency of the car antenna may be determined. If it is grounded, trace the lead--in to the antenna proper until the ground is discovered.

Generally, the above two reasons—tubes and defective antenna—account

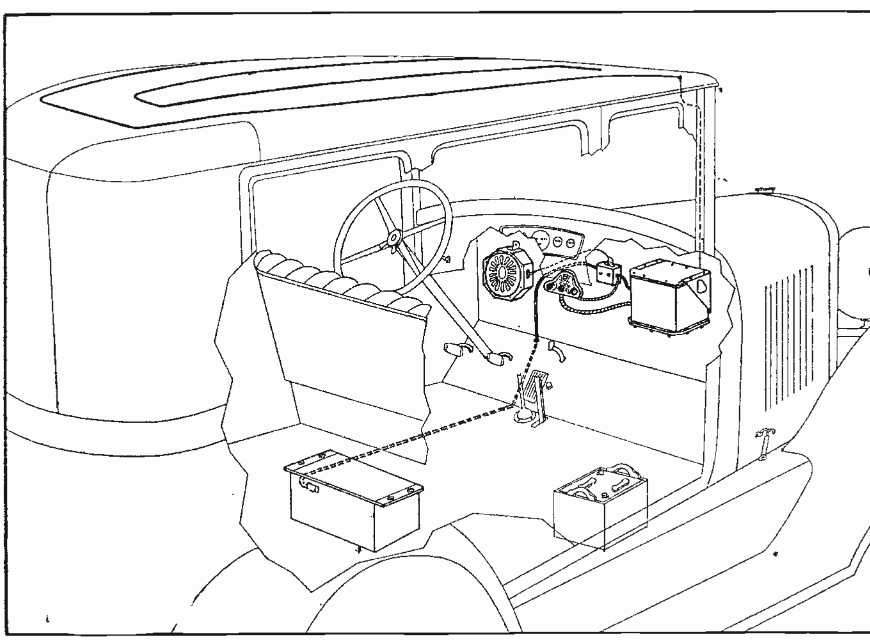


FIG. B
Inside view of layout of instruments for auto radio.

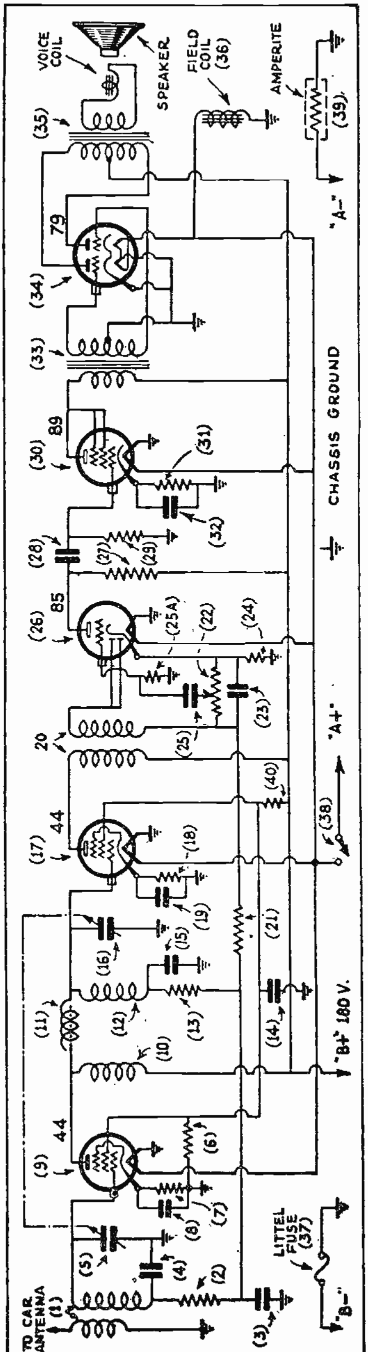


FIG. 5
Schematic wiring diagram of a T.R.F. receiver employing latest type tubes.

for approximately fifty per cent. of all auto service troubles. Where "B" batteries are employed, check their voltage and, if any 45-volt block indicates less than thirty-two volts discard it.

Chassis troubles can readily be determined with an analyzer. No plate voltage in a definite socket indicates open circuit in that particular tube circuit; low plate voltage (if batteries or eliminator are O.K.), a shorted bypass condenser. By referring to a schematic wiring diagram of that receiver, and tracing through that portion of the circuit in which the trouble is involved, the defect may be readily located. Wiring diagrams of all manufactured auto receivers are contained within the Official Auto Service Manual. It is a handy reference book, and will save the auto-radio service man considerable time and trouble in locating chassis defects.

Broad tuning is, many times, caused by slipping of the remote-control shaft leading to the gang condenser unit within the chassis housing. The earlier type of remote-control cable, in which a thin piano wire coils up around a drum, oftentimes has a tendency to stick, because of a kink in the cable housing. It is imperative that no sharp bends exist when this instrument is installed.

Some early Philco models employ a "B" eliminator and relay which turns the eliminator "on" or "off" when the "A" power to the tubes is turned on. The relay solenoid is operated by the current drain of the tubes, but may be sluggish in action or in-operative if the battery is low, or poor contact made to the battery.

Some still earlier models of auto sets employ the 224 or '51 type tubes. Generally, the heater circuits of these tubes are wired in series to keep current consumption down and also avoid an unnecessary resistor to create a drop from storage-battery potential (6 volts) to the voltage required for each tube. Where these tubes fail to heat up, the cause may be due to one or more defective tubes in the series arrangement. To find the defect, check tube-heater or filament prongs with a continuity tester.

CHAPTER II.

FEATURES OF LATEST SETS

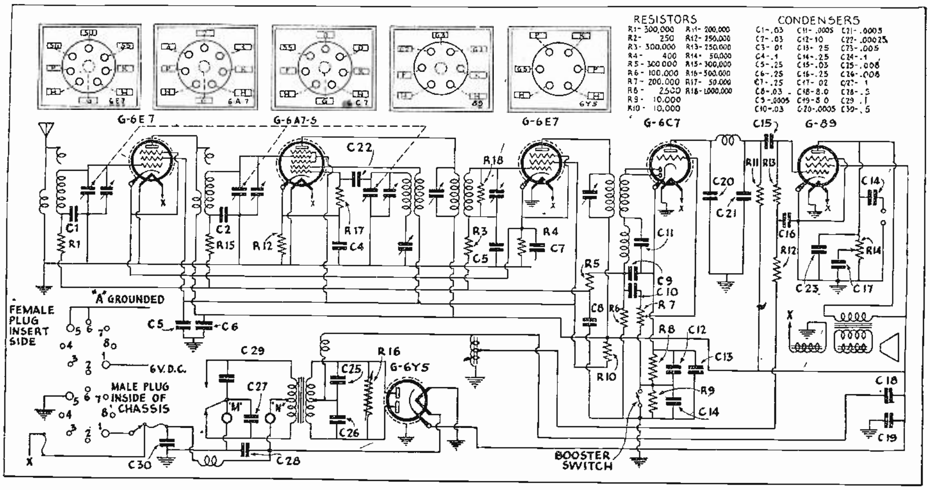


FIG. 6
Schematic wiring diagram of a Majestic auto set employing latest type tubes.

AUTOMOBILE sets now manufactured are in a class comparable in perfection with the home radio. Innovations, or rather, features incorporated in the design of these sets are so electrically advanced that few changes in this direction can be expected for a long time to come.

Their construction is similar to present-day midget sets—very compact in form and combining, in a single unit, the speaker (electro-dynamic), receiver chassis, power-supply unit and, in some cases, the tuning and volume controls. The preference seems to be, however, for remote control of the receiver from the steering column. Tone regulation is provided for in practically all of the models.

The superheterodyne principle is almost universally used in the newer models—since the sensitivity is greater with this type of circuit.

Some employ "Class B" audio amplification in the final stage, for greater audio output. All sets use the latest tubes with higher "mu" features; such as the 78; the 6A7, which permits combining detector and oscillator with two-tube efficiency; the 41, 42, 43 power-amplifier pentodes with higher undistorted output than the previous power tubes employed; and a new power tube just released, the type 12-A-5.

According to advance information, the old reflex principle may be brought back into use again and incorporated in the design of auto sets. We know that space is an important factor in this type of set—which limits the number of tubes that can be used. By reflexing, the number of tubes is reduced, since one tube can be made to function as audio amplifier, R.F. amplifier, detector and automatic volume control. In Fig. 7 is illustrated a superheterodyne circuit which uses a 6-B-7 tube for the aforementioned multiple functions. The 78 is an R.F. amplifier; 6A7, for first detector and oscillator; 6B7, intermediate frequency amplifier, second detector, automatic volume control and first audio stage; and finally, a 41 tube serves for the power stage.

Also, what may, or may not, appear in future sets, is a mechanical interrupter and rectifier "B" supply. Present types of power-supply units of the vibrator type employ a rectifier tube of the 6-Z-5, or 84, or some other similar 6.3-volt rectifier. The purpose of the mechanical rectifier device mentioned is to do away with this extra tube. An illustration showing the electrical scheme is shown in Fig. 8. One side of the vibrator acts as the interrupter, to break up the 6-volt D.C. into pulsations; these are stepped up by the transformer to the required voltage, then converted back to D.C. by the other set of vibrator contacts. The filter system is also shown in this illustration. "B—" is connected to ground, as is "A—".

The circuit diagram of a typical up-to-date auto set is shown in Fig. 9. It is a four-tube, two-gang condenser superheterodyne; but is counted as five tubes if the power supply unit employs a tube. It is compact and efficient, and really is the equivalent of a 6-tube ordinary set, since the 6-A-7 functions as both a composite detector and an oscillator, and the 75 as both second detector and A.V.C. tube.

In Fig. 10, we have a five-tube set of modern design—a six, if a rectifier tube is employed in the power supply unit. A pre-stage of R.F. amplification is employed, to boost the signal strength before first detection. As in the four-tube set, the 6-A-7 is a composite detector and oscillator, and the 75 both second detector and automatic volume control tube. The power tube, 12-A-5, is the latest released.

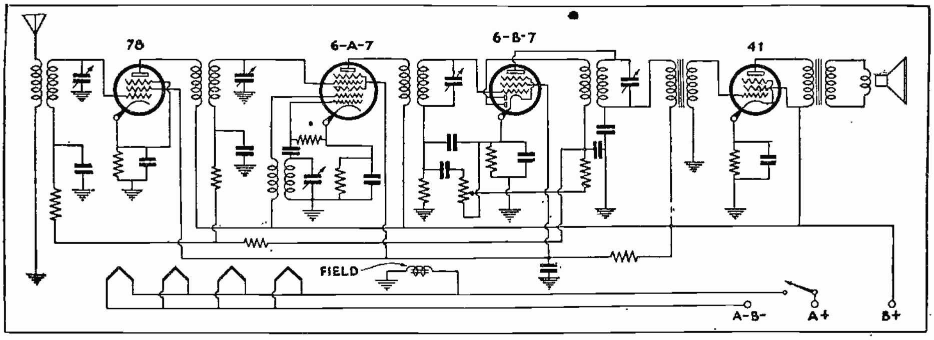


FIG. 7
A circuit of an auto set that has reflex features in addition to latest type tubes.

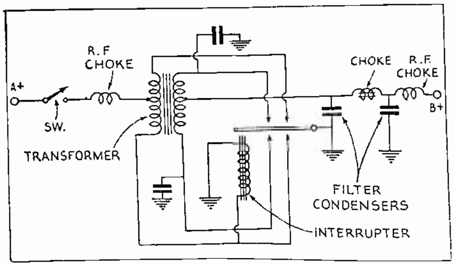


FIG. 8
A mechanical interrupter and rectifier for converting 6 volts to "B" supply.

Mechanical Construction.

As mentioned previously, all units, except the remote control, are in one housing, or case. The can is of heavy-gauge metal in most instances (which, incidentally, provides for more effective shielding and consequently less possibility of motor noises) with speaker grill opening in front; the tone control is in front on same case, so that it is accessible; the "B" power supply is separately shielded and installed along with speaker and receiver chassis, all adequately screened and shielded in one common housing. To obtain access to the tubes, in some cases the front cover plate can be removed by taking out the supporting screws; and in other sets the side or top plate is removed.

The greatest refinement, which is a boon to installation men, is that one large screw-bolt supports the chassis (in most models). This means only one hole to drill after the set's location is

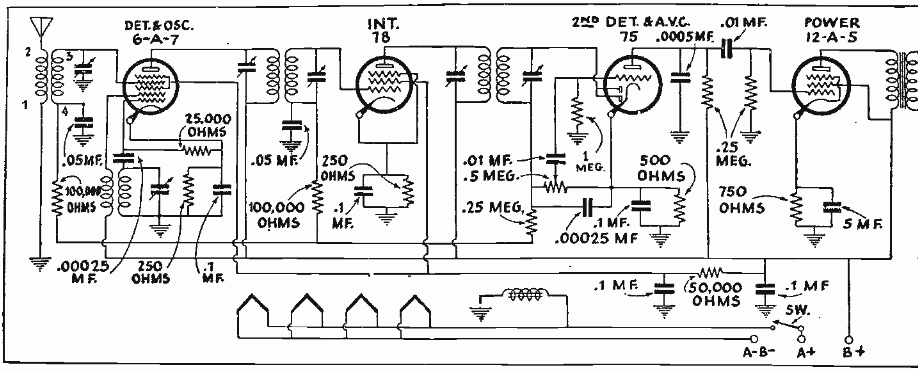


FIG. 9
An up-to-date superheterodyne receiver employing dual purpose tubes.

determined. Some sets have two "A" leads ("A+" and "A—") which connect to the ammeter and ground, others just one "A—" to the ammeter. The grounded side of the "A" battery connection is made through the chassis bolt after the paint is scraped away from the steel panelling, or "fireboard", as auto-mechanics term it. A tremendous improvement in the appearance of auto sets is, in no small part, contributed by the use of an "airplane-type" remote-control tuning instrument. Where the consumer would dread the installation of an auto radio, because of instruments cluttering up the compartment below the instrument board and marring the internal appearance of his car, he can now appreciate the beauty of a modern set.

In Fig. 11 is shown the auto set described above. Note the appearance of the tuning control, and the tremendous improvement over older types of controls; also, the single compact unit including all accessories.

Midget Sets in Cars

For those who do not desire a permanent installation of radio in their car, but prefer a model that can be taken anywhere, no matter what the voltage or current might be, the technician can advise a small midget receiver of the so-called "cigar-box" variety. Despite the nickname and the small appearance of these sets, they perform remarkably well. Up-to-date models employ the superheterodyne circuit, and include all the other features previously outlined as incorporated within the new auto sets. They operate on 110 volts, either A.C. or D.C., and the model mentioned includes a special cable which permits operation from a 6-volt storage battery for car use.

Of course, a car antenna is necessary when the set is used in a car—and some motor noise must be expected; but this can be held down to a minimum if the set is placed as far from the engine compartment (rear of car recommend-

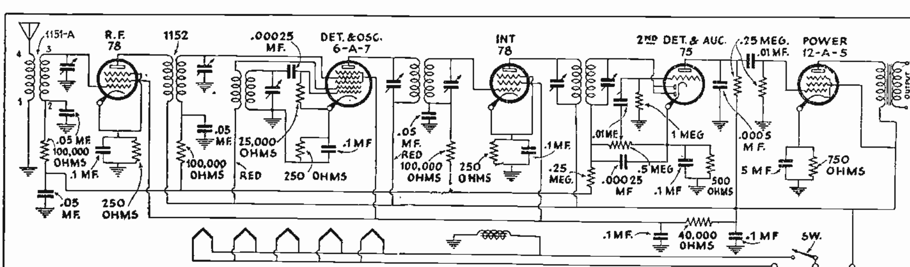
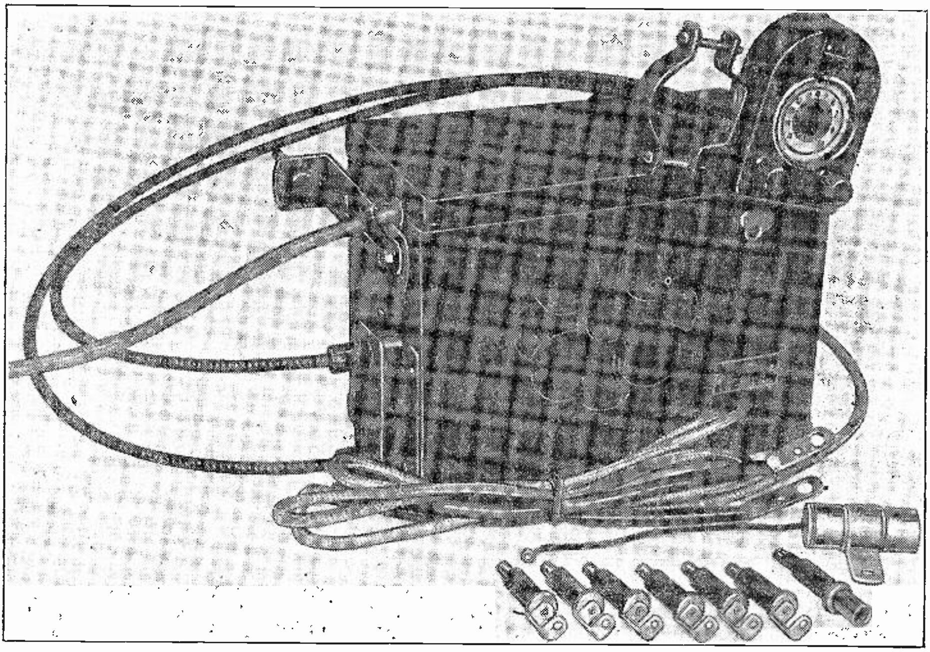


FIG. 10
A superheterodyne of late design, employing 6 tubes, including the rectifier.

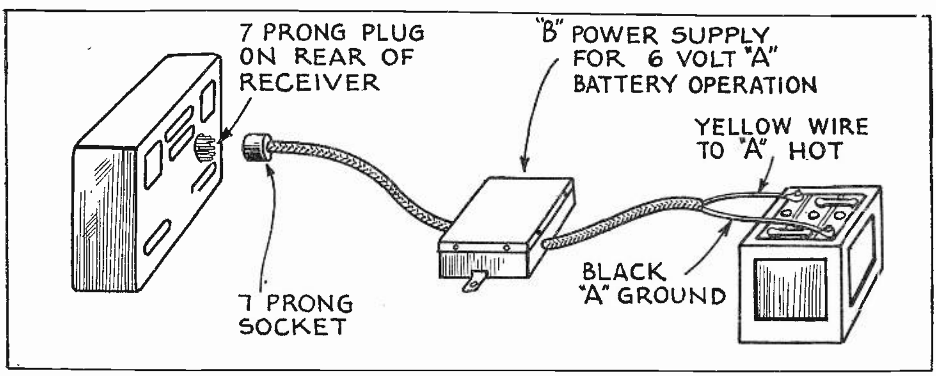


(Courtesy of Stromberg-Carlson Telephone Manufacturing Co.)

FIG. 11

Photograph of one of the latest models. Note the aircraft type remote tuning device. Speaker, "B" supply, and receiver are all in one housing.

ed) as possible. Suppressors on the spark plugs will also be of considerable help, but may not be necessary in some types of autos. The set and cable connector is illustrated in Fig. 12. This outfit is ideal where a portable radio for any location is required.



(Courtesy of Emerson Radio & Phonograph Corp.)

FIG. 12

Midget radios may be employed for auto radio reception. Special cables in "B" supply unit are necessary for conversion. The same set may also be used for 110 volts A.C.-D.C. reception.

CHAPTER III.

