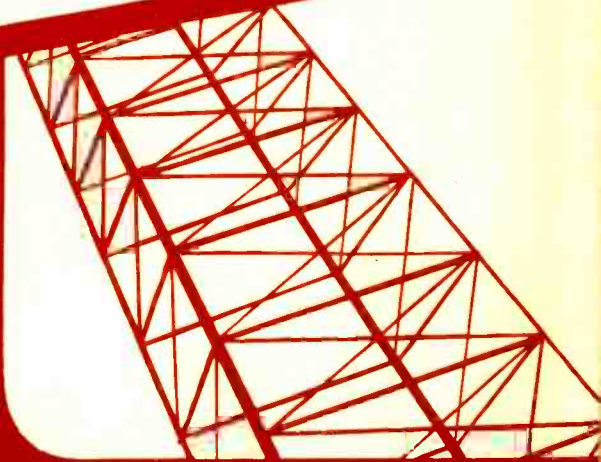




**AUTOMOBILE  
RECEIVERS**  
*Lesson RRT-12*



**DE FOREST'S TRAINING, INC.**

2533 N. Ashland Ave., Chicago 14, Illinois

**RRT-12**





## LESSON RRT-12

# AUTOMOBILE RECEIVERS

### CHRONOLOGICAL HISTORY OF RADIO AND TELEVISION DEVELOPMENTS

1919—The Radio Corporation of America was organized by the General Electric Company in cooperation with the Westinghouse Electric Corporation, after purchasing the Marconi Wireless Telegraph Company.

1920—The first commercial radiophone service in the world was established between Long Beach, California and Santa Catalina Island.

1920—Station KDKA put into operation in Pittsburgh by the Westinghouse Electric Corporation. It was the first station to broadcast regularly scheduled programs.

1921—The first radio broadcast of a championship prize fight (Dempsey vs. Carpenter).

**DE FOREST'S TRAINING, INC.**

2533 N. ASHLAND AVE., CHICAGO 14, ILLINOIS

# RADIO RECEPTION AND TRANSMISSION

## LESSON RRT-12

### AUTOMOBILE RECEIVERS

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#### LIMITLESS

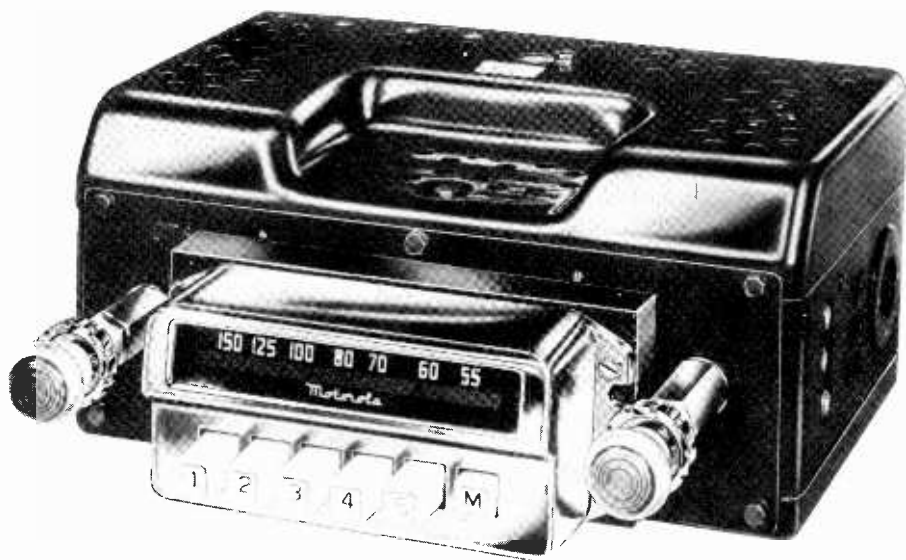
There is nothing, I hold, in the way of work,  
That a human may not achieve  
If he does not falter, or shrink or shirk,  
And more than all, if he will believe.

And whatever the height you yearn to climb  
Tho' it never was trod by the foot of man,  
And no matter how steep—I say you can,  
If you will be patient—and use your time.

## AUTOMOBILE RECEIVERS

At the time the original automobile radio receivers were designed, the only tubes available had  $2\frac{1}{2}$  volt or 5 volt filaments and various circuit arrangements were employed to operate them

to obtain almost any type of tube with a heater designed for 6.3 volts and a current of .3 ampere. Several power tubes require a higher value of current, but, in general, the present auto radio



External view of modern auto radio receiver. The chassis view of this receiver is shown on a following page, while the circuit diagram appears on the fold-out page at the end of the lesson.

Courtesy Motorola, Inc.

with the 6 volt auto battery. All of these were more or less make-shifts because some types of filaments, designed for small currents, were too fragile to give satisfactory life while others designed for larger currents, placed a heavy drain on the battery.

As shown in the tables of a former lesson, now it is possible

requires about the same value of current for all of the tube heaters as that formerly used for single tubes of some types.

In addition to this economy of current, the auto tube heaters are of rugged construction and not at all critical with respect to the voltage changes which occur in the average auto electrical sys-

tem. Like auto type lamp bulbs, they will operate satisfactorily from 5.5 volts up to 8.5 volts.

The development of these tubes has eliminated all complicated filament circuits, as it is now only necessary to connect the heaters in parallel across the supply without any series resistors, the same as is done in the usual a-c broadcast receiver used in the home. For the auto, the regular 6-volt car battery is the source, and for reasons we will explain later, the receiver connections are usually made directly at the battery terminals.

### HIGH-VOLTAGE SUPPLY

Although the 6.3-volt tubes have solved the problems of the filament and heater circuits, like other receivers, the auto radio requires a high-voltage d-c supply for the plate and screen grid circuits of the tubes. In the older types of receivers, B-batteries made up this high voltage supply; and although they gave satisfactory and fairly economical service, they had to be replaced periodically. This feature was objectionable to the average owner, who with his home receiver in mind, demanded an "All Electric" auto radio.

As you already know, by means of transformers it is a comparatively simple job to change the voltage of an a-c supply to almost

any desired value, but in an auto, we have a low voltage d-c supply. As the usual form of transformer will not operate on direct current, various other methods have been developed.

### MOTOR GENERATORS

In large commercial electrical systems, the change from one d-c voltage to another is usually made by means of a motor operating on the line voltage and driving a generator which develops the desired voltage. This same plan has been applied to auto radios, but the motor and generator are combined into a single unit which is known as a "Dynamotor" or "Genemotor".

As shown in Figure I, the circuits are simple and consist of a compound motor which operates on the 6-volt car battery. The low voltage terminals are connected across the battery, and to prevent disturbances in the output, there is a filter made up of the radio-frequency choke, (RFC) and condenser C1.

