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# AUTOMOBILE RADIO

## PRINCIPLES AND PRACTICE

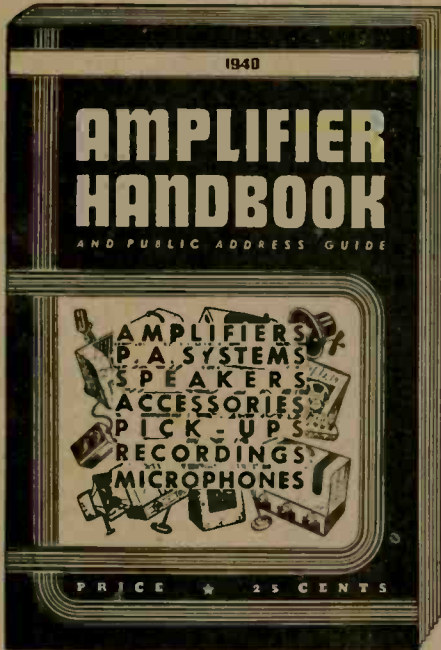
A Complete Treatise on the Subject Covering  
All Phases from Installing to Servicing  
and Maintenance

by B. Baker Bryant



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## A Resume of the Contents of the **Amplifier Handbook**

### AND PUBLIC ADDRESS GUIDE

#### FOREWORD

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Handy index to important articles on public address and sound

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*A Complete Treatise on the Subject Covering  
All Phases from Installing to Servicing  
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# Preface

THE discussions and directions for installing and servicing automobile radio receivers contained in this book represent the empirical endeavors of various commercial laboratories and receiver manufacturers spread over a period of many years. That automobile radio receivers have reached their present stage of development through the tireless efforts of these people, we must heartily acknowledge.

The writer wishes to also acknowledge the kind help in the compilation of material, use of illustrations, etc., without which the text would be difficult of presentation to the reader.

The purpose throughout has been to compile pertinent data on how to really install and service the modern automobile radio receiver. That the writer has attempted to weed out all the non-essential details which have crept into the art can be appreciated by the reader, and though, from lack of sufficient space, the text may not completely cover a phase to the minute detail, the writer feels and hopes that this book will serve the purpose for which it has been written.

The treatment of each topic has been such to contain a precise statement of the fundamental principle involved, to assure the reader's clear understanding of this principle, without distracting his attention by the discussion of a multitude of details and mathematical expressions, which are primarily for the engineer, and tend to confuse rather than clarify a statement for the auto-radio-technician.

In a word, this is a practical treatise based on practical experience by practical radio people for the practical radio-technician, he who is already conversant with the engineering but is primarily interested in the practical end of the art.

—B.B.B.

# CHAPTER I

## Introduction

**B**EFORE proceeding with the description of the modern day automobile receiver it may be pertinent to look back and review this important branch of radio and trace its growth from the earliest use of radios for mobile use.

Research by the author reveals that radio receivers have been used in automobiles since the beginning of the broadcast era by the Westinghouse Radio Station KDKA in 1920. In almost every instance these installations were adaptations of the battery-type home broadcast receiver to that of mobile use. Almost any small receiver of a satisfactory degree of sensitivity was suitable and to say the least these auto installations were very inefficient even as were the home receivers of that period.

During the years of 1925 and 1926, a prominent radio figure, Mr. Arthur H. Lynch, a former World War aviation

pilot, editor of Radio Broadcast magazine, conducted many experiments toward the view of manufacturing radio receivers designed exclusively for automobile and aviation use. In this work Mr. Lynch was assisted by Mr. Samuel (Wireless) Egert and Mr. Egert's engineer, Joseph Heller. After many models had been designed and constructed, the project was dropped as being premature.

During the time of Mr. Lynch's endeavors, a concern known as Transitone of Long Island City, New York, began production of automobile receivers. This concern was later purchased and merged by the Philco interests. While the Transitone receivers were manufactured on a commercial basis, it was invariably necessary to alter and effect many changes in the receivers which resulted in a more or less custom built receiver for any particular installation. One of the early Transitone models is shown in Fig. 1.

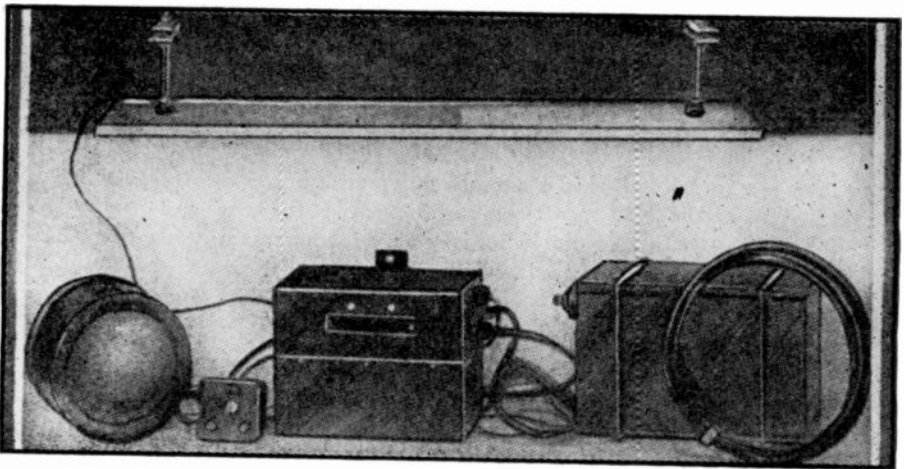


Fig. 1.—Illustrating one of the early automobile receivers.

Radio receivers in the home have become a part of every day life and therefore it was natural that the popularity of the automobile receiver should increase. The commercial and municipal use of mobile receivers also served as further incentive to manufacturers until now most all have added the mobile receiver to their production lines. This naturally was not before considerable laboratory work had been expended in development. The modern day automobile radio is therefore the accumulation of vast empirical work since 1920. In the early years the art knew none of the "Rule of the Thumb" methods of manufacturing, installation, and servicing, as are practiced today.

### EARLY AUTOMOBILE RADIO RECEIVERS

As mentioned in the above paragraphs, the early automobile receivers were similar in design to the home receivers. Most all were battery operated. The tubes, the only types available during that period, were the 01A, 12A and 71A. Most all of the receivers employed tuned radio frequency stages, followed by the conventional grid leak and condenser detector, and transformer coupled stages of audio frequency. These receivers were without benefit of automatic volume control (AVC); delayed automatic volume control (DAVC); automatic noise suppression (ANS); and of late, automatic frequency control (AFC), as used with many of the automatic and push-button tuning systems.

The receivers were very insensitive in comparison with the modern day receiver. The sensitivity was not improved until the advent of the screen grid tube (the old 222), which was later followed by the tube types 24, 32, 35, and 51. The introduction of these tubes injected new life into this branch of the radio industry, as by their use the sensitivity of the receivers was greatly increased resulting in greater volume, better audio quality, and less motor interference.

Much work had been expended during the early days on the ignition interference problem from which evolved the method wherein sparkplug and distri-

butor suppressors were employed. Elaborate bypassing of the low tension system and intricate shielding of the high tension system of the car was also necessary.

The above method of ignition interference suppression was very unsatisfactory from the standpoint of motor performance. Each suppressor had a resistance of from 10000 to 30000 ohms, and two of these in series limited the ignition power to such a degree that the motor performance became erratic. The use of a suppressor for each sparkplug and the distributor, in addition to the numerous bypass condensers, resulted in considerable accessory expense. In many cases installation was expensive and difficult because of the intricate shielding required.

Manufacturers, appreciating the above faults which naturally tended to limit sales, have gradually developed the present day system wherein only one master suppressor is employed, with simple bypassing of the low tension system, and the elimination of shielding. This system is made possible by the use of antenna and low tension filters within the receiver, these filters serving to isolate the receiver from the ignition interference.

### THE AUTOMOBILE ANTENNA

The antennae were of various designs. Some were installed in the roofs of the automobile and others under the chassis. The latter were in the form of coils, heavy cable loops, metal plates, screens and pipes or rods. Since the antennae of this type have comparatively small pickup, especially the under carriage type, it can be realized that the improvement in receiver sensitivity with the screen grid tubes contributed greatly to improve the volume, and the elimination of local ignition interference. The advent of the turret top all-steel automobiles doomed the roof-top antennae, and further impaired the pickup of the under-carriage type by greater shielding effects. Thus the development of the turret top and vertical rod (fish-pole) antennae used almost exclusively on the modern day automobiles.

### GENERAL CONSTRUCTION

From the beginning of the art there has been similarity in the general construction of the receivers. One of these being the inclusion of the components within a metal container for the protection of the components against damage, and for shielding against ignition interference. The receivers have been constructed along two general types, the entirely self-contained and the remote cable control. In the former the receiver, speaker, and tuning controls are within the one housing or container, and installed underneath the dash or directly behind the dash. The latter type can be installed in any convenient portion of the car but is most usually installed over the steering post. Either of these two types may be provided with additional or separate housed speakers. Especially, where large speakers are employed for greater fidelity, or where provisions have been made in the construction of the car for a header speaker of small size. Within the last two years many of the automobile receivers are provided with automatic tuning devices, which may be contained within the receiver housing or arranged to fasten onto the housing as an auxiliary unit.

### SPECIAL TUBES DEVELOPED

The radio tube manufacturers, realizing the necessity for increased sensitivity, developed a special series of tubes which were directly responsible for greater efficiency in receiver design. These tubes were designed to work on voltages of from 6 to 8 volts, but with the nominal voltage rating of 6.3 volts. The current consumption is slightly more than that of the 01A and is 0.3 ampere. These tubes are the type 36, a screen-grid pentode high-gain detector and amplifier tube; the 37, a triode; the 38 an output tube of the screen-grid pentode type, and the 39 a super-control screen-grid pentode radio-frequency amplifier tube.

The first series of automobile tubes were later followed by improved types such as the 76, 77, 78, 79, 84 and 89. The 84 is a special cathode type full wave rectifier used with vibrator converters. The type 89 is an output tube

of greater power handling possibilities. The type 79 is a high-gain twin-triode output tube especially developed for Class "B" amplification.

Special purpose tubes were also developed, these were the 6A7 converter tube used as a mixer and oscillator in superheterodynes; the type 6F7 which combined a high-gain screen-grid pentode and a triode in the same envelope. This tube found a variety of uses. The 6B7 contained a high-gain screen-grid pentode and twin-diodes in a single envelope. This tube was developed principally for use as an intermediate frequency amplifier and diode detector, the latter section used for automatic volume control.

Attention was given to the improvement of the output tubes which resulted in the development of the 12A5, the 6B5, 41 and 42. Followed by the 6V6 and 6L6, which are of the beam power type.

Upon the advent of the metal tubes (using the universal or octal base) the above types were supplied in many cases with the universal base and given new designations. Within recent months a new type base has been introduced and is known as the loctal, which however has not as yet been used in the automobile service due to greater voltage requirements for the filament.

### AUTOMOBILE

#### SUPERHETERODYNES

Upon the release of the new automobile tube series, the superheterodyne circuit became universally adapted for use in mobile receivers. The many tubes used in this type of receiver resulted in the need for a greater and more efficient source of power than was economically supplied by B batteries.

This need had been partially solved by the use of small motor-generators and converters. They had been used previously in the deluxe and expensive auto installations, but generally were unsatisfactory from the standpoint of low efficiency and bulk. The former in the order of 50 per cent. The mechanical noise of such devices necessitated remote installation, usually under the car and at some distance from the receiver. In many of the installa-



tions both the receiver and power supply unit were installed at some distance from the control panel, using flexible cables of varying lengths up to eight or nine feet in length.

The design engineers, undaunted and spurred by more modern requirements, adapted and improved upon Dr. Lee de Forest's vibrator converter, which was used by him for supplying power to the receiver and transmitting apparatus upon the occasion of the first public demonstration in 1907.

Vibrator converters have been developed to the efficiency of 90 to 98 percent. These units and their applications will be found described in a later chapter of this book.

Considering the great efficiency of modern day receivers, the author will not devote additional space for the detailed description of the older receivers, but will relegate them to the archives of auto-radio history with a salutation and the greatest of reverence.

#### FREQUENCY MODULATIONS RECEIVERS FOR AUTOMOBILE

At the time of this writing no information has appeared anywhere regarding the possible use of Major Armstrongs frequency-modulation system in automobile receivers. There is no doubt the "F M" system of broadcasting is the coming thing. Many stations have already "tooled-up" for it and several are already on the air. The main spurt will come as soon as the Federal Communication Commission allocates the frequency range and the band width.

For automobile radio F M is a "natural" since it is practically static-free; both man-made and the natural variety. It will make possible the complete elimination of ignition-noise suppressors as well as low-tension line filters. It will also open a new field of research on radio equipment designed for car use such as for example television, short-wave receivers and transmitters, facsimile etc.



## CHAPTER II

# Features of the Modern Automobile Radio Receiver

**R**ADIO receivers designed for automobile use, as now manufactured, are in a class comparable in perfection to the modern home receivers. The reader will appreciate that in many instances, tube for tube, the automobile receiver may be considerably superior

in sensitivity to that of the home receiver. That this is a fact, can be substantiated by comparison of the low pick-up possibilities of the automobile antenna to those of greater pick-up as used in the average home receiver installation.

The order of sensitivity of the usual automobile receiver, in which the mixer stage is preceded by a single stage of radio frequency amplification, is found to be in most cases, less than one micro-volt for the full output power to the speaker. In order to obtain this degree of sensitivity, the overall amplification of the receiver must be large. This necessitates high-gain stages, stability of operation, and adequate shielding, (without which the aforementioned gain and stability are not possible) all of which requires proper engineering design if the receiver is to be compact.

Economy of operation is also of prime importance as prolonged operation will place a drain upon the battery (which is already over-burdened) that will quickly run down the voltage to a point that the automobile as well as the radio becomes inoperable. It is for this reason that the special purpose and dual-type tubes have been developed, mention of which was made in the preceding chapter.

### THE CIRCUIT

The superheterodyne principle is now almost universally used with innovations or rather, features incorporated in the design which are so electrically advanced that few changes in this direction can be expected for some time to come. The circuits of the receivers may be broadly divided into two general classes; those in which a stage of radio frequency amplification precedes the mixer stage, and those in which the antenna is coupled directly to the mixer stage. The single stage of radio frequency amplification is used principally for adjacent channel selectivity rather than for the amplification. In the smaller receivers, in which the antenna is coupled directly to the mixer, adjacent channel selectivity is obtained by efficient design of the antenna coupling transformer or coil.