INSTALLING AUTO SETS

WHEN installing an auto set, it is always best to commence by studying the physical dimensions of the set, and then to ascertain precisely where it will fit in under and behind the instrument board. It must not be raised too high, or a good deal of the sound emanating from the speaker will be lost in the space existing between the dash and engine compartment wall; nor too low, or it will greatly inconvenience front-seat passengers by hampering their feet. Clearance must be allowed for all cowl-ventilator levers. Terminal strips or fuse blocks should be given room, or proper servicing of the car will be interfered with. Never kink the speedometer cable to force the set into a given area; or the price of a new speedometer cable will be taken out of the installation man's pay within a few days. Where a hot-water heater is already installed, the installation man will require a folding rule, infinite patience, and diligence. It may be necessary to move the heater a few inches, to find accommodations for the set. In early "Model A" Fords, the gas tank is located in the cowl and extends downward behind the instrument board. Be sure, when locating the set that holes are not drilled through the tank. To provide proper clearance below the set, for passengers in front, it is best to mount the set at an angle so that it flares downward. A washer made from a block of wood, in a triangular shape, should be used to fill the void between the back of the set and the compartment wall.

Always test the set before installing it. Although the set is tested at the factory, tubes or some part may work loose in transit to the jobber and dealer. And it is always easier to locate the defect at a bench than in a cramped position inside of the car. Use a short piece of wire (about 10 feet) for the aerial.

Connect the battery lead marked "hot" or "ungrounded" to an ammeter terminal. If the customer desires to have the ammeter register the drain of the receiver, then connect it to the proper meter terminal. In most cases it is desirable to connect it this way, so that the charging rate can be determined by the operator with the set in use. The grounded side of the battery lead from the set can be bolted to any metal part or bolt which is well-grounded. Scrape all paint clean where connections are made.

Car Chart Indicating Battery Ground

Positive Ground	Negative Ground
Auburn	Buick
Cadillac	Chevrolet
Chrysler	Continental
De Soto	Cunningham
Dodge	Essex
Franklin	Hudson
Ford	Lincoln
Graham-Paige	Nash—Single Ignition
Hupp	Oldsmobile
Marmon	Pontiac
Nash—Two Ignition	Reo
Plymouth	Stutz
Packard	Willys-Overland
Pierce-Arrow	
Rockne	
Studebaker	

Installation of Antenna

A good many of the late-model cars have antennas installed in the roof. In the contents to follow, a chart is given as to where the antenna lead-in may be located in most cars that have aerials. If further difficulty is encountered as to the location of the lead-in, or in regards to whether an antenna has been included or not, it is always good practice to look up a dealer who sells that model auto. The information will then be readily obtained.

Concerning those cars that have no antenna installations, the following information is supplied through the courtesy of the Philco Radio and Television Corp. regarding the standard procedure for making such an installation in various models of automobiles. In Fig. 13, car roof construction of a sedan and proper method of laying down the antenna screen is illustrated.

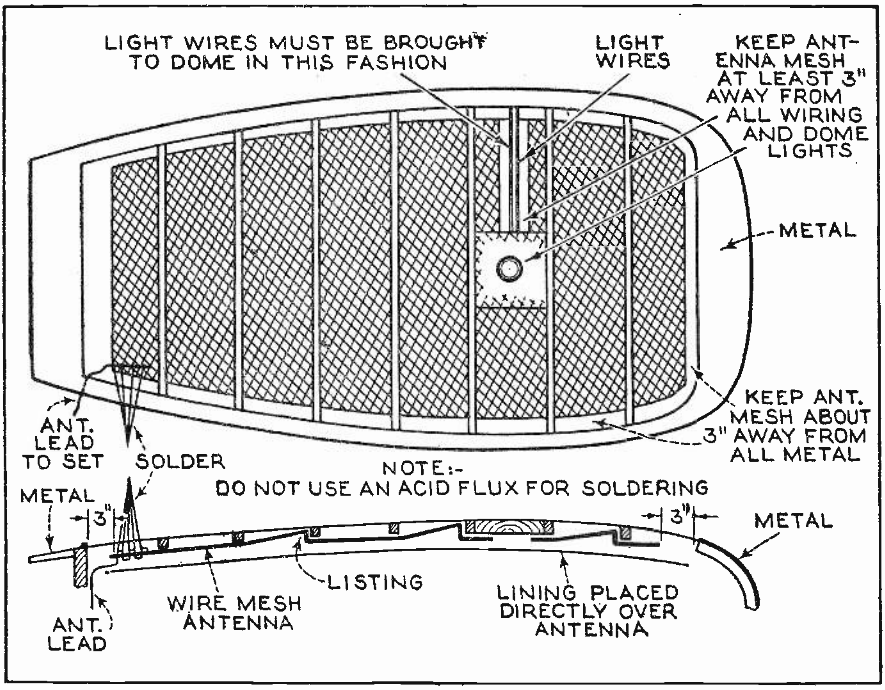


FIG. C
Top of roof of car showing how to install roof antenna.

Top Construction and Factory Antenna List

Car	Top Construction Wood Slat	Top Construction Poultry Screen	Antenna Wire	Antenna Poultry Screen	Lead-in Location
Auburn	V				
Buick	V				Front rt. post
Cadillac	V		V		
Chevrolet	V				Front rt. post
Chrysler	Imp. 80	All others	Imp. 80	All others	
Cord					Front rt. post
DeSoto		V		V	Front rt. post
Dodge		V		V	
Duesenberg			Special	Bodies	
Durant		V			
Essex	Fabric				
Ford A		V			No lead in
Ford 1932		V		V	Front rt. post
Franklin		V		V	
Graham	V				
Hudson	Fabric	Club Sdn.			
Hupmobile		V			
Jordan		V			Front rt. post

LaSalle	V		V		
Lincoln		V	Tops are	Cleared	Front rt. post
Marmon		V		V	Front rt. post
Nash			V		
Oldsmobile					
Packard		V			Front left post
Peerless		V		V	Front rt. post
Pierce Arrow		V		V	Front rt. post
Plymouth		V		V	
Pontiac					Front rt. post
Reo		V		V	
Rolls Royce					Front rt. post
Studebaker		V		V	
Stutz					
Willys-Knight					

By maintaining clearance between the poultry wire and the metal quarters of the body during the construction of the car, the car manufacturers have been able to build in a good car antenna. A few of the car factories install a wire antenna in the roof.

Installing an Antenna in Cars with Slat Top Construction—The headlining should be lowered from front to back, so that a copper-screen antenna can be installed in the roof.

1. Use a good grade of copper screen. No. 14 or No. 16 mesh, 36 inches wide, is satisfactory and can be used in practically all installations.

2. Maintain three inches clearance between the screen and the car body and all metal work in the top. Cut out a section to get this clearance around the dome light.

3. The wiring in the top to the dome light and switch must be run along the side of the top frame, then along the top edge of the side of a bow to the dome light fixture.

4. An 18-gauge stranded copper, rubber and cotton covered antenna lead-in should be soldered to a front corner of the antenna screen. If the receiver is to be located on the right side of the car, solder the lead-in to the right front corner of the antenna; if the receiver is to be located on the left side, the antenna lead-in should be soldered to the left front corner. It is a good plan to solder or bond the whole front edge of the antenna screen.

5. The copper screen must be tacked securely so that it cannot come loose.

6. The headlining and all trim must be carefully replaced.

Tack the screen to the farthest bow in the rear that will give three inches clearance from the rear metal apron. With the edge of the screen lined up with the bottom front edge of the bow, the screen is tacked against the face of the bow, close to the top. It is necessary to tack the screen in this manner, so that the listing strip used to support the headlining can be tacked to the face of the bow.

On bows on which the listing strip is not tacked, it will be quite all right to tack the screen along the bottom of the bow. Tack the screen to each bow from the back to the front of the screen. Do not come closer than three inches to the metal aprons along the sides and the metal frame above the windshield.

The lead-in should be concealed behind the windshield moulding, or if the front corner post is hollow, it can be run down the inside of the post. In a few cases, it may be necessary to bring the lead-in down through the wind hose along the side of the corner post.

After the antenna and lead-in have been installed, test the antenna for grounds. Use a high-resistance voltmeter and a 45-volt battery, testing between the antenna lead-in and the body of the car. Do not hold the test connections to the antenna and the car body with your fingers—as the leakage across your body will cause a high reading on the meter.

Having made certain that the antenna system is clear of grounds and leaks, proceed with replacing the headlining and trim.

Installing an Antenna in Cars with Poultry Wire Reenforcement—The poultry wire when cleared of grounds may be used as an antenna. This may be done in either of two ways. The top deck may be removed and the netting cleared where the edges ground on the car body. The more practical way is to drop the headlining the entire length of the car and clear from beneath.

A strip three inches wide is cut from the poultry wire reenforcement around the four sides. The poultry screen is then laced securely in place using double strands of No. 6 waxed lined cord. Use short lengths of cord and fasten securely. The poultry wire must be held taut; so that the top will not sag. Care must be taken to keep the sharp ends of the screen bent back; so that they will not puncture the padding and the top deck material and will not extend through the headlining.

On standard installations, the antenna lead-in must be soldered across the front end of the screen and brought down the front right corner post. In cases where the post is solid, the lead-in may sometimes be brought down inside the windshield moulding, or down the hollow rubber wind hose which is used in many cars.

Rearrange the dome-light wiring so that there is a minimum coupling between the wires and the poultry wire antenna. Test the installation for grounds, using a 45-volt "B" battery and a high resistance voltmeter. Replace the headlining and trim carefully.

Installing an Antenna in Cars with Fabric Top Construction—In a few cars, the top padding is supported by muslin strips stretched over wood bows. An antenna can be easily installed in these cars in much the same manner used in cars with the slat top construction. Instead of tacking the screen under the bows, however, the screen can be placed over the bows and tacked only at the rear and the front. Otherwise the procedure is the same.

Installing an Antenna in Cars with Metal Braces—In case there are metal diagonal braces in the top, the braces must be freed of grounds; or the efficiency of the antenna will be greatly impaired.

Usually the rear ends of the braces are fastened to the wood top frame while the front ends are fastened by means of brackets to the front corner posts.

Drop the headlining and work from the inside of the car. Release the front end of the braces. Ream out the hole in the bracket, and use fiber washers and sleeve bushings to insulate the cross-brace bolts from the brackets.

Usually the dome light is connected to one of the braces. Disconnect and lead from the brace and run a new ground to the car body.

When both braces have been insulated, the antenna can be installed in the standard manner.

Open and Convertible Model Cars—The tops of the open and convertible models are designed to fold back. Since the antenna cannot in any manner interfere with this, a wire antenna is the only practical one.

Remove the top material and lay it back, leaving the side flaps in place. Secure a piece of top fabric, matching that removed, and fasten it properly in place over the cross ribs and over the side flaps.

Cut a piece of drill cloth or muslin approximately three inches smaller than the width of the top and about the length of it. Punch holes in the drill cloth through which the antenna wire is to be woven. The holes should be in rows, three inches apart, parallel to the cross ribs. Space the holes about ten inches apart in each row. In case metal bows are used, be sure to space the wires three inches from each bow.

Use 18-gauge (stranded) rubber-covered wire and weave it back and forth through the holes in the cloth.

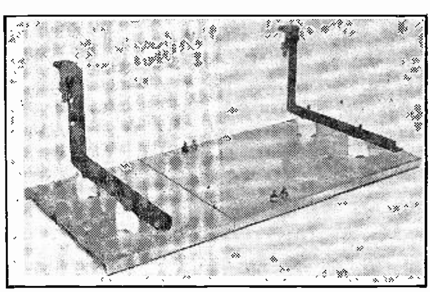


FIG. D

A typical metal-plate antenna.

When completed, the cloth is fastened to the front and rear bows only.

The antenna lead-in must be brought down in the rear so the top may be lowered easily.

The top material and all trim must be carefully replaced. While it is hardy probable that the antenna is grounded. check it with a voltmeter to make sure.

Miscellaneous Car Antenna

While the roof antenna will always be found to be more efficient than any other type which can be practically concealed in a car, it is sometimes impractical to install one. The labor charge for such an installation is necessarily high, because of the time and labor involved. Where the customer refuses to pay such a charge, a substitute installation must be made.

Next in practicality and efficiency to the roof aerial is the "capacitor plate" which is mounted underneath a running board. It should be suspended, for best results, as far from the running board as possible, and yet so high so that obstructions in the road will not strike it. A shielded lead-in wire is then brought to the set. This type of aerial, serving more as a counterpoise, is illustrated in Fig. D.

Strap antennas are the most economical, but they do not last long. One comprises a wire screen, 6 inches by approximately four feet, sewed into canvas or a rubberoid material with strings on each end. One end of this antenna is tied underneath to a bolt on the transmission housing; the other to a bolt above the rear axle (never to the axle). A lead-in, soldered to the screen within the insulating material, is connected to the chassis antenna lead.

The writer has made a very satisfactory antenna from a stiff cardboard, 10" by 30", by coiling fifty turns of bell wire around it (space-wound, so that the entire length of the cardboard is coiled). A shielded lead wire is then soldered to one end. Remove a few tacks from the roof upholster, drop the flap open and insert the coiled cardboard crossways, leaving the lead wire running outside; then tack the upholstery back, drawing the cloth tight as the tacks are inserted. The lead-in wire can then be brought down behind the narrow panel between the front and rear windows.

Always ground the shielding of any lead-in as close to the antenna and chassis (twice) as possible.

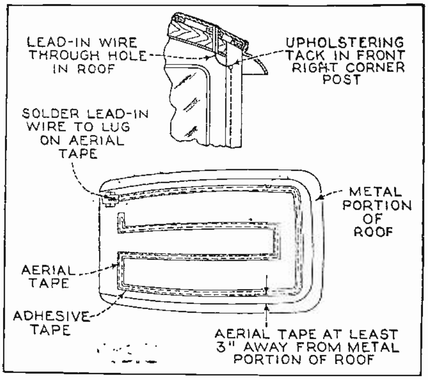


FIG. E
Installation of antenna in a car of the non-convertible type.

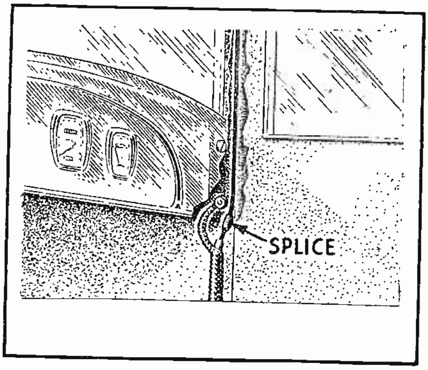


FIG. F
Sketch showing how an antenna splice is to be made.

CHAPTER IV.

CAUSES AND REMEDIES OF MOTOR NOISES

IN this section we will describe in detail some of the problems that arise during the course of installing and servicing automotive radio receivers. At the outset, it must be stated that the problems peculiar to one installation may require a method of solution radically different from that required of the same receiver in another type of car. These problems may be classified under three general headings:

(1) Mechanical difficulties;
(2) Electrical difficulties;
(3) Power unit.

A review of the electrical equipment which are the direct causes for radio interference, rather than extensive. installation data is described here. As will be appreciated at this time, the method of installing a receiver in a car varies both with the type of car and type of receiver. In this connection, it might be stated that manufacturers of automotive receivers furnish complete data regarding the methods to be used in installing their particular set in a car. Templates are furnished which provide for the mounting of both the loud speaker unit and the chassis.

In most of the installations in use today, a remote control tuning unit is provided. This, as was stated previously, is mounted either on the dashboard so as to enable tuning by either the driver or a passenger, or on the shaft of the steering wheel, so as to enable tuning only by the driver. This latter method of mounting the tuning unit seems to be gaining preference, but here again, complete mounting details are furnished by the manufacturer of the receiver. One precaution should be taken—that is, to avoid any sharp bends or kinks in the remote control tuning cable. This latter precaution should be adhered to rigidly in all cases where remote control tuning units are used, regardless of who makes them or where they are placed.

It is also quite obvious that all nuts, bolts, etc., be tightened as much as possible during the installation or servicing, inasmuch as the receiver is subjected to much more vibration than is ordinarily encountered in radio work. All that is required, beside a knowledge of radio and automobiles, is a little common sense.

Electrical Difficulties

The number of different troubles which may arise in an automotive receiver are greater than in a set designed for home use. This is not so much due to the type of design as to the location in which the receiver is to be used. It might be well to emphasize at this time that all of the methods used to service home receivers are applicable to automobile types. In other words, if a tube goes bad in an automotive receiver, exactly the same methods are used to locate it as are used in ordinary service work. True, it is a little more inconvenient to approach the various parts of a set of an automotive receiver, but nevertheless the same methods of attack must be used. Space does not permit a detailed analysis of the methods used to service receivers designed for home consumption, but the reader is referred to other books and radio publications on this subject. We will only concern ourselves with the analysis of, and what is far more important, the methods of solving problems which are peculiar to automobile receivers alone.

In the first place, every gasoline operated car has what is known as an ignition system. This system is the cause of 75% of the complaints of owners of automotive receivers. In order for the Service Man to more fully appreciate the difficulties that arise in operating a receiver in a car, it perhaps would be instructive to enter into a detailed analysis of the ignition systems of cars, then show why this system causes troubles and finally indicate the procedure to follow in order to eliminate the above mentioned difficulties. Consider the diagram of Fig. H. This is a very

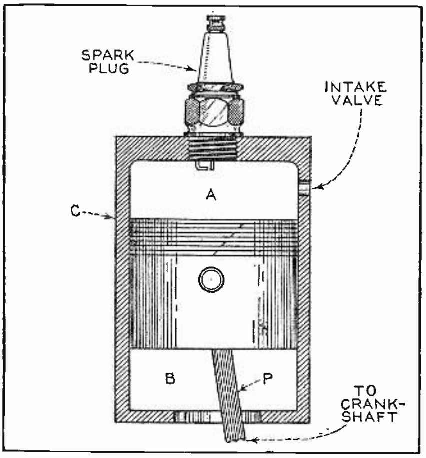


FIG. H
Diagram showing the relative location of piston and spark plug.

elementary sketch of a single cylinder in an automotive engine. As may be seen, it consists of an outer metal shell C inside of which is balanced a piston P. This inner chamber may be divided into two sections, A and B, section A being that above the piston and B that below the piston. Assume that the conditions are such that there is no gas in the cylinder itself and the piston P is just starting on a downward stroke. As it starts down, a mixture of gasoline and air enters the intake valve. When the piston reaches its lowest position, the intake valve is based. The piston then travels up, compressing the mixture as it travels. In order to make the piston travel down, it is necessary to expand this gas. In expanding, it would push the piston down which in turn would cause the wheels of the car to rotate due to the action of the crank shaft, etc. Now the method used in the ordinary gasoline engine for expanding this gas is an electrical one. As may also be seen by reference to the figure, the cylinder has a spark plug inserted at the head (top of the cylinder). This spark plug has two terminals which connect to a source of very high voltage. Now in order for the greatest power to be obtained, the gas must expand when the piston is starting its downward motion. In other words, just as the piston starts to go down, a spark is caused to jump the gap between the two terminals of the spark plug. As this spark occurs, the mixture of gasoline and air ignites and then expands, pushing the piston downward as it does so. The piston then travels to the end of the stroke and upon rising pushes out the gas in the chamber A above the piston, this gas going out through the same (or other) valve. The piston then starts downward again and in so doing, gas again enters the chamber at A with a repetition of the preceeding steps.

Now, it is quite clear that the spark plug must fire at the precise moment when the piston is at its highest point, else maximum power from the engine cannot be realized. This means that there must be some device or devices which are capable of timing the instant at which this spark occurs. This timing is done by a device called a distributor which is located under the hood of the car but outside the engine block. An ignition distributor may be defined as a device which is used for the timing and distributing of the ignition voltage to the spark plugs at the proper instant, and in the proper firing order of the engine. The distributor is composed of two separate and distinct parts;

(1) The secondary or high-voltage section;

(2) The primary or low-voltage battery section.

The Low-Voltage Section of the Distributor

The low voltage, or primary circuit, consists of a **breaker arm, contact points**, and a **condenser.** One contact point is mounted on the breaker arm and is held closed by a tension spring. It is forced open by the action of **breaker cam lobes** against a rubbing block pressed on the breaker arm; the contact points are in series with an ignition coil and the storage battery of the car.

The Secondary Circuit

The secondary or high-voltage circuit of the distributor consists of a **rotor** and **distributor cap** which is made of a phenol resin compound. The cap has a terminal for each cylinder in the car and two others which connect to a **high-tension coil.** The purpose of the rotor is to distribute the high voltage necessary for the firing of the plugs to the different plugs at the proper instant.