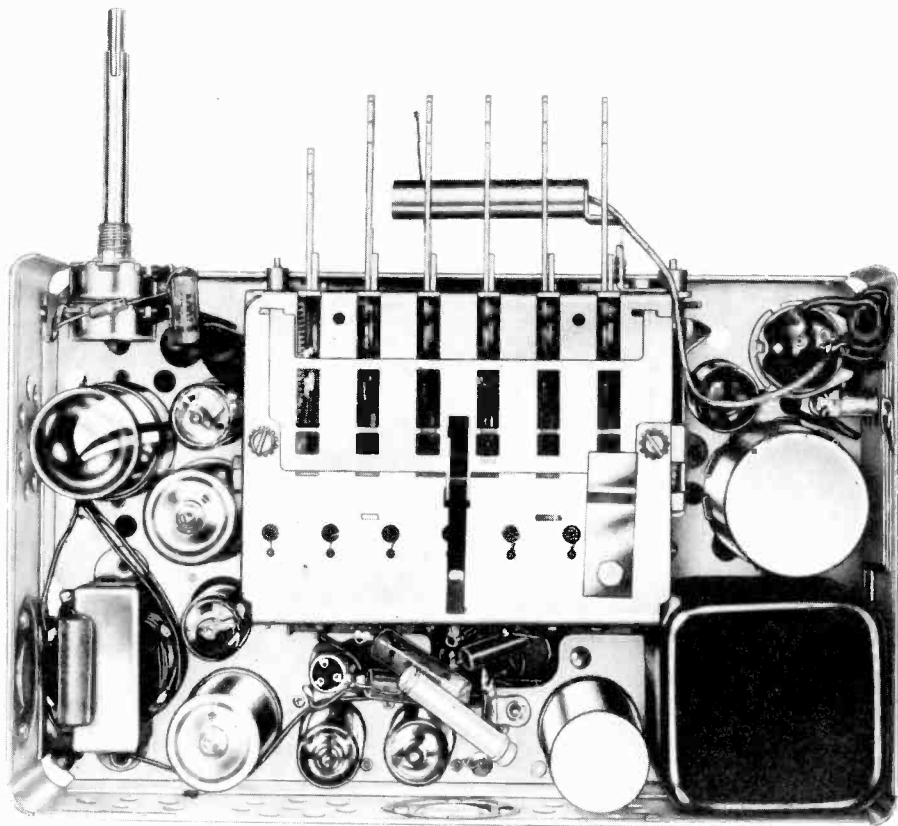
If the upper low voltage terminal is thought of as positive, one path of current will be through the choke, through the shunt field, and back to the negative terminal. Another path will be through the choke, one half of the series field, the armature, the other half of the series field and back to the negative terminal. Current in

these circuits cause the unit to act as a motor, and the armature revolves at a fairly high speed.

In addition to the motor winding, the armature carries a second winding with a separate commutator and brushes. Revolving with the motor armature in the magnetic field set up by the motor field coils, the large number of turns of this winding induce a

high voltage which is available at the brushes.

Between one of the high-voltage brushes and output terminals there is a filter made up of the audio frequency choke "CH" with condensers C2 and C3, much like the filter which follows the rectifier tube of the ordinary a-c home receiver.



Chassis view of auto radio, the external appearance of which appears on the previous page. The circuit diagram appears on the fold-out page at the end of the lesson.

Although d-c is available at the brushes, the changing contact between the brushes and commutator may cause slight variations called "Commutator Ripple", and the filter is needed to produce pure d-c at the high-voltage terminals.

Mechanically, the arrangement is on the order of Figure 2, the armature revolving between the poles and carrying a commutator on each end. The field windings of the motor circuit produce the magnetic flux which causes the armature to revolve. This flux also is cut by the second winding, and hence induces the high voltage in it.

While the unit would operate with a shunt or series winding only, the combination of both produces a more uniform output. For example, an increased high-voltage load would tend to reduce the armature speed, and this, in turn, would reduce the induced voltage. However, as the motor speed diminishes, the armature current increases, raising the series field current and thus the magnetic flux. The increased flux will strengthen the motor torque, compensating for the reduction of speed, and also increase the induction in the high voltage winding, thus holding its value more nearly constant.

Units of this type now on the market, are of small size and

weight with an efficiency high enough to make them an acceptable substitute for B batteries.

### VIBRATOR TYPES

As it is easy to increase or step up an a-c voltage, the most popular method found in modern auto radios is to use a vibrator to reverse the direction of the battery d-c in the primary of a step-up transformer. This section induces a high voltage a-c secondary voltage which is rectified by means of a tube. A circuit of this type is shown in Figure 3 where one low voltage terminal is grounded while the other connects to an r-f filter through a switch.

Because some Auto Electrical Systems ground the battery positive and others the battery negative, it is customary to speak of the battery connections as "Hot A" and "Ground". Thus, in Figure 3, the Low Voltage Terminal which is insulated from the chassis is called "Hot A". To simplify our explanations, we will consider the "Hot A" as positive, but the unit will operate equally well when the "Hot A" is negative.

Starting at the "Hot A" terminal of Figure 3, there is a circuit through the switch and through the filament of the rectifier tube to ground. Condenser C4 connects directly across the filament and helps to keep out any disturbances of the auto system.



The vibrator shown at the left of transformer "T", is made up of a magnet coil, a vibrating armature, and two pairs of contacts. The armature and one end of the magnet winding are grounded on the vibrator frame.

Resistors R1 and R2 across the contacts, have a value of 200 ohms each, the current through them being negligible for this explanation. However, the magnet winding with its relatively high resistance and large number of



Modern auto radio complete with speaker, designed for under-the-dash mounting.  
Courtesy Philco Corporation.

From the switch "SW" there is another circuit through the radio-frequency choke "RFC" and up to the center tap on the primary winding of the transformer, through the upper half of the winding, through the upper pair of vibrator contacts and armature to ground. Also, a circuit exists from the center tap through the lower half of the primary and the magnet winding to ground.

turns, holds the current in its circuit to a low value, but produces sufficient magnetic flux to attract the armature, thereby opening the upper pair and closing the lower pair of contacts.

With the upper contacts open, resistor R1 is in series with the upper half of the transformer primary, thus reducing the current to a negligible value. With the lower contacts closed, there is

a direct circuit from the center tap through the lower half of the transformer primary, and through the lower pair of contacts to ground. Notice also that closing the lower contacts shorts out the magnet winding and resistor R2.



Auto radio complete with speaker as used in Buick cars.

Courtesy General Motors Corporation

Shorting the magnet winding reduces its current to zero. This reduces the magnetic flux it sets up and allows the spring to pull the armature back to the position of Figure 3, when the entire action starts all over again.

As far as the transformer is concerned, when the upper contacts are closed, there is current in the upper half of the primary; and when the lower contacts are closed, there is current in the lower half. Then, because the center tap connects directly to

the battery, the current in each half of the primary is in opposite directions. This alternately sets up magnetic flux of opposite polarity and induces an alternating voltage in the secondary.

In other words, the action of the vibrator is to cause the steady direct current of the battery to keep changing in value and direction as it passes through the transformer primary. This changing primary current sets up a magnetic flux with similar changes, which cuts the turns of the secondary and induces an alternating voltage in it. The value of this voltage, like that of other transformers, will depend on the turns ratio between the primary and secondary.