The conventional receiver of the remote cable-controlled type consists of the tuned radio frequency stage; the mixer stage, in which is usually combined the local frequency generator or oscillator although the oscillator stage may employ a separate tube. The mixer

stage is coupled into a single stage of intermediate frequency followed by the second detector or demodulator. This stage also combines the A.V.C. or delayed A.V.C. function and the first audio frequency stage when the duodiode triode tubes are used. The output of the first A.F. stage may be followed by the output tube or by a driver stage, when the output stage is of the class "B" amplification type.

The smaller receivers which usually are of the single unit under-dash type, couple the antenna directly to the Mixer stage through an efficiently designed R. F. Coil. The local frequency generator or oscillator is combined with the mixer; this stage may be of the autodyne type, or may employ the converter type tubes such as the 6A7 or 6A8. In some instances, the 6F7 type tube may be employed, the triode section used for the oscillator portion and with the pentode section in the mixer portion of the circuit. The mixer stage is then followed by a single stage of intermediate frequency amplification that is coupled to the second detector or demodulator in which is also combined the A.V.C. function and first audio frequency stage. The plate of this stage is then coupled to the output tube of the 41 or 6K6 type, which seldom delivers an audio frequency output of more than two watts without distortion.

In either of the two types of receivers there may or may not be found an additional tube which is used solely for power rectification. For a further conservation of space and greater power economy, this tube may be dispensed with and a synchronous type vibrator used instead.

No changes have been made in the general circuit line-up for the past few years with perhaps the exception of the use of the newer type tubes which of course are more or less equivalents of the older types, but having the octal or universal type base. The advent of the push-button tuning system in the home receivers has also resulted in the use of this system in automobile receivers, especially in those receivers of the under-dash mounting type.

In the following pages of this chapter, commercial circuits are analyzed. The author, hampered by the lack of space,

has endeavored never the less to cover the various innovations in circuit design which may be broadly common to many manufacturers, although in such instances the actual circuit constants may be different.

COMMERCIAL  
RECEIVER  
CIRCUITS

In Fig. 3 is shown the model No. 1440 Ford-Philco circuit which may be said to be of the conventional type. With the exception of the values of the components, the lineup of the circuit is more or less common to many other manufacturers. This receiver is designed for use with a remote speaker, which in the case of the Ford Cars is of the "header" type, although under-dash speakers are adaptable. The antenna input of the receiver may be adjusted for any type antenna for most efficient response. Delayed A.V.C. is incorporated and is combined with the demodulator. This latter is of the half wave type, both diodes of the duo-diode triode type 75 being connected together. The octal base approximate equivalents of this tube are the 6Q7 and 6V7. The triode section of the tube is used for the first A.F. stage and is of the voltage-amplification type. Iron-core transformers are used, which has become more or less standard practice because of increased efficiency. Although this

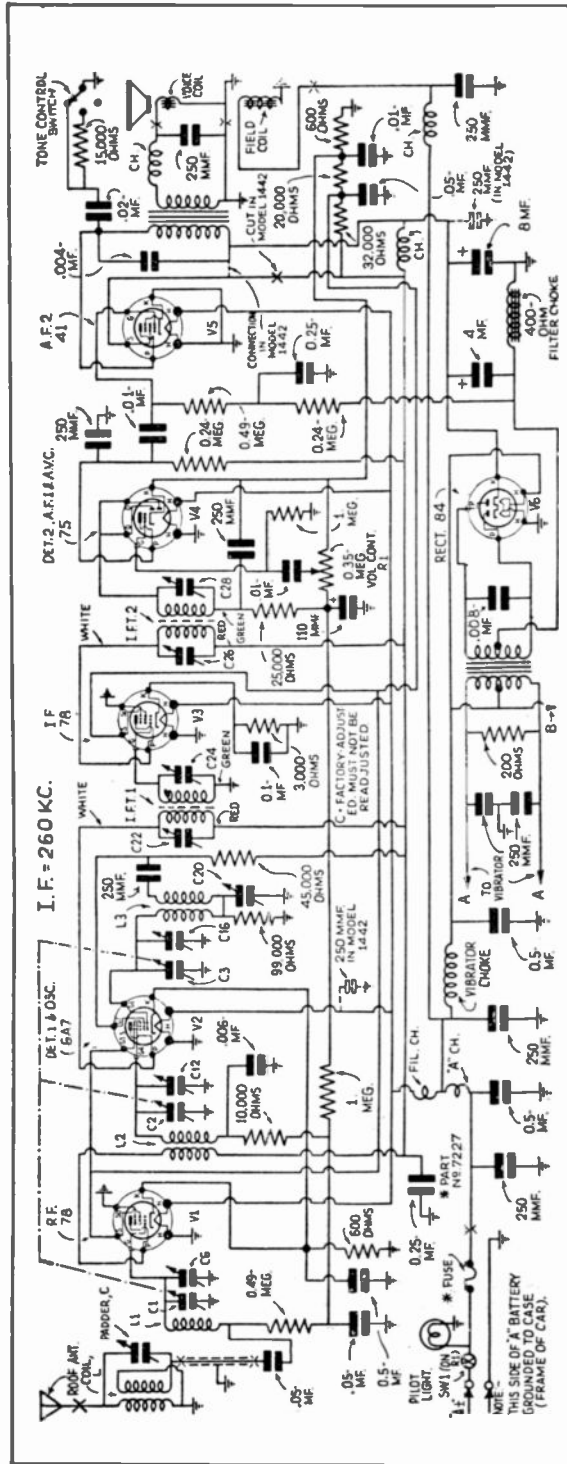


Fig. 3.—The schematic of the Ford-Philco Model 1440 Automobile receiver the circuit of which is more or less conventional.

particular receiver does not use iron-core R.F. transformers, they may be found as standard equipment in many of the current receivers. The A.F. output stage employs the type 41, the octal base equivalent being the 6K6. Many of the receivers may use the type 42 (octal base equivalent is the 6F6) which is slightly superior, or use the 6B5 (octal base equivalent is the type 6N6) which is a triple-twin or direct-coupled power output tube. Other receivers will be found to use the 6V6 which is of the beam power type, in which power sensitivity is greatly increased at the expense of some distortion.

In many receivers, the first audio stage is coupled to a driver stage which may employ any of the low- $\mu$  type tubes. They are coupled to the class "B" output stage either by transformer or auto-transformer, depending upon the driver output requirements.

The class "B" output stage may use any of the twin triode output tubes especially designed for that service. These are all hi- $\mu$  tubes, with a no-signal plate current cut-off characteristic.

The receiver uses a full-wave non-synchronous vibrator in conjunction with a full-wave rectifier tube to provide the high voltage requirements of the receiver. Other receivers may employ a synchronous vibrator in which case the necessity of the rectifier tube is dispensed with.

The receiver is provided with low voltage input filters which assist in ig-

niton interference elimination by isolation of the receiver supply circuits from the low tension system of the car. Fig. 4 shows the receiver in the especially shaped housing designed for the Ford cars, although it may be installed in almost any other car. Beside the receiver is shown the control head, flexible remote cables, medallion, and "header" type speaker. Some users may prefer under-dash speakers which may be used, connected to the receiver in the same manner as the connections are made to the "header" speaker.

The "header" type loudspeaker seems to have been short lived. The latest trend is either a one-unit receiver with self-contained speaker or a two-unit receiver with an external loudspeaker having a special universal bracket for mounting behind a grille on the dashboard. Most 1940 automobiles have decorative grilles designed specifically for this purpose. From the authors point of view, the header (above the windshield) is the best location for an auto-radio loudspeaker. Distribution of the sound is more even than with the speaker mounted under the dashboard where it tends to "boom," and where the volume, when too great for the driver, is not loud enough for the people riding in the rear seats. Header type speakers, unless provided for by the manufacturer, present installation problems such as suitable mountings, running wires through the corner posts, etc.

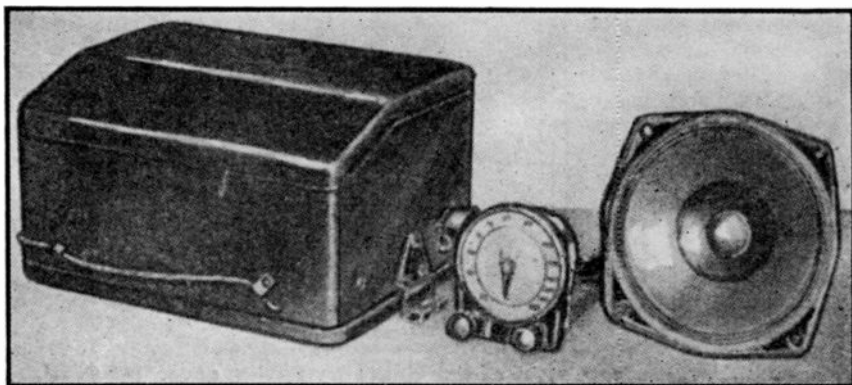


Fig. 4.—The complete Ford-Phileo receiver with the control unit and header type dynamic speaker. Note the familiar V8 on the remote control head.

THE MODEL A-177  
CROSLLEY ROAMIO  
RECEIVER

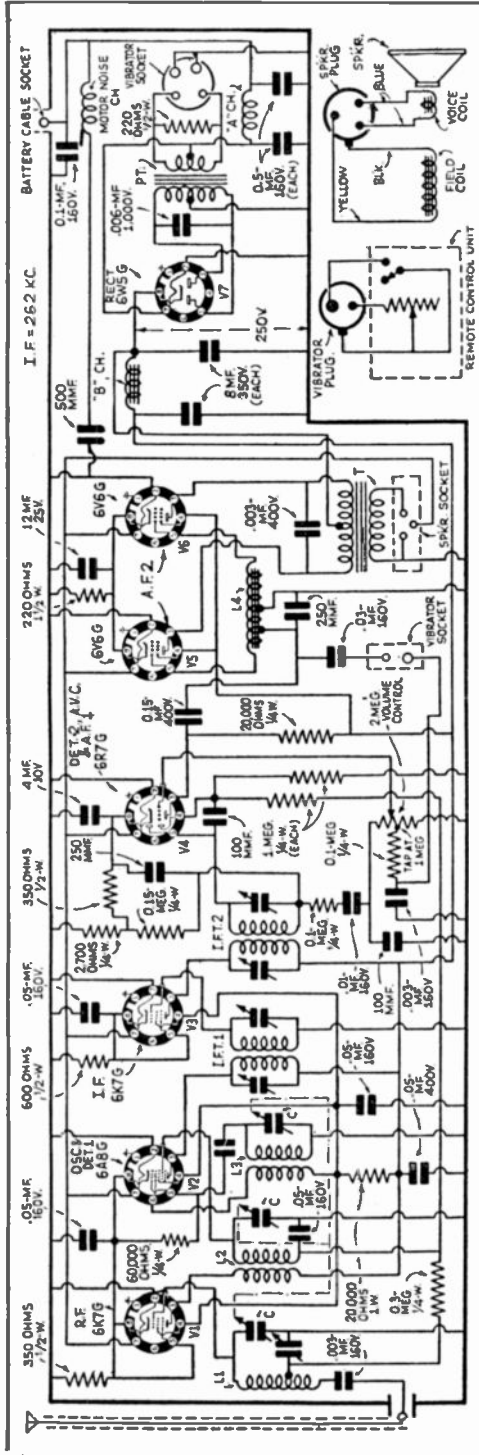


Fig. 5.—The schematic of the Crosley Roamio model A-177. The receiver uses the "G" or octal base G19AA tubes in a modern high-gain circuit. The circuit accommodates dual loudspeakers, one of which may be the header type.

In Fig. 5 is shown the Crosley Roamio Model A-177. In this receiver the R.F., Mixer, and I.F. stages are conventional and similar to the circuit in Fig. 3. Comparison of the circuits will show that a low-mu duo-diode triode, the type 6R7G, is used as the demodulator and first A.F. The output of the triode section is coupled by a step-up auto-transformer into push-pull 6V6G beam power output tubes. The A.V.C. circuit is arranged for noise suppression. The R.F. and I.F. transformers are of the aircore type. As considerable current is required by the two beam power tubes, a 6W5 - full wave rectifier tube is used in conjunction with the non-synchronous vibrator. Provisions are made for connections to two external speakers.

Regarding rectifier tubes, the OZ4 series are being used more and more for auto radio work. These are cold cathode (no filament) gaseous rectifiers which pass about 75 milliamperes of plate current. Since they require no filament current they represent quite a saving in battery current. Additional battery current is saved by the increasing use of multi-purpose tubes and permanent magnet dynamic speakers.

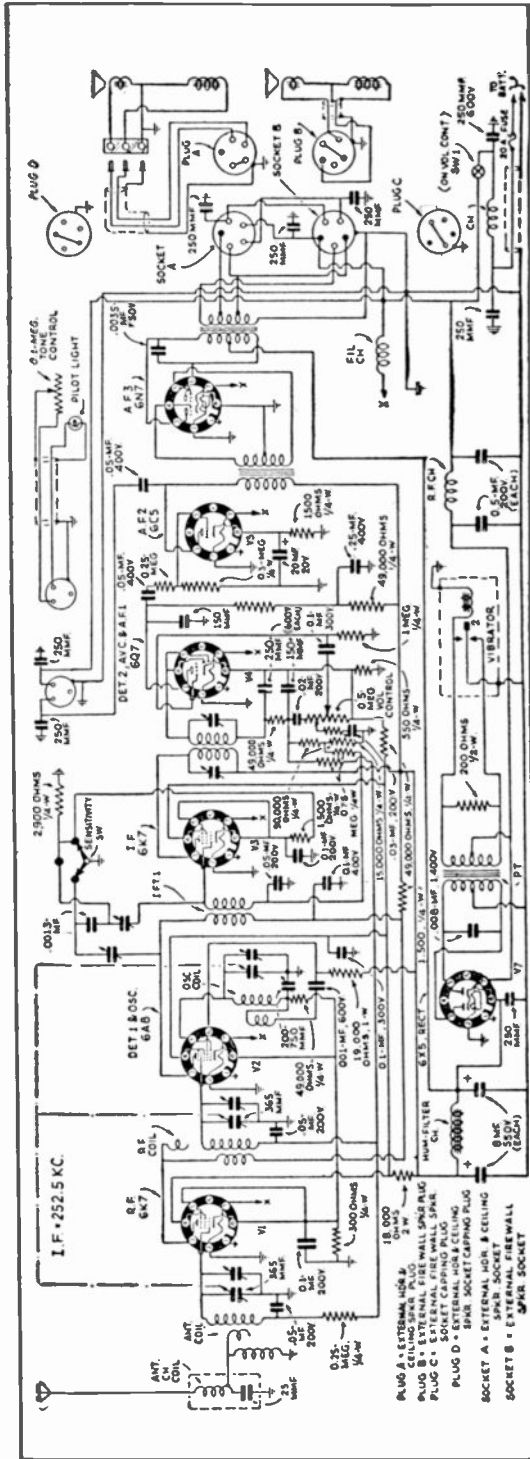


Fig. 6.—The schematic of the Zenith model 7M91 auto receiver. In this circuit class "B" amplification is employed in the output stage.