That relation between the **rotor** and the **breaker cam** is always such that when the breaker cam causes the contact points to open, the rotor closes to a spark plug which happens to be operating at a particular instant.

The device which is used to generate the high voltage is shown diagramatically in top Fig. I. As may be seen, the coil consists of a heavy winding (the **primary**) wound over an iron core. This primary circuit connects, as will be shown later, to the car battery through the breaker arm in the distributor. The **secondary** or high-voltage winding is wound over the primary and connects to the rotor arm of the distributor, as will be shown later. The theory of operation is very simple.

When the primary circuit is broken by means of the breaker-arm contacts, a high voltage is generated in the secondary circuit which is applied to the terminals of a spark plug; the particular plug being determined by the position of the rotor arm in the distributor. When the primary circuit is broken, the voltage generated in the secondary increases and it is at this instant that the rotor arm makes contact in the distributor. In other words, the breaker arm acts in exact unison with the rotor arm in the manner illustrated in center Fig. I. As may be seen by reference to the figure, when the ignition switch on the dash is closed and the motor is turning over, the contact arm is making and breaking the battery circuit which induces the voltage in the secondary of the ignition coil that is applied to the particular spark plug making contact with the rotor arm. The numbers in the circles in the rotor arm cap signify the firing order of the cylinders. In this case, a six cylinder car is assumed. The type shown in center Fig. I is the simplest distributor circuit that can be used. A condenser connected across the contact arm is used for the purpose of minimizing the sparking that occurs at the contacts when the breaker arm opens.

The second type of distributor shown in bottom Fig. I is that using a breaker cam having as many lobes as there are cylinders in the motor, but having two breaker arms operating in parallel. These breaker arms are set so that one point will open slightly later than the other. This allows the ignition coil a little longer period of time in which to build up and permits higher top car speeds. One ignition coil is used.

The third type is the one having a

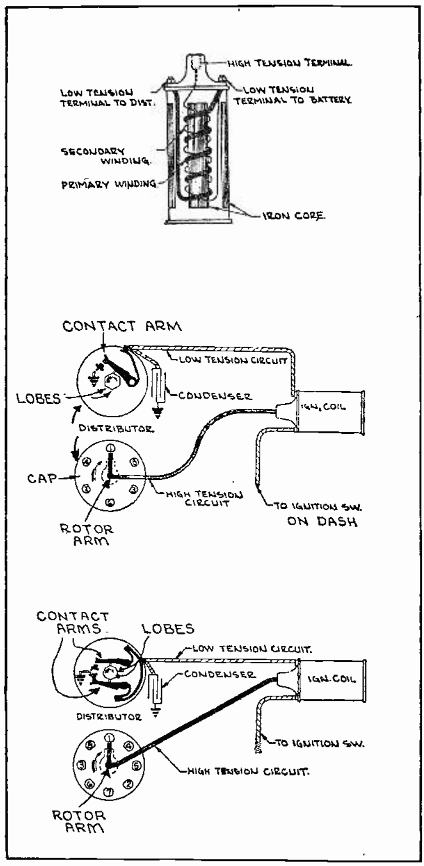


FIG. I

Above, detail of the spark coil; below, two types of distributor systems.

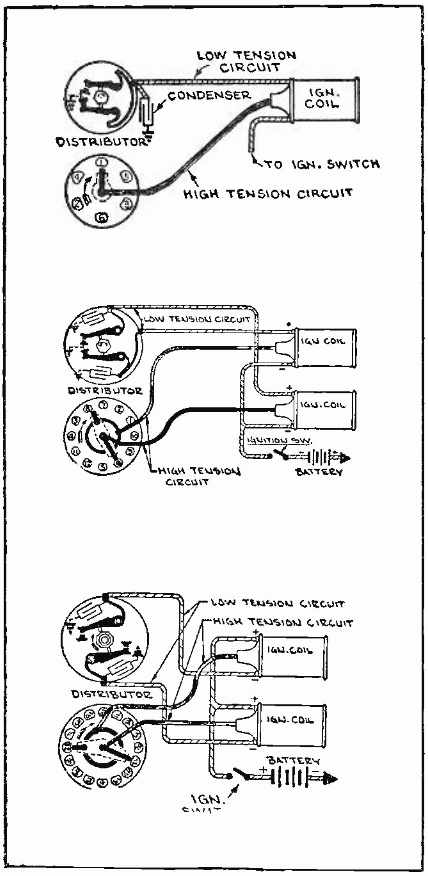


FIG. J

Three additional types of distributor systems. They are described in the text.

breaker cam with half as many lobes on the cam as there are cylinders in the motor and using two breaker arms. (Top Fig. J.) One breaker arm fires half the cylinders and the other breaker arm fires the other half of the cylinders. The fourth type of distributor uses a breaker cam having half as many lobes as there are cylinders in the motor and two breaker arms which have separate electrical circuits. (Center Fig. J.) The contact points must be set to open in proper relation to each other the same as with the third type. Two ignition coils are used, one for each set of contact points. The third and fourth types of distributors allow a greater length of time for the points to be closed and coil to build up. This permits a greater engine speed than can be derived from the single breaker arm type distributor. The fifth type of distributor is the same as the fourth except that the breaker cam has as many lobes as there are cylinders and the contact points are set to open at the same time, but are electrically separated. Two ignition coils are required. This type of distributor is used for dual ignition engines. (Bottom Fig. J.)

Besides the above, there are various other relays that are part of the ignition system. A detailed analysis of the function of these relays will not be entered into merely because they do not play a very important role in the servicing of automotive receivers. They will be mentioned from time to time throughout the discussion wherever it is deemed advisable.

As probably everyone knows, the usual automobile is equipped with extensive lighting systems which are necessary and really constitute a part of the ignition system of the car, inasmuch as they are controlled by the battery system and constitute a drain on the automobile battery. An examination of the distributor system of current automobiles show that that practically every car has a different mode of connection. Consequently, it would be both unwise and impractical to publish these diagrams as they will probably change with every new model of car that is placed on the market.

THE GENERATOR

If some means were not provided for renewing the energy in the battery of a car, it would not be very long before one would be unable to start the motor. In order to facilitate charging the battery in the automobile, there is provided a small generator which is rotated by the car engine and which supplies the power necessary for charging the battery while the engine is running. Since this generator is a constant source of annoyance to owners of automobile radio sets, and since it cannot be removed, it might be well to outline the theory of operation of these generators so that the means taken for eliminating the annoyance that it causes will be appreciated. Because the radio set in a car usually obtains its power from the storage battery, it might at times be necessary to increase the rate at which the battery is charged. For this reason, a complete description of the various types of generators now in use, including their care and maintenance, will be of vital importance to every radio Service Man. The natural question which arises is how does a generator produce voltage? The answer is to be found in the elementary laws of magnetism.

Rigorous experiments show that when a wire cuts a magnetic field at right angles to the field, a voltage is generated in the wire. The wire need not necessarily carry current in order for the voltage to be generated. This voltage is produced only while the wire is in motion, and ceases as soon as the wire stops moving. The general idea is depicted in Fig. K.

Poles N and S are the two poles of a permanent magnet, the lines of force of which extend directly from the N pole to the S pole. A wire, AB is placed above the magnet, and then moved rapidly down, cutting the lines of force as it moves. During the time it is moving, a voltage is generated between points A and B, which drops to zero after the wire has passed through the entire field. (The voltage would also drop to zero if the wire were suddenly stopped while still in the field.) Three conditions are necessary then, in order that a wire generate a voltage.

(1) The wire must be in motion;

(2) The wire must be in a magnetic field;

(3) The wire must not be moving parallel to the field.

The voltage generated in the wire is constant as long as the speed of the wire is constant, everything else remaining the same. If the strength of the field be increased, then the voltage generated increases in like proportion. The same rule holds in regard to the length of the wire in the field, i.e. the greater the length of wire in the field, the greater the voltage generated. These rules may be set down in the following manner:

(1) The voltage generated in a wire increases as the strength of the field increases.

This point requires some explanation. What is meant is that the voltage

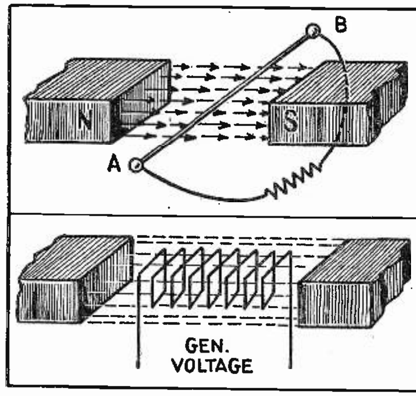


FIG. K

generated in a wire increases as the strength of the field **in which the wire is moving** increases. Thus, with a certain strength field, let us say that the voltage generated in a certain wire is 2 volts. Now if the magnet is replaced with one of twice the strength, the generated voltage will be 4 volts.

In practice, the permanent magnets are replaced with **electromagnets.** An electromagnet is simply a coil of wire wound over an iron core. A current is sent through this coil which generates a magnetic field. Since the strength of this field varies directly as the strength of the current through this field coil (called the **field current**) the voltage generated in the rotating wire (called the **armature**) may be increased or decreased by varying the field current.

(2) The voltage generated in a wire increases as the speed of cutting the field increases.

(3) The voltage generated in a wire increases as the length of the wire in the field increases.

The voltage that is generated depends upon each of the above factors, so that while any one of them might vary the magnitude of the voltage generated, all three must be taken into consideration in determining the actual value of the voltage.

The voltage generated in the manner shown in Fig. K will be the same if, instead of having the wire move and the magnet stationary, you have the wire stationary and the magnet move. It makes absolutely no difference to the amount of the voltage generated, whether the magnet or the wire moves, so long as one moves with respect to the other. This is in line with our previously mentioned statement that a voltage is generated when a wire cuts a magnetic field.

If the wire of Fig. K were looped as indicated in bottom Fig. K, the voltage generated in the loop would be greater, due to the increased length of wire in the field.

When voltage generation takes place, one end of the wire becomes positive, and the other end becomes negative. If the direction of motion is reversed, then the end formerly positive becomes negative and vice versa.

Now, in order that the terminals of the device generating the voltage be at a constant polarity, a device called a commutator is supplied. This is merely an arrangement of copper bars distributed around the periphery of the rotor's shaft and is rigidly mounted on the shaft of the rotor or armature. Two carbon brushes are mounted on this commutator, and their purpose is to collect the voltage that is generated by the armature. The source of magnetic field is a coil of very fine wire that connects directly to the brushes and is called the field coil. It is usually made in two sections diagonally opposite one another. In order to minimize the annoyance created by this generator in an automotive receiver, it is absolutely essential that there be no sparking between the brushes and the commutator. This brief description will serve to introduce the practical methods of dealing with automotive generators.

The purpose of a generator is to supply current for the lights and ignition of passenger cars, trucks or motorcoaches. It converts a small amount of mechanical energy from the engine into electrical energy which is carried through the wiring to the storage battery. The surplus electrical energy is stored as chemical energy in the battery for use at times when cranking of the engine is necessary, or when the consumption of electrical energy, due to lights and ignition, exceeds the generator output.

Generators are designed to take care of a particular kind of service and the total required current output determines the type of regulation (voltage variation) needed to supply the necessary current without damage to any part of the electrical system.

(1) Third Brush Regulation.
- (a) Thermostat control.
- (b) Manually controlled field resistance.
- (c) Lamp load control.
- (d) External voltage regulation.

(2) External Voltage and Current Regulation.

Third Brush Regulation

The third brush method of regulating current output is universally used because of its simplicity. It meets the average driving requirements as it provides maximum generator output at normal speeds and has a lower output at higher speeds. This system of current regulation involves the variation of the field strength and it accomplishes this result without any external apparatus or moving parts. The operation depends on the reaction of the magnetic field produced by the armature and the normal field from the poles.

The charging rate can be changed by altering the position of the third brush with respect to the main brushes. (See Fig. L.) The third brush is mounted on a movable plate located inside the commutator end-frame. This plate is usually held in place by a clamp and a small round-head screw.

Before changing the position of the third brush or adjusting the charging rate of the generator, the circuit should be free of grease and oil, the brushes set properly and the brush arms checked for proper spring tension. All connections in the generator circuit should be clean and tight. The storage bat-

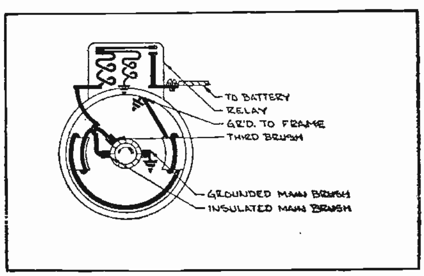


FIG. L

Sketch showing the location of the third brush.

tery should be checked for the proper water level. Driving conditions of the individual car should be investigated **and under no conditions should the charging rate be set beyond the maximum rate specified for the particular generator.**

In order to adjust the charging rate to a greater value, loosen the locking screw located outside the commutator end frame and shift the third brush **in the direction of armature rotation.** The current output is decreased by shifting the brush **opposite** to the direction of armature rotation. After adjustments have been completed tighten the lock screw so there will be no change in output while the generator is in operation.

An accurate reading ammeter should be connected in the charging circuit at the generator terminal when adjustments are being made, and the maximum current output observed as the car is speeded up. Current output readings taken at the generator terminal will be approximately two amperes higher than readings taken at the dash ammeter. In case a two-coil ignition is used instead of a single coil, the readings at the generator terminal will be approximately four amperes higher than the dash ammeter readings.

An important factor that must not be overlooked in this type of regulation is that the generator must not be operated unless it is connected to a battery or damage to the unit will result, as the battery plays an important part in maintaining a normal voltage. condition.

When the generator is operated on open circuit, the voltage will rise abnormally high, thus increasing several times the normal amount of current through the field winding and cause the insulation on the field coil and armature to be burned. When the generator is to be operated without being connected to the battery it should be short circuited by connecting the insulated main lead to the ground. (See Fig. L.)

With this type of regulation there is the tendency for the charging rate to increase as the battery becomes fully charged. This is caused by the rise in the terminal voltage of the battery as it becomes fully charged. Any rise in battery voltage causes an increase in generator voltage thus increasing the current in the field coils.

On passenger cars, the generator charging rates usually can be adjusted so that overcharged- or undercharged-battery conditions will not exist. When the generator leaves the factory its output is adjusted to a safe value that is suitable for average driving conditions for the car on which it is installed.

Thermostat Control

The thermostat control of the generator is used in addition to the third-brush regulation. This unit acts as a protective device as well as an output regulator and prevents overheating of the generator. The thermostat is mounted inside the generator at the

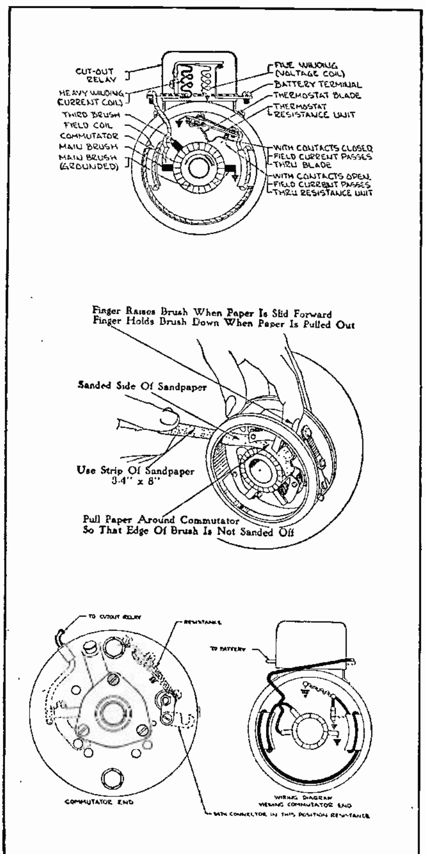


FIG. M

The center sketch shows how brushes are to be seated properly.

commutator end where it is readily influenced by internal heat.

The thermostat consists essentially of a resistance coil and a set of contact points. The lower contact point is mounted on a bi-metal strip, and when this is subjected to a certain predetermined temperature, the points open due to the warping action of the blade. (Top Fig. M.) These bi-metal strips are calibrated for either 165° or 200° Fahrenheit.

When the internal temperature of the generator reaches the calibrated temperature of the thermostat, the contact points will automatically open; thereby inserting into the field circuit a resistance which will decrease the charging rate approximately 40%. The field current which previously passed through the contact points is shunted through the resistance unit. (Top Fig. M.) Resistance units vary in size. They usually are ½, ¾, 1 or 1½ ohms resistance. The size of the resistance depends upon the type of operation to which the generator is adapted.

The contact points are closed, or returned to their normal position, as soon as the temperature has again become normal. The thermostat unit is entirely automatic and requires no attention other than to keep the contacts free from dirt. The unit is calibrated at the factory and properly adjusted. The contact points may be kept clean by passing a heavy piece of paper between them.

Manually Controlled Field Resistance

Some generators do not have the automatic feature of the thermostat control but have a resistance unit mounted on a bracket inside the generator at the commutator end. The unit can be inserted in the field circuit of the generator which will decrease the maximum current output. (Center Fig. M.)

This type of high- and low-output generator with third-brush current regulation gives a wide range of output adjustments and is applicable to trucks operated entirely in the day time when very little current is required. If the truck is driven considerably at night with normal lamp load, the full capacity of the generator would then be required.

When desiring to use the low output setting of the generator, insert the resistance unit into the field coil circuit by disconnecting one end of the small connector strap outside the commutator end frame. This connection is closed for high output. The current output is regulated by the third brush setting the same way as on other types of third-brush generators.

External Voltage Regulation

Another form of output regulation is the use of a third brush generator having an external voltage regulator. This type of regulation is usually confined to motor-coach installations.

Since there is a wide range between requirements of the generator at night when all lights are on and in the daytime when little current is consumed, an auxiliary control device will vary the output to suit the conditions.

The third-brush generator output has an inherent characteristic of tapering off at high speeds. The peak current output of a third brush generator tends to increase as the battery becomes fully charged, but with the use of external voltage regulation this variation in the charging rate is controlled. The voltage regulator will vary the charging rate according to the state of charge of the battery, and with a fully charged battery the rate will be reduced to a minimum of approximately five amperes. This protects the lights from damage and the battery from overcharge. The generator is protected by the third brush setting. This specified current output should not be exceeded when making adjustments on this type of generator.

Inspecting and Repairing

It is advisable to inspect the generator at least every twenty thousand (20,000) miles and make any adjustments or repairs needed. Have the various parts taken out, thoroughly cleaned and greased, and any parts excessively worn, repaired or replaced. If the commutator is worn or eccentric, it should be turned in a lathe to true it. The mica in the commutator (between the bars) should be undercut.

Commutator and brushes should be kept clean. Brushes should seat well. All circuits of the system should be tested for broken insulation, grounds, etc.

Squeaking Brushes

Squeaking of generator brushes may be overcome in most cases by carefully sanding the brushes with sand-cloth or sand-paper. (Bottom Fig. M.) **Emery cloth should never be used.** A squeak may be due either to a poorly seated brush, improper brush spring tension, or to a hard spot in the surface of the brush. If the commutator surface is rough or irregular, it should be made smooth before attempting to properly seat the brushes. This may require a turning operation in a lathe.

Correct Brush Seat

To obtain a correct charging rate with any given position of the third brush, all brushes must be well seated on the commutator. It is comparatively easy to thread a strip of No. 00 sandpaper or sandcloth around a portion of the commutator with the rough side next to the brush or brushes. A few strokes with the sandcloth correctly forms the brush seat. If brushes are fully seated on the commutator there will probably be less arcing, thus preventing commutators from becoming dirty.

A brush which is set at the proper angle on the commutator, but is very poorly seated, will greatly vary the output as it wears down to the proper seat. Also improperly seated brushes tend to be noisy.

Brush Spring Tension

In case the brush tension becomes weak for any cause, the charging rate will be reduced, and more or less arcing and burning of the commutator will result because of poor contact of the brushes on the commutator.