As we explained in the earlier Lessons, when an inductive circuit like the transformer primary is opened suddenly, the magnetic flux collapses and, by self induction, induces a high voltage in such a direction that it tries to maintain the current. Here, this action will take place as the contacts open, and the induced voltage will be high enough to cause an arc between them.

To reduce "pitting" and rapid wear caused by arcing, in Figure 3, the 200 ohm resistors,  $R_1$  and  $R_2$  are connected across the contacts. Then, when the contacts separate, the circuit is not opened but the 200 ohm resistor is

placed in series, forming a path for the current caused by the self induction and reducing the arc.

The same general action takes place in the primary circuit of the auto ignition system, but there you will find a condenser connected across the contacts. While the condenser absorbs the arc between the contacts, it also discharges rapidly and then charges in the opposite direction producing a few high frequency cycles.

The discharge action of the condenser causes a more rapid change of flux in the ignition coil, thereby increasing the secondary voltage and improving the spark. In the circuit of Figure 3, however, the high frequency discharge of the condenser could cause noisy reception without greatly improving the action.

Although non-inductive resistors are connected across the vibrator contacts, the action is not perfect and some unwanted frequencies will appear in the secondary. To eliminate these, condenser C1, usually with a capacity of .02 mfd, is connected across the entire secondary winding.

The tube is a full-wave rectifier with circuits like those of the common type 80, but it has a cathode which is the positive or high potential terminal of the

high-voltage circuit, while the center tap of the secondary winding is the negative or return terminal.

The action in this secondary circuit is exactly the same as that explained for full-wave rectifiers, therefore, we will not go into further detail. However, there is



Chassis view of Buick auto radio shown on previous page.

Courtesy General Motors Corporation

a rectified a-c voltage across the high-voltage terminals of Figure 3, and the usual form of filter will be needed between the rectifier and plate circuits of the tubes of the receiver.

### SYNCHRONOUS VIBRATOR

To obtain the benefits of reduced cost and space by the elimination of the rectifier tube, the vibrator action has been extended

on the general plan of Figure 4. Here you will find five pairs of contacts, the single pair at the left in the circuit of the vibrator magnet, the center double pair in the secondary circuit, and the right hand double pair in the primary circuit.

With the armature in the position shown, there will be a circuit from the Hot A, through the switch and RFC, through the magnet winding and single pair of contacts to ground.

As we explained for Figure 3, current in the magnet coil sets up a magnetic flux which pulls the armature toward the core. Here, as the single pair of contacts open, the magnet coil circuit is completed to ground through the 50-ohm resistor R1, which reduces the current and flux to a value low enough to allow the spring to pull the armature away from the core and close the contacts.

In Figure 4, the vibrator circuits are entirely separate, and the armature will vibrate at a frequency which depends on the mechanical construction, spring tension and so on. However, as the armature vibrates, both double pairs of contacts will be opened and closed as explained for Figure 3.

The primary circuit of Figure 4 is similar to that of Figure 3, and

the action is exactly the same. We do not show any resistor connected across the primary contacts because the inductance of the primary winding may be so low that some manufacturers do not install them.

Because the action in the primary circuit changes d-c to a-c, this part of the unit is often called an "Inverter" to distinguish it from the more common rectifier which changes a-c to d-c. However, as d-c is required, the secondary contacts must operate as a rectifier, and thus the complete unit is known as an "Inverter-Rectifier" or Synchronous Vibrator.

To simplify our explanation, we want you to imagine that when the direction of primary current is up through transformer T of Figure 4, the direction of the induced voltage is down through the secondary winding.

In the position shown, the path of the primary current will be from the Hot A, through the switch and RFC to the center tap, up through the top half of the primary, through the upper pair of contacts, and through the armature to ground.

The secondary voltage or current, passing down through the winding, has no circuit from the lower end, because the lower secondary contacts are open; but

there is a circuit from the center tap to the "Pos" high-voltage terminal and through the circuits of the receiver to the "Neg" or

ground through the battery, Hot A terminal, switch, RFC, upper half of the primary, and upper primary contacts to the armature.



External view of auto radio receiver complete with speaker. Control connections are made through flexible cables that plug into special sockets.

Courtesy Philco Corporation

ground. The path is completed from ground, through the armature and upper pair of contacts to the upper end of the secondary.

Should it confuse you to follow the primary and secondary currents through the armature in opposite directions at the same time, you can think of the secondary circuit as being completed from

When the magnet pulls the armature down, both pairs of lower contacts are closed and there is a current down through the lower half of the primary. The direction of the secondary current is up, and its path will be from the center tap to the high-voltage "Pos" terminal, through the receiver circuits to ground.

From ground, the path is as previously traced, except that it passes through the lower pair of contacts to the lower end of the secondary.

The condensers C1 and C2, connected across the secondary contacts, act to reduce the arc when the circuits are opened, but as both condensers are in series across the entire secondary winding, they also provide a filtering action as explained for C1 of Figure 3.

With the synchronous type of vibrator, a reversal of battery connections will reverse the polarity of the high voltage d-c output. Therefore, most power supplies of this type provide for a reversal of the connections between the transformer secondary and the contacts. For plug-in type vibrators, this is done by wiring the socket for two positions, 180° apart. Although not shown, it is necessary to have the usual type of filter between the high voltage terminals and the circuits of the receiver.

As far as actual size is concerned, the units of Figures 1 to 4 are all made in compact form, small enough to be built into the receiver chassis. Although the general trend seems to be toward building the power supply, receiver chassis, and speaker in one complete unit, you will still find many installations in which they are made up as separate units.

However, the difference between the single and separate units is entirely mechanical, the electrical circuits remaining practically the same in all cases.

## REDUCING INTERFERENCE

Although the operation of the receiver proper in an automobile is the same as that of a set used in the home, there are many problems encountered in reducing the noise to a point where satisfactory reception is obtained. There are no hard and fast rules governing the elimination of this interference, but we want to show you a few common causes of it and methods employed for its reduction.

There are two general classes of auto interference known as chassis or lead pickup and antenna pickup. The first step in eliminating interference is to determine which type exists. This can be accomplished by grounding the antenna lead close to the chassis, and if the interference continues it is chassis pickup, but if it ceases, it is antenna pickup.

If the interference is found to be chassis pickup, be sure that all ground connections are clean and tight, that all cables, tubes and pipes of the auto are grounded and are not rubbing against the metal plate of the receiver itself. If the receiver has been installed according to the manufacturer's

specifications and the receiver wires have been kept out of the motor compartment, or have been properly shielded, there should be no chassis noise.

The most common cause of auto radio interference is antenna pickup, and we want to show you the points of the auto electrical system most likely to cause trouble, and the methods to reduce it. In Figure 5, we have the simplified generator and ignition circuits of an automobile. The starter is used only occasionally and the lamps seldom cause trouble, therefore these circuits have been omitted.

When the engine is running, the generator produces a voltage and forces current through the shunt winding of the cutout relay, magnetizing its core and closing the contacts. With the contacts closed, the generator furnishes energy for the ignition and lamps, and also charges the storage battery.