**THE ZENITH MODEL 7M91 RECEIVER**

Another receiver similar to those described above is that of the Model 7M91 Zenith, shown in Fig. 6. This receiver uses a class "B" output stage in which the twin-triode 6N7 is employed. The 6Q7, a duodiode triode (hi-mu type) functions as demodulator, A.V.C. and 1st A.F. stage. The output of this voltage-amplifier is resistance coupled to the driver stage in which the 6C5 is employed. The driver-stage output is coupled by a step-down class "B" push-pull transformer into the grids of the 6N7 output tube. The balance of the circuit is more or less conventional.

**THE ARVIN MODEL 7 RECEIVER**

In Fig. 7 is shown the Arvin model 7 receiver. This circuit is of particular interest and was developed expressly for economical battery drain. The lineup has been used in many of the Delco and General Motors receivers as well as by other manufacturers.

Inspection of the circuit reveals only five tubes but three of these tubes are of the dual purpose variety and thus give the same performance as would be expected with 7 or 8 single tubes. The pentode section of the 6F7 (octal base equivalent is the 6P8) is used for the R.F. stage, the triode section of this tube serves as the first A.F. stage; a 6A7 or 6A8 combines the mixer and oscillator functions as these tubes are frequency converters. The pentode section of the 6B7 or 6B8 functions as the single intermediate frequency stage. The duo-diodes being connected together in a half-wave circuit for the demodulator-function, and also provide the A.V.C. voltages. The demodulator output is then coupled by resistance-capacity to the triode section of the 6F7 or 6P8. The plate of the first A.F. stage is resistance coupled to the A.F. output stage in which the type 41 or 6K6 is employed.

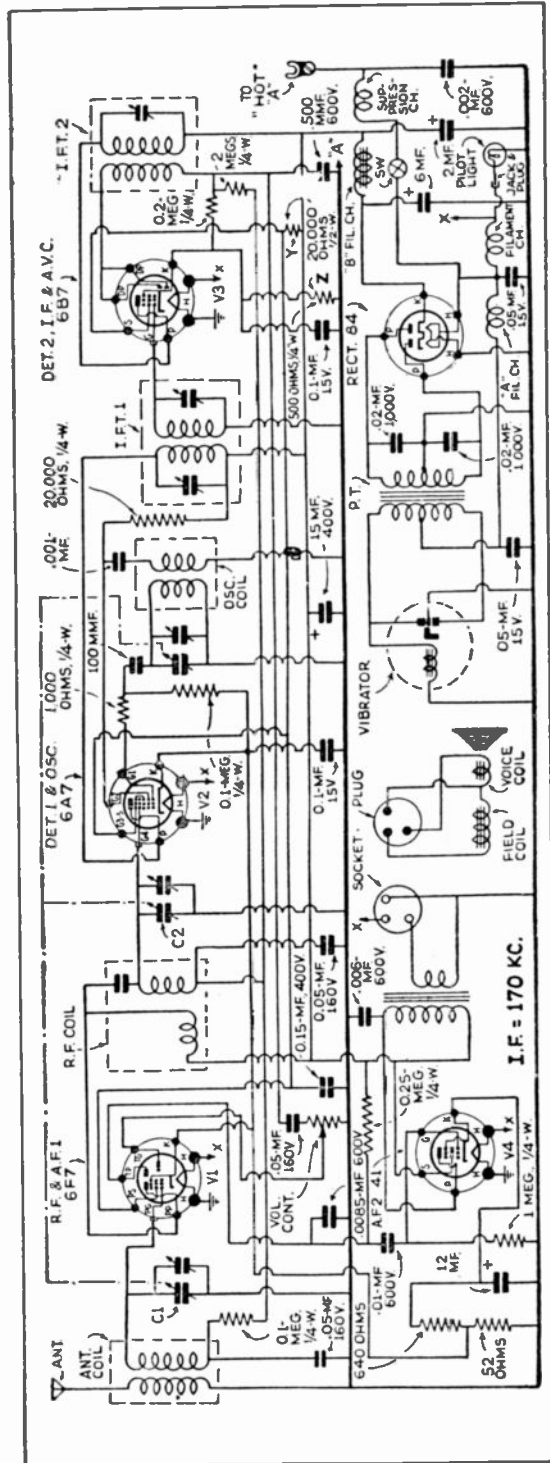


Fig. 7.—The schematic of the Arvin model 7 receiver presents a circuit of much interest in which economy of operation is obtained by the use of multi-element dual purpose tubes.





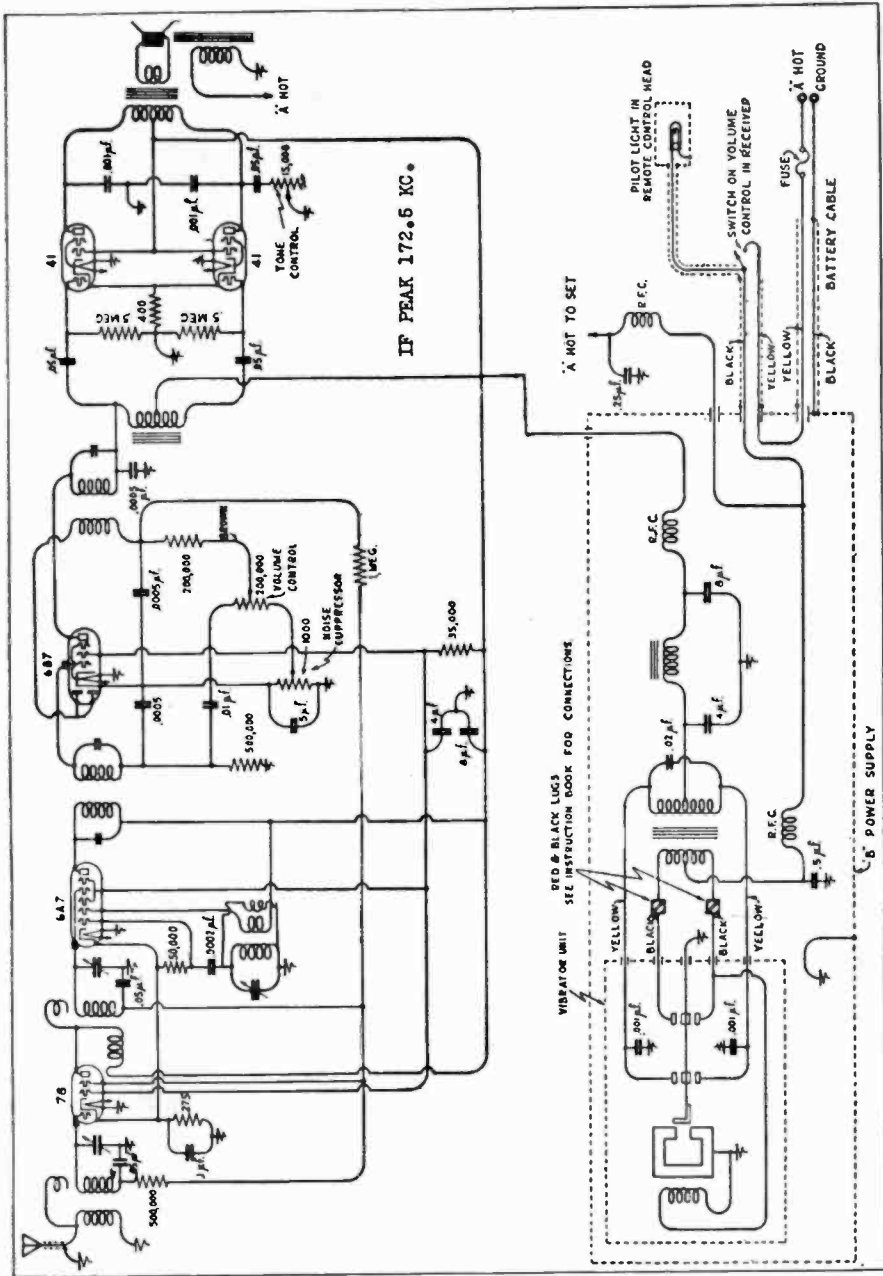


Fig. 9.—The schematic of the Emerson model 678 uses only five tubes although the performance rivals that of an eight tube receiver. The reflex principle plus dual-purpose tubes are employed.



**THE EMERSON MODEL 678**

In Fig. 9 is shown the Emerson Model 678, a circuit in which the pentode section of the 6B7 or 6B8 functions as a reflex amplifier of both the intermediate and audio frequencies. The demodulation and A.V.C. functions are accomplished in the halfwave diode circuit. The A.V.C. is of the delayed type and the circuit is also arranged for noise suppression, the degree of the latter being adjustable by the 1000 ohm potentiometer in the cathode circuit of the 6B7 or 6B8.

This receiver was made in two types, their difference being in the manner by which the plate circuit of the pentode section is connected to the push-pull 41 or 6K6 tubes. The first or early type used an expensive specially designed low-distributed-capacity audio transformer, while the improved or second type uses a center-tapped impedance coil as a auto-transformer. With the second type arrangement, greater gain is possible with a more even or flat audio response curve.

The high-voltage power supply is of the conventional type in which a synchronous vibrator is used for conversion. Likewise the R.F. and oscillator-mixer stage are of the conventional type.

**THE MOTOROLA MODEL 8-80  
(GOLDEN-VOICE) RECEIVER**

The Model 8-80 (Golden-Voice) Motorola receiver shown in Fig. 10 is of the super-deluxe type. The arrangement of the R.F., Mixer and oscillator portions of the receiver is for both push button and "spot" tuning. For the former arrangement a motor is employed to rotate the tuning condenser shaft. Manual tuning of the tuning condenser may be accomplished by the conventional cable control, a part of which is the spot tuning arrangement. Frequency drift of the oscillator, always a problem in push-button tuned receivers and which is usually controlled by one of the various A.F.C. systems, is controlled by the use of bi-metallic type condensers. These condensers operate on the same principle as a thermostat, and are constructed in such manner as to keep the capacity within minute tolerances.

The push-buttons control the tuning

motor through relay magnets which are pre-set for the stations desired. This mechanism will be found at the right hand end of the receiver.

The spot tuning arrangement operates in conjunction with the manual control. The mechanism consists of a small ball bearing, a brass raceway in which the ball moves, and a slotted retainer clip which acts as a guide. To adjust the receiver for spot tuning the mechanism is first exposed. A desired station is accurately tuned to resonance, then with a pair of slip-jaw pliers, one jaw of which rests on the bottom of the unit, enough pressure is applied to the ball to force an indentation in the brass raceway in which it moves. Other desired stations are set in the same manner. The raceway is provided with a double track, which may be used for a new series of stations. A third station setting can be made only by the replacement of the raceway. See Fig. 11, for details of both mechanisms.

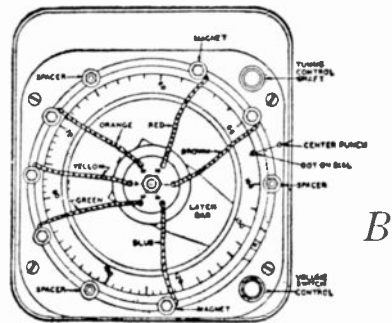
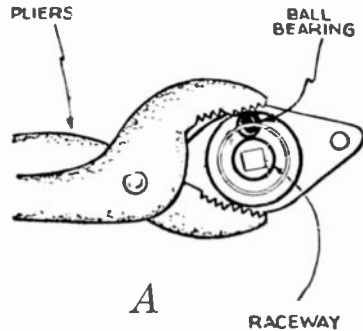


Fig. 11.—"A" shows the mechanical arrangement for push-button tuning, while "B" indicates how the spot tuning mechanism is adjusted.

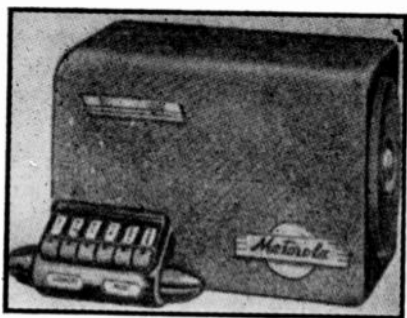


Fig. 12.—The Motorola model 8-80 is shown here with the "Acoustinator-Push-Button Tuning Head". The speaker is an auxiliary unit which is not shown.

The receiver is also provided with a remote type of combined "sensitivity and tone control" called an "Acoustinator." This unit also contains the six push-buttons and is mounted under the dash-rim convenient to the car operator.

A 6V7G is used as the 2nd detector or demodulator and 1st A.F. stage. The A.V.C. voltages are separately obtained from one of the diodes and the other is used for the detection. Class "AB<sub>1</sub>" output is obtained through the use of push-pull 6V6G tubes, which are driven by a 6C5G. Push-pull coupling is obtained through the use of a center-tapped impedance or auto-transformer. The triode of the 6V7G is resistance coupled to the driver tube input.

Antenna compensation is provided for efficient matching to any type antenna. The power supply circuit is conventional but a cold cathode gaseous type rectifier (full-wave), the type 0Z4, is used because of the heavy current drain. Supply circuits are well filtered against ignition interference. Fig. 12 illustrates the receiver, the "Acoustinator" and push-button head.

#### THE GENERAL ELECTRIC

##### MODEL F.A. 80

In Fig. 13 is shown another receiver circuit of the deluxe class which is the General Electric Model F.A. 80. Automatic frequency control is employed, and while push-button tuning is not incorporated in the receiver, this control provides a desirable "safety factor" for

the car operator in that he has only to tune to the approximate setting of a given station and the circuit then automatically does the vernier tuning.

The R. F. and Mixer portions of the receiver are conventional. The oscillator tube and circuit is controlled through a special circuit arrangement which includes the 2nd I.F. or discriminator transformer; the full-wave 6H6 diode rectifier circuit, which in addition to functioning as the second detector or demodulator, supplies the discriminating voltages to the A.F.C. control tube (V8) which is a type 6C5 triode. This tube in turn controls the conventional oscillator circuit as inspection will reveal.