Excessive spring tension will cause the commutator and brushes to wear faster, reducing the amount of service to be obtained from them.

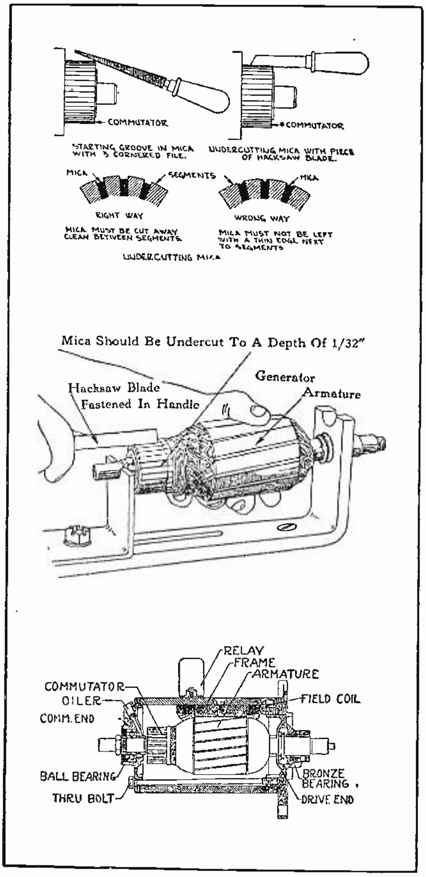


FIG. O
The sketch above indicates the method used to undercut mica.

Undercutting Insulation

The commutator bars of all generator armatures are insulated from each other by mica or a bakelite composition known as **micarta.** This insulation between the bars should be undercut about 1/32 inch in depth. (See Fig. O.) When renewing brushes in a generator with an undercut armature, it is necessary to sand the brushes to a good seat to prevent noisy operation and arcing.

If an armature in service is found with the commutator worn, grooved or with a rough and burned surface, showing high insulation leakage between the commutator bars, it should be placed in a lathe and the commutator turned down. This work should be done carefully, as the surface of the commutator must be concentric with the armature shaft to insure proper performance. Before placing the armature in the lathe, remove any burrs or foreign material that may have collected in the center hole of the armature shaft. Turn the armature at a reasonably high speed and use a fine feed and a very sharp tool.

When the commutator is turned down, undercut the mica between the copper bars to 1/32 inch, keeping the slot rectangular in shape and the edges free from the insulating material.

There are several undercutting machines on the market which can be used for this purpose. In the absence of a machine, the work may be accomplished with a hack saw blade, after having ground off the sides of its teeth until it will cut a slot slightly wider than the insulating material. The final assembly of a typical generator in its frame is shown in Fig. O.

After the undercutting operation remove burrs and smooth off the commutator with No. 00 sandpaper. With the use of air, blow out all loose particles between the commutator bars after sanding.

INTERFERENCE

Since the installation of the first motor car radio, interference originating in the circuits necessary for the proper functioning of the car as a motor vehicle has been serious. With the advent of motor car receivers for high sensitivity (about 5 microvolts per meter) these effects have become even more bothersome. It is the purpose of this section to discuss the nature of these disturbances and the practical means of reducing them to such levels that their effects in the loud speaker of the auto radio are inaudible. We all dream of that radio Utopia where noises from all sorts of electrical interference are eliminated, but for the present, let us assume that circuits outside the car itself are beyond our control.

Practically all motor vehicles using radio sets are equipped with lighting generators and battery ignition systems. The sources of interference with such ignition systems, as previously described, may originate at any one of the following places:

(1) At the spark plugs.

(2) At the high-tension distributor or at poorly connected leads in its circuit.

(3) At the low-tension interrupter.

(4) At the generator brushes.

Any sparking which may occur at any of the above mentioned locations may be conveyed to the radio receiver either by **radiation** from the point of sparking or by conduction along the car wiring and other insulated conductors or by both. These discharges occur at an **audio-frequency** rate and are of sufficient intensity to be picked up by the antenna even though the supply leads to the receiver are filtered or sealed.

In some cases, the voltage developed in a neighboring circuit by one discharge is sufficient to produce a secondary spark which, in turn, is a source of radiation. The conductors composing the car wiring may also act as an antenna and radiate energy into the automotive receiver exactly as does a broadcasting station.

The **frequencies** of the discharges (radiation) may be determined by the distributed inductances and capacitances of the leads coupled to the various sources. Since the leads are short and are insulated these distributed constants are small, and **the frequency of radiation is well above the broadcast band.**

Short-wave fans are acquainted with the fact that in the short-wave bands, the radiation from passing motors is very troublesome. In fact, an amateur who was particularly interested found that the radio disturbances from a model "T" Ford was most noticeable at a wave length of about 5 meters.

Shielding

An obvious means of reducing the radio interference in any motor installation equipped with spark ignition is by shielding the complete electrical system. This method is standard practice in airplanes and has been successfully applied to motor cars. Complete shielding, however, is impractical in stock cars due to the complexity of the wiring and the cost involved.

It should be pointed out that shielding does not reduce the energy of the disturbances but merely confines it within the enclosure of the shield. Partial shielding may even increase the radiation from the remaining unshielded wiring by **resonating** parts of the circuit to frequencies **nearer** the broadcast band. This change of resonant frequency is brought about by the additional capacity of the shield to the ground. In other words, it may be said that sometimes connecting a capacity to ground may increase the energy of the interference.

A BETTER REMEDY IS TO REDUCE THE DISTURBANCES AT THEIR SOURCES BELOW TROUBLESOME LEVELS WITHOUT IMPAIRING THE OPERATION OF THE VEHICLE.

Relative Location of the Circuits

Fig. P shows schematically the location of the circuits which must be considered. The heavy lines indicate the car body, usually of metal, and the receiver chassis R, which are considered to be at ground potential. A1 and A2 are alternative antennas, that is, the antenna may either be of the roof or of the metal-plate type. All ordinary initial disturbances occur within the engine compartment. I is the high tension ignition wiring, the principle source of disturbance; W any wiring from the engine compartment to the receiver or space near the receiver; D any long leads coupling the antenna to the source. The breaker arm in the distributor and the lighting generator (not shown) are also located in the engine compartment, and as far as general position is concerned, may be considered with the high-tension circuits. It may also be noted that the steering column C and the gear shift lever are not above suspicion in certain types of cars. Antennas of the above type have almost no inductances and have capacities of from 100 to 300 mmf. They are practically non-directional, regardless of the type of antenna used; their leadins should be shielded by copper braiding and be located as far back as possible from the source of interference—the engine compartment. The braid should be well connected to the receiver chassis and prevented from grounding intermittently at any other points. Because the strength of the interference is somewhat stronger above the car than in the shielded space beneath it, the capacity plate antenna A2 is sometimes preferable to the roof type A1.

High Tension Ignition Circuits

By far the greatest intensity of interference is from the spark plugs.

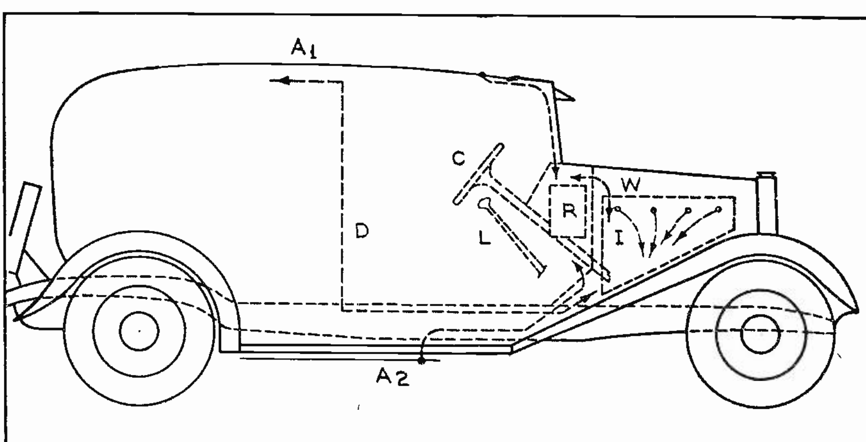


FIG. P

Schematic circuit of an automobile showing the circuits to be considered in analyzing interference.

Figure Q shows the wiring of a typical high-tension battery ignition system. The car battery, which also supplies power for all of the other electrical equipment on the car, feeds the primary winding of the ignition coil

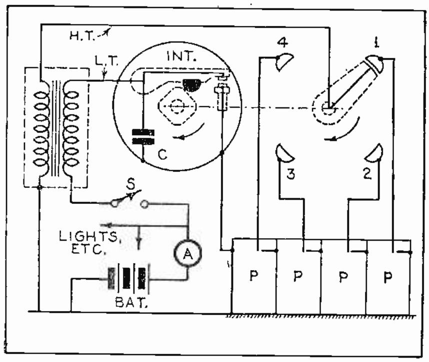


FIG. Q
Wiring diagram of a typical distributor system.

through a cam operated interrupter which, incidentally, is run at ½ crankshaft speed. The secondary winding of the coil is connected successively to the spark plugs through the rotating distributor switch, or rotor, which is operated synchronously with the cam. This has been covered previously in another section. The condenser C, across the interrupter contacts, aids in extinguishing the contact arcing and is of a size to resonate at a frequency of from 2000 to 3000 cycles per second with the primary inductance of the coil. This condenser is an integral part of the distributor system and is supplied with the car. It is interesting to know that during the time secondary current flows (when one of the plugs is firing) the high-tension winding is practically short circuited by the spark at the plugs and the frequency of radiation is of the order of 8000 cycles per second; while with the secondary open, (no current flowing) the frequency is of the order of 2300 cycles per second. It might be well to mention that the above numbers are the audio frequencies and not the carrier frequencies.

Figure R shows the distributed inductances and capacitors of the spark-plug circuit. It is impossible to represent them accurately because of the variation in the cable lengths and the distances to the engine block, hood, low-tension leads, and to high-tension leads to different spark plugs. An examination of this figure will indicate that at a critical voltage (about 6000 or 7000 volts), depending upon the fuel mixture, the temperature and the separation of the plug electrodes, a spark passes to ground at the plug which which practically short circuits the secondary end of the high-tension coil. The stored energy in the dielectric field of the distributed capacities about the conductors all the way back to the coil is discharged, and is a source of radiation of considerable power.

Shielding only the high-tension leads has the effect of increasing the capacity to ground and of increasing the energy to be released when the spark discharge at the plug occurs. However, adding a single "lumped" series inductance changes the frequencies and may re-

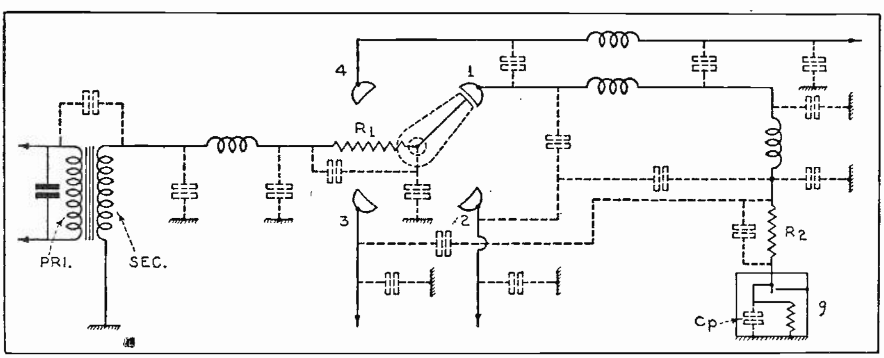


FIG. R
An excellent sketch of the distributed inductances, capacitances and resistances in a car.

duce the number of harmonics radiated but does not decrease the energy, and cannot be depended upon to eliminate interference.

Ignition Suppressors

The most effective means of reducing these radiations is to insert series resistances in the leads leading to the sparking electrodes. A single resistor, close to the rotor in the distributor, connected in series with the ignition-coil lead that terminates at the rotor arm, and resistors in the leads at each of the spark plugs are quite effective. Fig. S shows several types of commercial resistors, called suppressors, which are all of carbon mixtures. The long unit showing the two types of terminals, and whose component parts are shown immediately to the right, has a bakelite case to prevent it from grounding. The porcelain covered units shown at the top and bottom are sealed and may not be disassembled. The two units of larger diameter, shown to the left, were of earlier manufacture and are discussed below. Two qualifications that suppressor resistors should have are (1) the ability to carry high instantaneous currents without deteriorating and (2) must have a low terminal capacity to prevent coupling around them.

The first commercial resistors used as suppressors were of short length, of comparatively large cross-section, and had large terminals as shown to the left of Fig. S. The resistance material used was carbon, and had intense voltage drops between particles, resulting in luminous destructive discharges from particle to particle through the binder. The large terminals added self capacity to the suppressor and also to ground from the spark plug terminal, and were rather ineffective. In some cases, flash-over actually occurred between the terminals. A better suppressor was formed of materials of smaller resistance per unit length, of greater length and smaller cross sectional area. The area of the terminal attached to the plug was reduced and the resistor located as near as possible to the plug.

Spark plugs are now being manufactured with the resistance material included inside the porcelain insulator. This construction still further reduces the self capacity of the resistor and the exposure of the unprotected circuit. It is predicted that when motor cars are factory equipped with radios, it will be found

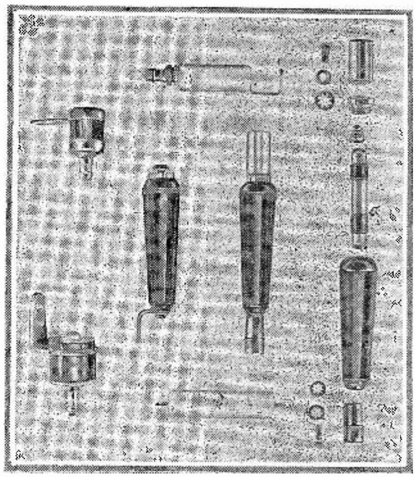


FIG. S

Photograph of the commonly used types of suppressor resistors. (Courtesy, Lynch Mfg. Co.)

advantageous to include the suppressor resistors in the structure of the distributor rotor itself.

Unexpected Discharges

The high-tension current easily passes through the cables from the coil to the plugs even though the wire in the cable does not actually make contact with the terminals of the plugs. This often happens with installations which have seen several thousand miles of service. All cables should be checked for continuity to terminals to eliminate these extra sparks. The interrupter mechanism is often mounted on a plate which is movable by means of the spark-advance lever. Sometimes the whole distributor housing is turned for advance and retard of the spark. In such cases it is necessary to eliminate sparking through the oil and dirt between these metal surfaces by shunting the joint with a flexible braid.

Effect of Suppressors on Ignition

Even the smallest spark at the plug electrodes is capable of producing ignition, but it may only be produced at a critical voltage. The equivalent low frequency diagram of a spark-plug circuit involved in this discussion is shown in Fig. T. The insulating resistance of the spark plug and of any foreign deposits on its surface is represented by g. At high engine temperatures, or low temperatures if the porcelain is wet, this may be considerable. Now with large series resistances R1 and R2, the voltage developed across G (the spark-plug gap) may be insufficient to produce a spark across the gap terminals. With excessive cable leakage, or gap capacity to ground, the spark-plug voltage would be further reduced. Suppressor resistors of the order of 15,000 ohms are perfectly satisfactory from an ignition standpoint. These resistors are large enough in value to materially reduce the interference, but even for these values, the cables and plugs must be in good condition, and the plug gaps must be as small as is consistent with fuel mixture, compression and engine speed.

Low-Tension Interference

Figure U shows the primary circuit and the distributed constants involved in interference originating at the low-tension interrupter or breaker arm. The function of condenser C1, as previously stated, which is connected across the interrupter or breaker arm is to form a low-frequency oscillating circuit with the primary of the ignition coil and to assist in extinguishing the arc or spark at the contacts. This capacity must not be increased in size as the frequency of the primary oscillation and consequently the induced voltage in the secondary, would be thereby reduced.

Excessive capacity across these leads also causes pitting of the tungsten contacts. A resistance connected in series with the primary lead near the interrupter is not allowable since this would reduce the primary current below an operating value. An additional condenser C2 on the supply terminal of the coil effectively grounds the high-frequency impulses at this point and prevents their conduction along the supply lead. The lead from the ignition coil to the interrupter should be as short as possible and not coupled (placed adjacent to) to other conductors which might direct the impulses. In some cases, it is advisable to shield this lead carefully and ground it at both the interrupter and coil housings. Shielding this lead is usually necessary if the coil is mounted on the bulkhead or under the instrument panel. The shielding and the condenser C2 above mentioned also serve to keep any interference from residual high-tension disturbances, which were not eliminated by the suppressors but which were bypassed to other low-tension terminals by the capacity of the windings of the coil, from passing further along the supply leads.

Both high- and low-tension disturbances are more easily eliminated if

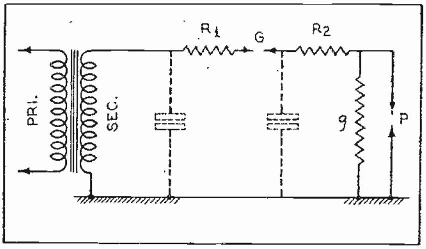


FIG. T

Equivalent circuit of a spark plug connection.

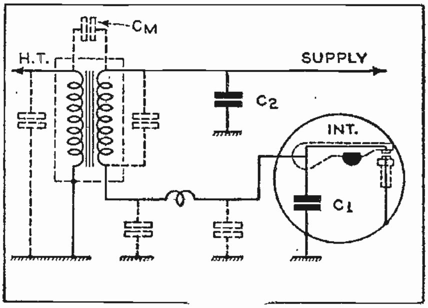


FIG. U

Distributed constants of the primary circuits of the coil.

the coil is close to the distributor, and no conductor connected between the coil and interrupter is led to the instrument panel. This connection as well as the high-tension cable should be as short as possible. For the Service Man who is in doubt as to the location of this condenser, C2, a table, given in a following section should be consulted.

Commutator Interference

The circuit of a typical third brush lighting generator is shown in Fig. V. A spark originating at brush B causes the radiation of energy which is conducted along the live lead through the generator cut-out to the car wiring from which they may be radiated. An effective means of eliminating this source of disturbance is to bypass the live lead as near as possible to the source. Condensers mounted on the cut-out cover are sometimes ineffective because of the resistance of the cover to ground. The ground connection should be as short as possible and securely bonded to the generator frame. The complete job should be checked at all engine speeds since brush sparking depends upon load and speed.

Residual Interference

In spite of the precautions taken as described, it is safe to say that in every case the disturbances are not completely eliminated but are only reduced in level. Conditions of coupling and radiation vary widely between different models of cars and even between chasses which are supposedly identical. Where the engine is mounted on rubber and the connections from the car body to the frame vary in resistance or actually fail to make contact, the complex high-frequency field is radically changed. Long leads for high- and low-frequency circuits are often a source of trouble. It is therefore advisable to filter or shield the supply leads entering the receiver. Since the filaments of the tubes in the set must be supplied by the same battery which is connected to the devices causing the interference, shielding the filament leads is usually ineffective unless both leads and shields are carried directly to the battery terminals. These leads may remain entirely unshielded if a choke and condenser filter is provided at

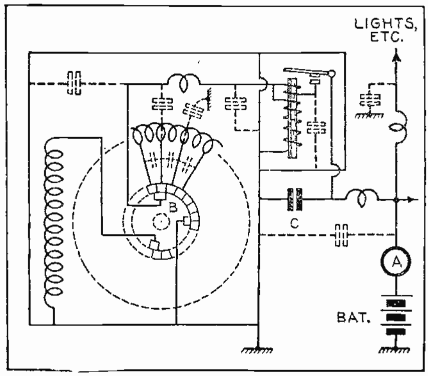


FIG. V

Complete circuit of a typical third-brush generator circuit.

the point where they enter the receiver chassis. The leads from the "B" battery or "B" eliminator may remain unshielded if they are not closely coupled to interference circuits and if a bypass condenser is used where each lead enters the receiver housing.

Interference tests are usually made by listening for noise in the loudspeaker with the receiver adjusted for full sensitivity but not tuned to a broadcasting station. This should be done in a location where external interference is low. The engine hood should be closed and latched to prevent other than normal radiation from the engine compartment.