The generator voltage varies with the speed of the armature, and the cutout opens when the generator voltage drops below that of the battery. When the engine is running at slow speeds, the cutout contacts are likely to keep opening and closing. Also, the generator brushes may spark if they do not make perfect contact on the commutator. Both of these actions cause high frequen-

cy discharges which produce noise in the radio.

By placing a condenser with a capacitance of about 1 mfd across the output terminals of the generator, most of this trouble is eliminated. Notice that one side of the condenser connects to the generator terminal, and the other side of the condenser is grounded.

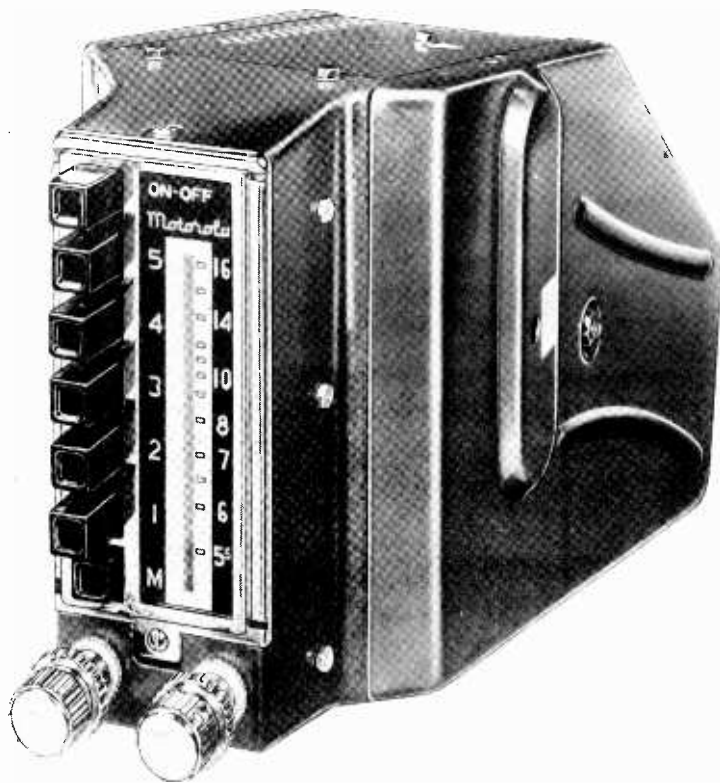
Then, in order to cause a spark at the plugs, the primary circuit of the ignition coil must be opened suddenly. Remember, the circuit has to be opened for every spark, therefore the breaker contacts operate very rapidly. There is a condenser, C3, across these contacts to reduce the sparking and increase the secondary voltage, but the action still causes interference in the radio receiver.

Here again, a fixed condenser in the position of C2, Figure 5, will reduce the noise, but it must be connected between the battery terminal of the ignition coil primary and ground. Usually, a .25 mfd condenser is sufficient.

It may be hard for you to locate the correct terminal by looking at the coil, but after the receiver is installed, start the engine and tune the receiver until the ignition interference is loudest. Then connect the condenser to the terminal which gives the best results.

The interference from the high-tension or spark plug wires can usually be eliminated by the use of a suppressor in the lead from the secondary of the ignition coil

advisable to reroute them so that they are as far apart as possible. Quite often the condenser in the position of C3 will be found defective, and a replacement with



External view of modern auto radio, showing the pushbutton station selectors and the manual tone and volume controls.

Courtesy Motorola, Inc.

to the distributor. This connection is shown by the upper resistor marked S in Figure 5.

However, if the noise persists, check the position of the low-tension and high-tension leads. If they are run close together, it is

one of the same capacitance is necessary.

The gap between the distributor rotor and outer contacts in the cap may become too large. The clearance should be approximately .005 inch and it may be

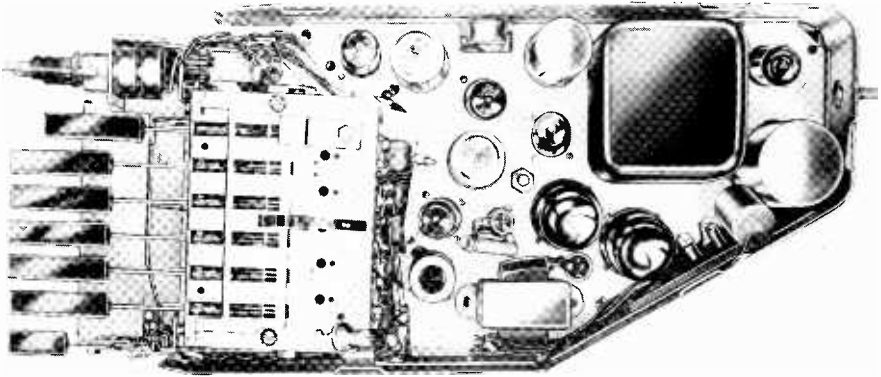


necessary to replace either or both parts. Also, spark plug interference may be carried through into the radio by the pressure gauge tube, windshield wipers, etc. These tubes should be securely bonded with a piece of heavy braided copper fastened to a good ground. By bonding, we simply mean the offending units should be securely connected together with a good conductor so as to keep them at the same potential.

In very stubborn cases of spark plug interference, it is sometimes necessary to use spark plug sup-

and therefore reduce the efficiency of the automobile engine.

Another type of antenna pick-up interference, and one which is very difficult to locate and cure, is caused by the auto body itself. If the car has been in service for some time, it is advisable to go over the entire auto, tightening all body bolts and screws which make contact with the metal parts of the car. One loose bolt, by making interrupted contact, may cause a noise which makes satisfactory operation of the receiver impossible.



Chassis view of auto radio shown on the preceding page.

Courtesy Motorola, Inc.

pressors, connected as shown in Figure 5, between the distributor and plugs. However, these suppressors should not be used unless they are absolutely necessary, because they tend to reduce the strength of the spark at the plugs

In automobiles using rubber-floated motors, a large portion of the noise may be eliminated by bonding the motor to the frame with a heavy flexible braided conductor. When bonding here, be sure to leave enough slack so that

when the motor is vibrating, the braid will not be broken, and also be sure that the connections are bright and clean. If there is a possibility of the muffler making interrupted contact with the frame, they should be bonded together.

Interference may also be due to static charges set up in the wheels of the car. This can be determined by allowing the radio to operate while the car is coasting on smooth dry concrete, with the ignition switch turned off. To eliminate such interference, springs can be purchased for installation in the wheel hub. Some cars, however, already have these installed.

The brakes may also cause a noise similar to wheel static if they drag slightly, the noise stopping completely or getting worse when the brakes are applied. In this case, a heavy bond should be placed between the brake shoe and the car chassis. Interference of this kind can be carried to the radio receiver through the lamp wires, horn leads or accessory leads, in which case they should be by-passed with a condenser of about .1 Mfd.

Cigar lighters, windshield defrosters, heater fans, etc., may cause or carry interference from an offending source to the radio. In such cases, a condenser should be used between one of the termi-

nals and the chassis. When making the chassis or ground connection, be sure that all the paint is scraped away so that good contact is made. Electric, oil, temperature and gas gauges may also cause interference and should be by-passed with a condenser.