The audio frequency voltages are amplified by another type 6C5 (V7) which is coupled to the triode section of the 6R7 (V5), the diode section of which is employed to supply the A.V.C. voltage. The plate of the driver tube (the 6R7 is a low- $\mu$  tube) is coupled through a class "B" push-pull step-down transformer into the control grids of the Class "B" twin-triode output tube, type 6N7 (V6).

The antenna circuit is arranged for matching to the particular type Antenna used. The high voltage supply system employs a synchronous vibrator. Adequate filtering in the supply circuits guards against ignition interference. The receiver, ready for installation is shown in Fig. 14.

#### THE CROSLEY MODEL A-157

The Crosley Model A-157 receiver is shown in Fig. 15-16. Here we have an example of the single-unit under-dash type receiver. The circuit as can be seen is of the conventional type with the exception of the R.F. stage which is not incorporated. The newer type tubes are employed which in general have slightly greater trans-conductance which partially compensates for the lack of the R.F. stage as far as sensitivity is concerned. The selectivity naturally would be greater were a stage of R.F. employed but through correct coil design, the selectivity is held up to a high level. The tuning control is of the direct type, that is, no flexible cable is employed. The antenna circuit is arran-

ged for proper matching to the antenna used.

When possible, the receiver should be mounted in the mid-section and underneath the dash in such manner that the panel of the receiver is even with the dash. This makes for a symmetrical appearance, short leads, and within easy reach of both driver and passenger.

The receiver design of this unit has been adapted by many manufacturers as it may be economically produced in comparison to the larger more complicated receivers. Thus the manufacturer is able to place a receiver on the market which may sell for twenty dollars or less, depending upon the quality of parts used.

**THE ARVIN MODEL 6 RECEIVER**  
The Arvin Model 6 under-dash receiver

er is of the same general type as that of Fig. 15 and is shown in Fig. 19. The only difference other than component values is that tuning is accomplished only by the use of push-buttons. Provisions are for the selection of one of six stations. The circuit is conventional for receivers of this type in which no R.F. stage is employed. Oscillator stability or control of frequency drift is accomplished by the use of iron-core

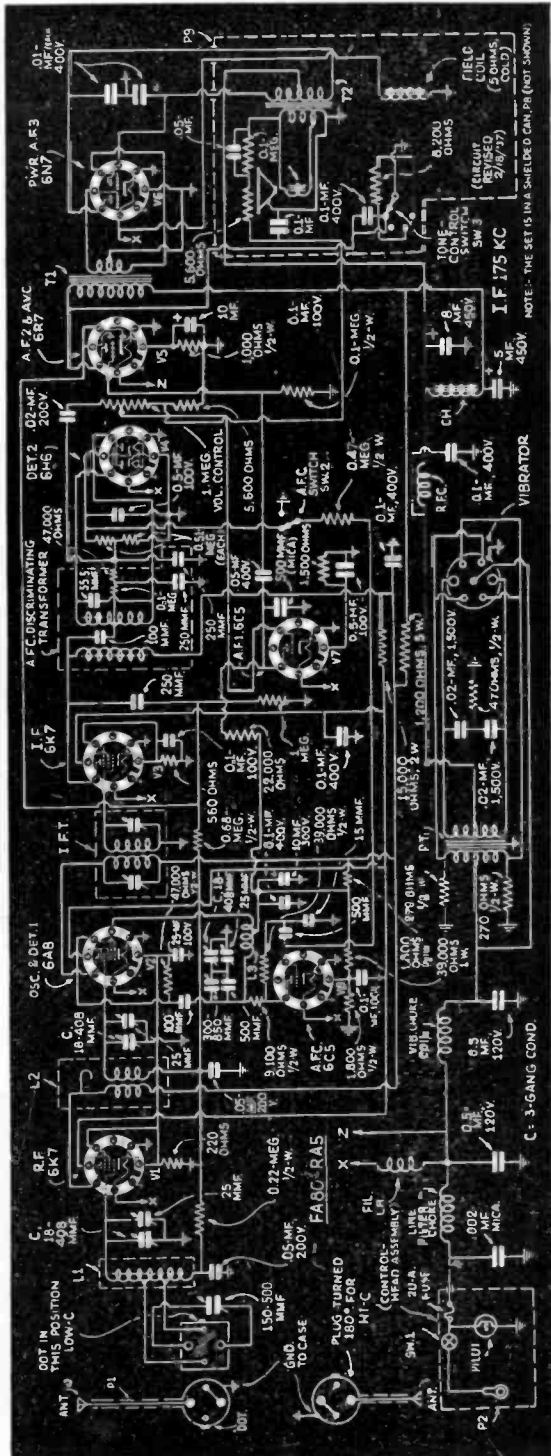


Fig. 13.—This schematic shows the circuit connections of the General Electric model FA-80 in which automatic frequency control is employed for vernier tuning.

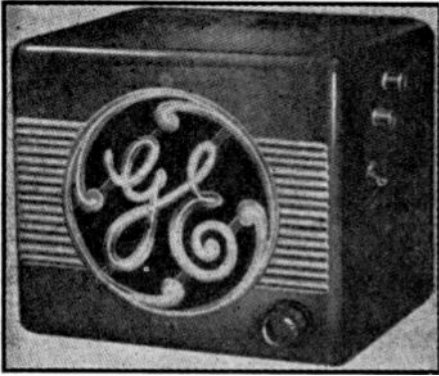


Fig. 14.—The General Electric model FA-30 which in addition to the A. F. C. feature has an output of four watts and antenna matching facilities.

tuning coils, which have the property of compensating for changes in inductance, partly through iron-core thermal effects, and by the resultant smaller winding and less wire used for a given inductance when compared to that of the air-core type. See Fig. 18 for appearance of receiver.

#### THE CONTINENTAL TOUCH-O-MATIC CONTROL

In Fig. 19-20 is shown the appearance of the Continental Touch-O-Matic push-button tuning attachment which may be applied to any receiver. The device employs an electro-magnet which through its vibration, started by the touch of a button, causes levers to rotate a ratchet wheel. On the shaft of the ratchet wheel are arranged two two-section six-position switches. Three of the sections are employed for the Antenna, R.F. and Oscillator circuits respectively. Each point of each section of the switch is connected to a small trimmer condenser. These are contained within the unit's housing. Sets of these trimmers are tuned to any of five different stations. The additional button (White) is employed when the operator desires to change the circuit back to manual tuning, with which the attachment has no other connection.

#### SUMMARY OF VARIOUS RECEIVER CIRCUITS

The writer, as mentioned before, hampered by lack of space has selected the receivers described above as representative of the various receivers on the market. The reader will naturally find many differences between different models and between different manufacturers, but to express the thought in a more common vernacular, tube for tube, they are all sisters under the cover.



Fig. 19-20—Illustrates the appearance of the push-button control mounted on the steering column.

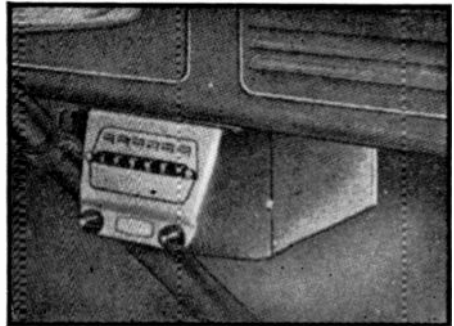


Fig. 18.—Illustrates the appearance of the Arvin model 6 installed under the dash.

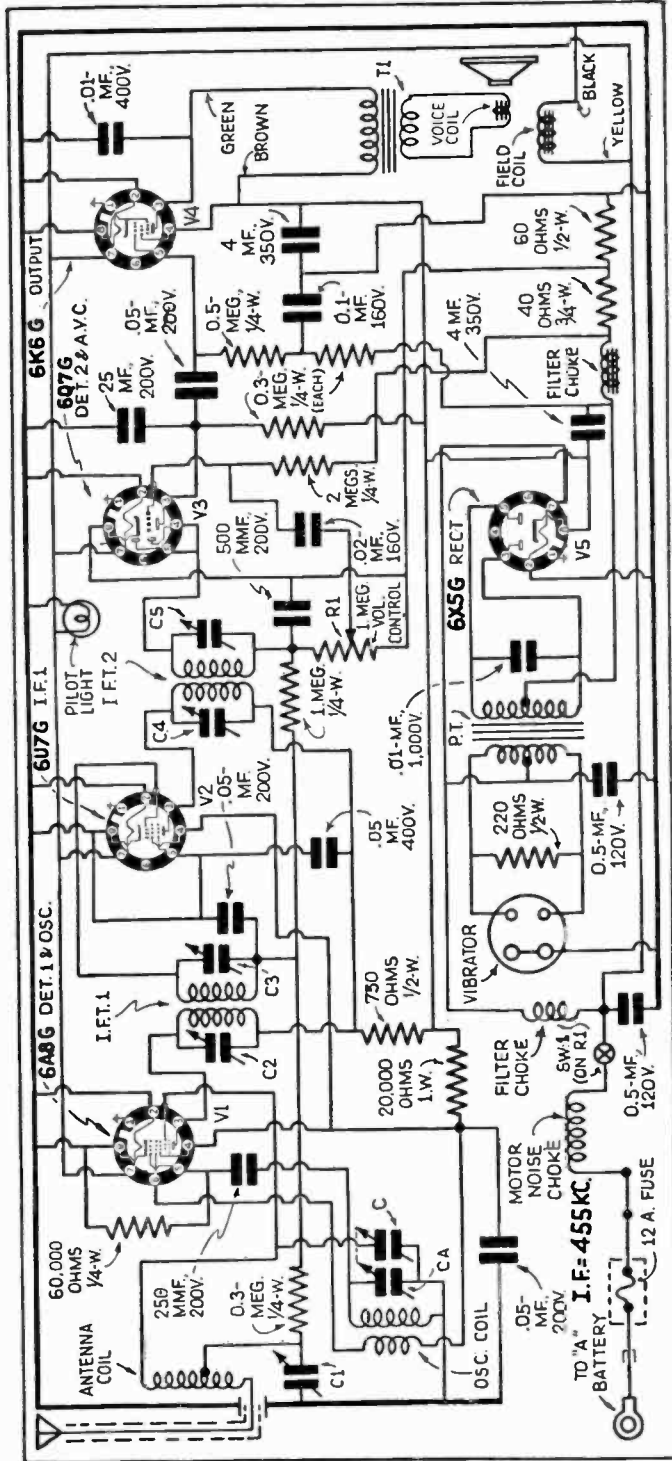


Fig. 15-16.—The schematic of the Crosley Model A-157 single-unit under-dash type of receiver. With the exception of the lack of the R.F. stage the circuit is conventional.





## CHAPTER III

## Installing Auto Sets and Antenna

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 panel. It must not be raised too high, or a great 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 "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.

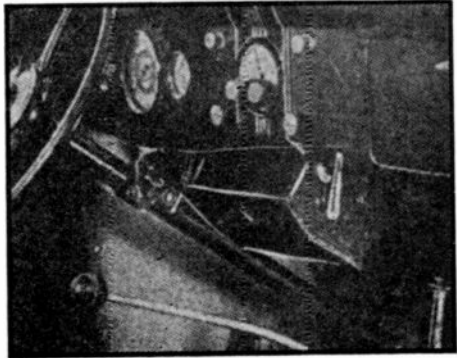


Fig. 21.—Here is a typical Ford installation. Note the clearance which is a result of matched design of the receiver to the automobile.

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.

## 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. See Fig. 21 for appearance of a typical installation of a Ford receiver in a 1936 Ford car. Fig. 22 shows typical installation of a receiver in a Chrysler car. After the actual installation of the set, control, or speakers, and before the antenna of the set is connected, put on the distributor suppressor, distributor and generator cut-

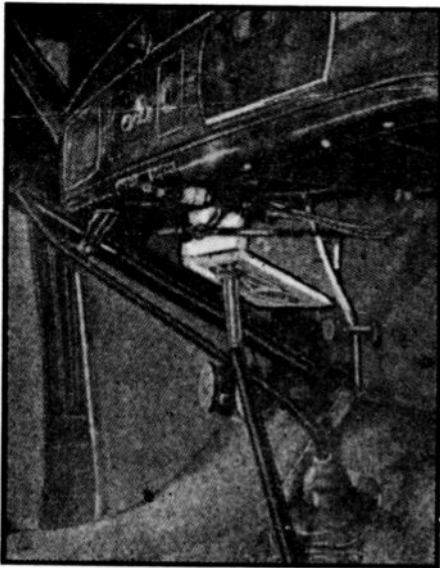


Fig. 22—A Chrysler installation, which also uses a receiver designed to fit the car.

out 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 be found to be 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 is apt to puncture 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 lock 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 slight 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 tip there is a great chance of the distributor cap being split the first time the motor is started. A few tests will generally show how much to use in each individual case. It is better to

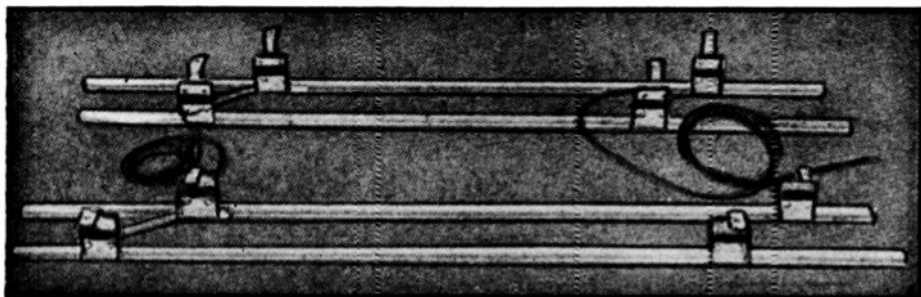


Fig. 23.—An easily installed double runningboard car-radio antenna.

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 pick-up. Try all three suitable places for the least amount of "back up" namely the hot terminal of the battery, the starter hot terminal and the ammeter terminal. When the best place is found, make that lead as short as possible. The writer has found cases where a healthy-size R.F. choke properly by-passed to ground helped immensely. For this purpose a simple choke is made up from annunciator wire wound on a suitable form. From  $\frac{1}{4}$  to  $\frac{1}{2}$  pound of No. 14 is sufficient.

With all these tests made, install the antenna which is to be used, and again compare 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 under car aerial alone, not using the car aerial at all.

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 fish-pole or vertical rod aerials. Whereas the under-car 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 fish-pole or rod aerial.