Causes and Remedy of Motor Noises

THE present method of eliminating motor noises by means of suppressors, generator and ammeter condensers, is considered standard practice. That it is the best leaves ample room for argument—which the writer will take up in detail after the present practice has been discussed.

Very complete information regarding standard methods of eliminating motor interference is furnished by courtesy of Galvin Mfg. Corp., manufacturers of the Motorola receiver. The following is their explanation and instructions:-

"There are two types of interference. These are commonly called Chassis and Antenna pick-up.

"Briefly, chassis pick-up is motor interference heard through the loud speaker with the antenna of the radio disconnected. It is an indication that waves set up by the motor and ignition system are passing through the radio and being amplified as radio frequency.

"Often chassis pick-up motor noise comes into the set through the "A" lead. A Dome Lite filter, used at the point of the "A" lead attached to the "A" battery of the car, whether at the battery or the starter, usually overcomes this noise entirely.

"If chassis pick-up still occurs in the model 77 it is due to either of the following causes: (1) Defective condenser in the Eliminode system. Check by replacement with another condenser of the same value. (2) Cover of set making poor ground to set housing. Remove cover, and clean lips of cover and set housing with fine sandpaper.

"If chassis pick-up occurs in the Model '55': (1) Use Dome Lite filter. Connect one side to the battery circuit of the car, and the other to the end of the yellow wire. Connect battery condenser wire to the ground. This Dome Lite filter can be obtained from the distributor for about 50c. (2) If the high-tension coil is located on the instrument panel, shield the high-tension wire from coil to bulkhead, grounding this shield at the bulkhead. In some cases it may be necessary to cover the head of the ignition coil with a metal shield.

Antenna Pick-Up

"Interference reaches the antenna through the following methods: (1) direct radiation. (2) Conduction and radiation. (3) Eddy currents in surrounding metal.

Direct Radiation

"This type of interference is radiated directly from the ignition system, high-tension wires, coil distributor, etc. Spark-plug suppressors reduce the radiation from the spark plugs and high-tension wires; they do not, however, eliminate the radiation from the coil and distributor proper. As the distributor is usually well shielded by the hood of the car, it is not necessary that any steps be taken to shield it further, other than to make sure that the hood is making good contact to the hasps that hold it in place.

"In cars such as the 1932 'V8' Pontiac, where the distributor is mounted close to the wooden floor-board, it is sometimes necessary to tack copper screening to the floor-boards and ground it to the frame of the car. This prevents the distributor from radiating directly, either to the antenna or to be picked up by the feet of the driver or passenger of the car and re-radiated to the antenna.

"The coil when mounted under the hood may be considered as being as well shielded as the distributor. Also, as in the case of the distributor, where the coil or high-tension wire leading from it to the distributor comes close to the wooden floor-boards, a copper screening should be tacked on the floor-board to prevent the occupants of the front seat from picking up the interference when they have their feet in a position near the coil. Chevrolet is a good example; cars with coils mounted on the dash or on the bulkhead in the driver's compartment are likely to radiate to the antenna.

"Where the coil is mounted on the bulkhead in the driver's compartment, the most simple and positive remedy is to remove it in the motor compartment. It can usually be mounted in the motor compartment, directly opposite the position it assumed in the driver's compartment, and the same mounting holes used. Examples of cars on which this is necessary, are Lincoln '8' and LaSalle 1932 models.

"Coils mounted on the dash are difficult to move to the motor compartment, because the ignition switch is mounted in the base of the coil. For this reason, a separate ignition switch would need to be used if the coil were removed. Usually, in the case of dash-mounted coils, it is sufficient to shield a high-tension lead that runs from the coil to the distributor. The most satisfactory way to do this is to slip a piece of loom over this high-tension wire, and then slip braided shielding over the loom; keeping the ends of the shielding one or more inches from the coil and distributor. The loom increases the gap between the ignition wire and shielding and not only makes the shielding more effective, but prevents leakage that might effect the ignition system.

"This shielding should be grounded to the bulkhead at a point where it enters the driver's compartment. Some coils, however, are very violent radiators and it is necessary to go further and partially shield the coils themselves. This may be done best by **placing a metal shield can** around the front of the coil. Drill a hole in can, to admit the high-tension lead, and slot the sides of the can to admit the low-tension wires. Flare the end of the can, turning the ends of the flares up. Wrap wire around the tips of these flares and draw it tight so as to hold the shield securely in place.

Conduction and Radiation

"Interference reaches the antenna through being induced in wires that come close to high-tension radiators. These wires may then conduct the interference to a point near the antenna. A striking example of this is the dome-light lead, which in many instances runs very close to the antenna or to the antenna lead. So common is this type of interference that it should be one of the first things checked when interference is encountered. The best method of checking it is to cut this lead at a point four or five inches from where it enters the front corner post. It should then be left disconnected until all other types of interference have been eliminated. Afterwards it may be reconnected. If it causes interference when reconnected, a Dome Light filter should be connected in series at the point where the lead was clipped. In some cases the ground lead of the dome light will be carrying interference up to the antenna . This may be eliminated by transferring the point where this lead is grounded to a point on the frame that is not carrying ignition currents. Various wires that run in the motor compartment or near the coil will pick up interference and carry it to some point near the antenna and re-radiate it to the antenna or lead-in. Connecting a 0.25 to 1 mf. condenser from the ammeter or from the individual wire to ground will usually eliminate this type of interference.

"In some cases of an under-car antenna, the tail light and spotlight leads are often a source of interference. By passing these with a 0.25 to 1-mf. condenser is often sufficient; but the Dome Light filter inserted in series with the wire is usually a positive cure.

Eddy Currents In Surrounding Metal

"As the body and frame of the car act as a return path to the battery for ignition currents, and as this metal is of a type which offers considerable R.F. resistance, it is subject to very strong eddy currents. The metal corner post up which the lead of the antenna runs, and the metal frame around the top of the car, are the most troublesome objects for eddy currents. The simplest and, in most cases, the complete remedy for this is to shield the antenna lead from a point four to six inches from the antenna proper and down to the shielded loom of the antenna lead to the set; so as to make a continuous shield from the set to the top of the corner post of the car. The shield should be grounded at this point near the antenna to the metal framework at the top of the car. Use a wire insulated as heavily as possible, so the shield is kept far away from the antenna lead. The capacity between the two sometimes causes eddy currents to be induced in the antenna lead shield itself, by its coming in contact with the dash, which frequently carries violent eddy currents that are induced in the wire.

"For this reason it is very good practice to check whether the interference is less or greater if this shield grounds to the dash. If grounding to the dash increases the noise, it will be necessary to insulate the shield with friction tape where it comes in contact with the dash. Grounding the antenna lead shield to a point on the bulkhead is often helpful in reducing eddy currents. The 1931 and 1932 Chevrolets are excellent examples, where it is often necessary to ground the shielded lead-in to the metal frame at top of the car and insulate it from the dash.

"Further steps may often be taken to reduce the flow of these eddy currents through parts of the car body that come near the antenna. The best remedy for this is to supply a shorter and lower-resistance path, through which ignition current may return to the storage battery. Leading the motor to the bulkhead and frame of the car with heavy flexible bonds will usually accomplish this. In cases of a floating-power type motor, and where the motor is mounted on rubber, this bonding is often absolutely necessary. In cars, such as the Chevrolet models, where the car battery is grounded to the transmission or motor, it is sometimes necessary to run a flexible bond to the channel frame of the car from the grounded side of the battery. Braided copper shielding, not less than ⅜" wide, is the best type of bonding for this purpose.

"The metal loom of various controls that lead from the dash into the motor compartment must sometimes be bonded to reduce eddy currents and radiation. The spark-control loom, throttle loom, etc., may be bonded to the bulkhead at points where they enter the driver's compartment. In soldering the loom of these controls, be careful not to solder the inter-control wire to the loom. The best way to prevent this is to have some one operating the control continuously while the loom is being soldered.

Accumulative Discharge

"This type of interference is one of the most peculiar encountered. It appears as a spasmodic discharge and is very familiar to atmospheric static in its irregularity.

"The cure is a .002 to .006 mica condenser, connected directly across the primary breaker points of the distributor. This condenser gives power factor control to the paper condenser, which is already across the distributor breaker points as part of the ignition system. This mica condenser tends to make the paper condenser much more effective in reducing interference. It cannot affect the ignition system in any way.

"Before concluding it might be well to point out that the success in the elimination of ignition interference is governed by common-sense procedure. First, carefully examine the car on which the radio is installed or is to be installed and try to decide which are the most likely causes of interference in that particular type of car. Don't overlook a possibility for noise. Then proceed in a step-by-step manner in the order of their importance. Always bear in mind that the interference may be coming from several different sources and that, unless all of these are eliminated at the same time, you will not have accomplished anything. Elimination of one of the sources of interference and leaving the others will as a rule have no apparent effect.

"The quickest method of eliminating possible source of interference is to equip yourself with a number of lengths of flexible test bonds which are equipped with storage battery clips at either end. Also equip yourself with a few good grade, non-inductive, 1-mf. bypass condensers. Equip the leads of these condensers with test clips. This equipment makes it possible to quickly clip on test bonds or condensers at points that are possible sources of interference. Then, as each possible source is eliminated by this method, be sure to leave the test bond or condenser in place until interference has been entirely eliminated. After the interference has been eliminated, the various test bonds and condensers may be removed one by one. When the removal of a bond or condenser causes the interference to reappear, a permanent one should be mounted in its place.

* * *

"As a handy list the following suggestions are given for the suppression of ignition interference. In this list we have endeavored to give these hints in the order of their importance:

(1) Apply suppressors to spark plugs and distributor.
(2) Apply generator condenser.
(3) Re-route primary wire from coil to distributors, keeping it as far as possible away from high-tension wire.
(4) Connect Dome Lite filter to dome light wire at point where it enters front corner post.
(5) Shield high-tension wire, if coil is mounted on instrument panel.
(6) Shield antenna lead-in wire from radio set to top of front corner post. Ground shield at both ends.
(7) Shield primary wire from coil to distributor.
(8) Connect a .002 to .006 high-grade mica condenser directly across the primary breaker points of the distributor.
(9) Bond the upper metal parts of the car body to one another and return a heavy copper bond from these points down to the bulkhead of the car. (This is usually necessary in cars using composite wood and metal body construction).
(10) Bond, where necessary, all control rods and pipes passing through the bulkhead.
(11) Shield head of coil when mounted on instrument panel.
(12) Cover floor-boards of car with copper screening.
(13) Adjust spark plug points to approximately .028 of an inch.
(14) Clean and adjust primary distributor breaker points.
(15) In cars having rubber motor mountings, connect heavy bond from grounded side of battery directly to frame of car.
(16) Connect a .50 to 1-mf. condenser from hot primary side of ignition coil to ground.
(17) If ignition coil is mounted on driver's side of bulkhead, move it to the motor compartment side, using the same holes for mounting.
(18) Clean ignition system wiring. Clean and brighten all connections. Replace any high-tension wiring having imperfect insulation.
(19) Ground metal sun visor and rain troughs, if necessary.
(20) Make sure hood of car is well-grounded. Clean hold-down hasps on both sides.
(21) Ground instrument panel and steering column to bulkhead.
(22) When under-car aerial is used, connect a .50-mf. condenser to tail and spotlight wires."

Procedure for Various Cars

While the previous information by the Galvin Mfg. Corp. takes in everything in noise-elimination work, some real practical information obtained by experience was used as the basis of an article on this subject, submitted in a contest held by Federated Purchaser, Inc., by Mr. R. L. Dougherty of Neptune, N. J. and published in the November issue of RADIO-CRAFT Magazine. With the exception of two of his suggestions, the writer believes that the information is as complete and practical as could be obtained from any long-experienced auto-radio trouble shooter.

Those two suggestions, to which exception are taken—

(1) Balancing a set when testing before installation; the writer presumes Mr. Dougherty refers to the trimmer condensers on the gang unit. This is not really necessary, unless the set is actually way out of alignment. Then—unless the equipment required for balancing (I. F. calibrated oscillator, and standard broadcast range oscillator) is on hand—it would be best to return the set to the jobber for proper realignment.

(2) Removing ignition coil from dash in cases where it is placed there by car manufacturer. Certainly, if I were a customer having an installation done, I would permit no such change. It must be remembered that a radio-technician is not a car mechanic and should never intrude into the domain of another man's work. What can be suggested in a case of this type is that, where the coil case is made of bakelite or other insulating material, a metal casing can be made to fit over it. This can should be grounded to the instrument board (or dash), which in turn is grounded to the car frame with

a heavy braid. The high-tension lead is then shielded with braid, allowing approximately one half-inch clearance from terminal openings on coil and distributor. Ground this shielding.

Another criticism, but of less significance, concerns building up the distributor rotor with solder. Solder, as we all know, will burn away quickly in this case. It would be best to "pean" the rotor with a small hammer until it is lengthened properly.

ELIMINATING AUTO-RADIO NOISES

WITH the lower pricing of automobile radio sets, and the fact that conditions are getting more prosperous throughout the country, the sale and installation of these units is taking a big jump. This is everywhere evident in the number of queries concerning this work, and the amount of noise elimination that the writer has been called upon to do. As this type of work is not new to me, but is to the majority of radio men, this article is addressed to those who "would like to know" but cannot find out.

The first time that the average radio Service Man or technician attempts to install an automobile radio set it is a case of "imagine my embarrassment" when, after the set has been nicely and firmly placed, the nice new suppressors installed, condensers wired into circuit, possibly an under-car aerial connected and the motor turned on, there is a faint sound of music subdued in the "foreground" of ignition static! If he is the average Service Man, he has doubtless been queried countless hundreds of times about removing static —and here he is, after swearing that it is not possible, with the prettiest bunch of localized static in the world to remove. Oh well, that's what he gets for being a "radio master mind."

Then there is also the fact that the newer sets are so greatly advertised as being "Installed in less than three-quarters of an hour—even by a novice." Blah, and more blah! It generally takes more than two to three hours of continuous and steady work before the job is fully completed. If you don't believe that, here is a positive shop record of a professional "auto-radio" man over a period of a week.

Seventeen cars: thirteen of which were current models, one was one year old, and two more were three years old but, a make which doesn't get old with the years." In these seventeen cars four different makes of radio sets were installed—Philco, RCA, Motorola and Atwater Kent. From actual shop time records, with every minute of actual work accounted for (no time off for smokes or going next door to get additional parts), the average time for the seventeen sets was three hours and fifty minutes! Furthermore, as a check, fully three-quarters of that time was marked down to noise elimination. Also, take into consideration the fact that as a specialist, all the necessary equipment, wrenches, shielding and all tools necessary to a neat, speedy and efficient installation were right at hand.

Routine Procedure

In all cases a set routine should be followed. First and foremost the set should be placed on a bench, hooked up and balanced. This is really important. Never under any consideration take a new set out of a carton and slap it into a car. Go over the set thoroughly. If it is a superheterodyne of the latest make with everything in one case, this simply means connecting a suitable storage battery, connecting the remote controls, and tuning the set. **Do not attempt to balance the set on an outside or regulation set aerial.** If the set is to be installed in a garage or place that is fairly well shielded, connect the antenna that you are going to use, and supplement it by laying on top of the antenna a length of insulated wire about thirty to fifty feet long to increase the pickup to normal. If the shop is to specialize in installation, it would be a good idea to use two plate antennas spaced about ½-in. apart, one being connected to a regulation aerial, and the other to the set proper. A ground is not necessary and in the shop is not used. Balance the set accurately by means of a calibrated oscillator after the fashion of a house radio set, and note the noise level of the particular set. It is the habit of a majority of the newer sets that are being built in one unit (with a vibrator-type "B" eliminator) to be very "buzzy" sometimes when first hooked up. If the set seems to be exceptionally noisy in this respect, change it. Otherwise, if there is just a slightly noticeable buzz it will wear off after breaking-in of the eliminator contact points.

With car sets using the "dynamotor" for furnishing the high "B" there should be no ripple at all and the sound of the motor itself should be just barely noticeable when you stand about two feet from the unit. If there is any ripple at all in the speaker when the set is tuned to the frequency of a local station—replace the unit.

Installing the Set

Select the location for the set, watching that you have plenty of room on all sides, and making sure that the remote cable from the steering column will reach to where you are going to place the set. After the actual installation of the set, control, eliminators or batteries, and before the antenna of the set is connected, put on the suppressors, distributor and generator cutout condensers, and with the battery connected, turn on the set to allow it to warm up. Coil the antenna lead from the set around on itself to neutralize outside pickup and turn on the motor. Nothing will be heard as far as a signal goes but plenty of noise will be heard.

Have a couple of spare condensers handy. One equipped with test prods will always find it a very handy tool. If the noise sounds excessive, this shows that there is a great amount of ignition noise getting into the circuit through internal pickup, battery lead, remote control lead, etc. This should be minimized before anything is done about connecting or locating the antenna. Shunt one of the "spare" condensers from the key side of the ignition coil to ground. Likewise try a connection from the gas indicator side; also, the battery side of the coil, if it is a three-contact coil. Do not try to connect a condenser from the mid-point of the coil to ground because, besides getting a nasty "shot in the arm," you will "kill the motor," since high-tension current goes through a small condenser like sand through a sieve, and a puncture is liable to happen to the low-pressure condensers used for the purpose. Bypassing one or more of the points mentioned should bring the noise down decidedly.

If the ignition coil is mounted under the dash-board, on the set side of the bulkhead, it is best not to waste time but to remove the coil and place it in the motor compartment, as near to the distributor as possible. It sometimes happens, when the switch is an integral part of the coil, that when the coil is removed it will be necessary to obtain a separate switch and put it on the dash; then, lock the original key in the coil and solder it into place in the locked position. Bring the leads from the new key to the coil by using ordinary, heavy-duty twisted lamp cord, first sheathing it in copper shielding.

Connect up the coil, close the hood and, using a coil of fifteen or twenty feet of insulated wire connected to the antenna lead and thrown on the ground outside the car, tune in a station and note the noise level with the motor running. Unless the car is a Buick or a similar car which has everything practically inside the motor block, it is to be expected that noise will be heard, but it should be decreased to some extent.

"Trimming the Rotor"

The next procedure is "trimming the rotor" of the distributor. Remove the cap on the distributor head and take out the rotor (that little gadget which goes 'round and 'round and actually distributes the "kick"). Lightly dress down the running-edge with a file to remove the corrosion from the firing side, and then carefully build it up with hard solder so that it makes an actual wiping contact with the spark plug point contacts. Some cars use a rotor which makes an actual wiping contact by means of a spring slider. In this case simply dress up the cap contacts and rotor with very fine emery cloth or, preferably sandpaper, until shiny.

In the case of fixing the rotor, it need not be stated to use extreme care, because if a slight amount too much solder or a sloppy job of soldering is done on the point there is a very great chance of the distributor cap being split the first time the motor is started up. A few tests will generally show how much to use in each individual case. It is better to make several tries each time, adding a little until it just makes a light contact, than it is to spend time and money buying your customer a new cap for his distributor.

The placing of the "A" battery lead can also cause a goodly amount of pickup. Try all three suitable places for the least amount of "back up" namely the positive "A" of the battery, the starter positive and the ammeter positive. When the best place is found, make that lead as short as it is possible. The writer has found cases where a healthy-size R.F. choke properly bypassed to ground helped immensely. For this purpose a simple choke is made up from annunciator wire wound on a suitable form. From ¼ to ½ pound of No. 14 is sufficient.

With all these tests made, install the antenna which is to be used, and again compart the reception with that when the outside wire was being used. If the noise level goes up it means that your aerial is either inefficient or insufficient. If you are using the antenna supplied with the car, in the roof of the tonneau, try supplementing it with an under-car aerial; also try using just an undercar aerial alone, not using the car aerial at all. With due respect to the manufacturers of the cars, they sometimes make very good noise pickups out of what was meant to be an efficient radio aerial.

Next bond all the pipes, wires and control rods coming through the bulkhead, on both sides, grounding both securely and soldering all connections. Ground the electrolock cable as well as the speedometer cable at several places along their lengths—first making sure that the metal you are grounding it to really is a ground and not "above," or just hanging onto a wood frame-piece.