In some cases, the dome light is a big source of radio interference and the noise can be reduced by a by-pass condenser. To find out if this is a source of noise, disconnect the dome light lead from the back of the dash and ground it. Should the noise cease, you have located the source.

Remember also, a loose connection anywhere in the entire radio and auto electrical system will cause considerable interference. Be sure all light bulbs are tight in their sockets, that all battery connections are tight and well grounded, that secondary leads at the distributor and spark plug leads all make good tight contact.

### ANTENNAS

From your earlier Lessons, you know that for maximum pick-up, an ideal broadcast receiving antenna must have considerable length, 50 ft. or more and be well elevated above ground. An auto radio must be very sensitive because in no case is this ideal antenna approached for car installations.

An antenna placed beneath the car is not in the best position be-

cause it is located near a number of sources of interference, such as wheel static, mechanical noise, etc. Also, it represents a large capacitance to the chassis and is hard to keep well insulated from it. Then, there is the difficulty of keeping it in place, as ruts, stones and vibration tend to loosen it from its mountings.

Here, however, the car owner may not want his automobile decorated with an antenna of this type, and therefore a compromise must be made. As far as possible, the requests of the customers should be met.

When installing an antenna of any type, be sure that the lead-



Complete auto radio receiver as used in Oldsmobile cars.

Courtesy General Motors Corporation

The general opinion seems to be that the rod or whip type of antenna mounted on the top of a car, or the hinge of a door, is preferable due to its greater pickup.

in is well shielded and the shield connected to ground so as to reduce interference. This brings up another method of reducing interference caused by antenna pickup.

The procedure here is to solder one end of a 4 or 5 foot piece of wire to the lead-in shield, at a point closest to the antenna proper. The receiver is then turned on with the car motor running, and tuned to the point of highest interference. Then, the loose end of the wire is used as a test probe and touched to various parts of the auto chassis until a reduction in noise level is noted. Once this point is found, a permanent connection is made. In many cases, this simple procedure has completely eliminated interference caused by the automobile.

As we told you earlier in this Lesson, there are no hard and fast rules governing the elimination of all noises in auto radio receivers, and the above explanations are only to give you a general idea as to the sources of noise and methods of reducing them. The only thing to do in cases of interference of this type, is to employ your knowledge to the fullest extent, roll up your sleeves, and go to work with the determination that you are going to eliminate it.

However, in general, always follow the manufacturer's specifications, as to placement of condensers, suppressors, etc. Above all, be sure that every trace of paint is scraped off around the mounting holes so that good ground connections are insured. If installations are made in a hap-

azard way, you may save a little time at the moment, but in the long run, an exacting job will be the most successful.

Quite often, it is necessary to spend considerable time in locating interference which is due to carelessness in following the manufacturer's specifications as to good grounds, connections, or the installation of a condenser in an out of the way place. Therefore, always follow these specifications, and in the end you will save time.

### GENERATOR CHARGING RATE

One point that is often overlooked in an auto radio installation is the fact that the radio draws current from the battery, and in order to keep the battery fully charged, this extra energy must be supplied by the generator. Therefore, when a receiver is installed, it is quite frequently necessary to increase the charging rate of the generator.

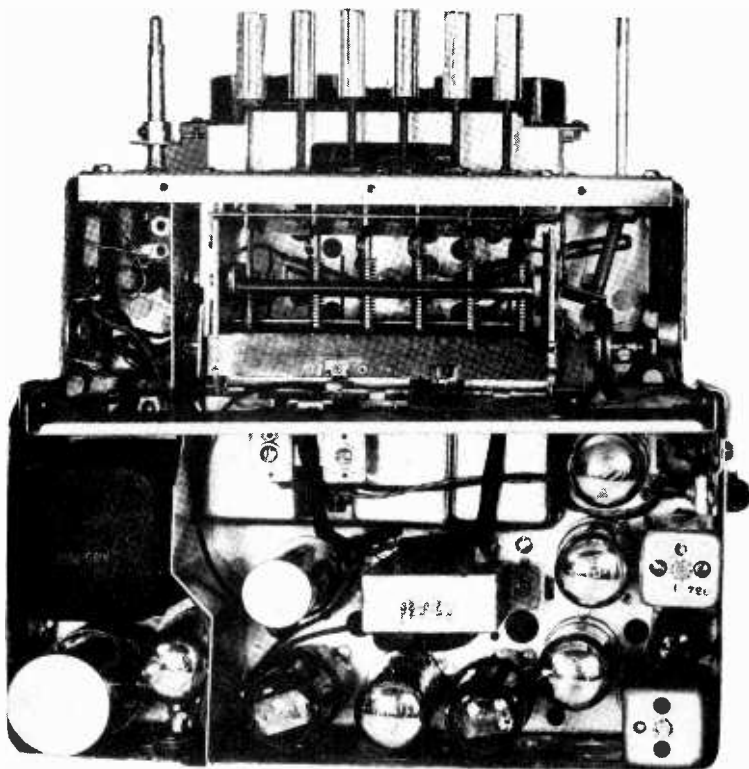
However, before this is done, the instruction book which comes with the car should be consulted as to the maximum output of the generator, and this value should never be exceeded because it may result in a "burned out" armature. If no instruction book is available, it is advisable to obtain the information from the car

dealer or local agent of the generator manufacturer.

Should this fail to keep the battery fully charged, a generator of higher output should be installed, or else the customer

## REVERSING AUTO BATTERY CONNECTIONS

The effect of reversed battery connections on the operation of an auto electric system, has caused so many questions that we



Chassis view of auto radio receiver used in Ford cars.

Courtesy Zenith Radio Corporation

should purchase one of the small home chargers which may be put on once or twice a week and left over night, thus assuring a good hot battery at all times.

want to give you a brief explanation. With the exception of the generator, all the auto electrical units consume battery power and will operate equally well with the

current in either direction. Thus, a reversal of battery connections affects only the generator-battery or charging circuit.

In the circuits of Figure 5, you will notice the generator is shunt wound, the field being connected from one main brush to the third brush. Also, there is no circuit between the generator and battery until the cutout contacts are closed.

When the engine is started, the generator armature revolves and the residual magnetism in the generator frame, causes it to "build up" to its proper voltage. The engine always drives the armature in the same direction, therefore, the polarity of the generator voltage depends on the polarity of the residual magnetism. For proper operating conditions, the generator voltage across the shunt winding of the cutout, produces sufficient magnetism to close the cutout contacts, thus completing the circuit and connecting the generator plus to battery plus.

With the battery reversed, closing the cutout contacts would connect generator plus to battery negative and thus allow a high value of current. However, under these conditions, one end of the generator field would be connected to generator plus and battery negative, with the other end to battery plus and generator negative.

As a result, the voltage across the field will be only the difference between battery and generator voltages, usually less than two volts. This low voltage across the field reduces the field current which, in turn, reduces the generator voltage. When the generator voltage drops to a value less than that of the battery, the generator field current is supplied by the battery in a reverse direction, reversing the polarity of the field and thus reversing the polarity of the generator.