#### INSTALLATION OF THE ANTENNA

The installation of antennae for automobile use may be in some instances at variance with the recommended type of installation. The owner may desire that a roof antenna be used (in the older cars) while practice would indicate the use of some other type antenna for that particular type car. If one will cast the eye over the variable array of antenna types, some confusion may arise as to what type would be best for any particular installation.

As mentioned before the writer has a penchant for the fish-pole type antenna, principally because results have always been satisfactory, which cannot be said of the other types. Perhaps the writer is prejudiced but as earnings are a result of the least time spent on a job, the writer has learned to steer clear of those elements that give rise to prolonged labor. While the writer has installed radios where the roof antenna was used, he would not do so now even if the installation should be lost.

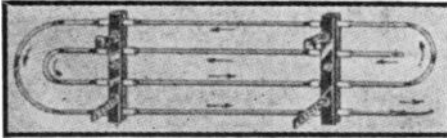


Fig. 24.—The rods of this under-car antenna are arranged so that the pick-up of ignition noise is as low as possible.

In Figs. 23 and 24 are shown running board antennae which have proved satisfactory in many installations. The former is of the dual type, that is, installations are made under each running board. In installing those under-car antennae, it is seldom necessary to drill holes through the running board as the running board studs serve also as a means for fastening antenna brackets. The lead-in, in most cases, should be shielded from the set to within a few inches of the antenna. The pig-tail of the shielding braid should be fastened to the chassis which is always the best ground. The shielding should be grounded to the receiver housing also.

The antenna shown in Fig. 24 is of an improved type, designed so that the pick-up of ignition noise is as low as possible, but the signal pick-up as great as possible.

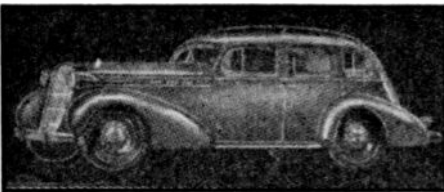


Fig. 25.—The Philco car-top "Topper" antenna conform to the lines of the top of the car and is fastened down with vacuum cups and cement.

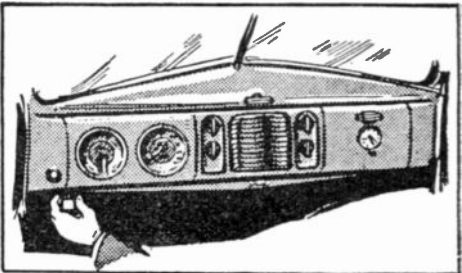
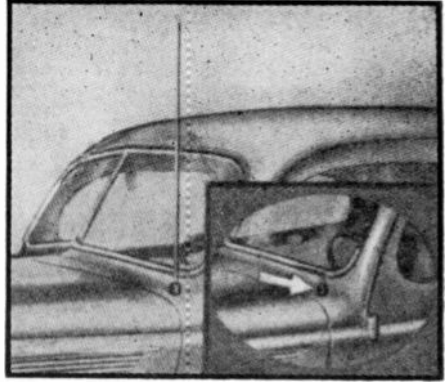


Fig. 26.—Zip!, and this car antenna extends to a height of 44 ins.; Zip! and it recesses to nearly cowl-height (arrow, insert). Note control knob below car's instrument panel.

Some cars have an antenna which is of the high capacity type and is a variant of the roof antenna. This is the solid metal panel recessed in the top of the body. Its use is effective but not recommended because of ignition pick-up troubles involving considerable time in the elimination thereof.

For the turret top cars, the topper type antenna, shown in Fig. 25, can be used. This antenna is fastened to the top of the body by vacuum cups and cement.

Fig. 26 illustrates one of the cowl type antennae, the extension of which may be from the inside of the car, by manual operation or by connection to the vacuum system of the engine. This is of the fish-pole type. Other cowl antennae fasten to the side of the cowl, and require that holes be drilled in the cowl. This is not usually desired by the car owner. Another type of fish-pole antenna is that shown in Fig. 27. This type was primarily developed for use in Ford cars but may be used with

any other type car in similar manner.

Other fish-pole type antennae (not illustrated) have a special bracket which allows them to be fastened to the upper front door hinge. These may come in various lengths and bracket arrangements, but will all be found of more or less equal response. A very satisfactory arrangement is two antennae of this type, one on each side of the car with the lead-ins connected together at the receiver. The leads should be shielded in the usual manner of course.

Another fish-pole antenna which is not illustrated is the bumper type, which is fastened to the rear bumper. This type is not usually satisfactory as the lead-in must be shielded and because of the length the resultant capacity is very high resulting in considerable signal loss. This same condition applies when the rear bumper is insulated from the chassis by fibre washers and is used as an antenna.

In Fig. 28 are shown what may be called ornamental type antennae; these are fastened over the side louvres of the hood. The writer has never used them and would not recommend their use as they by necessity must be installed very close to the metal hood, thereby decreasing pick-up, and increasing capacity.

For Buicks and Oldsmobiles, kits of insulating washers and inserts may be obtained, which are used to insulate the running boards from the body and chassis; thus they may be used as satisfactory antennae.

The writer has insulated the rear deck of Lincoln Zephyrs and Fords, using this rear compartment door as an antenna. The capacity is very high, and the shielded lead long. Unless absolutely necessary this arrangement is not recommended.

There are divers undercar antennae, which are generally not recommended as they are subject to breakage by road-bed obstacles, which also is one of the faults of the running-board antenna.

SUMMARY

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 rewir-

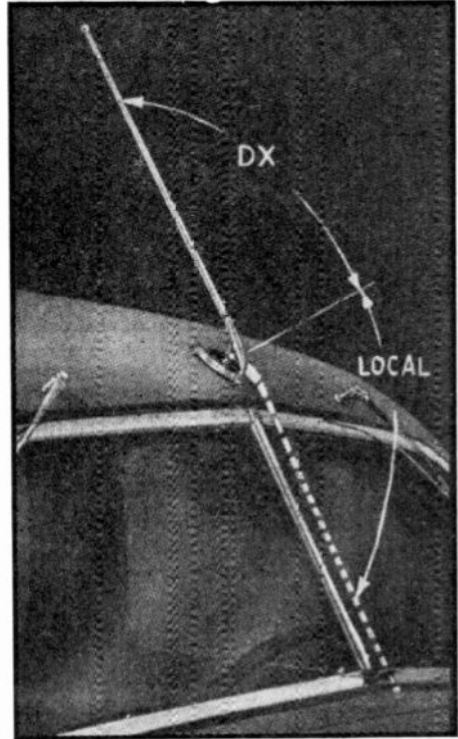


Fig. 27.—The Ford type of "fishing-rod" antenna. A knob on the header bar controls either the raised or lowered position. An extension telescopes into the rod shown, extended, the total length is 30 inches.

ing ignition systems for new switches there is any chance of a short, take the time first to disconnect the hot 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

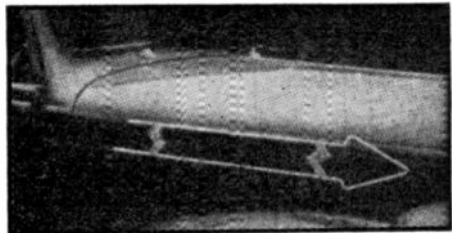


Fig. 28.—An ornamental type of antenna which is fastened over the louvres on each side of the engine head.

your own customers send around their friends. Fully 75 per cent of the work done is by recommendation to the shop, simply because the men were clean and courteous. Where a man sees a technician 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 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 every wire should be properly installed so that the shielding cannot possibly short and cause 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 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, 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 "dig up" \$700 for the damage.

So 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 misplacement 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 \$5 plus cost of aerial 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 \$1.25 is deducted from this figure.

On all outside work where it is simply "noise elimination," a flat rate of \$1.00 to \$2.00 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.

## CHAPTER IV

## Automobile High and Low Tension Electrical Systems

IN order that effects of interference from the various electrical systems of the automobile may be eliminated from response of the automobile receiver, it is first necessary that the purpose and functions of the systems be thoroughly understood.

Every gasoline operated automobile has what is known as a high tension or ignition system. This system is the direct cause of at least 75% of the complaints by the owners of the receivers. The interference may be induced into the receiver through the antenna system or through surges and voltages induced into the low tension system. To thoroughly understand the nature of these interfering disturbances let us now analyze the electrical systems of the automobile and in this way understand how they are produced.

In Fig. 29 is given an 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 closed. 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 gaso-

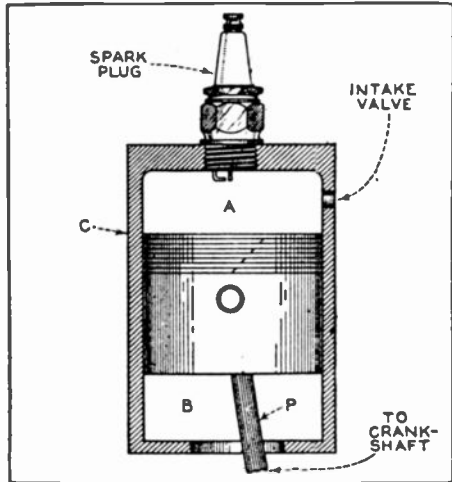


Fig. 29.—A sketch that illustrates the elements of an elementary single cylinder of an automobile engine.

line 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 another) valve. The piston then starts downward again and in so doing, gas again enters the chamber at A with a repetition of the preceding steps.

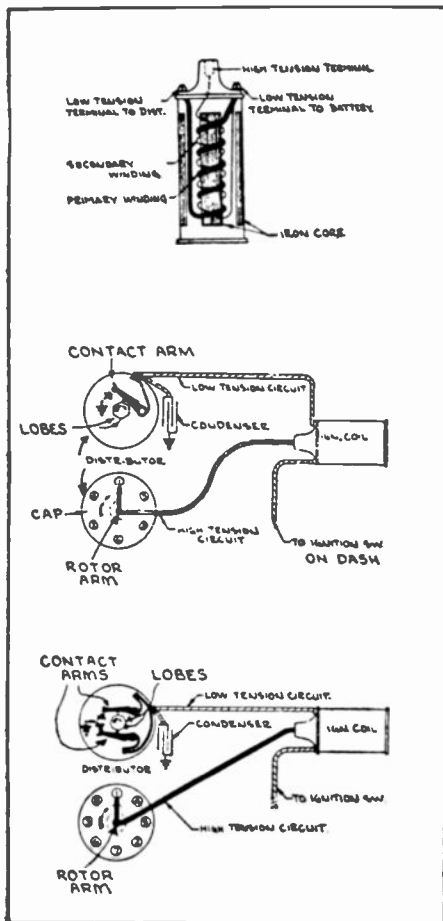


Fig. 30.—Above, details of the spark coil; below, two types of automobile distributor systems.

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 of the motor 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 diagrammatically in [top] Fig. 30. 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 sec-



ondary 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. 30. 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. 30 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. 30 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 breaker cam with half as many lobes as there are cylinders in the motor and using two breaker arms. (Top Fig. 31) 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. 31). 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 dis-

tributor 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. 31).

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.

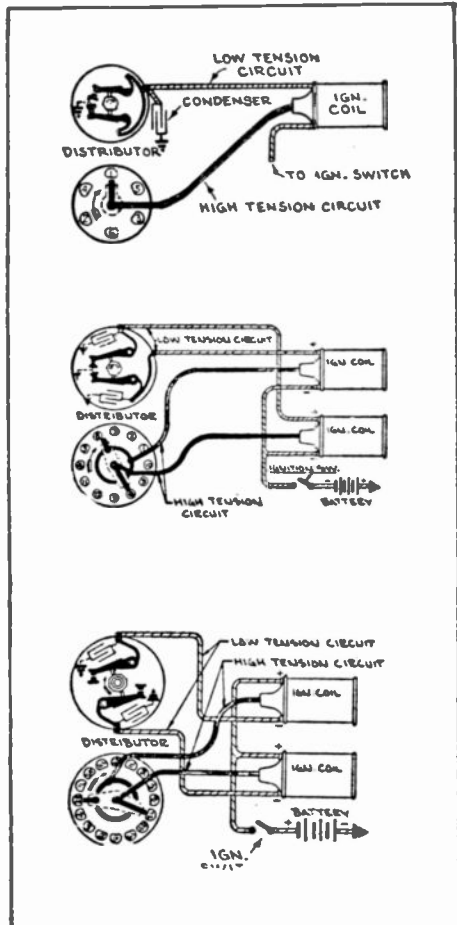


Fig. 31.—Three additional types of distributor systems to which the text refers.

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 will show 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. 32.

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, 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 generated in a wire increases as the strength of the field in which the wire is

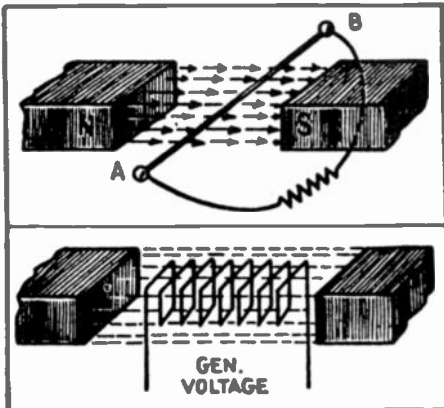


Fig. 32.—Illustrating how a moving wire passing through a magnetic field develops electrical energy.

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. 32 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 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. 32 were looped as indicated in bottom Fig. 32, 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 motor-coaches. 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

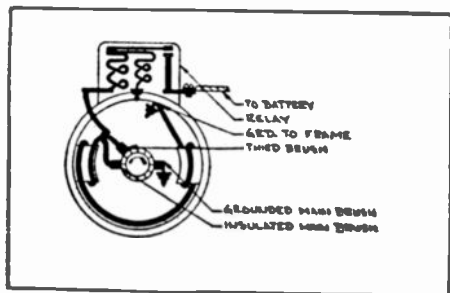


Fig. 33.—Sketch indicating the position of the third brush in the housing of the generator.

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. 33) 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 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 battery 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. 33)

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 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. 34.) 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. 34.) Resistance units vary in size. They usually are 1/2, 3/4, 1 or 1 1/2 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. 34.)