If after all these precautions have been made a great deal of the noise is not removed, obtain a piece of copper screen and place it under the floor mat, directly beneath the location of the set, and ground this securely to the bulkhead. If an overhead antenna is being used, make sure that the springs in the seats and back of the seats are all well bonded together and grounded to the chassis of the car; as well, ground all the metal accessories which may be placed on the car. The robe-rail of one particular open car caused two men to spend over three-quarters of an anxious hour on a car only to find out that this member was screwed into a wooden back-post and was not grounded. When this rail was grounded securely to the chassis, a drop in the ignition noise level which was really unbelievable was noted.

The writer has a penchant for under-car aerials. Whereas the overhead antenna may be more efficient in some instances—I like to know that my results will be the same all the time, so for that reason always use the same style antenna, supplementing it from time to time with the car aerial furnished when it proves to be as good as the under-car aerial. The aerial used is simply a piece of copper screening a foot and a half wide and from six to seven feet long, set in a flat bag made of top material (waterproof of course) and with a tape at each of the four corners. Fastened between the front and rear axle of a car they are neat, clean, efficient and cost but 45 to 50 cents to make up.

The following are some of the methods regularly used to eliminate noise in some of the most popular makes of cars on the market. To list all of the cars would be too great a task, but the few popular ones noted cover about all the methods used.

BUICK.—Battery lead installed in shield, antenna wire shielded, suppressors and condensers connected. A small piece of screening sometimes used on floor of car under set, securely grounded to frame. This will generally eliminate all of the noise in these cars as they are the easiest to work on, everything electrical about the car being shielded and the spark plugs being encased in the block.

CHEVROLET.—Coil moved up and fastened to motor block in close relation to distributor. Leads from switch to coil being run in a twisted pair, shielded in copper shielding. This lead should be run in such fashion that it passes low on the motor block alongside of the distributor. Build up the rotor of the distributor. Bond all wires, pipes and control rods coming through the bulkhead on both sides and ground well. Install set on right side of car. Use all suppressors and condensers, and if a slight noise is still heard use a condenser on the switch or battery side of the coil. On some of the earlier models of this car, notably the 1930 and 1931, it was necessary to install a fairly heavy R.F. choke in the "A" lead, bypassed to ground.

PONTIAC.—Place coil in motor compartment near distributor and follow precautions as outlined above for the "Chevvy." In addition it is sometimes necessary to bond and ground all the cushion springs and robe racks. An under-car antenna is generally more efficient on the smaller closed models and roadster jobs of this make.

DODGE.—Use highly efficient under-car antenna and extremely short leads from coil to distributors. Shield all ignition leads from switch and use condensers on switch side of coil to ground. For some undecipherable reason it is sometimes necessary to run the wires from the distributors to the plugs in shielded wire. When this is being done make sure however that there is sufficient space left between the suppressors and shield to avoid a jump-over to ground. Regulation Packard "Lackard" shielded ignition wire split for about an inch or so and that part of the shield removed, is generally O. K. Ground all shielding well but take care that in doing it no chance of grounding due to rain is possible.

CHRYSLER.—Coil moved up next to distributor and all wires on both sides of bulkhead shielded and bonded. Coil bypassed and a goodly portion of shielding used under floor mat in region of set. Under-car aerial preferred.

PACKARD.—Best results are met with the use of an under-car aerial in addition to overhead aerial when car is furnished with same. Thoroughly bypass all coil leads and shield ignition wires from coil to distributor. Some of these jobs have had to have the coils moved up to the front of the motor block. There are a great many custom-built body jobs in this class and great care will have to be taken in bonding the cushion and back springs. Bypass all dome-light leads at the light, and ground thoroughly not only the protective cable on spotlight but also the standard used to hold the spare tire in the fender "well" on the sport jobs.

AUBURN.—One of the toughest cars to work on is this job. This is especially true of the models which encase the leads coming from the distributor in an aluminum-topped hood. It is necessary to spare no pains or copper shielded wire on this car, as every available lead must be thoroughly shielded, every control rod bonded and grounded, and the coil placed in close relation to the distributor. Also ground all metal floor panels that are not already grounded. Run the "A" battery lead-in shield from the ammeter lead or starter positive. Make sure that every piece of metal in the chassis, even down to the window raising mechanism is grounded, as well as grounding thoroughly the frame holding the spare tires. If the car uses a tonneau windshield (as so many of this make do in the open cars) ground this and the metal back of the front seat thoroughly, not being content with merely grounding the metal back and relying on the screws holding the windshield to bond it to the back. To the Service Men who can lick an Auburn completely on the first "crack" belongs the title "The complete 'Auto-trician'." It has been done, but generally if an Auburn comes into the shop the owner is given to understand that "some little noise may be present at times." This is to forestall calls when the owner finds other, less expensive cars with little or no noise at all. It can be reduced to a minimum by careful work and attention to details as shown in the first part of the article.

FORD.—This is another easy car to work on, especially some of the older model A's, as all that is necessary in these cars are the suppressors, and condensers, and shielding of the coil leads. In the later models of 4's and V8's; it is a little harder as the distributors will have to be dressed down and the coil sometimes moved up. Bonding and grounding of all wires and control rods is of course part of the job. In the two-door sedans it is best to supplement the overhead antenna with an under-car aerial, and also bond and ground the springs of the back seat.

PLYMOUTH.—Coil should be moved up to the distributor or placed as far front as possible. Shield and bond wires on both sides of bulkhead. Not much trouble. However, on account of the "floating power" feature of these cars some trouble is experienced due to incomplete electrical bonding of the block to the chassis. A copper bond strap made from shielding, fastened under one of the bolts and thence to frame will lick it easily.

Now a word at this time about the care necessary when working on and around ignition systems. A "short" plays havoc with a car battery and if when changing coils around and rewiring ignition systems for new switches there is any chance of a short, take the time first to disconnect the positive lead from the battery and then go on with the work.

Remember also, that a grease spot on the upholstery leaves a bad impression on the customer, besides showing you up as a careless worker. If you want repeat business the surest way of getting it is to do good, clean work and let your own customers send around their friends. Fully 75 per cent of the work done last fall was on recommendation in the shop, simply because the men were clean and courteous. Where a man sees a fellow in a nice clean suit of white coveralls and with clean hands working on his car, and the upholstery covered over with nice grease-proof covers, the wheel covered with a cloth, and a shield over the painted parts—it leaves an indelible impression.

If you are going to specialize more or less in this installation work—and it is one of the few branches of radio now really active—get a complete set of wrenches suitable for the removal of the bolts and nuts on the motor and chassis. Also make sure that each job is really finished to the best of your ability before it is turned over as completed. It is far better to advise a customer that "It was impossible to complete the entire job today to my satisfaction—I will finish it at your own convenience tomorrow," than it is to let a customer go out with the idea that you have not done the job right and be forced to come back.

Be **positive**—and the bold type should be hearkened to—that when you work on a car nothing is left undone when the job is turned over. All bolts and screws should be as tight as they were when you got the car, and ever wire should be properly installed so that the shielding cannot possibly short out anything and cause any trouble.

For emphasis, let me state a case in point. An owner of a car (a Packard to be exact) had one of his neighborhood radio men install a radio set in his car. The job was turned back presumably finished. But—the next day the same radio man was visited by an irate car owner and **his attorney!** In doing his work the man had loosened up a bolt on the steering column to enable him to bolt the set into the corner "out of the way." This bolt was not put back securely and that evening when driving the bolt had dropped out, the steering column came loose, and an accident had ensued. The man was held liable because it was afterwards proved that it was his negligence which had caused the trouble and he had to "soak up" $700 for the damage. So-o-o-o (to emulate that fire-whistle of the air, Ed Wynn)—when you take it off, put it back so tight that the next fellow will have trouble taking it off again.

Some cars have double ignition systems, and these contrary to the first notion will not be as hard to work on as a first glance would seem to indicate. However, a word about these: don't "fool" with the spacing of the points of these systems, as a fraction of an inch in their placement means trouble with the car. Building up the rotor is O.K., but do not try to dress the points down or bother with their adjustment unless you are an ignition specialist and have worked on double ignition before.

As a final word, the actual mounting of the set in the car is simple; but, before you promise the complete installation in "one hour", prepare to have a half-dozen experts ready to work on the car so that it can be done. Ask a fair rate per hour for outside work and keep in touch with the neighboring automobile agencies. Do their work for them and see how many of the friends of the owners of new cars will come around and "get one put in."

In the matter of just what charges should be made, a great deal will of course depend upon your location. For the average installation of a new set a charge of $10 is made to the customer. Where the work comes from one of the automobile agencies who most naturally have to be "counted in" on the labor, there is a tacit understanding that they are to bill the customer for this amount and their commission of $2.50 is deducted from this figure.

On all outside work where it is simply "noise elimination," a flat rate of $1.00 per hour is fair. This should be adhered to in all cases and no cut rates given. It will be found that a great deal of this work can be obtained. Especially, from car owners who have had their sets installed in an unsatisfactory manner and have never received satisfaction from the original installation man — either because of lack of knowledge on his part as to the correct procedure, or because of no desire to satisfy the customer."

Improved Methods For Noise Cure

At the beginning of this chapter, the statement was made that the present method of suppressing noise was "open to discussion"—that is, as to its efficiency. In this matter much can be learned and copied from airplane radio practise—where engine performance is of prime consideration and a foremost requisite that concerns the lives of the pilot and, in many instances, the passengers. There can be no question as to whether resistances (suppressor) in the high-tension lead from the distributor and at each spark plug affect the motor efficiency. The loss in efficiency is, easily, fifteen per cent. And, while with a car motor, performance does not necessarily mean the safety or lives of its passengers, it is nevertheless surprising to note that, in this age where efficiency counts so much, such waste of motor power should be condoned.

Aircraft installation practise calls for shielding of the spark-plugs,—all wires, high- and low-tension, are covered with shielded braid loom. Not even so much as half an inch of either wire is left exposed, since the leads to the plugs enter into the plug shield before the braid is peeled and contact with the plug made. No suppressors are ever used and, needless to say, the reception must be, and is, perfect.

Fig. 13 illustrates a shield which can be easily made from a small coil shield and adapted to this purpose.

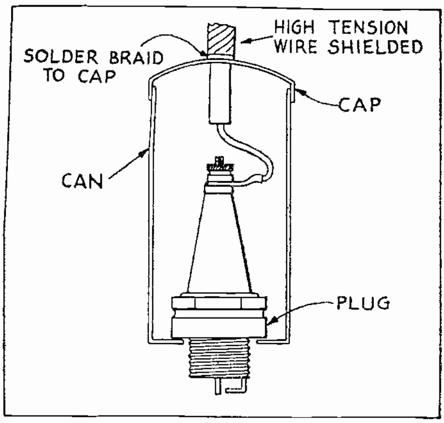


FIG. 13

An improved method for suppressing high tension noises at the spark plug source. A coil can be used for the shield. No suppressors are necessary if the wires are shielded and this method is employed.

More complete information regarding this method of ignition noise suppression will be found in an article written by the writer in the April, 1934, issue of Radio Craft magazine, title "New Method for Auto Noise Elimination."

CHAPTER V.

POWER SUPPLY UNITS, SERVICE HINTS AND CONCLUSION

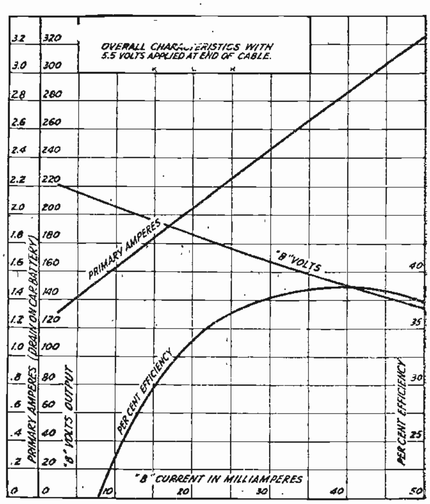
AS in analyzing ordinary radio receivers, an analyzer I.F., R.F. (200-550 meters) oscillators, continuity meter or ohmmeter, capacity meter and tools (such as soldering iron, wrenches, pliers, etc.) are stock and equipment of each auto-radio technician. To attempt to service correctly a radio of any type without proper instruments will, in many cases, lead to an unfortunate failure. A great many auto-sets will be in use within the next year or two and, consequently, service work from this direction can be expected. The outlay for adequate tools and instruments will eventually be repaid to the investor many times over.

THE POWER SUPPLY

Many automotive receivers were designed so that their "B" potential is secured from batteries. In this connection, it may be stated that the old question, "how long will my batteries last," is now more difficult to answer than ever before. A set of batteries may last, say for example, six months when used with a certain receiver in the home a certain number of hours per day. This same set of batteries may last two weeks when used the same number of hours with the same set in an automobile. Why? The answer is relatively simple.

If the batteries are placed in such a location that water from rain, splashing, etc., falls upon it, the battery becomes water soaked and its life decreases rapidly. This obviously, is an objection to the use of batteries for supplying the "B" potential for the radio set in a car. The usual inconvenience of replacing batteries just at the time when it is desired to use the set most is another reason for its discontinuance. However, in view of its relatively quiet operation, lack of moving parts, etc., it is preferred by many owners of auto radio receivers. The present trend, however, seems to be toward an electrical device capable of supplying sufficient power to operate the ordinary broadcast receiver.

This device, whatever it may happen to be, depends for its operation upon the automobile battery in the car. Usually, the car battery is already taxed to its maximum capacity by the lighting system of the car and any other contrivances such as cigar lighters, spotlights, etc. Before an electrically operated power unit can be installed, one must be absolutely sure that the additional drain



Overall characteristics of the Magmotor with 5.5 volts applied.

on the battery will not cause its voltage to decrease to the point where it will not start the car or operate the lights when the motor is not running.

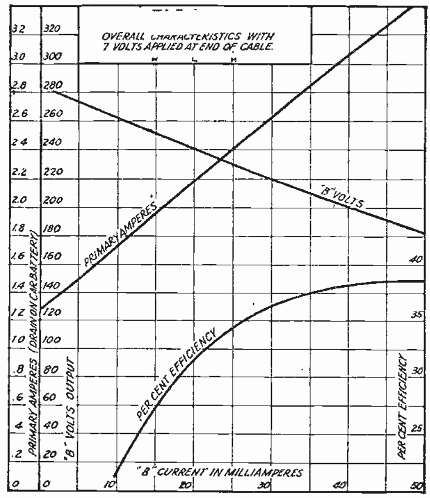
There are several power units available which are suitable for use in automotive radio receivers. These may be substituted for the "B" batteries already in use.

A general description of these devices is not possible since every manufacturer has his own idea as to just what they should contain. The only general statement possible is that they are all of the rotating type and in order to clarify the design factors in the minds of the readers, we will present a description of some of the more important replacement units that are available on the market.

United American Bosch Magmotor

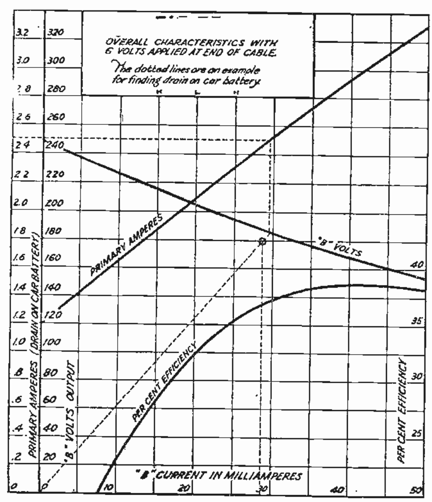
"Magmotor" is a trade name for a dynamotor to be used for supplying "B" power to motor-car radio receivers, eliminating "B" batteries. This unit is operated from the car battery and does not place an excessive drain on the battery. The general scheme of this device comprises a low-voltage winding with commutator and brushes for rotating an armature in the field of a permanent "U" magnet when connected to the six-volt storage battery; a high-voltage winding in the same slots with the low-voltage winding; a commutator and brushes for collecting the "B" current generated in this latter winding; a filter condenser on the low-voltage side for controlling the radiation of "noise energy"; a filter of resistors and condensers on the high-voltage side for controlling "noise energy" and for minimizing ripple; a suitable base-plate with mounting brackets and a cover or housing of the "umbrella" type. The generating unit is supported between rubber cushions when the cover is in place.

The armature runs in ball bearings held in end plates which close the die-cast frame. The frame carries the pole shoes and the brush holders. Screwed to the pole shoes (the iron on which the field is wound) is the permanent magnet which lies horizontally, rather than vertically, thus conserving space. The filter unit is disposed in the housing at one end of the generating unit.



Characteristics of the Magmotor with 6 volts applied.

Installation may be made in any convenient location on the car near the radio set, provided it is not subjected to splashing mud and water. Either the motor side, or the driver's side of the body bulkhead may afford



Characteristics of the Magmotor with 7 volts applied.

space for mounting. Disposition may also be made under the front seat in some cases. The location is limited only by the length of the Magmotor cable. This may not be increased on account of the resistance of the leads. The Magmotor must always be installed so that its mounting plates forms a bottom for the cover box; otherwise it may shake out of its rubber cushions and short its brushes. This shorting may cause serious damage.

Four bolts are attached to the mounting brackets for use in fastening the Magmotor to vertical surfaces. If it is installed under the front seat, it need not be fastened, but it is well to lay it on a felt pad or piece of carpet to isolate it from the floor boards.

The application of this device is governed largely by the total filament drain of the receiver, speaker field, and Magmotor upon the car battery and the "B" drain of the receiver upon the Magmotor.

The charts shown may be used to determine the approximate drain of the Magmotor upon the car battery. To do this proceed as follows

(a) The "B" voltage and "B" current in milliamperes of the receiver to be used with the Magmotor must be known.

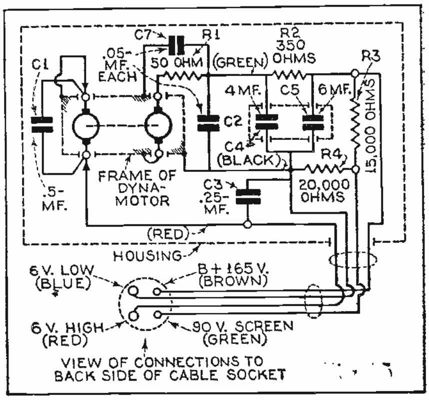
(b) Locate the intersection of two lines, viz., the horizontal line through the rated "B" voltage found on the left margin and the vertical line through the rated "B" current on the bottom margin.

(c) Project a line through the intersection just found and the lower left corner of the chart.

(d) From a point where this line intersects the graph marked "B" voltage, follow a horizontal line to the left margin and read the amperes drain on the car battery.

When the Magmotor is used, care must be taken to install a ¼ mf. (or larger) non-inductive foil condenser between "B+" and "—B" in the receiver, providing it is not already there. The same precaution may be necessary between the screen-grid supply line and "—B."

The Magmotor is designed for use with receivers having the "—B" grounded. With receivers having other circuit arrangements, additional filtering, consisting of a series coil and shunt condenser to ground from the "—B" lead, may be needed. The

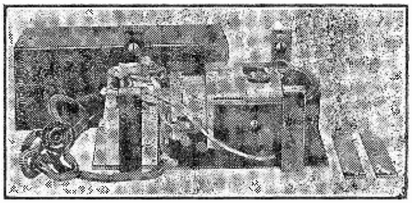


Complete schematic circuit of the Magmotor.

Magmotor cannot be used with receivers having "Push-Push" (class B) power amplification.

Where the total drain of the receiver, speaker and Magmotor, does not exceed the surplus discharge rate of the battery, application can be safely made. Of course, if other electrical apparatus already installed upon the car demands this surplus charging rate, then choice should be made between the electrical apparatus desired and the risk of unsatisfactory operation due to excessive battery drain.

The Magmotor BD-6-180-Ed.1 differs from all competing apparatus of the rotating type in that its field is supplied by a permanent "U" magnet. No current for field excitation is necessary. This effects economy in



Photograph of the Magmotor.

the drain on the car battery and assists in raising the efficiency of the

Magmotor above that of competitive devices of similar output.