When this has taken place, the system will operate normally but the dash meter will be reversed showing "Charge" when the lamps are lighted and "Discharge" when the car is running.

In practice, the battery posts are of different diameters and if reversed, may not fit the cable connectors properly. Also, like the dash meter, any electrically operated indicators containing permanent magnets will read in reverse. Therefore unless required for some specific purpose, the battery polarity should not be reversed. **CAUTION**—Never open the battery circuit while the engine is running.

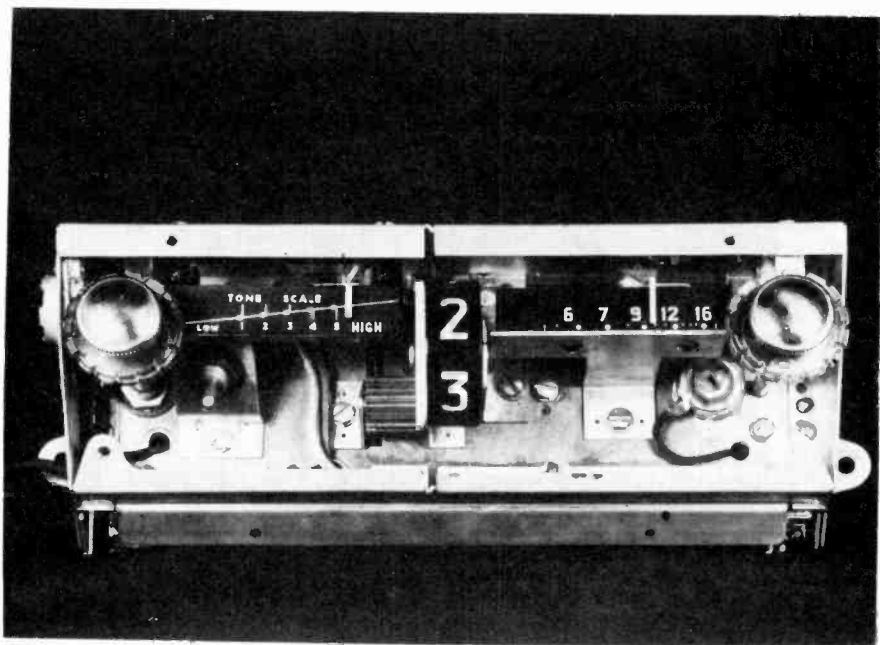
### TYPICAL AUTO RADIO RECEIVER

In Fig. 6 we show the circuits of a typical modern auto radio receiver designed for operation from a 6-volt car battery. It is

the superheterodyne type, and contains a preliminary r-f amplifier, a combination oscillator-modulator stage, an i-f amplifier, a composite detector-avc-audio-frequency amplifier, and an output power-amplifier. Hi-voltage d-c power is supplied by a circuit

### THE R-F, MIXER, AND I-F STAGES

The antenna-ground circuit is essentially a series resonance system in which the resonant signal voltage is built up across condenser C-1, and transferred through C-2 to the grid circuit of



Auto radio receiver manufactured by Zenith Radio Corporation.

containing a non-synchronous vibrator operating in conjunction with a full-wave rectifier.

We will now consider each portion of the circuit in detail, so that you will have a clear understanding of how the entire system operates.

the r-f amplifier tube, a remote cut-off r-f pentode. The tuning element in this grid circuit consists of the permeability-tuned coil L-1 and the trimmer condenser C-3. The magnetic slug in L-1 is moved in unison with the slugs in L-2 and L-3, so that all three are tuned at the same time

by adjusting the pushbutton station selectors.

The grid of the r-f amplifier tube also is supplied with an avc potential through the filter consisting of R-1 and C-4. The cathode is grounded through the fixed biasing resistor R-2 and the sensitivity control R-5. This sensitivity control is merely a 700-ohm variable resistor (screw driver adjusted) connected in series with the cathode for setting the bias on the tube to the optimum value for any particular installation. The suppressor grid is grounded directly, while the screen grid is supplied from the high-voltage line through resistor R-6. C-5 is the screen bypass condenser.

The plate circuit of the r-f tube is tuned to the frequency of the incoming signal by means of coil L-2 and the shunt trimmer C-7. Condenser C-6 is the plate bypass and decoupling condenser. From the plate the signal is transmitted to the next tube through the coupling condenser C-8.

The second tube is the oscillator-modulator or mixer, and is of the heptode converter type. The cathode and first grid together with the plate, operate as a triode oscillator. L-3 is the oscillator coil, while L-4 serves as a padder to bring about proper tracking over the low-frequency range. Resistor R-4 is the oscillator grid

load, and C-9 the grid condenser. The signal grid together with the screen, suppressor and plate operate as a remote cut-off pentode amplifier in which the incoming and oscillator signals are mixed. The cathode return also is completed through the R-5 sensitivity control. The output frequency of the mixer is the difference between the oscillator and incoming signal frequencies, and constitutes the operating intermediate frequency, (i-f) of 455 kc. The return circuit of the signal grid is closed through resistor R-3 to the avc line.

The two i-f transformers are permeability tuned, and are set to the proper frequency by adjusting the position of the iron slugs. The i-f tube is a high-gain remote cut-off pentode similar to the initial r-f tube, with the grid return completed to the avc line. The cathode is grounded through a 150-ohm biasing resistor.

### THE DET-AVC-A-F STAGE

Following the i-f stage is the composite detector-avc-audio-frequency stage that employs a twin-diode high-mu triode. The two diodes are operated independently, one to provide the audio-frequency signal and the other to operate a delayed avc system. The a-f diode plate is connected directly to the terminal No. 4 of the i-f transformer secondary. When



this terminal is positive, the diode conducts and current exists in the cathode circuit leading to the bottom terminal on the volume control R-13. From the top terminal on the volume control the circuit is completed through the 47K-ohm resistor to the terminal No. 6 on the i-f transformer secondary.

The slider of the volume control is connected through condenser C-16 to the grid of the triode, which accordingly functions as the first audio-frequency amplifier stage. Resistor R-14 is a 3.3-megohm grid leak connected directly between the grid and the cathode.

The second diode plate, it was stated, serves to excite the avc circuit. It also is connected to the upper terminal of the secondary of the second i-f transformer, but through condenser C-17. When the voltage pulse through C-17 is such that this diode plate is positive, the diode conducts and current exists between the plate and cathode. The circuit then continues through resistor R-15 to ground, it is picked up again at the lower end of R-19, extends to the left and upward, and terminates at the diode plate.

The current in this circuit sets up a voltage drop across resistor R-19, and this drop then becomes the avc voltage. The avc line ex-

tends to the left through R-10 and has three upward branches: the first to the grid of the i-f amplifier tube, the second through R-3 to the grid of the mixer, and the third through R-1 to the grid of the r-f amplifier.