This type of high- and low-output generator with third-brush current reg-

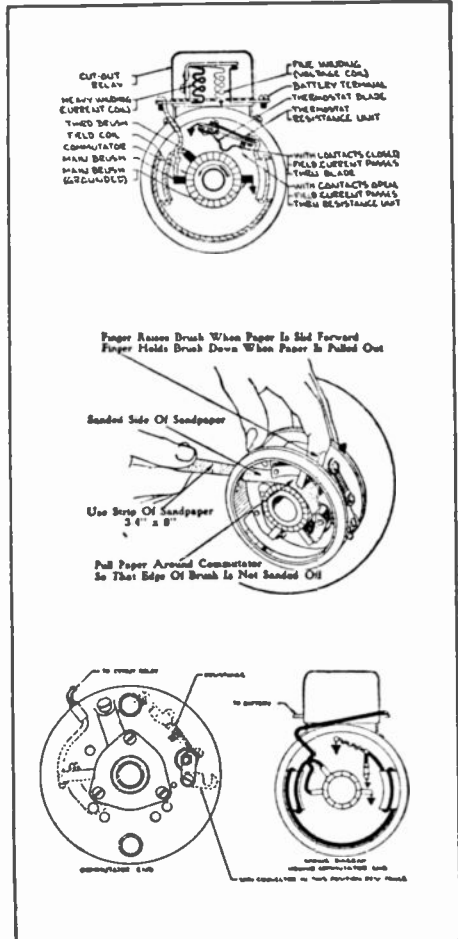


Fig. 34.—Elements of the automobile generator. The center sketch illustrating how the brushes are seated properly.

ulation 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 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. (Center Fig. 34). 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 sand-paper 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.

### 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 depth. (See Fig. 35). 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. Be-

fore 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 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. 35.

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.

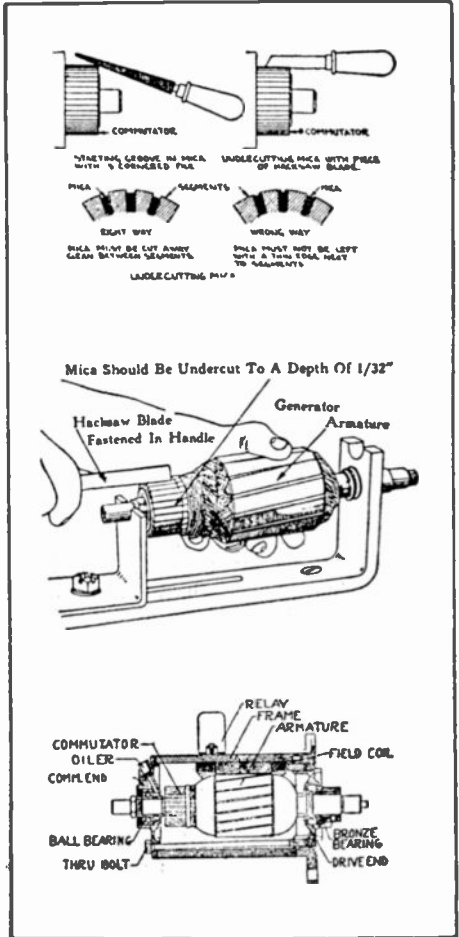


Fig. 35.—The automobile generator commutator and how the mica is undercut as explained in the text.

## CHAPTER V

# Automobile Electrical Disturbances

### 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 of high sensitivity (about one microvolt 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 plug;
- (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 second

dary 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.

### HIGH TENSION IGNITION CIRCUITS

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

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 disturbance 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 cir-



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 more satisfactory remedy is to isolate the receiver from the electrical system of the automobile by suitable filters. In the modern day receivers, these filters, both in the antenna and the low tension supply circuits, are an important part of the receiver's design.

In many instances the filtering, though extensive, is not adequate because of the intensity of the disturbances, and must be supplemented by the reduction of the disturbances at their sources to below troublesome levels without impairing the operation of the vehicle.

RELATIVE LOCATION OF THE CIRCUITS

Fig. 36 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 principal 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 leads 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.

Antennae of the fishpole variety which

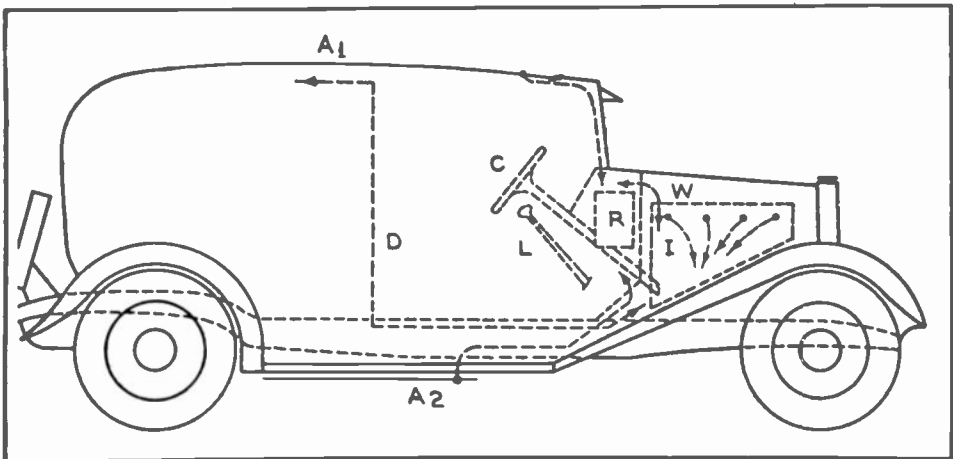


Fig. 36.—Schematic circuit of an automobile illustrating the circuits to be considered in the locating and analyzing of interference.

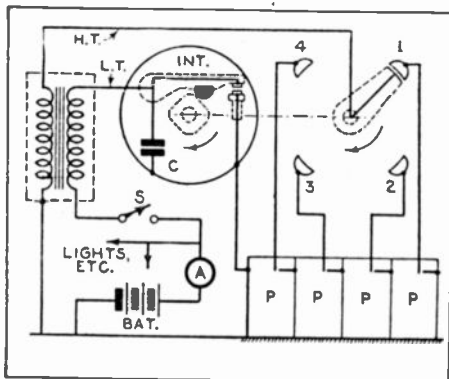


Fig. 37.—Wiring diagram of a typical distributor system.

are not shown in the figure, are preferable for present day receivers and automobiles, but the handling of the leads must be carried out in the same manner as for the antenna types described above.

Figure 37 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 through a cam operated interrupter which, incidentally, is run at  $\frac{1}{2}$  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 extinguish-

ing 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 values are the audio frequencies and not the carrier frequencies.

Figure 38 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 of 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 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.

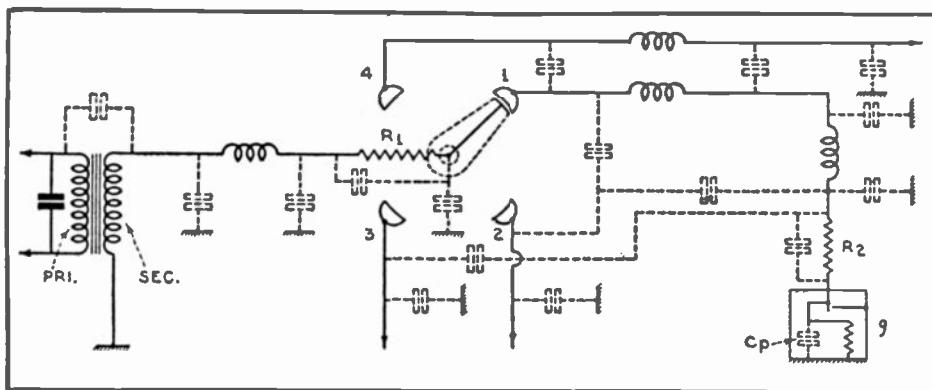


Fig. 38.—This diagram indicates the distributed inductances, capacities and resistances in the ignition system of the automobile.

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 reduce 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 or better still the wire wound or inductive type suppressors in the leads leading to the sparking electrodes. A single suppressor, close to the rotor in the distributor, connected in series with the ignition-coil lead that terminates at the rotor arm is usually effective but if not additional suppressors in the leads at each of the spark plugs are quite effective. Fig. 39 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. 39. 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 suppres-

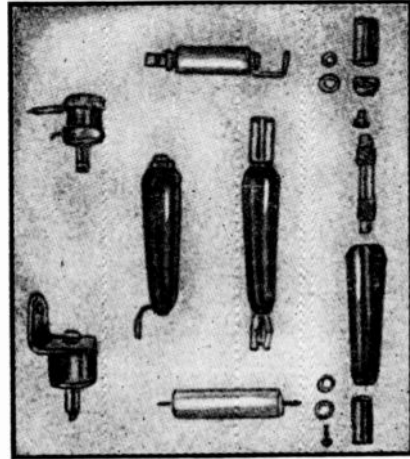


Fig. 39.—Illustrating some of the commonly used types of suppressor resistors.

sor 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 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.

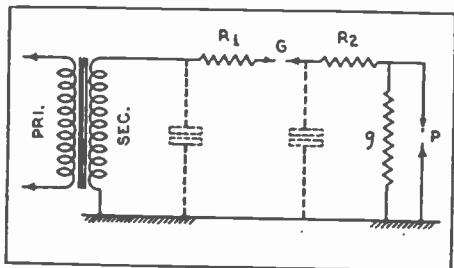


Fig. 40.—Equivalent circuit of a spark plug connection.

### 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. 40. 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  $R_1$  and  $R_2$ , 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 although the wire wound inductive type is preferred. 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 41 shows the primary circuit and the distributed constants involved in interference originating at the low-tension interrupter or breaker arm. The function of condenser  $C_1$ , 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  $C_2$  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

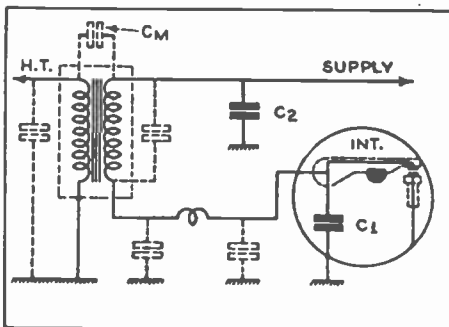


Fig. 41.—Illustrates the distributed constants of the primary circuit of the ignition coil.

as possible and not coupled (placed adjacent to) to other conductors which might absorb 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  $C_2$  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 the coil is close to the distributor, and a short conductor connected between the coil and interrupter. This connection as well as the high-tension cable should be as short as possible.

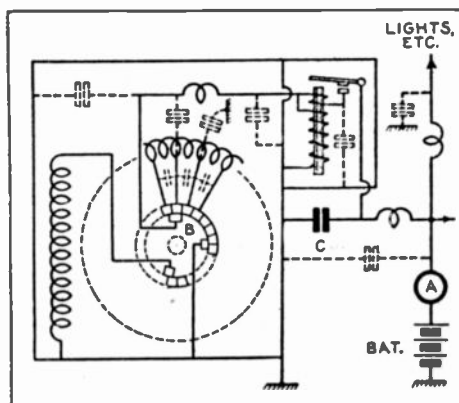


Fig. 42.—Shows the complete electrical circuit of a typical third brush generator circuit.

#### COMMUTATOR INTERFERENCE

The circuit of a typical third brush lighting generator is shown in Fig. 42. 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 it 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 chassis 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 the point where they enter the receiver chassis. The leads from the "B" battery or "B" eliminator if not contained within the receiver housing 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 loud-speaker 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.

"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, when experienced in older model cars where roof aerial is used.

"If chassis pick-up still occurs it is due to either of the following causes: (1) Defective grounds and bonding. (2) Cover of set making poor ground to set housing. Remove cover, and clean lips

of cover and set housing with fine sandpaper. (3) 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 lumps that hold it in place.

"In cars such as the 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 to the motor compartment. It can usually be mounted in the motor compartment, directly opposite the position it assumed in the driver's compartment, and using the same mounting holes.

"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; because of internal high voltage breakdown and arcing, 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. Bypassing the leads 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.

"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. Bonding 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  $\frac{3}{8}$ " 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 similar 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. by-pass 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 the writer has endeavored to give these hints in the order of their importance:

- (1) Apply suppressors to distributor or to spark plugs.
- (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, in older type cars.
- (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 .5 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 an 0.5-mf. condenser to tail and spotlight wires."

#### 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 many, but is to the majority of radio men, this section 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, 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 Zenith. From actual shop time records, with very 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  $\frac{1}{2}$ -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.

Installation and service hints on various receivers and cars will be found in the rear of the book.

## CHAPTER VI

# Vibrator Converters and Motor Generators

FOR some years past the vibrator converter has been more or less universally employed as a means of changing the 6 volts D.C. from the automobile battery into the higher voltages as required for the efficient operation of the modern automobile receiver.

The principle of operation is very old,

and as mentioned in the first chapter, was employed in Dr. Lee De Forest's apparatus back in 1907. It was not until the years of 1931 and 1932 that rapid strides in the improvement of these devices were made.

The first commercial type vibrators were crude and inefficient devices, but in them the far-sighted engineers were able to see the possibilities for the conversion of the 6 volt D.C. from the automobile battery into the alternating current that could be stepped-up to the high voltages as required for the efficient operation of a receiver.

### VIBRATORS OF THE SERIES TYPE

The mechanical and electrical design of the early vibrators was of the series type, in which the current flows through the magnet coil only when the vibrator reed is in contact with one of the vibrator points, so that in the starting position the reed must be in contact. The action of this type of vibrator is shown in Fig. 43A and 43B. It will be noted that the current flows through the circuit less than one half of the cycle

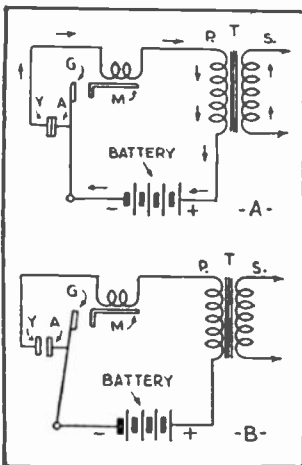


Fig. 43.—Illustrating the principle of operation of the series type of vibrator.

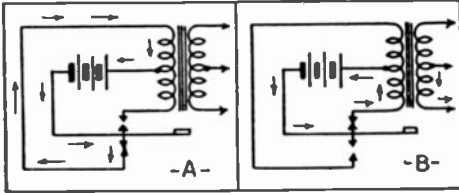


Fig. 44.—Illustrates the action of the full-wave type of series vibrator.

or complete excursion of the reed.

The 6 V. coil of the power transformer is the only resistance in the circuit at starting, accordingly there is a very heavy load of about 10 to 12 A. placed across the battery. Since the resistance of the filaments is also low when they are cold, there is an additional load of something like 10 A. or a total of 20 A. at starting.

When this drain is placed on a partially discharged or undersized battery, it can very easily drag the battery voltage down to a point where there is insufficient voltage to start the vibrator as well as the car.

When such a condition occurs it may result in the burning out of the vibrator or the power transformer or at least opening the line fuse.