The Magmotor is simple. It consists of three major assemblies:

(a) The generating unit, small, light, compact, dust- and moisture-proof, with no rotating parts exposed, which is easily removable from the base-plate by unclipping three wires.

(b) The base-plate with mounting brackets, filter unit, and connecting cable.

(c) The "umbrella" type cover box which fits down over the base-plate completely protecting the generating unit and filter from mechanical injury and from dust and dripping water.

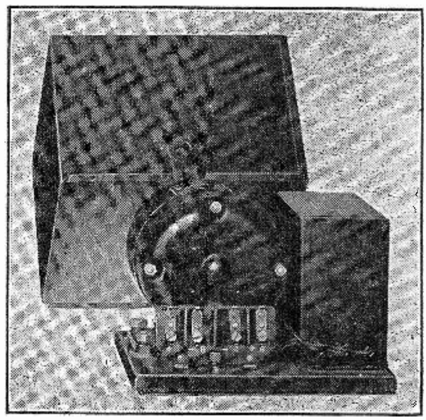
The wiring diagram of this device is shown along with photograph on the preceding page.

The Emerson "B" Power Unit

The unit to be described is a very compact one (the overall dimensions being 7¾ x 6 x 8⅞ inches) consisting of a dynamotor and filter mounted on a steel base-plate. The entire unit is protected by a removable metal cover. The unit requires the same space as a set of three "B" batteries; in fact, it is designed to fit into the standard "B" battery box. It is designed to operate from the standard battery used in the car, and consumes but 2 amperes; its output is 180 volts at 40 ma.

It is equipped with a suitable filter so as to both smooth the output and prevent the pickup of stray noises originating in the car. The completed unit is mounted in the "B" battery box and fastened securely with bolts; or if there is no battery box, it may be mounted in any convenient place under the floor boards or in the body of the car. **Do not mount under the hood.** The unit is assembled for mounting with its base-plate down. If it is mounted in a suspended or side wall position, the two screws in the clamping strap on the dynamotor should be loosened and the dynamotor turned until the oil holes are at the top. The two screws should then be fastened.

Use shielded rubber-covered wire for connections; No. 14 or 16 being suitable for ground and battery leads and No. 18 or 20, or the regular "B" leads from the radio, for the "B" connection. The shielding on all leads should end a few inches from the case of the unit and should be grounded to the chassis at this point



Photograph of the Emerson unit.

with copper braid or ribbon. The lead should be left long enough to permit the removal of the unit from the case without cutting the lead. All leads should be brought through the rubber bushing in the case and connected to the terminal plate as marked.

It is necessary to determine which side of the storage battery is grounded so that the corresponding leads from the terminal plate to the radio-control switch may be connected. It is absolutely essential that a good connection be made between the "ground" connection on the unit and the chassis of the car.

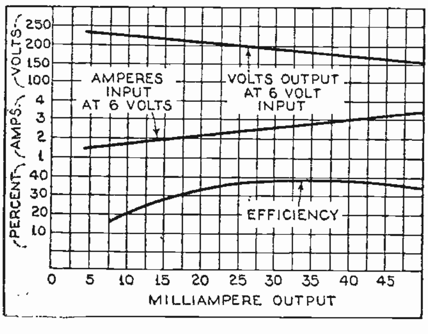
In certain automotive receivers only 135 volts of "B" potential is required. In such cases it is necessary to place a resistor in series with the "B" of the power unit. The size resistor may easily be computed if the "B" current drain of the receiver is known. This may easily be determined by connecting the receiver to a set of "B" batteries and measuring the current consumed. The size resistor may then be computed from the formula

$$R = \frac{180 - \text{(rated voltage of set)}}{\text{"B" current drain}}$$

Pines "B" Battery Eliminator

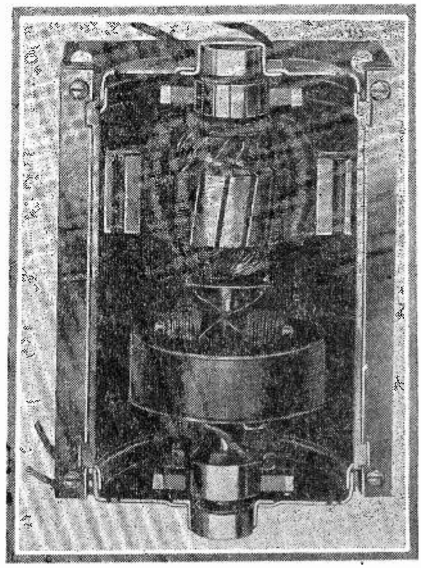
The Pines "B" battery eliminator for automobile radio is designed to insure constant high voltage for the operation of a radio set in an automobile, bus, airplane or home.

It consists of a motor in combination with a rotary transformer. It receives its operating current from the regular "A" battery, which, through the medium of a rotary transformer, is stepped up to the required high A.C. voltage, rectified, and filtered through a filter pack which is self-contained in the eliminator, and delivers a smooth D.C. voltage to the radio set.



Characteristics of the Pines power unit.

This eliminator is made in two types; one (No. 6331) whose output voltage is 135 at 30 ma., and the second (No. 6332) whose output is 180 volts at 30 ma. Above chart shows the relation between voltage output, current consumed by the storage battery, and efficiency compared with the current drain of the receiver. As may readily be seen, the voltage output drops uniformly from 230 volts with a current drain of 5 ma. to 155 volts with a current drain of 50 ma. It is seen that the output voltage is about 180 volts with a current drain of 30 ma. With this latter value of current 2.5 amperes are drawn from the car battery and the efficiency is 38%. See following pages for wiring diagram of the unit and filter system, and external view of the device.



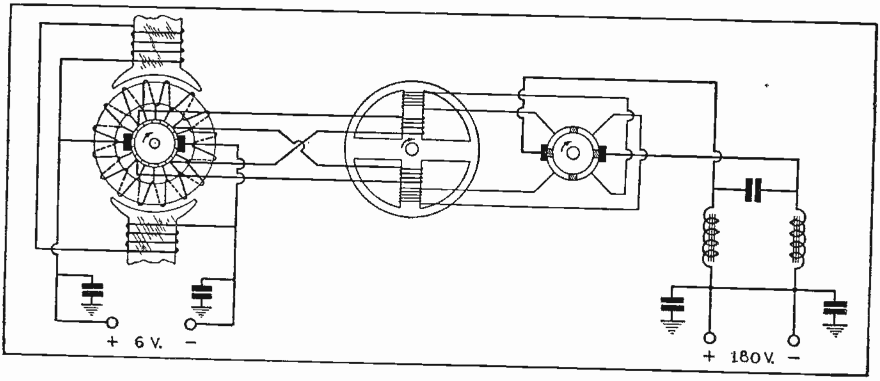
Detail view of the Pines power unit (internal).

The Dynatrope

The "Dynatrope" is a rotary converter, which permits the playing of standard A.C. household midget radios in automobiles, boats, or wherever a 6-volt source of supply is available.

In designing any converter suitable for automotive radio use, three factors must be considered. First, to change the direction of D.C. input voltage without ever breaking the circuit. Second, to maintain constant speed even though the input voltage changes considerably. Third, to keep the output voltage, under varying loads, as constant as possible.

To cope with the first problem it was necessary to use an especially designed chopper for breaking up the input D.C., in conjunction with the center tap primary winding on a



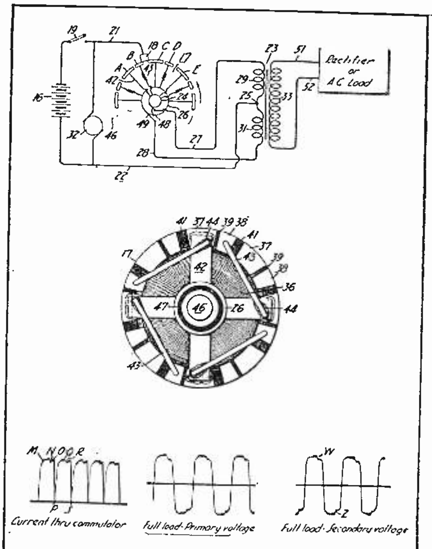
Detail schematic circuit of the Pines "B" power unit.

transformer. This chopper is composed of sixteen alternate sized bars, the wide or main bars being connected direct to collector rings on each side

Photograph of the Pines unit, closed, ready for operation.

of the chopper, four alternate main bars to each side. The eight remaining narrow bars connect through resistors to the main bars, the amount of resistance depending solely on the amount of current to be carried.

For instance, the "Dynatrope" under 110 volts, A.C. 60-watt output load, with 5.8-volts D.C. input, has a voltage drop between the main feed bar and the resistance coupled bar of 1.0-volt. Under these conditions it can be seen that as the feed brush passes from the main bar to the resistance coupled bar, the current change in the transformer windings is proportional to the value of the resistances used. Now as the chopper moves under brush, a main bar connected to the opposite end of the primary winding is coming in to take the maximum current load from the feed brush. This occurs before the previous resistance coupled bar leaves.



Sketches illustrating the unique method of operation of the Dynatrope.

Consequently, the predominating current now flows through this half of the primary in the opposite direction, reversing the direction of the current flow in the half that is still connected, through a resistance, to the feed brush. It is at this time that the resistance coupled bar leaves the brush. In this way the circuit is never completely broken, and arcing is eliminated. In the preceding page a diagram of connections of a unit, an end view of the commutator and the wave form of the various currents and voltages throughout the system are shown.

The drive which was adapted for this chopper is a 2200 R.P.M. shunt wound motor geared for 900 R.P.M. and has a current consumption of 1 ampere at 6 volts. Due to the fact that this motor is practically running under no load, the chopper speed will not vary 10% with a voltage change from 5½ to 6½ volts. Fig. O shows the location of the "Dynatrope" in a typical motor car installation.

As may be seen by reference to the photograph, the best location for this unit is under the motor hood bolted to the cowl; in some cars it may be necessary to place it elsewhere, but in any case the shortest distance between battery, switch and converter will give best results.

This converter will handle any A.C. standard 110-120 volt radio that consumes from 40 to 80 watts. Care should be taken that No. 16 (or greater) wire must be used from the "Dynatrope" to the radio receiver.

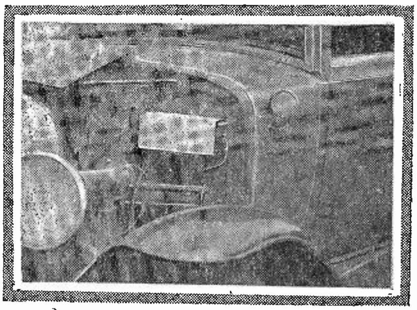


FIG. O

Note the rather unusual location of this unit.

The Esco Dyna—B

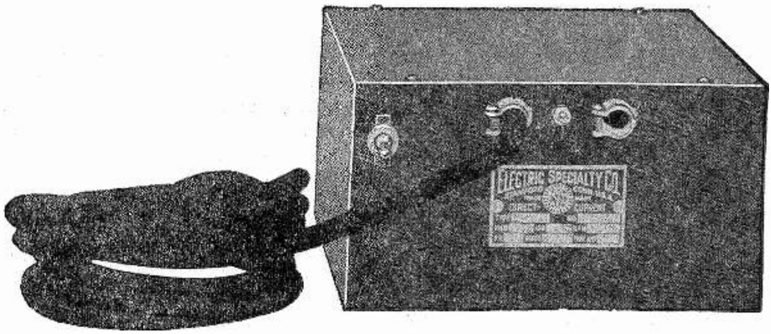
The Electric Specialty Co. has produced a small neat unit that is certainly worthy of consideration. It is a complete power unit consisting of a dynamotor, filter and voltage divider all constructed and enclosed in a compact metal case. This case measures 7⅞ inches x 7⅛ inches x 4½ inches—the size of the average single heavy-duty 45-volt "B" battery. The unit may be mounted either in a flat position such as under a seat, or in an upright position as behind a seat or in a parcel compartment.

The laminated frame and armature core are made of annealed steel punchings. The bearings may either be wool packed or of the ball bearing type, as desired. The unit comes equipped and ready to install. Eight feet of double, shielded and insulated wire is supplied for connection to the car battery. The unit is also equipped with a switch that enables the starting and stopping of the dynamotor at will. This switch may, of course, be installed on the dash board, or if so desired, controlled by the radio switch.

These units may supply either 135, 180 or 200 volts. The current output is rated at 40 ma. and easily meets the requirements of the average radio receiver. These units are available in six different sizes, depending upon the requirements.

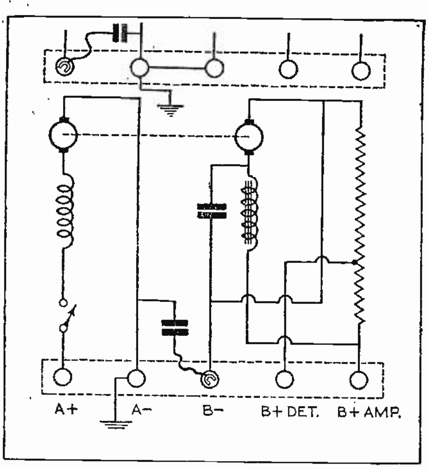
Primary Voltage	Secondary Voltage	Type
6.3	135	D1
12.5	135	D2
32	135	D3
6.3	180	D4
12.3	180	D5
32	180	D6

For auto-radio work, the input to the device is 6 volts. This feeds into the dynamotor which rotates between the field poles which is excited by the car battery. The secondary or high-voltage winding also rotates on the same shaft as the armature. The diagram of connections



Here is a photograph of the Esco power unit that takes but a minimum of space.

of this unit is shown in diagram below. This unit is shipped with filter connected as shown by the lower figure. It is the best connection for use with Bosch, Atwater-Kent, Philco and Sparton receivers. For some sets such as the Majestic better results may be secured by removing the red lead connected to "—B" and placing a wire between "—A" and "—B". This latter connection is shown below. A photograph is shown above.



Schematic circuit of the Esco power unit.

U. S. Electric Works

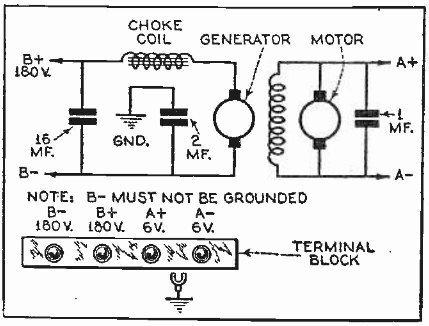
The type T Genemotor is suitable for use in automobiles for supplying "B" voltage to radio receivers. It is used with Philco-Transitone and all similar type sets where "C" bias is taken from the "—B" to the ground. It is rated at 180 volts at 35 ma. drain with 6 volts input. When installing the Genemotor, it is absolutely necessary to have not less than 6 volts at the Genemotor terminal block.

The common ground connection is to the "A" when the positive terminal of the battery is grounded, and to the negative terminal when the negative side of the battery is grounded. The correct polarity may be determined from the chart given elsewhere in this book. If the "A" battery terminals are reversed, this automatically reverses the polarity of the "B" supply. A chemical paste-type condenser (electrolytic) is used across the "B" supply, and when the polarity is reversed, this condenser becomes short-circuited; when allowed to operate in this manner for a little while, the condenser becomes defective.

This unit may be mounted almost anywhere, but it is advisable to mount it as close to the control switch as possible. Do not mount it on the side or end—be sure that the motor is horizontal, that is. with the base up or down. The "hot" "A" line to the motor must come through the radio control switch so the switch controls both the Genemotor and the radio set.

It is recommended that the leads to the motor from the "A" battery be no less than No. 12 B&S wire. All wires to the unit must be shielded and well bonded (connected); the shielding should be grounded to the chassis of the car in as many places as possible—every 6 inches if convenient. A diagram of the Genemotor is given below.

As may be seen by reference to the figure, the unit consists of a separate motor and generator unit. A 1 mf. condenser across the 6-volt line bypasses any interference that might exist there. At the output of the generator, a suitable filter is provided which will minimize any ripple due to the commutator segments. A sketch of the terminal



Circuit arrangement of the Genemotor.

block is also shown in the same illustration.

Performance characteristics of the Genemotor is given below.

INPUT

volts	amps.	watts	volts
6	1.5	9.0	200
6	1.7	10.2	195
6	1.85	11.1	190
6	2.05	12.3	185
6	2.2	13.2	178

OUTPUT		EFF.	REG.
amps.	watts		
.020	4.0	44.4	.98
.025	4.875	47.99	.91
.0030	5.7	51.35	.89
.035	6.475	52.64	.86
.040	7.12	53.86	.83

Janette "Auto-B-Power"

The Janette "Auto-B-Power" consists of a rotary converter mounted, together with a suitable filter, in a splash-proof steel box. They are obtainable in four types, all operating from the battery supply of the car. The first type delivers 135 volts; the second, 180 volts; the third, 135 volts (from a 12-volt battery); and the fourth, 180 volts (from a 12-volt battery). With receivers drawing 25, 40 and 50 ma., the battery drains of these units are respectively 2.3, 2.8 and 3.0 A.; 2.5, 3.0, and 3.5 A.; 1.15, 1.4, and 1.5 A.; 1.25, 1.5, and 1.75 A.

If so desired, a bleeder resistor may be obtained which, when connected across the output of the device, permits several lower voltages to be secured. The taps on this bleeder resistor are variable, so that the voltage may be adjusted for any set of conditions.

GENERAL CONSIDERATIONS

The descriptions of the various eliminators given above brings out some very pertinent facts. First, the physical location of the eliminator is subject to that stated by the manufacturer, although considerable leeway is allowed in some cases. Second, it is essential that the device be mounted horizontally, else end-play (axial movement of the rotating member) will result. Third, the grounded side of the car battery must be determined. Fourth, all leads to the eliminator must be shielded, and the shield thoroughly grounded. Fifth, all leads must be as short as possible.

In every case, a filter is included as part of the unit. This filter is perhaps the most important accessory of the device, insufficient filtering of the eliminator is sure to result in noisy reception, so that care must be taken to see that it is connected properly, if once removed.

After some time has elapsed, it is well to sandpaper the commutators and reseat the brushes or else sparking will take place; and sparking is one thing that will ruin a commutator. The noise that results when brushes are poorly seated cannot be eliminated by the filter, for it was not designed for that purpose. A

Service Man may spend hours looking for noise when it is right where he least expects it. The moral is to examine the most likely places first, and then proceed to the more difficult.

Incidentally, advising the owner of a car radio and eliminator that it (the eliminator) needs looking over every three months might bring in **additional business that might not be obtainable otherwise.**

Service Hints

A summary of troubles and where to locate the offending item along with its remedy, is given below.

If the Receiver Fails to Operate:

"A" Fuse—Check the "A" line fuse in the chassis box.

"A" Line Open—See if power is being supplied to the speaker, tube heaters, and "B" eliminator.

"B" Eliminator Not Working—See if the "B" eliminator is in proper working order, by checking the high-voltage points at the tube plate terminals.

Antenna and Lead—See if antenna is properly connected to lead-in wire and antenna lead from set. Be sure the antenna system is not grounded at any point.

Defective Tubes—Try out a new set of tested tubes, and make sure they are correctly inserted.

Grid Caps Not Connected—See if all grid caps are properly connected to the tops of top-grid-connection tubes.

Variable Condenser Plates Shorted—Check condenser sections in chassis carefully for foreign particles, or rotor-stator rubbing.

Weak Reception

Defective Tubes—Try out a new set of tested tubes, and note any difference in performance.

Poor Antenna—To try out the effectiveness of the antenna used, check the volume with regular antenna against the volume and when using a straight length of wire about fifteen feet long, run the wire out of the car through one of the windows. If, upon test, the external wire is found to be much superior as far as volume is concerned, the antenna is not satisfactory and will have to be revamped or a new one installed. The antenna or lead-in may be too near grounded metal portions of the car frame or body, resulting in a high capacity to ground. There may be grounded metal mesh in the car roof. There may be a poor soldered connection between the antenna and lead-in, or antenna lead from the set. The antenna system may be partially grounded at some point.