The voltage drop across R-15 does not affect the operation of the a-f amplifier section of the tube but biases the cathode positive with respect to the avc diode plate. On checking the circuit again, you will note that the cathode is connected to the upper or positive end of R-15, while the lower or negative end is grounded. But the avc diode plate is also connected to ground through R-19; and as long as the diode does not conduct, there is no voltage across R-19.

As a result, the diode plate is negative with respect to the cathode by the amount of drop across R-15, and the diode cannot conduct until the incoming signal through C-17 is sufficient to overcome this negative potential and make the diode plate positive. In other words, we have here an application of delayed avc, the delay being not a matter of time, but rather an electrical delay, in that the avc cannot go into action until the signal voltage is capable of overcoming this delay. Consequently, the avc cannot operate on weak signals and full receiver output is obtainable.

## THE TONE CONTROL AND POWER AMPLIFIER STAGE

The triode first audio stage is resistance-capacitance coupled to the output power amplifier, with R-17 as the plate load resistor and C-18 the coupling condenser. Condenser C-19 is a high-frequency bypass that prevents any radio-frequency signals getting into the final amplifier.

Also in the plate circuit of the audio triode is the manually operated tone control, consisting of condenser C-22 and the variable resistor R-22. The slider on R-22 is tied directly to the cathode of the triode. On checking the volume control once more, it can be seen that the control resistor is tapped slightly below the midpoint to provide the necessary compensation at the lower frequencies when the volume is cut down.

A beam power amplifier is employed in the output stage, with the plate circuit coupled to the voice coil of the speaker through transformer T-3. The voice coil connections are shown in the lower center portion of the diagram. Resistor R-20 provides the bias for the power tube, and is bypassed by a 20-mf. low-voltage condenser that forms part of the triple-section filter condenser C-21, shown in the lower right-hand corner of the diagram. Resistor

R-18 is the grid leak across which the input signal is built up.

## THE POWER SUPPLY SYSTEM

The power supply is shown in the lower section of the diagram. One side of the car battery is grounded, while the other is connected through a fused cable to the main line that feeds the vibrator and filament circuits of the tubes. This line, it can be seen, is well filtered to prevent any high-frequency noise from entering the receiver. First there is the line filter consisting of coil L-5 and C-13, and this is followed by the main line switch S-1. Next is a tap at point X that feeds the filament circuits of the various tubes, the return line being through the grounded chassis. The dial light also is connected between this point X and chassis. Then there is another choke or retard coil, L-6, between X and the primary of the vibrator transformer at the center tap.

As the vibrating reed in the vibrator alternately makes contact with terminals 2 and 3, current is set up in one direction through the upper half of the primary winding and then in the opposite direction through the lower half. This sets up an alternating magnetic flux in the iron core, and as a result, an alternating voltage is induced in the secondary winding.

Since the transformer is of the step-up type, the secondary output voltage is quite high compared to the battery voltage, usually between 250 and 300 volts.

This high a-c voltage is next sent through a full-wave rectifier, and the d-c output passed through a pi-type smoothing filter consisting of series resistor R-21 and the two shunt condensers C-21. The filtered d-c voltage is then fed to the plate circuits of the various tubes, and through R-6 to the screen-grids of the r-f mixer, and i-f tubes. R-6 serves merely as a voltage-dropping resistor for the screen circuits. The screen grid of the power amplifier tube is fed directly from the high-voltage line.

Also across the secondary of the step-up vibrator transformer is the buffer condenser C-15 in series with resistor R-16. The

purpose of this buffer condenser, it will be recalled, is to absorb any high-voltage surges that might otherwise be harmful to the rest of the circuit. The resistor in series with the condenser prevents excessive charging currents into the condenser. Similarly, resistors R-11 and R-12 prevent destructive sparking at the make and break contacts in the vibrator.

In general, the receiver is a conventional five-tube superheterodyne, the important and outstanding feature being the nature of the power supply, which permits operation from a standard 6-volt car battery. Also, on account of the difference in operating conditions, and the nature of the installation, the mechanical construction of an auto radio is quite different from that of the familiar home receiver, but electrically the two receivers are quite alike.

**IMPORTANT WORDS USED IN THIS LESSON**

**BUFFER CONDENSER**—A small high-voltage condenser connected across the secondary of a vibrator transformer to absorb the voltages surges that otherwise might be destructive to the rest of the associated apparatus.

**COMMUTATOR**—The group of copper bars mounted on one end of the armature of a d-c motor or generator, and used to connect the rotating armature winding to the external circuit through a set of stationary brushes.

**COMMUTATOR RIPPLE**—The small variations in voltage output of a d-c generator caused as the brushes make contact with successive commutator bars.

**CUTOUT**—An electromagnetic device that, in an automobile electric system, prevents the battery from discharging through the generator.

**DEFROSTER**—A means for melting the ice and removing the frost from the wind shield of an automobile. Usually this is accomplished by directing a blast of warm air against the wind shield.

**DISTRIBUTOR**—A rotating switch employed in auto ignition systems to distribute the high voltage developed by the ignition coil to the various spark plugs in the proper order.

**DYNAMOTOR**—An electric machine with two sets of armature windings on a single rotor, and with a common set of field poles. One winding receives current and causes the machine to rotate as a motor, while the other winding operates as a generator. Used commonly with mobile radio equipment to convert an available d-c voltage to one of a higher value or to an a-c voltage.

**GENEMOTOR**—An electric machine with two armature windings (similar to a dynamotor) usually employed to convert a low-value d-c voltage, as from a 6 or 12-volt storage battery, to one of a higher value suitable for exciting the plate and screen circuits of portable receivers and transmitters.

**MOTOR-GENERATOR**—Two electric machines, one a motor and the other a generator, mounted on a common shaft and employed to convert the available line voltage to a voltage of another value or another frequency.

**NONSYNCHRONOUS VIBRATOR**—A vibrator that interrupts the direct current and develops an alternating voltage at a frequency depending upon the frequency of the vibrating reed.

**SUPPRESSOR**—A form of resistor connected in series with the spark plug leads of an auto engine to suppress high-frequency radio interference.

**SYNCHRONOUS VIBRATOR**—A vibrator that interrupts the direct current and also rectifies the high voltage a-c that is developed across the secondary of the step-up transformer.

**VIBRATOR**—An electromagnetic device employing a vibrating reed and used to develop an interrupted direct current. When this interrupted direct current is sent alternately through the two halves of the center-tapped primary of a transformer, an alternating voltage is developed in the secondary.

**WHIP-TYPE ANTENNA**—A form of radio antenna used extensively on automobiles. It usually consists of a number of telescoping sections of small steel or brass tubing.