Arrows show current flowing from the negative terminal of the battery, up the vibrator reed, across point A-Y through magnet coil M, around through the transformer and returning to the positive side of the battery. This flow in the primary sets up a secondary current, flowing in the opposite direction.

When the current flow reaches the magnet coil, it causes the magnet to attract counterweight G, breaking the contact Y-A. Breaking the circuit halts the action of the magnet, and the spring action of the vibrator reed causes it to rebound, again making contact at Y-A.

Because of the heavy drain at start-

ing, this type of vibrator is difficult to start and should it fail, it will be observed that the vibrator points must carry the load of the low-resistance magnet coil and the transformers primary in series across the battery.

In Fig. 44A and 44B is shown the action of the full-wave type of series vibrator. Note that a 12 volt winding is used for the primary of the transformer, the center-tap of which is connected to the supply voltage.

Here the core of the transformer is used as the magnet. At starting position the reed is in contact with the lower point permitting current to flow from the negative pole of the battery, as shown by the arrows, through the upper half of the primary of the transformer. The pull of the magnet attracts the reed counterweight, breaking the contact and halting the flow of current. The reed continues its swing until contact is made with the upper point of the circuit causing current to flow.

Objections to this type of vibrator are the same as to any series vibrator.

VIBRATORS OF THE SHUNT TYPE

Fundamental design of the shunt vibrator overcomes all of these difficulties. In this type of unit at starting or neutral position, the vibrator reed rests midway between the two contact points. A high-resistance magnet coil is inserted in between the battery and the vibrator and is shunted out when contact is made at the vibrator points. The result of this resistance is a reduction in starting drain from 10 to 2 A. Should the vibrator fail to start (and the low drain makes starting considerably easier), the vibrator cannot be harmed because it is out of the circuit, and the high-resistance magnetic coil guards the power transformer.

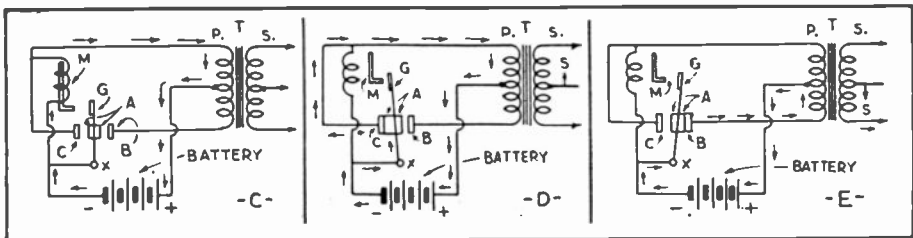


Fig. 45.—Illustrates the principle of operation of the full-wave shunt type of vibrator.

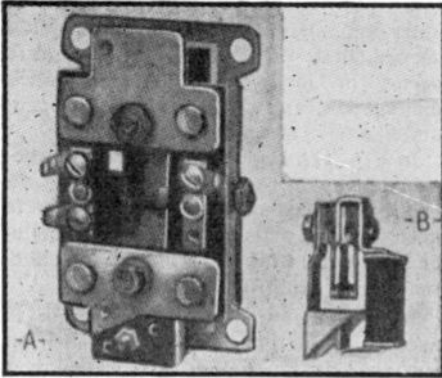


Fig. 46.—Shows the old series type (A) as compared to the smaller more efficient shunt type vibrator (B).

Vibrator engineers have continued to make progress in mechanical as well as in circuit design, as may be seen readily in comparing the modern full-wave shunt vibrator illustrated in Fig. 46 with the older model, full-wave series vibrator it was designed to replace.

The new shunt vibrator will give more than three times the life of the older model, and at the same time deliver considerably more current at higher voltage. Likewise it provides a steadier output, and it might also be mentioned that it requires less than 1/6th the space.

Many years of intensive research with materials has resulted in better spring steel for the reeds, better tungsten for the points, and better bronze for the contact arms.

Development has proceeded steadily in increasing the frequency of the vibrators, which likewise has contributed to steadier operation, longer life and lower "hash" or interference level.

Workmanship has, of course, kept step with other developments. Through the use of such modern scientific instruments as the "comparator" and the "oscilloscope", vibrators now coming from the production line are held to very close limits of adjustment and performance.

Figures 45C, D and E represent the complete action of the full-wave, shunt-type, non-synchronous vibrator.

In the starting position it will be seen that the vibrator reed rests midway between the two points and should it fall

to start, the vibrator will not be damaged. Also the fact that the magnet coil in this shunt vibrator may be of high resistance, as it is shunted out of the circuit, when contact is made at either point, protects the transformer.

Figure 45C shows current flowing through the magnet coil, attracting counterweight G, causing the action outlined in Fig. 44. Contact has been made at A-C, shunting the magnet coil from the circuit, and current continues to flow through the upper half of the primary of the transformer. The secondary current is, of course set up in the opposite direction.

Shunting the magnet coil from the circuit has caused it to lose its attraction for counterweight G and spring action in the reed causes it to rebound until contact is made at A-B as shown in Fig. 45D.

Here it is seen that the flow of current in both primary and secondary has been reversed from that of Fig. 45C, and a more or less true form of A.C. has been generated.

After contact has been made at A-B, spring action causes reed to reverse itself, breaking contact, and putting magnet back in circuit.

Figures 46A and B represent the old type full-wave series vibrator and the new and smaller shunt type (B).

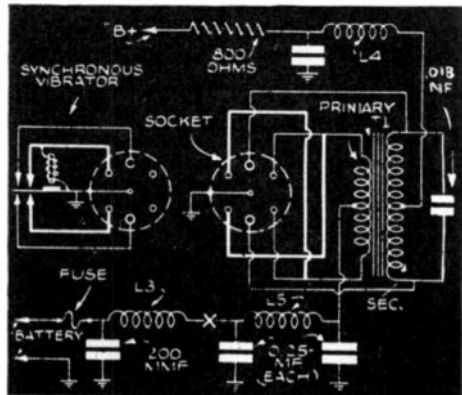


Fig. 47.—Illustrates the circuit arrangement of the full-wave synchronous shunt type vibrator.

VIBRATORS OF THE SYNCHRONOUS SHUNT TYPE

In Fig. 47 is shown the schematic of a full-wave synchronous shunt type vibrator which is used in many of the current receivers. The use of the synchronous vibrator effects economy of space and will handle larger values of current on the secondary side as compared to the non-synchronous vibrator used in conjunction with the conventional rectifier type.

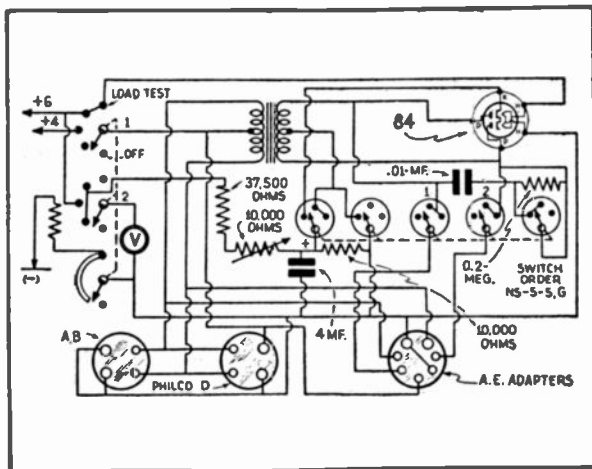


Fig. 48.—Here is given the circuit of a vibrator tester. Component values are given for critical elements. Other components such as the transformer are conventional.

In the synchronous type of vibrator which serves as a primary circuit interrupter and a synchronous rectifier for the high-voltage output, the polarity of the primary determines the polarity of the output voltage produced. In a tube rectifier, the tube can make use of current flowing in only one direction, thus insuring the correct output polarity. However, the synchronous rectifier is essentially a 2-way circuit, depending entirely on timing of the contacts. Thus, it can produce an output of either polarity.

To compensate for the fact that in some automobiles the negative of the storage battery is grounded, while in others the positive is grounded, the primary or secondary of the power transformer must be reversed for one of the connections. In Fig. 47 the vibrator socket is noted to be a symmetrical 6-hole socket, while the vibrator is a plug of the same pin arrangement, but using only 4 pins. Both socket and plug are marked with polarity for either installation.

Note in Fig. 47 that when the vibrator is removed, turned 180 degrees and replaced, the primary connections are unchanged while the secondary terminals are reversed.

SERVICING VIBRATORS

Vibrators are one of the major service problems of the serviceman that specializes in automobile radio service. The cost of the present day efficient plug-in replacement, hardly makes it worth the trouble and time for re-conditioning and re-adjustment of old vibrator units, which are arranged for vibrators. However there are times that emergency service must be rendered in which case the points may be ground or filed down. Adjustments on old vibrators are seldom satisfactory and the serviceman should be equipped with a suitable vibrator tester which will save him much time in determining the conditions of suspected units. There are various of these testers on the market which although in many instances an additional expense will prove their worth in many instances. In Fig. 48 is given the schematic of a suitable vibrator tester which will handle all types of units. This device is simple of construction and operation and can be easily constructed in a short space of time.

THE MOTOR-GENERATOR

There are numerous devices of this type on the market and as their principles of operation are much the same, only one type will be described. These devices are generally used nowadays for trouble-free installations where large voltage and current requirements would

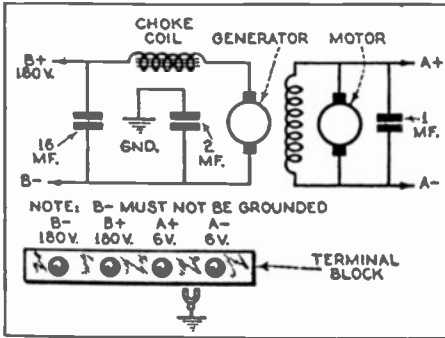


Fig. 49.—Here is the electrical circuit of the Genemotor.

prove too great were a vibrator used. However, in passing, it can be mentioned that heavy duty vibrators have been developed which are just as satisfactory and require less physical space. The efficiency of the motor-generator is generally around 50 to 60% as compared to the 90 to 98% efficiency of vibrators.

In Fig. 49 is shown the schematic of the Genemotor. These devices may be considered as rotary transformers. While some use a separate driving motor from the generator, others of the Genemotor type have two windings on a single armature. These windings are the low voltage and high voltage windings which terminate in commutators at each end which serve in the former instance for converting the direct current into alternating current, and in the latter case for converting the high voltage alternating current into direct current. The field winding which is of the shunt type is supplied by the battery to which the low voltage side of the armature is connected. The low voltage side of the device is shunted by a condenser to reduce commutator sparking, while the high voltage side is filtered by filters of adequate design that smooth out the commutator ripple. Some of the devices are provided with voltage-dividers on the high voltage side in order that the desired voltages may be selected. Other

devices are of a dual type and these are used where very large output current requirements are necessary in the operation of mobile public address equipment, etc. Fig. 50 shows one of the single unit Genemotors, which is placed within a shielded compartment or housing for both interference elimination and protection from outside elements.

### SERVICING THE MOTOR-GENERATOR

After some time has elapsed, it is well to sandpaper the commutators. As described in a early chapter for the care of the automobile generator, emery paper should never be used. Care must be exercised so that the commutator segments are not shorted. The mica separators between the segments should be undercut in the same manner as for the automobile generator. The brushes should be reseated or else sparking will take place; sparking is one thing that will ruin a commutator. The noise that results when brushes are poorly seated cannot be eliminated by the usual filter, as it is not designed for this purpose.

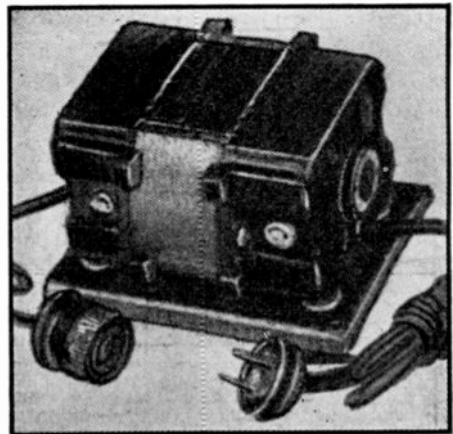


Fig. 50.—Illustrates one of the Genemotor models from which an output of forty watts may be obtained. The cover is not shown.

## CHAPTER VII

## Service Hints, Automobile Installations

## GENERAL CONSIDERATIONS

**A**S in servicing ordinary home receivers, an analyzer, or multimeter, oscilloscope, tube and vibrator tester, ohmmeter and capacity meter, in addition to tools (such as soldering iron, wrenches, pliers, etc.) are necessary equipment of each auto-radio technician. To attempt to service correctly a radio of any type without the proper instruments will, in many cases, lead to an unfortunate failure. A great many auto-sets are installed each year and consequently much service work from this direction can always be expected. The outlay for adequate instruments and tools will eventually be repaid to the investor many times over.

The description of the various elements given in this book dealing with the subject of automobile radios brings out many very pertinent facts. First, the physical location of the receiver and antenna with their respective leads and cables, is usually subject to rules stated by the manufacturers of both the car and the receiver, although considerable leeway is allowed in most instances. Second, it is essential that the receiver be mounted in such manner that there will not be interference in the control and operation of the car. Third, the grounded side of the battery (polarity) must be determined for correct installation and operation of the receiver. Fourth, all leads must be shielded and well grounded. In this connection the writer might emphasize the fact that in any automobile installation of a receiver, the ground is highly important. Remember, there is only one good ground on a car and that is the chassis. Fifth, all leads must be as short as possible.

All modern automobile receivers have filters included as a part of the receiver design. These filters are perhaps the most important element of the receiver as far as interference is concerned. Insufficient or defective filtering is sure to result in noisy reception, so that care must be taken to see that they are connected properly, and proper part values employed, if ever repaired or replaced. The service-man may spend many 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 that it needs looking over every three months might bring in additional business that would not be obtainable otherwise.

## SERVICE HINTS

A summary of possible 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 applied 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-connections 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 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 if roof antenna is employed. 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 600 and 550 K.C., with the volume control about three-fourths on. On some part of the chassis housing will be found an opening or hole. Directly under the hole in the chassis housing 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 fully 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 three types:—

- (1) Vibrator-interrupter type—using tube for rectifiers.
- (2) Synchronous type vibrator.
- (3) Motor-generator type—motor operating on 6 volts.

In the first and second types of units, replacement of the tube and vibrator contacts must be expected after they have 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.

**PROCEDURE FOR VARIOUS  
CARS**

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.

**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 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 at 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.

**Buicks**

Install screening on floor under receiver in older model cars, ground the screening to the chassis.