Antenna Trimmer Not Adjusted—After the wiring has all been completed, and before the chassis is permanently installed, try out the set and adjust the antenna trimmer. To do this, tune in a weak signal between 1200 and 1400 K.C., with the volume control about three-fourths on. On one end of the chassis box are two small metal plates. Directly under the hole in the chassis box is the antenna trimmer condenser screw. Turn this adjusting screw up or down until maximum output is obtained.

Car In Shielded Location—If the car is within or near a steel structure, the signals may be weakened by absorption.

Storage Battery Run Down—Check the condition of the battery.

Defective "B" Eliminator—Check "B" voltage at sockets.

Misalignment of Variable Tuning Condensers—Do not attempt realignment unless other causes of low volume have first been investigated.

Other Causes of Low Volume—Defective speaker; poor battery, antenna, grid-cap or other connections; defective A.V.C. system in the receiver; and various opens, grounds and shorts in the receiver assembly.

Distorted Reproduction

Receiver Oscillating—See section on oscillation, below.

Defective Tubes—Try out a new set of tubes.

Incorrect Voltages—Check the voltages at the sockets.

Incorrect Tuning—The signal must be carefully tuned in to the clearest and loudest point. It must not be tuned "off resonance".

Defective Speaker—Try out a new one, if it is available.

Defective Audio System in the Receiver — Make continuity resistance tests.

Signal Transmission—Quality fading in the signal transmission can cause poor tone quality.

Oscillation

Cover of Box—May not be on or, if on, may not be sufficiently tightened down.

Off-Characteristic Tubes — Tubes whose characteristics vary considerably from the standard may cause oscillation. Try out some new ones.

Open Bypass Condensers—Check the bypass condensers and leads to them for open circuit.

Poor Ground Connections—Check the ground connections in the chassis for poor contact.

Grid Caps and Leads—The grid caps may not be making good contact to the tops of the tubes, or the wires of the grid caps may be too close together.

Frequently-Discharged Battery

If the storage battery runs down frequently, with the additional drain of the radio receiver imposed on it, it is generally due to the failure of the installation man to "set up" the generator charging rate. This can be easily done by rotating the third brush (in the generator) in the direction of the armature's rotation until the desired charging rate is obtained.

"B" Power Supply Devices—Service

"B" power units for auto-sets are of two types:—

(1) Vibrator-interrupter type — using tube for rectifiers.

(2) Motor-generator type — motor operating on 6 volts.

In the first type of unit, replacement of the tube and vibrator contacts must be expected after it has been in service for some time. The vibrator assembly is almost always removed in one unit and replaced with another. They can be purchased from the manufacturer or most mail-order houses. The filtering unit seldom will give trouble; should a condenser puncture, the symptoms would be no plate voltage at the tube sockets. A bad ripple would indicate an open condenser unit. In both cases the defective item must be replaced.

Where a motor generator is employed for "B" supply, less trouble is likely to be encountered. Brushes should occasionally be replaced, the bearing oiled, and the commutator cleaned with fine sandpaper (**not emery cloth**). Neglecting these precautions may cause a bad ripple which the filter cannot be depended upon to eliminate.

Conclusion

The purpose of revising the previous "**Automobile Radio and Servicing**" booklet was to dispense new auto-receiver information and general data regarding improved practice in installing and eliminating motor noises. It was the latter subject which has bothered most old-timers and newcomers to this field. Considerable experience on the elimination of ignition noise has been gained by those active in auto-radio installation work during the past eighteen months. Practical and successful methods for suppression, we believe, are contained in this book. By diligently following the instruction outlined, we also believe, any interested party with a flair (and some knowledge) for radio can duplicate the results.

Concerning future improvements, the present design of auto-sets almost borders on perfection. Yet no industry can afford to remain at a standstill. More refinements will unquestionably follow; particularly in the tuning and control of the radio from the instrument panel with instruments to harmonize with the remainder of the car instruments on the "dash". Car manufacturers will undoubtedly make provision for this in future automobiles.

New methods for eliminating ignition noise will be evolved. Car manufacturers will probably co-operate by shielding all offending wires in cars while they are in production. Perhaps this branch of the industry will employ in the future the methods used by aircraft-radio installation engineers. With the co-operation from the car manufacturers, installation would be much more effective and efficient than present procedure.

HOW TO MAKE A MODERN CAR SET

The radio set consists of 7 tubes used as follows: one type 39 tube as first R.F. amplifier, one type 39 tube as a combination first-detector and oscillator, one type 39 tube in the I.F. stage, one type 85 tube as a combination second-detector and A.V.C., one type 37 tube in the first A.F. stage, and two type 89 tubes in push-pull as second (output) A.F. stage.

Wiring the Chassis

The whole wiring job of the chassis can easily be accomplished by following the connections shown on this general wiring diagram and adhering strictly to all resistor and condenser values specified.

For further and complete information in regards to the construction of this set, the reader is referred to the Dec. '33, and Jan. '34, issues of Radio Craft. This receiver was described in those two numbers, and created a good deal of interest amongst the constructors of car sets.

In this description of the set, constructional data such as coil windings, mechanical details, layout (which may be changed somewhat to suit the constructor), and the complete schematic wiring diagram.

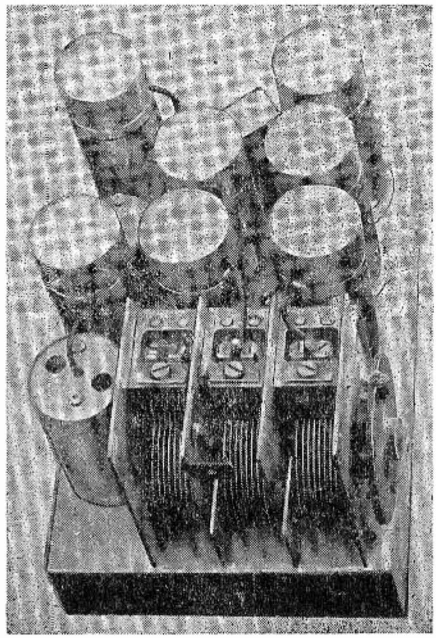
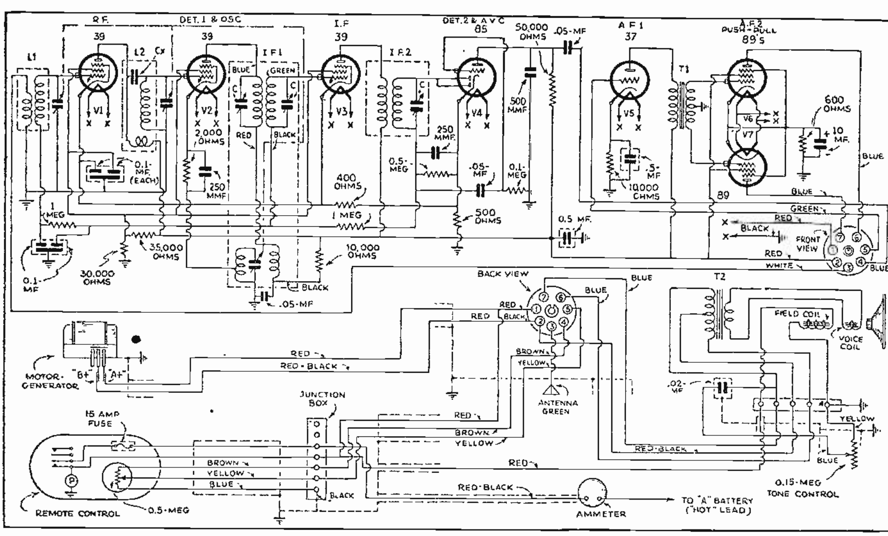


Fig. W

One model of the car radio, showing location of parts on chassis. This unit when completed fits in a metal case.



The radio is designed for a floor mountaing installation, which is believed in most instances, preferable, as it is by all means the most rigid installation; rigidity being a main factor in auto radio construction. The design covers all the different features, and great stress is laid upon drawings; which makes the understanding much more simple than words can explain. The article gives full information on the wiring, both by general wiring and detail wiring diagrams; such as remote control, speaker and coil diagrams. All the parts which can be made by the constructor are fully specified on drawings with complete dimensions.

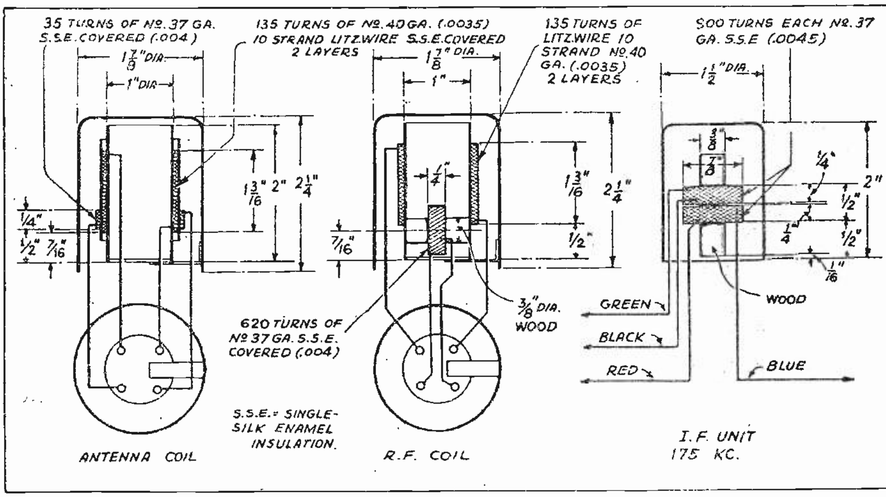


FIG. 14
Constructional details for making the antenna, R.F. and I.F. coupling coils.

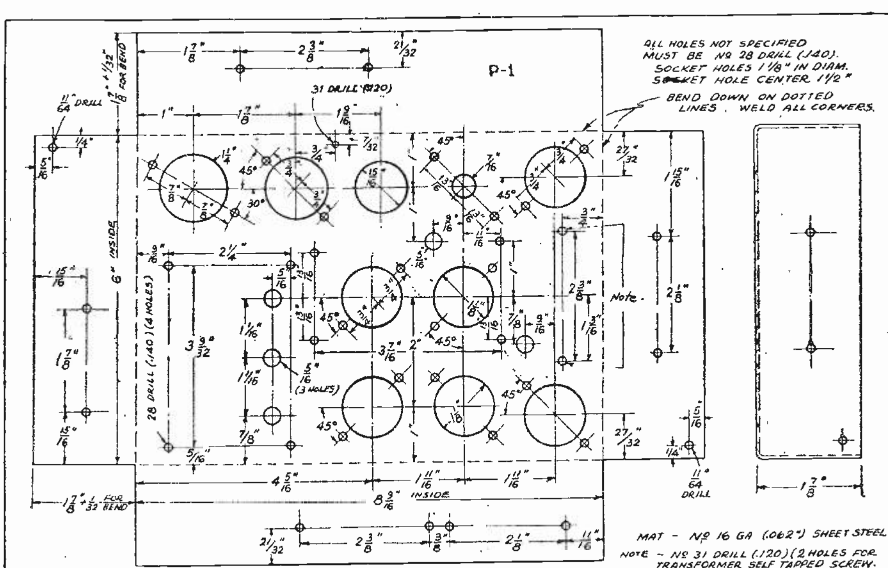


FIG. 15
Drilling specifications for the car radio receiver chassis.

List of Parts

One chassis No. 16 gauge sheet steel, part No. 16;
One chassis box No. 16 gauge sheet steel, part No. 2;
One chassis box cover No. 16 gauge sheet steel, part No. 4;
One motor-generator box No. 16 gauge sheet steel, part No. 5;
Four condenser brackets, part No. 6;
Two chassis brackets, part No. 7;
One chassis box packing—soft rubber, part No. 8;
Two motor-generator box packing strips, part No. 9;
Two motor-generator box packing strips, part No. 10;
One junction box packing, part No. 11;
Seven tube cushion rings, part No. 12;
Five rubber grommets for 5/16-in. hole, part No. 13;
Two rubber grommets for 7/16-in. hole, part No. 14;
Two resistor and condenser mounting brackets, part No. 15;
One 7-prong socket, part No. 16;
One 7-prong plug, part No. 17;
One antenna coil with shield can, part No. 18;
One R.F. coil with shield can, part No. 19;
One composite I.F. oscillator unit, part No. 20;
One I.F. coil unit, 175 kc., part No. 21;
Four 5-prong sockets, parts Nos. 22 and 23;
Three 6-prong sockets, parts Nos. 24 and 25;
Seven tube shields, parts 26, 27 and 28;
One push-pull input transformer, part No. 29;
One 350 mmf. 3-gang variable condenser, ⅝ x ⅜ shaft, part No. 39;
One .002 mf. mica condenser, part No. 31;
One 250 mmf. mica condenser, part No. 32;
Three .05 mf. tubular condensers, 200 V., part No. 33;
One 500 mmf. tubular condenser, 600 V., part No. 34;
Two double 0.1-mf. condensers, 200 V., part No. 35;
One .02-mf. condenser, 200 V., part No. 36;
One .5-mf. condenser, 200 V., part No. 37;
One .5-mf. condenser, 200 V., part No. 38;
One electrolytic condenser 10 mf., part No. 39;
One .15-meg resistor, part No. 40;
Two 1 meg. resistors, ⅓-watt, part No. 41;
One .5-meg. resistor, ⅓-watt, part No. 42;
One .5-meg. resistor, ⅓-watt, part No. 43;
One 500 ohm resistor, ⅓-watt, part No. 44;
One .1-meg. resistor, ⅓-watt, part No. 45;
One 2,000 ohm resistor, ⅛-watt, part No. 46;
Two 10,000 ohm resistors, ⅛-watt, part No. 47;
One 35,000 ohm resistors, ⅛-watt, part No. 48;
One 30,000 ohm resistor, ⅓-watt, part No. 49;
One 400 ohm resistor, ⅛-watt, part No. 50;
One 600 ohm resistor, ⅓-watt, part No. 51;
Six screen-grid connectors, part No. 52;
One 6 or 8 in. speaker with 4 ohm field, part No. 53;
Six or eight spark plug suppressors, part No. 54;
One distributor suppressor, part No. 55;
One tone control knob, part No. 56;
One motor-generator, part No. 57;
One remote control unit, complete with junction box, part No. 58;
Ten 8-32 flat-head screws, ⅜-in. long, part No. 59;
Eight 8-32 round-head, self-tapping screws, ¼-in. long, part No. 60;
Eight ¼ thread, round-head screws, 1¼ ins. long, complete with nuts and washers, for box mounting, part No. 61;
As needed: 6-32 round-head screws, part No. 62;
As needed: 6-32 nuts and lock washers, part No. 63;
One tone control bracket for instrument board mounting, part No. 64;
One shielded cable, 2 No. 16 gauge wire, approx. 3 ft. long (if motor-generator is mounted in rear), part No. 65;
One shielded cable (remote control to radio set) 3 wires, No. 14 gauge, 8 ft. long, part No. 66;
One shielded cable (ammeter to remote control junction box) No. 14 wire, 4 ft. long, part No. 67;
One shielded cable (remote control junction box to speaker) 1-wire, No. 16 gauge, 4 ft. long, part No. 68;
One shielded cable (radio set to speaker) 3 wires, 8 ft. long, part No. 70;
One tone control cable, 2 wires, No. 18 gauge, 3 ft. long, part No. 71;
One type 37 tube;
Three type 39 tubes;
One type 85 tube;
Two type 89 tubes.

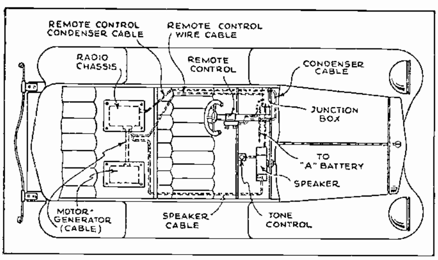
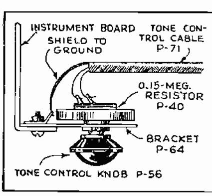


Fig. X

Illustrating placement of radio in car.



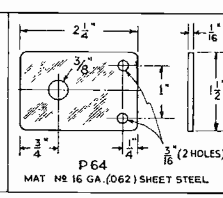


Fig. 16 above; Fig. 17 right.

Tone control with bracket. Complete installation.

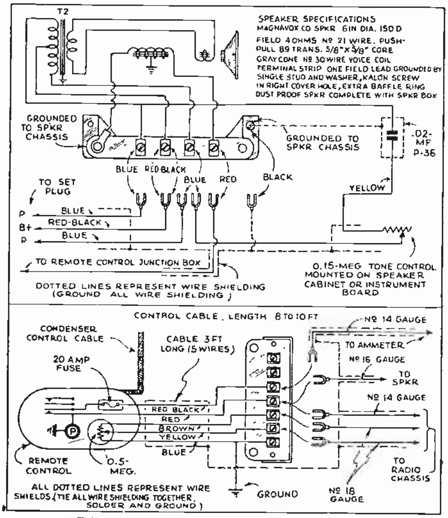


FIG. 18, top; FIG. 19, bottom. Speaker and remote control wiring details.

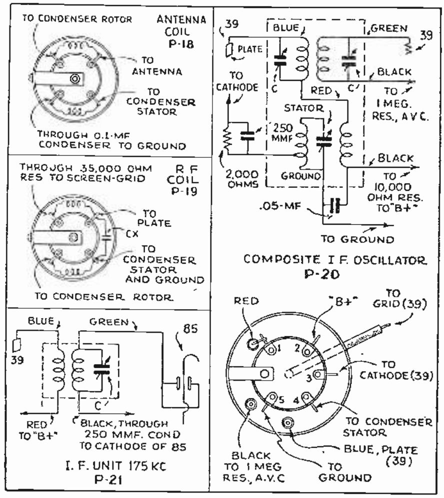


FIG. 20

Connections for the aerial, R.F. and I.F. coils.

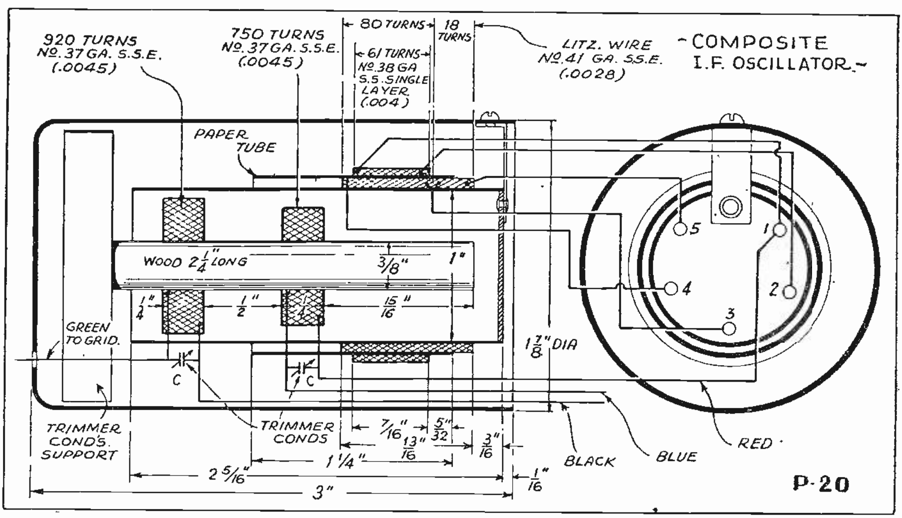


FIG. 21

Constructional details for the composite I.F. and oscillator tuning coil unit.

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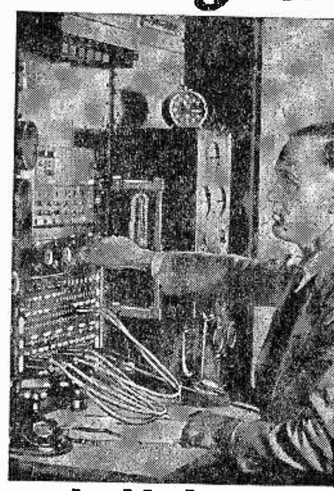

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