STUDENT NOTES

FIGURE 6

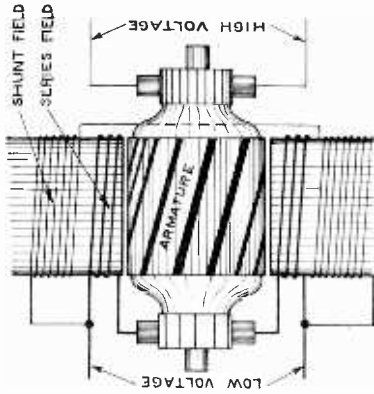
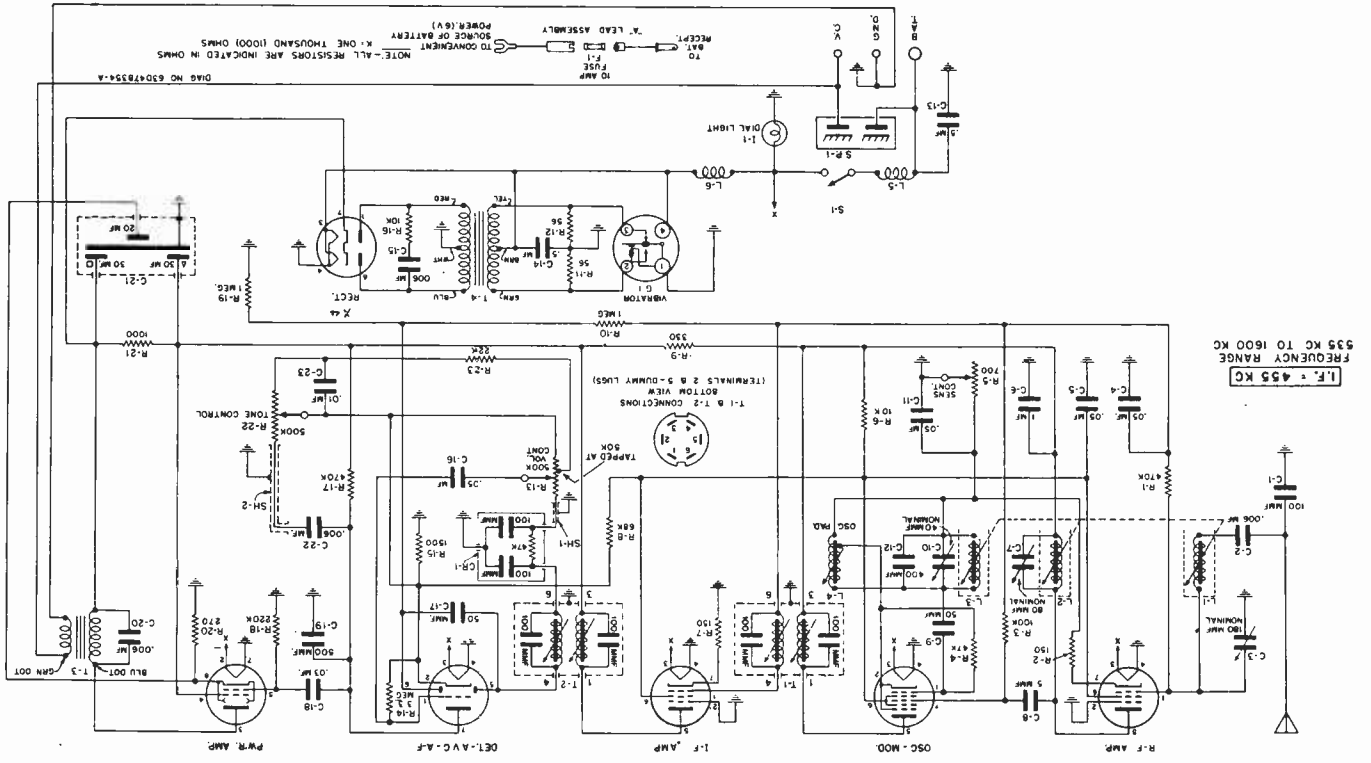


FIGURE 2

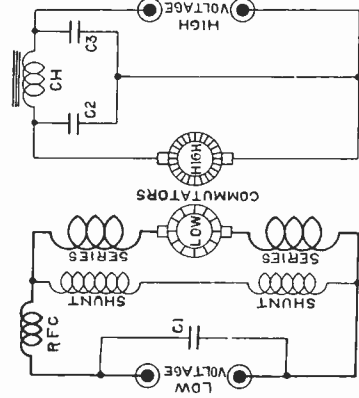


FIGURE 1

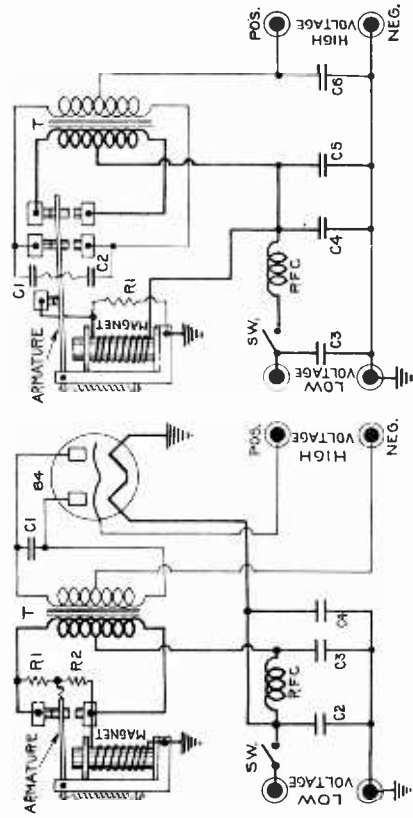


FIGURE 3

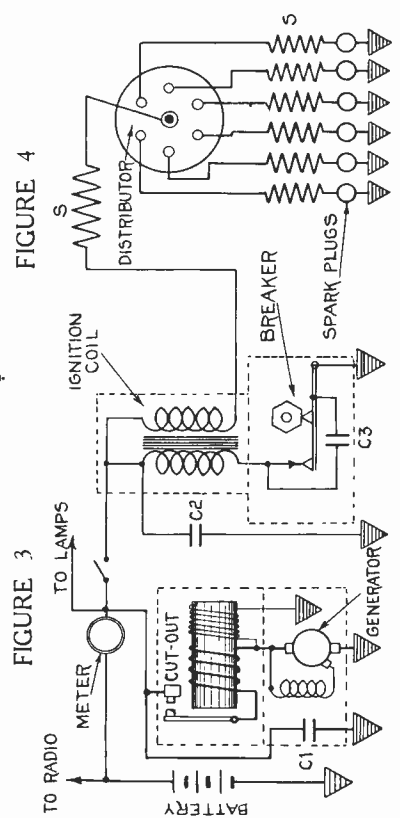


FIGURE 4

FIGURE 5









FROM OUR *President's* NOTEBOOK  
MAN'S MEASUREMENT

A man's no bigger than the way  
He treats his fellow man!  
This standard has his measure been  
Since time itself began!  
He's measured not by tithes and creeds,  
High-sounding though they be;  
Nor by the gold that's put aside,  
Nor by his sanctity!  
He's measured not by social rank,  
When character's the test;  
Nor by his earthly pomp or show,  
Displaying wealth possessed!  
He's measured by his justice, right,  
His fairness at his play,  
His squareness in all dealings made,  
His honest, upright way.  
These are his measures, ever near  
To serve him, when they can;  
For man's no bigger than the way  
He treats his fellow man!

*W. B. Devery*  
PRESIDENT