Install a generator voltage control, if the generator is not already equipped. Ground the terminal marked "F." Charging rate should not exceed 20 amperes.

Install distributor suppressor, generator and ammeter by-pass condensers.

**Cadillac, and La Salle**

Install by-pass condensers on generator, and across terminals of electric clock.

Install condenser across low tension side of coil, with the condenser placed inside the coil case. Solder one end of the condenser to the inside of the case.

Install wheel static collectors.

**Chevrolet—Older Models**

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. Use all suppressors and condensers; 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.

High tension interference in many of the pre-turret top General Motors cars, especially the Chevrolet, is almost unavoidable when the radio is mounted on the right side of the car. The ignition coil and electro-lock cable, mounted on the motor side of the bulkhead or fireboard, is so closely coupled that despite all the shielding and tuned filtering, there is still a certain amount of coupling. Remedy is to mount the radio on the left side, keeping the battery and antenna leads as far from the coil as possible.

In other Chevrolet installations, cover the floor boards with copper screening which should be grounded to the chassis.

In some installations, a .006 mfd mica condenser connected across the points of the distributor is effective.

**Newer Models**—Install a dual bypass condenser on the Master 6 models. Connect another bypass condenser from the discharge side of the ammeter to the bottom edge of the instrument panel.

Install wheel static collectors. Install distributor suppressor.

#### **Chrysler, DeSoto, Dodge and Plymouth**

In pre-turret top cars, antenna lead is in left front pillar, but either hinge or running board type antennae are recommended. If roof antenna is used, shield lead from pillar to receiver. Ground shield at both ends. Install bypass condenser, or better still a dome-light filter on dome light lead at pillar.

Install generator and ammeter condensers, and distributor suppressor.

Bond engine at front and rear to chassis. Bond steering post, speedometer and other cables together and to chassis. Bonding of the top metal section of the distributor to the lower section will some times help.

In older model cars, coil should be moved up next to the distributor. Bypass coil to engine.

In stubborn cases try inductive type spark-plug suppressors.

#### **Fords**

**Model A**—May be necessary to replace the choke rod with flexible type in order to install receiver, if the receiver is large. Use distributor suppressor, generator and ammeter bypass condensers. Bond steering post and metal cable through fireboard. In stubborn cases sparkplug suppressors may be required.

**Model V8**—Install condenser with special bracket on distributor. Bypass condensers on oil and gasoline gauges. On the former watch for accelerator arm clearance. In cars prior to 1937, use dome-light filters, although a condenser may be sufficient in many cases. Running board or hinge antennae are recommended. Try bypass condensers on starter relay and low voltage "hot" lead behind instrument panel. Shielding of lead from ammeter to terminal block is sometimes effective. Ground the cable to the fireboard or bulkhead with a self-tapping screw.

Some installations require the engine to be bonded to the chassis. Separate low from high tension leads, and as far apart as possible. In extreme cases must use special distributor suppressor.

On installations where the roof antenna is employed, the resistance between the antenna and the body should be above 5 megohms if the antenna is to be effective.

#### **Hudson—Terraplane**

Bypass generator and ammeter. Use distributor suppressor. Bond floor boards to transmission, one on each side. Bypass electric gasoline and water gauges.

Bond metal cables and steering post on motor side of fireboard, together, and to chassis. Bond the muffler to the chassis.

Door hinge or under-car antenna recommended for these cars.

#### **Hupmobile**

Bypass generator and ammeter. Install distributor suppressor. Use condenser or filter on dome light lead, if roof antenna is used. Shield and ground

antenna lead at post and receiver ends. Bond metallic cables that pass through fireboard, as well as steering post.

#### Lincoln V12

If roof antenna is used, lead is found on left side of car behind rear seat. Drill hole through floor-boards, and pass shielded antenna lead up front to the receiver. Shield and ground the lead at each end, and at middle, to chassis.

Install bypass condensers on generator and ignition coil. For extreme cases employ inductive or wire-wound spark-plug suppressors. Use distributor suppressor where possible.

#### Lincoln Zephyr

Roof antenna lead-in at base of left center door pillar, but in those cars equipped with the roof antenna, hinge or under-car antenna is recommended.

Install generator condenser. Two condensers with special brackets on distributor. Use bypass condenser on starting relay, and electrical oil gauge. Install bypass condensers on gasoline gauge and the water gauge terminals. Use bypass condenser across the coil resistance under the left cut-out mounting strip bolt at the dash and connect the lead to the battery terminal of the relay.

May be necessary in some instances to use the special distributor suppressor, and sparkplug suppressors. Also to bond all metal cables through fireboard, as well as steering post.

#### Nash and Lafayette

Install generator and ammeter condensers, distributor suppressors. Bypass or filter dome light lead, especially when roof antenna is used. On later cars hinge or cowl rod antenna is recommended. Some cases require additional bypass condenser on coil.

Bond metallic cables through dash. Some times grounding steering post is effective.

#### Oldsmobile

Install generator and ammeter condensers. Use distributor suppressor. Bond transmission to chassis cross member. Be sure of good electrical connections. Bond engine at left rear cylinder head bolt to the bolt at top of starting pedal bracket.

Install wheel static collectors.

#### Packard

Install generator and ammeter condensers. Use distributor suppressor. Bond all metallic cables through fireboard. Bond the steering post to fireboard, dash and chassis. Install inductive type distributor suppressor; some installations may require sparkplug suppressors, the spark plug gap should be .030 inch. Ground all ungrounded metal.

Use hinge or cowl or under car antenna where ever possible.

#### Pierce-Arrow

Install generator and ammeter condensers. Another bypass condenser on the current-limiting relay. Bond metallic members through fireboard. Install distributor suppressor. Hinge or cowl antenna recommended. Undercar antenna is also good.

#### Pontiac

Older Models—Place coil in motor compartment near distributor, with same procedure as recommended for Chevrolet installations. Some times necessary to bond and ground cushion springs, and robe racks. Use either hinge, cowl or under-car antenna rather than the roof antenna.

On all cars, install generator and ammeter condensers. Distributor suppressor. Bond torque tube to KY chassis member. Hole provided in K member for this purpose. Have good electrical connection.

#### Studebaker

Install generator and ammeter condensers. Distributor suppressor. On the President models, condenser between ignition coil and bottom edge of instrument panel. Ground front end of muffler to chassis, also back of starter to floor board. Hinge, Cowl or under-car antenna effective in order given.

#### Brake Static

May be apparent in all installations but only when car is moving, whether engine is on or not. In this type of trouble install wheel static collectors to suit the particular type car. Any technician specialising in auto installations should stock various types. See Fig. 51 which illustrates some of these devices.

#### Tire Static

With car under motion, when it has been determined that brake static has

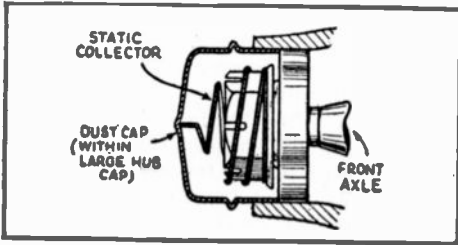


Fig. 51.—Shows front and rear wheel type of static collectors; the rear type (B) has a wiping contact.

been eliminated by wheel static collectors, look for tire patches on both the tube and casing. The noise is usually a loud rasping sound.

**Brake Rod Static**

In those cars which use brake rods a static condition may develop when joints become worn. Remedy is to use anti-rattle springs or better still, flexible copper bonds across the joints.

**Miscellaneous**

A device known as the "Interferotrol" is some times effective in eliminating ignition noises picked up by the antenna. See Figs. 52 and 53.

The filter is placed as close to the set as possible, and a shielded connection made to the antenna lead from the set. The other shielded lead is connected to the regular car antenna. The rubber-covered wire is grounded to any part of the car (to be determined by experiment) which will feed into the system an amount of ignition noise approximately equal to that coming in over the regular car aerial.

The balancing coil is then moved in or out with the set-screw at the end of the can, until the noise is eliminated from the radio set output. The efficien-

cy of the car set is not impaired in any way, and the adjustment holds for all frequencies, and for all conditions of the ignition system.

In order to obtain the best results from the balancing arrangement just described, it is very important that there be no noise entering the set through the battery leads. The line filter at B may be connected in the "hot A" lead and will remove all such noise

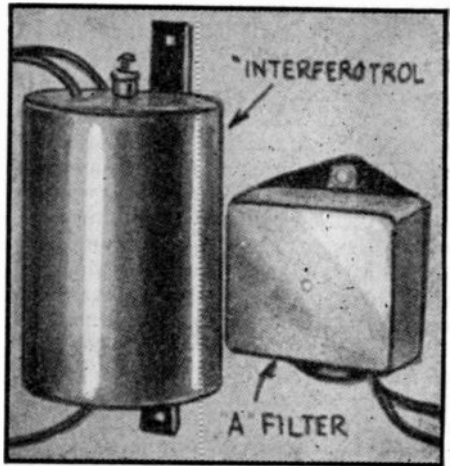


Fig. 53.—The appearance of the Interferotrol beside which is an "A" filter that must be used when the "A" filter in the receiver is not adequate.

before it reaches the circuits of the receiver, so that the balancing system may work to full efficiency. The filter may also be used in other lines which enter the receiver case, such as the pilot lamp lead. There should be no noise in the set with the antenna disconnected.

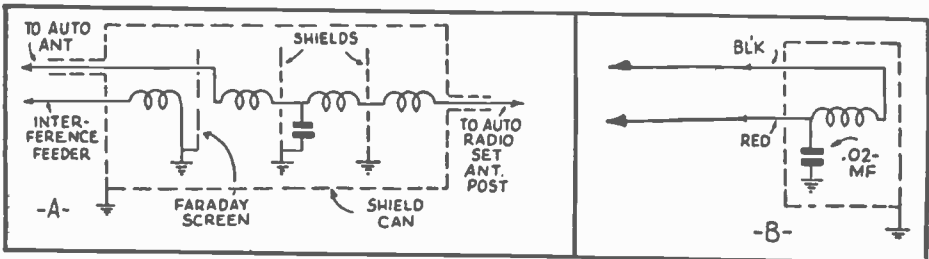
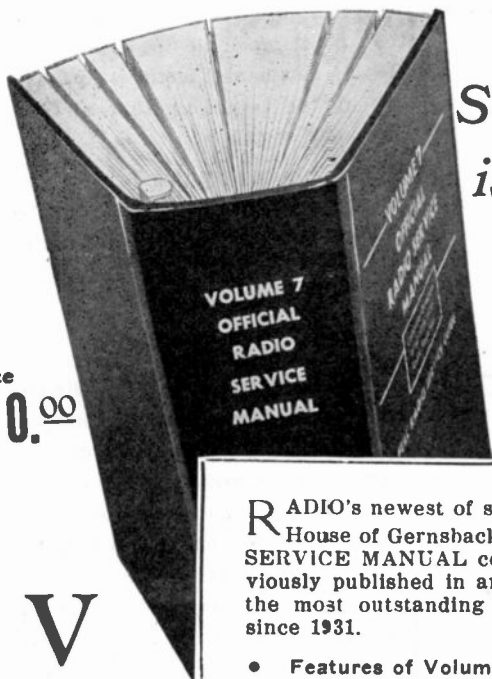


Fig. 52.—The circuit of the "Interferotrol" antenna filter as described in the text.



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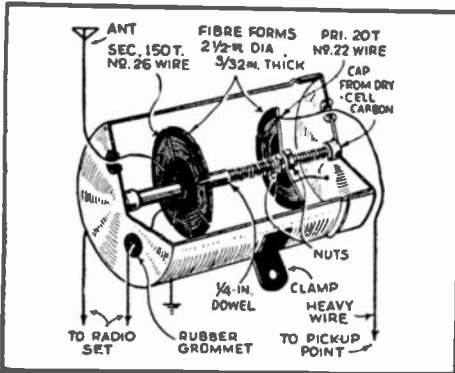


Fig. 54.—Here is a satisfactory antenna filter that may be quickly and cheaply constructed by the serviceman.

Fig. 54 shows schematic of home made arrangement of this type.

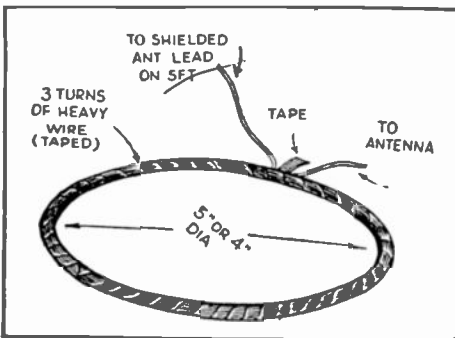


Fig. 55.—Another type of antenna noise bucking arrangement which can be easily constructed and installed by the serviceman.

Another type of antenna bucking arrangement which may be found effective in curing antenna ignition pick-ups is shown in Fig. 55.

Motor noise can be eliminated by mounting a bucking-coil, in the antenna circuit, under the dash of the car. This coil is 5 in. in diameter (see Fig. 55) and consists of 3 turns of heavy bell-wire, one end of which is connected to the shielded antenna lead of the radio, the other end to the antenna lead-in. By means of very little experimenting, while set is in operation and the car running, the exact plane or position in which the coil should be mounted can be determined.

When this position is found the coil can be clamped to the speedometer cable by means of 2 metal straps. The coil should be taped together all the way around to make it stiff.

The voltages set up in the coil buck that set up in the antenna and lead-in. No suppressors, or shielding is needed.

## CONCLUSION

The purpose of completely 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 hothered 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 few years. Practical and successful methods for suppression, we believe, are contained in this book. By diligently following the instructions 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 improved engine design. Perhaps this branch of the industry will employ in the future the methods used by aircraft-radio installation engineers. With co-operation from auto manufacturers, installation would be much more effective and efficient than present procedure.

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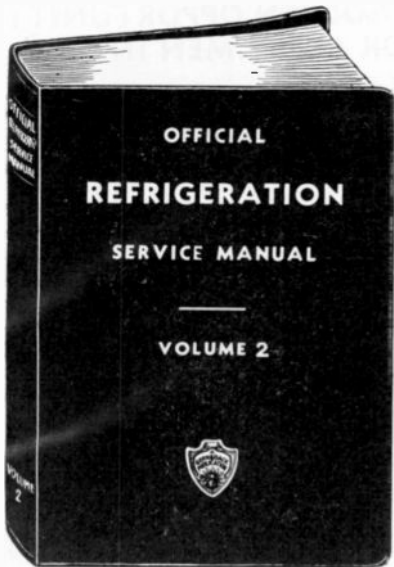
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